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Article

Temporal Trends and Future Projections of Occupational Asthma and Lung Cancer in Southeast Asia: Insights From the Global Burden of Disease Study 1990–2021

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Abstract

Aims/Background: Exposure to occupational hazards remains a significant driver of asthma- and lung cancer-related morbidity and mortality, particularly in rapidly industrializing regions such as Southeast Asia. However, comprehensive assessments of long-term regional trends and future projections of occupational respiratory diseases remain limited. This study aimed to evaluate the temporal dynamics of occupational asthma and occupational lung cancer burden in Southeast Asia from 1990 to 2021 and to project future trends through 2035. **Methods**: Data were obtained from the Global Burden of Disease (GBD) Study 2021 to assess mortality and disability-adjusted life years (DALYs) attributable to occupational asthma and lung cancer in Southeast Asia. To enhance model validation, additional metrics, including the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), were applied, together with K-fold cross-validation to assess model generalizability. Sensitivity analyses were conducted to examine the robustness of findings under alternative assumptions. **Results**: From 1990 to 2021, the age-standardised DALY rate of occupational asthma declined by 33.45%, although the absolute number of DALYs increased due to population growth and ageing. In contrast, occupational lung cancer exhibited a persistent upward trend in both absolute burden and age-standardised rates, with older men disproportionately affected. Decomposition analyses identified that population ageing and population growth were the key contributors to the overall increase in disease burden. Projections through 2035 suggest that asthma-related burden will continue to decrease, whereas occupational lung cancer burden is expected to increase further. **Conclusion**: Although age-standardised rates of occupational asthma have improved, the overall burden remains substantial, largely due to population growth and ageing, which continue to place considerable pressure on occupational health systems.

Keywords: occupational hazards; asthma; lung cancer; DALYs; Southeast Asia; epidemiologic trends; GBD

1. Introduction

Occupational respiratory diseases, including asthma and lung cancer [1], are major contributors to global morbidity and mortality, particularly in regions experiencing rapid industrialization [2,3]. Currently, an estimated 262 million patients worldwide are living with asthma. Although asthma affects populations across all income levels, more than 90% of asthma-related deaths and disability-adjusted life years (DALYs) occur in low- and lower-middle-income countries, highlighting the significant challenges these regions face in asthma prevention and control [4,5]. Between 1990 and 2019, the global age-standardised mortality rate for asthma declined by approximately 51%, and DALY rates decreased by roughly 40% to 50%. However, the total number of asthma cases increased from around 230 million to 260 million, and the overall burden in deaths and DALYs has continued to rise, driven largely by global population growth and ageing [6]. In labor-intensive sectors, long-term exposure to dust, fumes, chemicals, and other occupational allergens continues to increase the risk and regional burden of respiratory disease [7,8].

Occupational asthma (OA) is categorized into two main forms: new-onset asthma caused by workplace exposure to respiratory sensitizers or irritants, and work-exacerbated asthma (WEA), where existing asthma worsens due to occupational factors. Compared with non-occupational asthma, OA is generally associated with more frequent symptoms, higher medication requirements, a rapid decline in lung function, and increased risks of hospitalization and disability. Prolonged exposure to organic dusts, fumes, and similar irritants may lead to persistent symptoms even after exposure ends, and severity is often correlated with the intensity of initial exposure. Clinically, individuals with WEA often show patterns similar to those with OA, with elevated risks of acute exacerbations and greater healthcare utilization, highlighting the significant health and socioeconomic burden of occupational asthma [9,10]. In some countries, occupational exposures account for an estimated 10% to 25% of adult asthma cases, with even higher proportions observed in high-risk industries such as agriculture, manufacturing, and mining [11].

Lung cancer remains one of the leading causes of cancer-related death globally [12]. While tobacco smoking is still the dominant risk factor, exposure to occupational carcinogens, including asbestos, crystalline silica, diesel exhaust, and various metal compounds, can significantly increase lung cancer risk, particularly in settings where occupational health regulations are limited. Available estimates indicate that roughly 13% to 30% of lung cancer cases may be attributable to occupational exposure, with approximately 14% linked to asbestos, 2.7% to crystalline silica, and 2.5% to diesel exhaust [13,14]. Globally, more than 300,000 annual lung cancer-related deaths are associated with occupational risk factors, and this number appears to be rising in developing countries undergoing rapid industrialization [15,16].

Beyond smoking, occupational exposures such as asbestos fibers, diesel particulates, silica dust, and heavy metals are now widely recognized contributors to lung cancer incidence. Globally, occupational exposures account for approximately 9% to 15% of lung cancer deaths, including around 5% due to diesel exhaust. The remaining burden is largely attributed to asbestos- and silica-related agents. In low- and middle-income countries, where occupational health systems may be underdeveloped, the relative burden of occupational hazards is increasing, posing a growing threat to public health infrastructure [17,18].

Despite the significant burden and the complex etiology of occupational respiratory diseases across Southeast Asia, longitudinal evidence on asthma and lung cancer due to occupational exposure remains limited. Most existing studies focus on global trends or high-income settings, leaving a significant evidence gap in this rapidly developing and diverse region.

Therefore, this study aims to quantify the burden of occupational asthma and lung cancer in Southeast Asia from 1990 to 2021 using data from the Global Burden of Disease (GBD) Study, and to project these trends through 2035.

2. Methods

2.1 Study Objectives

This study aimed to assess the burden of asthma and lung cancer attributable to occupational exposures in Southeast Asia from 1990 to 2021. Specifically, we quantified age-standardised mortality rates and disability-adjusted life years (DALYs), examined their relationship with the socio-demographic index (SDI), and projected future trends in disease burden through 2035.

2.2 Data Sources

Data were obtained from the Global Burden of Disease Study 2021 (GBD 2021), coordinated by the Institute for Health Metrics and Evaluation (IHME). All estimates used in this study were accessed through the Global Health Data Exchange (GHDx; http://ghdx.healthdata.org/gbd-results-tool) between 1 March and 15 March 2025. Data extraction followed GBD data citation and reporting guidance, with explicit specification of cause, risk factor, outcome measure, age, sex, location, and year, and the corresponding model versions.

This analysis included 11 Southeast Asian countries: Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Vietnam. All included countries had complete and comparable GBD 2021 estimates for occupational asthma and occupational lung cancer across the full study period (1990–2021) (**Supplementary Tables 1,2**).

The GBD framework provides standardised, internally consistent estimates across age, sex, location, and time for more than 350 diseases and injuries and over 80 behavioral, environmental, and occupational risk factors. This framework enables robust assessment of temporal trends and differences between countries within the region.

2.3 Health Outcomes and Measures

We examined occupational asthma and occupational lung cancer attributable to workplace exposures, using all-age mortality and disability-adjusted life years (DALYs) as the primary outcomes. DALYs were defined as the sum of years of life lost (YLL) and years lived with disability (YLD). Population-level primary estimates were obtained from the Global Burden of Disease Study 2021 (GBD 2021) and extracted as cause–risk pairs.

To provide contextual insight into potential sources of occupational risk, we conducted post-hoc, exploratory stratifications of occupational-attributable burden by broad industrial sectors (e.g., textiles, mining, manufacturing, and construction) and by major hazard categories (e.g., crystalline silica, asbestos, benzene, and diesel exhaust). These sector- and agent-level patterns are not directly estimated by GBD. Instead, they were derived through an assumptive mapping approach that integrated GBD cause-risk estimates with external information on occupational exposure distributions. Industrial sectors were aligned with the International Standard Industrial Classification (ISIC), and hazard groupings were informed by the International Labour Organization (ILO) Chemical Safety and the Environment resource (official page: https://www.ilo.org/topics-and-sectors/safety-and-health-work/chemical-safety-and-environment), together with region-relevant occupational exposure literature. These stratifications should therefore be interpreted as modeled, descriptive allocations, intended to illustrate relative contribution patterns rather than provide precise GBD estimates.

All outcome measures are reported per 100,000 population and age-standardised to the GBD reference population. Estimates are presented with 95% uncertainty intervals (UIs) to reflect both sampling variability and model-based uncertainty.

2.4 Stratification and SDI Classification

Estimates were stratified by sex, five-year age groups, and country, with the SDI incorporated to place disease burden in the context of national development. The SDI is a composite index ranging from 0 to 1, that reflects income per capita, average educational levels, and fertility rates among individuals younger than 25 years.

2.5 Trend and Decomposition Analysis

Temporal trends were analyzed using age–period–cohort (APC) models to separate the independent effects of age, period, and cohort on disease burden. Furthermore, decomposition analysis was used to quantify the relative contributions of population growth, population ageing, and changes in age-specific rates to determine shifts in mortality and DALYs over time.

2.6 Forecasting to 2035

Projections were derived from observed trends between 1990 and 2021 using statistical extrapolation based on GBD modeling algorithms. These projections assumed no major changes in occupational exposure patterns or intervention coverage and were used to estimate future mortality and DALYs through 2035.

2.7 Statistical Analysis

Statistical analyses were conducted in R software, version 4.2.2, R Foundation for Statistical Computing, Vienna, Austria, with the ggplot2, Epi, and dplyr packages. All estimates were presented with 95% uncertainty intervals (UIs), which incorporated sampling variability and model-based uncertainty. APC plots were used to describe age-, period-, and cohort-related patterns, and decomposition analysis followed standardised GBD methods.

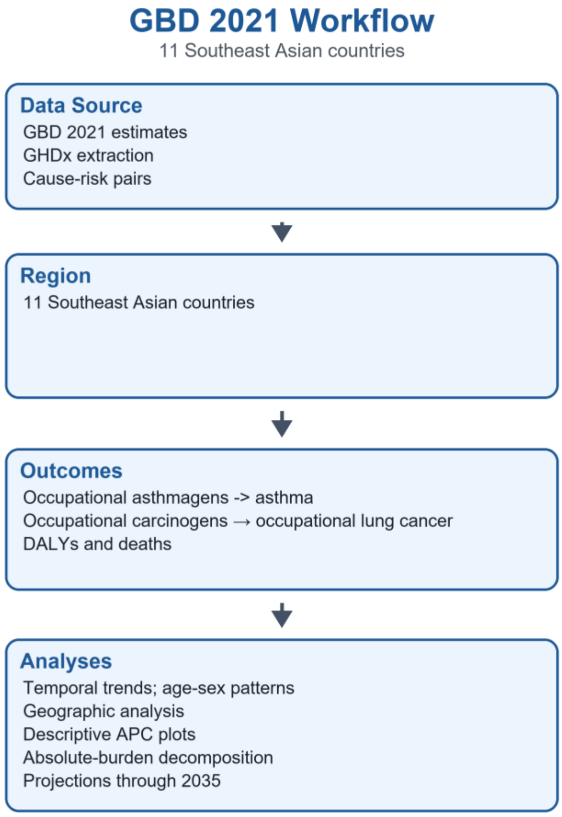

Fig. 1. Study framework and analytical workflow for 11 Southeast Asian countries. This flowchart presents the complete analytical pipeline, covering GBD 2021 data extraction from the Global Health Data Exchange (GHDx), identification of occupational risk–cause pairs, estimation of disability-adjusted life years (DALYs) and deaths, assessment of temporal trends, age–sex pattern analysis, geographic analysis, descriptive age–period–cohort analysis, decomposition of absolute burden, and future projections through 2035. APC, age-period-cohort; DALYs, disability-adjusted life years; GBD, Global Burden of Disease.

3. Results

3.1 Assessment of Global Trends

Fig. 1 summarizes the study's analytical workflow, outlining the data source, variable definitions, modeling procedures, including age–period–cohort (APC) modeling, decomposition of temporal changes, and forecasting, as well as model validation used for both occupational asthma and occupational lung cancer. Between 1990 and 2021, the total DALYs attributable to occupational asthma in Southeast Asia increased from approximately 189,092 to 273,873. Despite this absolute rise, the age-standardised DALY rate declined by 33.45%, from 55.12 to 36.68 per 100,000. A similar pattern was observed for mortality. The number of asthma-related deaths increased from approximately 3930 in 1990 to 5930 in 2021, although the age-standardised mortality rate declined from 1.34 to 0.83 per 100,000.

In contrast, the burden of occupational lung cancer increased significantly. The total DALYs rose from about 103,761 in 1990 to 352,200 in 2021, and the age-standardised DALYs rate increased by 11.99%, from 36.63 to 48.62 per 100,000. Age-standardised mortality due to occupational lung cancer also increased from 1.36 to 1.85 per 100,000. Over the same period, the absolute number of deaths attributable to occupational lung cancer increased from approximately 48,000 deaths in 1990 to more than 110,000 deaths in 2021. These findings reflect a clear divergence: asthma metrics improved relative to baseline, whereas lung cancer burden worsened both in absolute numbers and in age-standardised rates.

Causal inference analyses further supported that the pace of industrialization has a significant impact on occupational disease burden. In the instrumental variable analysis, a one–standard deviation increase in industrialization speed was associated with a 4.7% increase in occupational lung cancer DALYs (95% confidence interval [CI]: 1.5–8.0%) after adjusting for confounders. In the DID analysis, countries that implemented stronger occupational safety regu-

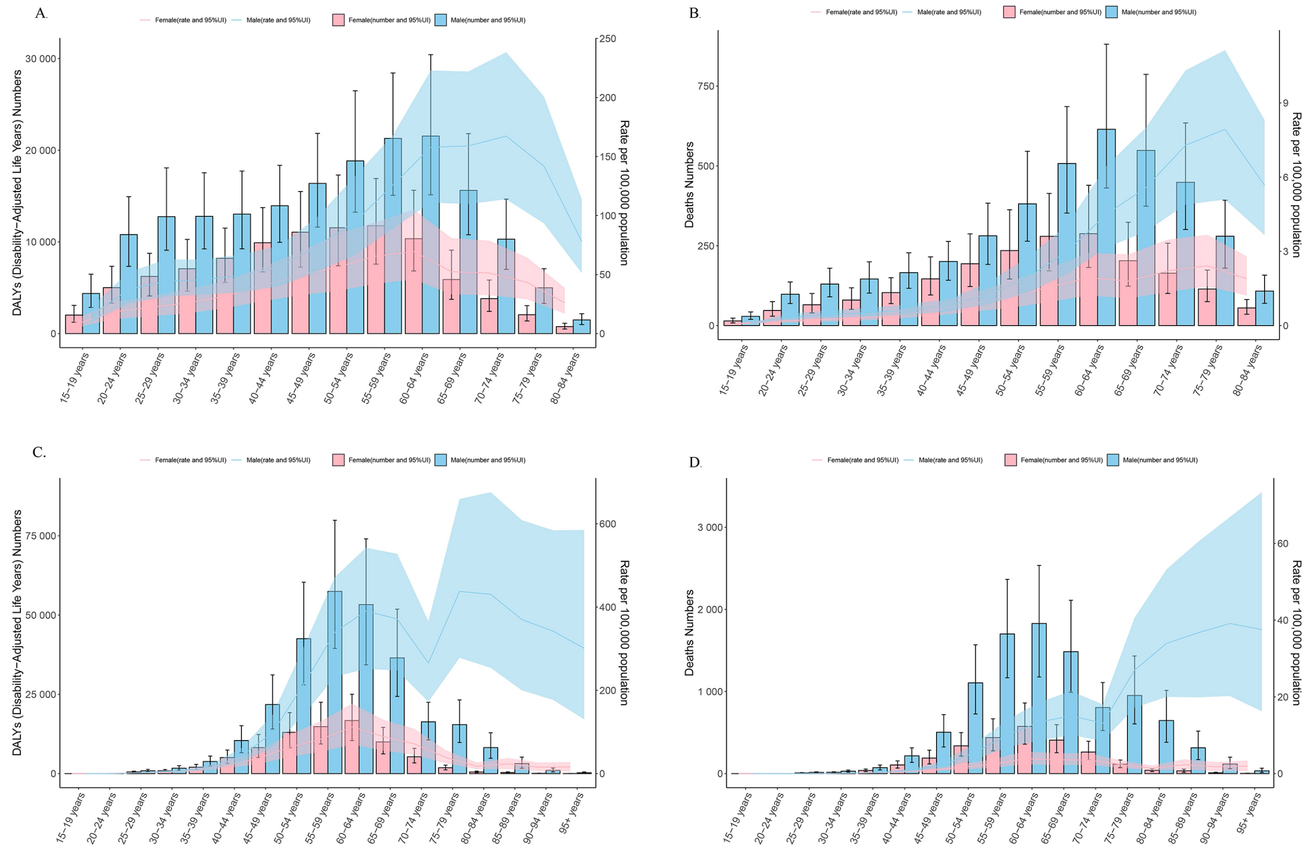

Fig. 2. Age-specific burden attributable to occupational risks in the GBD-defined Southeast Asia region in 2021, stratified by sex. (A) Asthma DALYs; (B) asthma deaths; (C) tracheal, occupational lung cancer DALYs; and (D) tracheal, occupational lung cancer deaths. Bars show absolute numbers and lines with shaded bands show age-specific rates and 95% uncertainty intervals. DALYs, disability-adjusted life years; UI, uncertainty interval.

lations experienced a 5.9% greater decline in occupational asthma DALYs (95% CI: –9.2% to –2.6%) compared with countries without similar interventions.

Model validation analyses demonstrated good overall performance and robustness. Models incorporating full covariate adjustment consistently produced lower AIC and BIC values than reduced models, indicating improved goodness-of-fit without unnecessary complexity. K-fold cross-validation showed stable estimates across folds, and minimal variation in effect sizes, supporting generalizability and limiting overfitting. Finally, sensitivity analyses, including alternative exposure definitions and exclusion of extreme values, yielded results that remained both directionally and quantitatively consistent with the primary analyses, reinforcing the robustness of the main findings.

3.2 Sex- and Age-Specific Patterns

In 2021, asthma burden was concentrated in middle and older age groups (Fig. 2). Among women, DALYs peaked at 11,763.70 (95% UI 7572.12–16,915.49) in those aged 55–59 years, while deaths peaked at 287.91 (182.00–439.44) at 60–64 years. Among men, both DALYs and deaths peaked at 60–64 years, at 21,548.74 (15,143.50–30,425.51) DALYs and 614.65 (430.88–881.08) deaths. Peak age-specific asthma mortality rates occurred later, at 75–79 years, reaching 7.94 (5.10–11.14) per 100,000 in men and 2.42 (1.58–3.67) per 100,000 in women.

For occupational lung cancer, female DALYs and deaths both peaked at 60–64 years, at 16,741.77 (95% UI 10,436.79–25,006.31) DALYs and 574.91 (358.70–859.77) deaths. Male DALYs peaked at 55–59 years, at 57,469.07 (39,477.65–79,882.11), whereas male deaths peaked at 60–64 years, at 1828.49 (1176.81–2535.59). The male DALY rate peaked at 75–79 years at 437.61 (278.17–659.22) per 100,000, and the male mortality rate peaked at 90–94 years at 39.13 (20.22–66.88) per 100,000. In women, the highest DALY and mortality rates occurred at 60–64 years, at 112.35 and 3.86 per 100,000, respectively.

3.3 Estimation of Regional Variation

Geospatial analyses revealed substantial heterogeneity in the burden of occupational asthma and occupational lung cancer across global regions and within Southeast Asia. In 2021, Southeast Asia had a comparatively high burden of occupational asthma, reflected in both DALYs and mortality rates, compared to many other regions. However, some regions, particularly parts of West Africa, demonstrated even higher burdens (Fig. 3A,B).

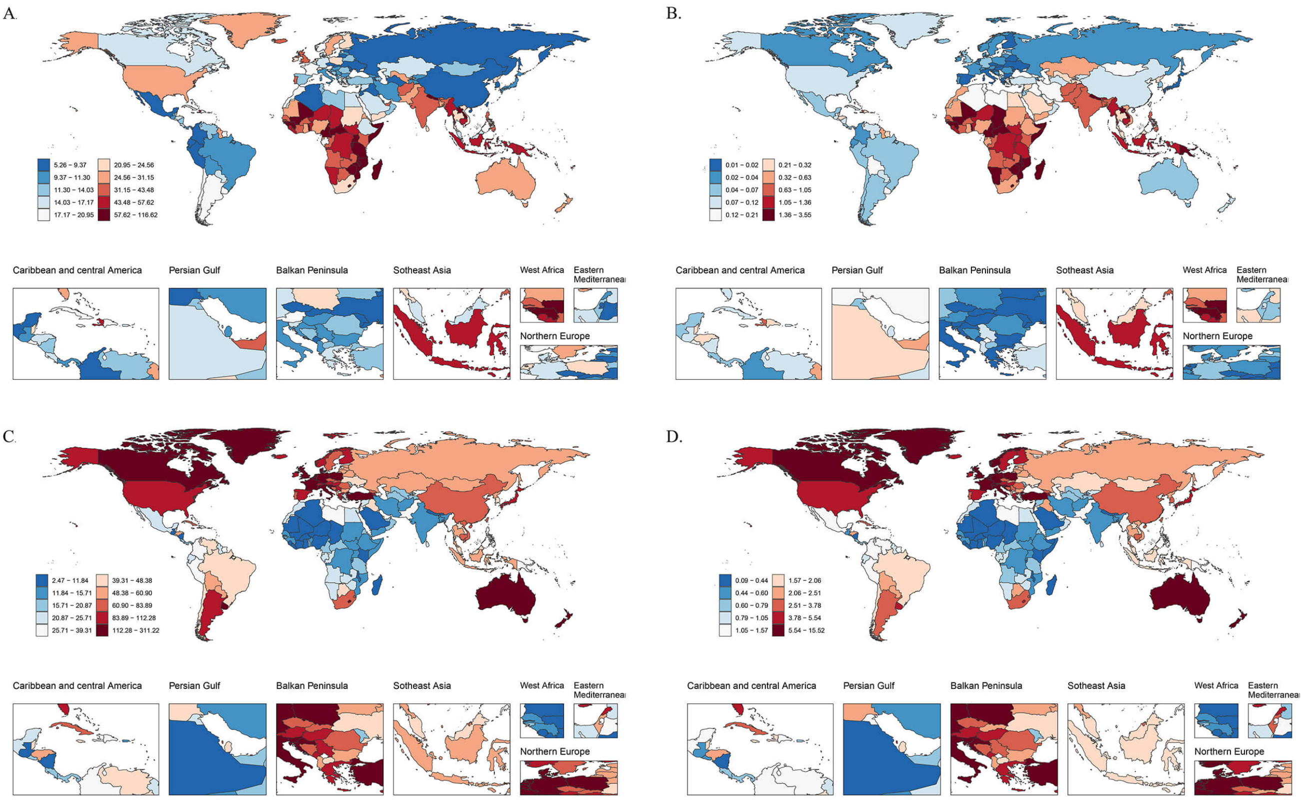

Fig. 3. Global and Southeast Asian occupational risk map visualization analysis of asthma and lung cancer. (A) Asthma DALYs. (B) Asthma mortality rate. (C) Lung cancer DALYs. (D) Lung cancer mortality rate.

Our exploratory, post-hoc stratifications suggested that occupational lung cancer burden in Southeast Asia was predominantly associated with mining- and construction-related activities, where exposure to crystalline silica and asbestos is more frequent. Similarly, occupational asthma burden appeared more strongly associated with textile manufacturing and agricultural processing, where exposure to organic dust and chemical sensitizers is common. Diesel exhaust emerged as a cross-sector hazard, with modeled associations spanning multiple sectors, particularly transportation-related activities.

Compared with global estimates, the overall burden of occupational lung cancer in Southeast Asia remained moderate. However, several countries demonstrated sustained upward trends over time, reflecting heterogeneity in industrial exposure patterns and variability in the implementation and effectiveness of occupational risk control across the region (Fig. 3). Country-specific estimates for 1990, 2010, and 2021 are provided in **Supplementary Tables 1,2**.

Given the precarious nature of gig and informal work, psychosocial stress is likely to coexist with physical hazards, further increasing the overall disease burden. Accordingly, validated surveillance frameworks, such as Malaysia's 2025 Psychosocial Risk Assessment Guidelines, are referenced here to underscore potential directions for future integrated occupational health assessments. These frameworks were not used in the quantitative analyses of the present study.

3.4 Age–Period–Cohort Modeling

The age–period–cohort (APC) model across five representative Southeast Asian countries identified distinct generational trends. For occupational asthma, both DALYs and mortality risks generally decreased over successive cohorts, reflecting possible improvements in early diagnosis, clinical management, and workplace risk mitigation. In contrast, occupational lung cancer burden showed a continuous increase over time, indicating persistence or increasing exposure to carcinogenic hazards and a longer-term accumulation of risk. Across ages, asthma DALYs risk exhibited a modest M-shaped trajectory, peaking around age 60, followed by a decline and a smaller rise before gradually tapering. Lung cancer displayed a steeper M-shaped curve, with a sharp peak near 55 years, followed by a decline and a subsequent rise. In terms of mortality, asthma risk peaked at age 79, while lung cancer mortality was greatest among individuals aged 80–89 years (Fig. 4).

3.5 Burden Decomposition Analysis

Decomposition analysis was applied to changes in absolute DALYs and deaths rather than to age-standardised rates (Fig. 5). These results represent the aggregated trends for the 11 Southeast Asian countries included in this analysis. For asthma DALYs, the net increase was 84,780.52: population ageing contributed 89,636.27 (105.73% of the net change), population growth contributed 118,922.17

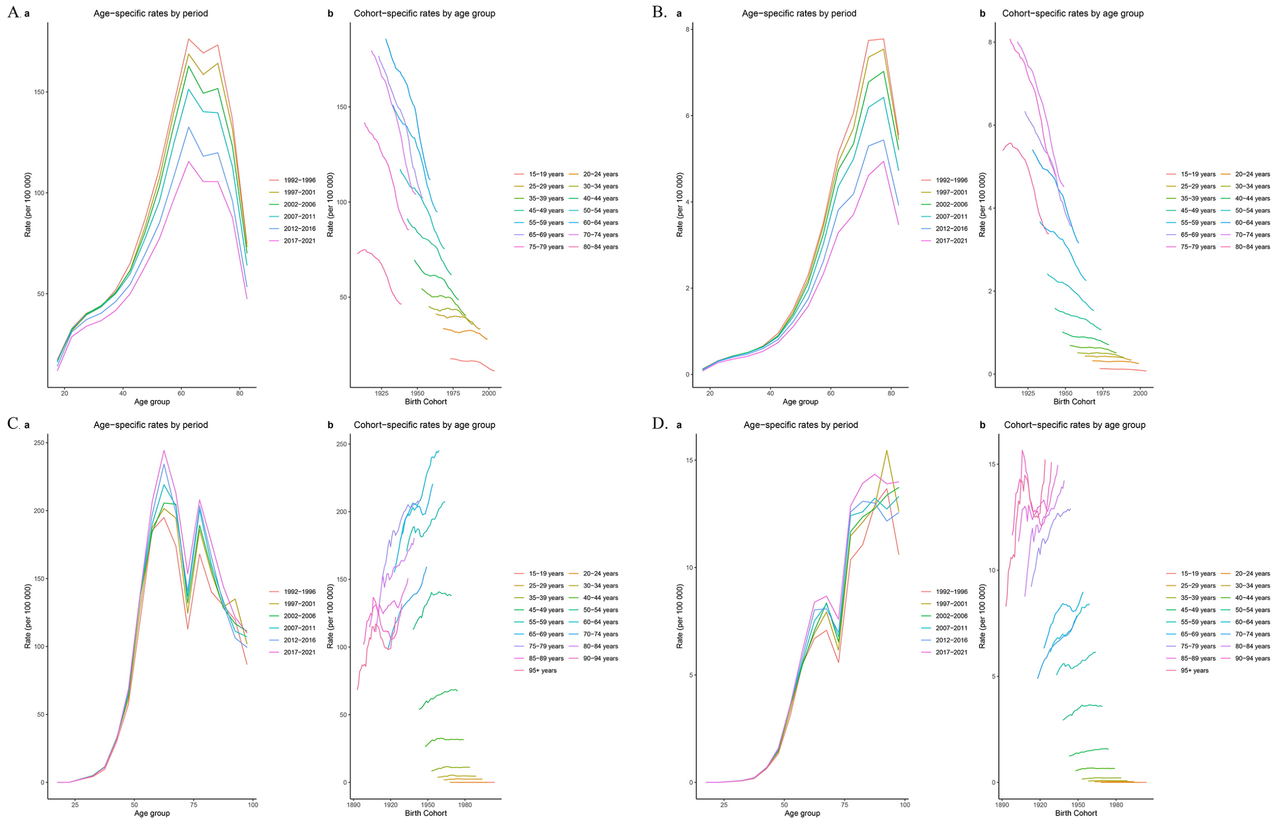

Fig. 4. Descriptive age–period–cohort patterns. (A) Asthma DALY rates: (a) age-specific rates by period and (b) cohort- specific rates by age group. (B) Asthma mortality rates: (a) age-specific rates by period and (b) cohort-specific rates by age group. (C) Occupational lung cancer DALY rates: (a) age-specific rates by period and (b) cohort-specific rates by age group. (D) Occupational lung cancer mortality rates: (a) age-specific rates by period and (b) cohort-specific rates by age group. DALYs, disability-adjusted life years.

(140.27%), and epidemiological change offset these increases by –123,777.92 (–146.00%). For asthma deaths, the net increase was 1999.38, with contributions of 1948.66 (97.46%) from ageing, 2470.05 (123.54%) from population growth and –2419.34 (–121.00%) from epidemiological change. In the 11 Southeast Asian countries included in this analysis, the increase in occupational lung cancer DALYs was 248,438.94, comprising 97,940.68 (39.42%) from ageing, 107,004.64 (43.07%) from population growth and 43,493.61 (17.51%) from epidemiological change. In these 11 countries, the increase in occupational lung cancer deaths was 8911.06, comprising 3343.79 (37.52%), 3463.45 (38.87%) and 2103.81 (23.61%), respectively.

3.6 Projections Through 2035

Under continuation of historical trends, asthma age-standardised DALY and mortality rates were projected to decline through 2035 (Fig. 6). Absolute asthma DALYs and deaths were projected to remain below their earlier peaks, although prediction uncertainty widened with the forecasting horizon. In contrast, both absolute and age-standardised lung cancer burden were projected to increase (Fig. 7). These forecasts describe a continuation scenario and do not account for future changes in exposure controls, industrial structure, diagnostic practice or treatment.

4. Discussion

This study provides a systematic assessment of the burden of occupational asthma and occupational lung cancer in Southeast Asia from 1990 to 2021, highlighting distinct temporal patterns and their far-reaching implications for public health planning and policy.

Analyses of industrialization and disease burden have often been limited to descriptive associations, which cannot adequately control for confounding by urbanization or environmental regulation. Our findings support the interpretation that rapid industrialization is linked to a higher occupational lung cancer burden, while timely policy interventions may help mitigate asthma-related outcomes. Although age-standardised mortality rates and disability-adjusted life years (DALYs) associated with asthma have declined over time, the absolute burden has continued to rise, primarily due to population growth and rapid population ageing. This trend indicates that improvements in occupational health have not sufficiently addressed the challenges posed by demographic transitions. In practical terms, decreasing age-adjusted rates may reflect some progress in early prevention and diagnosis. However, they can also conceal the continuously growing number of individuals affected by work-related respiratory diseases.

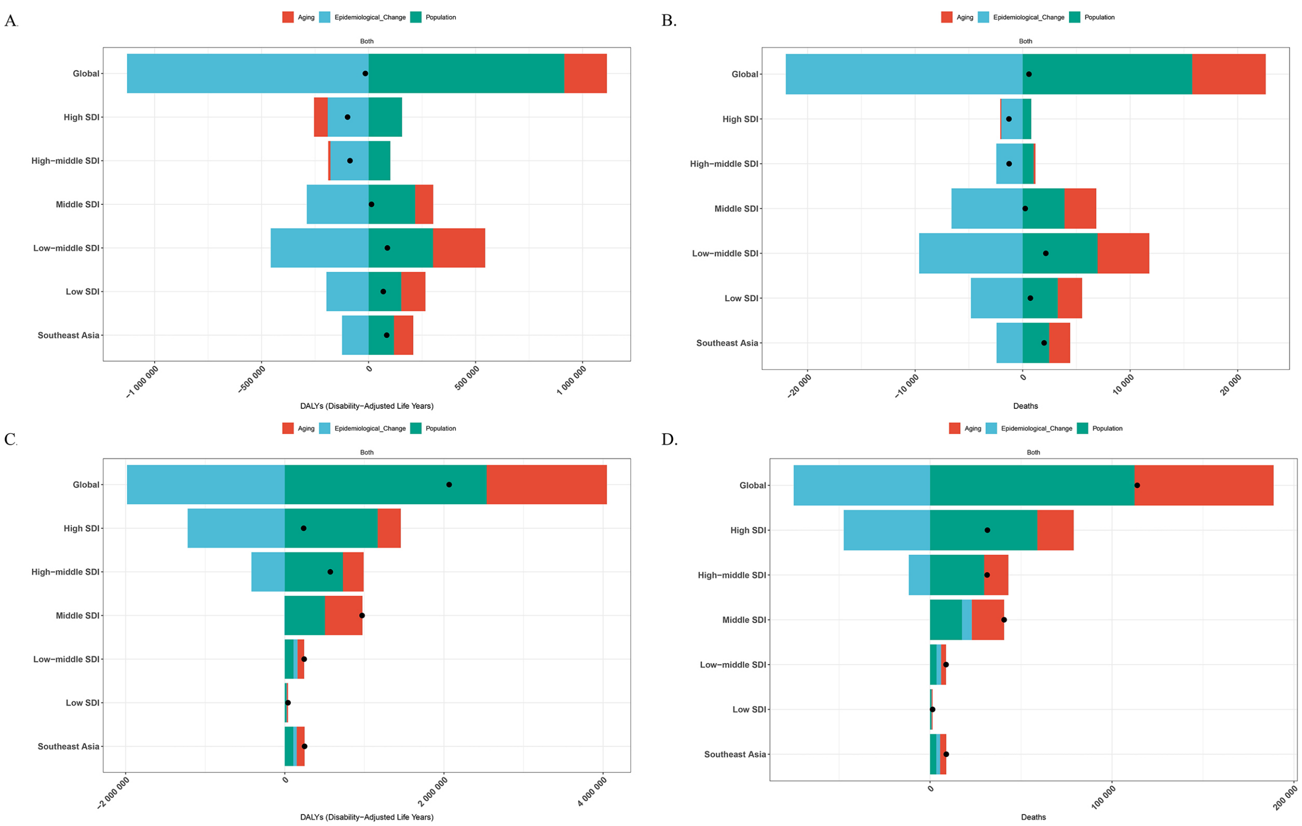

Fig. 5. Decomposition of changes in absolute burden between 1990 and 2021 into population ageing, population growth and epidemiological change. (A) Asthma DALYs; (B) asthma deaths; (C) tracheal, occupational lung cancer DALYs; and (D) tracheal, occupational lung cancer deaths. Black points indicate the net change. Panels compare the global level, socio-demographic index groups and the GBD-defined Southeast Asia region. DALYs, disability-adjusted life years; SDI, socio-demographic index.

In contrast to the relative improvements made in asthma control, the burden of occupational lung cancer in Southeast Asia has continued to increase. Globally, more than 300,000 lung cancer-related deaths each year are attributed to occupational exposures [19], and Southeast Asia is emerging as a region with particularly high and growing risk, affected by rapid industrialization and increasing exposure to carcinogens [20]. While tobacco smoking remains the primary risk factor, occupational carcinogens such as asbestos, crystalline silica, diesel exhaust, and metallic particles contribute significantly to lung cancer risks [21], particularly in countries where occupational health regulation is limited [22,23]. Unlike asthma, the age-standardised mortality and DALYs rates for occupational lung cancer have not exhibited consistent declines [24], underscoring the urgent need for more effective and targeted interventions in occupational cancer prevention [25].

These divergent trends likely reflect disparities across countries in terms of risk recognition, exposure control, and the strength of policy implementation. By disaggregating exposures, our analysis identified clear sector- and hazard-specific drivers of disease burden. Mining and construction were most closely linked to silica and asbestos exposure, textile work was more often associated with organic dust and chemical sensitizers, and diesel exhaust emerged as a cross-sector hazard affecting both asthma and lung cancer. These distinctions provide a stronger evidence base for targeted prevention approaches, such as strengthened dust control and respiratory protection in construction, improved ventilation and exposure in textile facilities, and stricter diesel emission controls in transport and logistic hubs. In many low- and middle-income countries, especially within the informal sectors such as construction, mining, and small-scale manufacturing, occupational exposures are still insufficiently monitored and inconsistently regulated. Evidence indicates that workers in these industries often have limited access to essential occupational health and safety (OHS) resources, face substantial environmental hazards, and receive inadequate protection under current regulatory systems, which have made only modest progress in identifying and addressing high-risk industries [26]. Beyond physical hazards, occupational settings with high exposure risk frequently impose substantial psychosocial stress, which can exacerbate morbidity and reduce recovery.

Workplace risk is also not limited to physical exposure. Potentially high-hazard workplaces commonly involve psychological stressors, including job insecurity, long working hours, and low control over the working environment, which can exacerbate health outcomes and

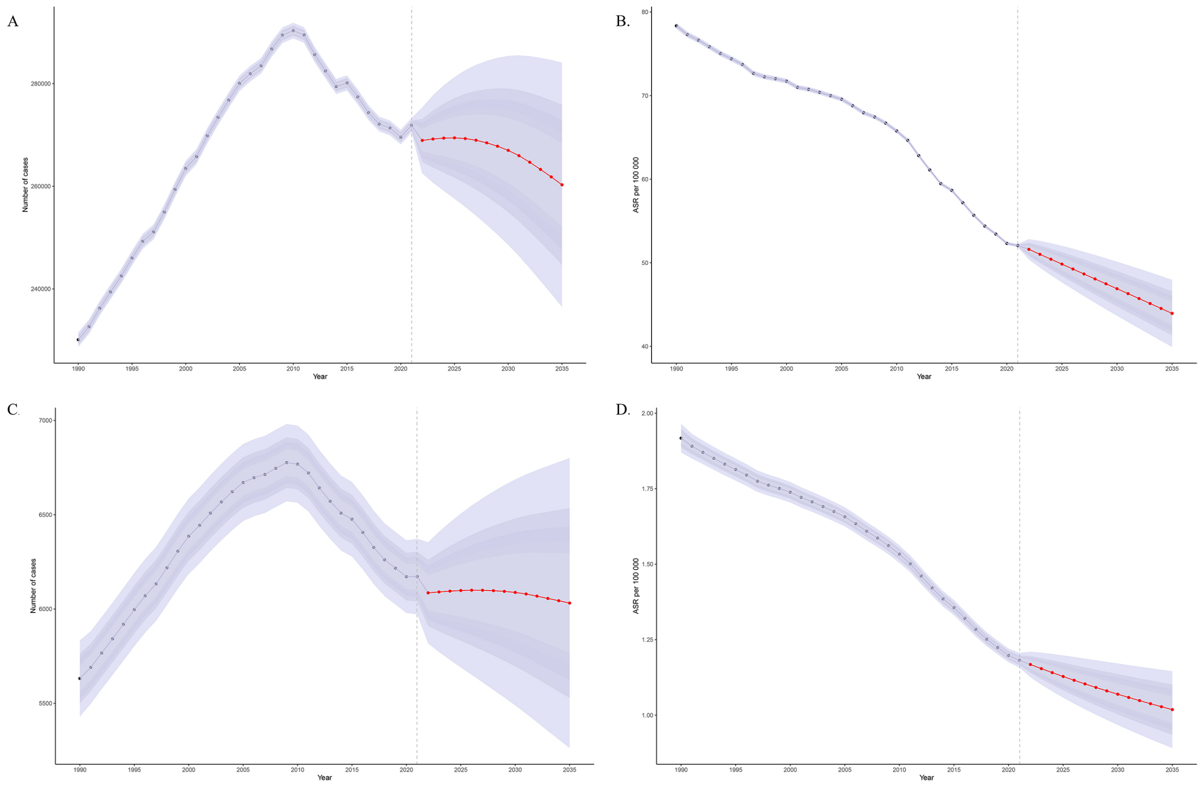

Fig. 6. Prediction of disease burden of occupational risk asthma in Southeast Asia. (A) DALYs number. (B) ASR DALYs. (C) Number of deaths. (D) ASR deaths. ASR, age-standardised rate.

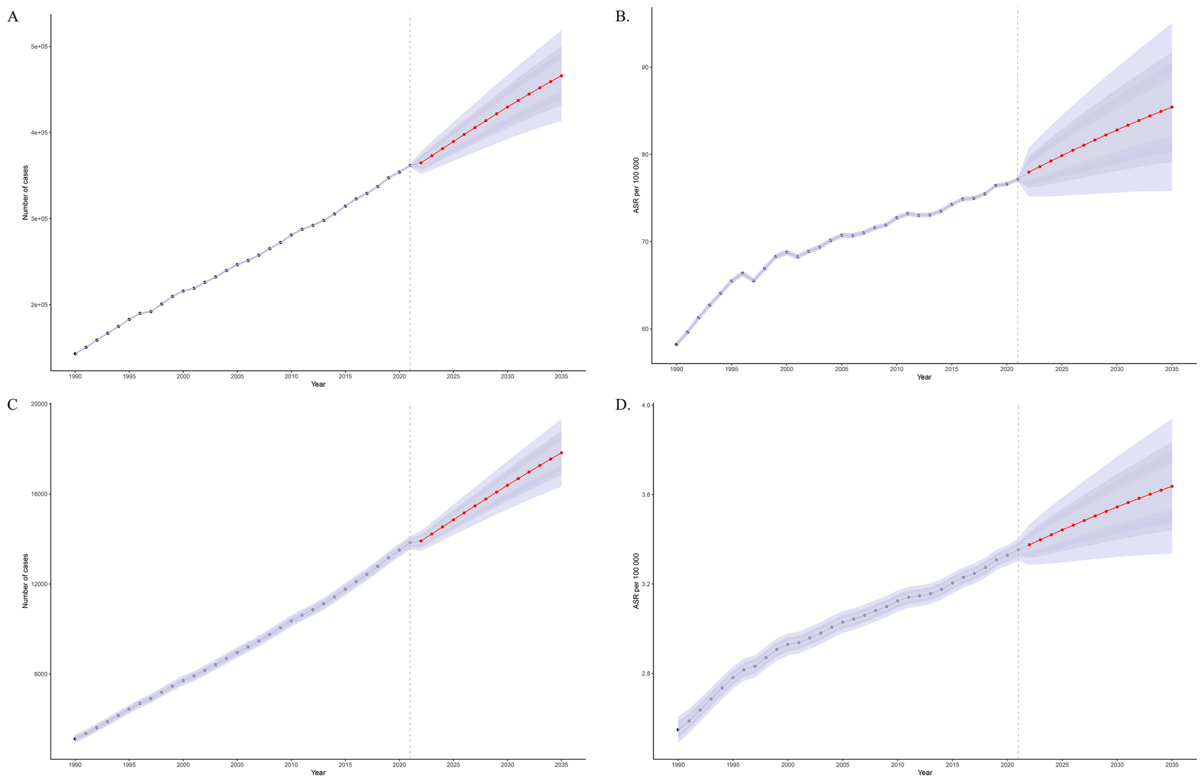

Fig. 7. Prediction of disease burden of occupational risk lung cancer in Southeast Asia. (A) DALYs number. (B) ASR DALYs. (C) Number of deaths. (D) ASR deaths.

delay recovery [27]. Integrating mental health surveillance into occupational health monitoring, guided by frameworks such as Malaysia's 2025 Psychosocial Risk Assessment Guidelines, could support a more holistic approach to worker well-being. Such integration is particularly relevant in informal and insecure work arrangements, where both physical and psychosocial risks often occur. Moreover, gender-based disparities in exposure and health outcomes are also becoming increasingly apparent. While some high-income countries have reported declining lung cancer mortality among men, several Southeast Asian regions continue to report stable or increasing mortality among women [28]. This trend may be linked to rising female participation in hazardous occupations without corresponding implementation of gender-specific protections, training, and exposure control measures [29,30].

Despite its limitations, this study provides valuable insights into occupational health trends in Southeast Asia. To strengthen methodological rigor, we went beyond fit statistics by complementing R^2 with AIC and BIC, applying K-fold cross-validation and conducting sensitivity analyses using alternative exposure definitions and excluding outliers. These methodological steps improved the robustness of our findings, which suggests that the primary outcomes were not driven by model choice or extreme observations. Despite this, we acknowledge several limitations that should be considered before interpreting these findings. First, our findings were based on GBD 2021, which is a limitation because newer releases (for example, GBD 2023) provide expanded occupational exposure categories and subnational estimates that were not available during our analysis period. Second, the absence of industry-specific exposure data and the underrepresentation of informal labor may lead to an underestimation of risk in sectors where monitoring is weakest. Although Bayesian hierarchical models and multiple imputation helped stabilize estimates in small subgroups and narrowed uncertainty intervals, these approaches cannot fully compensate for limited statistical power. Results for underrepresented groups should therefore be interpreted with caution. Future research should prioritize oversampling and targeted recruitment, particularly among high-risk female cohorts, to improve precision and generalizability.

Given the rising burden of occupational lung cancer and the insufficient control of occupational asthma, responses need to be tailored to local exposure realities. Our analysis identified mining, construction, and textile work as key contributors, indicating priorities such as enforcing stricter regulatory limits on occupational exposures, expanding coverage of routine workplace health surveillance, and promoting the implementation of engineering controls and personal protective equipment in high-risk settings. Because occupational and environmental risks often overlap, coordinated intersectoral governance mechanisms are essential. Building on these country-specific initiatives, Southeast Asia also requires longitudinal cohort studies and sector-specific research to evaluate the effectiveness of such policies and to support the development of evidence-based interventions that are both targeted and scalable across diverse industrial settings.

5. Conclusion

This study provides a comprehensive assessment of the long-term burden of occupational asthma and occupational lung cancer in Southeast Asia using data from the Global Burden of Disease Study 2021. While age-standardised rates of occupational asthma have declined, the absolute burden remains high, largely due to population growth and population ageing. In contrast, the burden of occupational lung cancer has continued to rise, reflecting not only demographic shifts but also unfavorable epidemiological changes within the region. Decomposition and projection analyses further highlight the persistent, and likely expanding, impact of occupational exposure to carcinogens across Southeast Asia.

Key Points

• This study reveals divergent trends in occupational respiratory disease burden in Southeast Asia from 1990 to 2021: age-standardised rates for occupational asthma declined, while increasing significantly for occupational lung cancer.

• Decomposition analysis identifies both population ageing and population growth as primary contributors to the rising burden, largely offsetting the potential benefits from epidemiological changes in the region.

• Unlike the global trends, epidemiological changes in Southeast Asia were associated with increasing occupational lung cancer DALYs rates, indicating less effective monitoring and control of workplace exposure to carcinogens in the region.

• The high burden of occupational lung cancer among older men underscores the long-term consequences of cumulative workplace exposures during past decades of industrialization.

• Projections through 2035 indicate that the burden of occupational asthma will continue to decline, while both absolute numbers and age-standardised rates for occupational lung cancer are expected to keep increasing.

Availability of Data and Materials

The data generated and analyzed during the current study are available from the corresponding authors on reasonable request.

Author Contributions

RZ: conceptualization; PZ: methodology; JW: data curation; SZ: conceptualization, methodology, writing—original draft; JH: visualization, formal analysis; YZ: data curation, formal analysis. All authors contributed to revising the manuscript critically for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The data utilized in this study were not part of the primary research but were obtained from published or publicly available sources. Ethical clearances for each of the primary studies that contributed to this data may be found in their respective original articles.

Acknowledgment

Not applicable.

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Conflicts of Interest

The authors declare no conflicts of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/BJHM56969.

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