Unhealthy Years Attributable to Air Particulate Matter in European and Asia-Pacific Countries

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Abstract

Air quality concerns are intensifying globally, impacting human health and longevity. While Europe has achieved progress in reducing mortality from air pollution, many countries in Asia-Pacific (APAC) region are still experiencing increases in mortality due to air pollution. This study quantifies and compares the burden of unhealthy years (UY) resulting from ambient particulate matter (APM) and household air pollution from solid fuels (HAP) between European and APAC countries, highlighting gender and age disparities. We find that females for all countries in both regions experienced higher UY burden due to HAP than their male counterparts. The UY burden in APAC exceeds that in Europe. Specifically, Pacific islands were affected by HAP, while West Asia faces APM challenges. Southern Europe had more UY from both pollutants. From 1990 to 2019, UY from HAP decreased in both regions. Conversely, UY from APM had risen in APAC and parts of Southern Europe, predominantly affecting adults and the elderly. Moreover, the APAC showed a more significant decline in HAP-related UY but an increase in APM-related UY compared to Europe. Considering age and gender differences is crucial for targeted environmental health policies and interventions. Efforts should prioritise countries with high levels of UY and address specific vulnerabilities and health risks faced by different population groups.

Introduction

Air particulate matter (PM) and its detrimental effects on human health have attracted attention from global public health. Recognising pollution as the fifth-leading risk factor for deaths worldwide[1], the Sustainable Development Goals (SDG) specifically target a reduction in pollution-related mortality by 2030 under Goal 3.9[2].

Outdoor or ambient particulate matter (APM, particles with a diameter of 2.5 $\mu g/m^3$ or smaller), which severely impacts human health[3], has been further studied than indoor pollution. Specially, since household air pollution (HAP) from solid fuels has declined in high-income countries. However, traditional indoor cooking and heating still persist in a considerable amount in low- and middle-income countries[4]. Low-income countries, especially in Africa and Asia, are more likely to rely on solid fuels in houses than higher-income countries leading to health effects from HAP[5].

From 1990 to 2019, Europe achieved an impressive 39.68% reduction in PM-related deaths, compared to other regions[6]. However, most Asia-Pacific countries (APAC) not only saw an increase in air pollution-related mortality, but also consistently exhibited among the highest PM levels globally[7]. The drivers behind these differences are the widespread use of high-polluting vehicle and fuel technologies, industrial and agricultural practices that contribute to particulate air pollution, and lack of effective environmental health policies in the Asia-Pacific region, as opposed to Europe[8]. Furthermore, despite Europe showing a decreasing trend in particulate matter-attributable deaths, the detrimental health effects persist, with prolonged periods of poor health especially pronounced in its ageing population. Since people live longer, they might also have more health effects. Thus, we focus on the UN region of APAC, as a highly polluted region, and compare it to Europe as a region with improved air quality.

Air pollution research frequently highlights sex and age disparities in mortality and morbidity, yet the burden of APM and HAP related mortality and health are still unclear. While many studies found that men, children, and the elderly often face the highest exposure levels[9], some findings contradict these observations[10]. However, existing research often narrowly focuses on vulnerable populations in specific regions, or on single pollution and specific causes of death[5, 11]. In contrast, our study seeks to provide a broader, more holistic understanding by examining specific sex ratios and detailed age group effects across different regions and pollution types.

To enhance our findings, we assess unhealthy years (UY) due to air pollution. By incorporating the Sullivan method in our calculations, our model offers a comprehensive approach to estimate the impact of air pollution on health outcomes. Similar to life expectancy, which is measured in years, UY refers to the duration an individual spends in poor health, offering a greater understanding of the impact of PM. Since all is based on life tables, without the confounding effect of the population composition, comparisons of life expectancy and UY can be done across the APAC and European countries.

This study aims to quantify and compare the burden of unhealthy years (UY) resulting from ambient particulate matter (APM) and household air pollution (HAP) between European and APAC countries, highlighting gender and age disparities.

Materials and methods

Data sources

The data for this study were obtained from the Institute for Health Metrics and Evaluation (IHME) through the Global Burden of Disease (GBD) Results Tool updated in 2019[12]. Further details regarding the data sources and methodology have been presented elsewhere[13]. From this source, we used age- and sex- specific information on the number of years lived with disability (YLD) attributable and non-attributable to particulate matter, as well as the population data and age-specific probability of death.

The study analysed 69 Asia-Pacific countries and 43 European countries. The continental classification by United Nations (UN)[14] was used. However, some Pacific Island nations in APAC were not included in the analysis because of unavailable information in the database.

The IHME data included age- and sex-specific information on the number of YLD attributable to two categories of particulate matter: ambient particulate matter (APM) and household air pollution from solid fuels (HAP). Both types of pollution were considered in the calculations for this study. We accessed data from age 0 to 95 years between 1990 and 2019. Moreover, the age-specific probabilities of death were used for calculating abridged life tables for each country. This enabled us to estimate life expectancy, healthy life expectancy and unhealthy years within that age range.

Statistical analysis

To calculate UY, both Healthy life expectancy (HLE) and life expectancy are needed for the calculation. HLE is a component of the healthy life table and was calculated using Sullivan's method[15]. The age- and sex-specific probability of death (q_x) from the GBD result tools was extracted to calculate the other values in the life table for all countries in Europe and the Asia-Pacific region. The calculation of healthy life expectancy was summarised by Molla (2001) as the following equation:

$$e_0^H = \sum_{x=0}^{\omega} \pi_H(x) L_x, \quad (1)$$

where e_0^H represents healthy life expectancy, ω is the last age in the life table, $\pi_H(x)$ is the proportion experiencing healthy conditions at age x which is calculated from the years lived with disability (YLD) and the population in each country, and L_x is the life table person-years. Further details of the calculation procedures for healthy life expectancy are presented elsewhere[16].

Unhealthy years measure the number of years people live in an unhealthy state. This function quantifies the average healthy years lost attributable to air pollution, categorised into components of healthy life expectancy and life expectancy. Specifically, UY attributable to particulate matter were calculated using the Sullivan method and distinguishing between specific air pollutants (HAP and APM). Formally written, years of bad health due to HAP and APM were calculated by subtracting ${}_{95}e_0^H(i)$ from life expectancy as:

$$ {}_{95}e_0^{UY}(i) = {}_{95}e_0 - {}_{95}e_0^H(i), \quad (2) $$

where ${}_{95}e_0^{UY}(i)$ and ${}_{95}e_0^H(i)$ are the unhealthy and health years attributable to air particulate matter i and ${}_{95}e_0$ is the life expectancy all between ages 0 and 95. We calculated sex ratios for UY attributable to air particulate matter, using ${}_{95}e_0^{UY}(i)$ for females divided by the corresponding value for males.

The UY were further separated by age-groups to obtain their corresponding age allocation as:

$$ {}_{95}e_0^{UY}(i) = {}_{4}e_0^{UY}(i) + {}_{34}e_5^{UY}(i) + {}_{64}e_{35}^{UY}(i) + {}_{95}e_{65}^{UY}(i). \quad (3) $$

Results

Sex disparities in air particulate matter-related health and mortality

Figure 1 shows the sex ratios (SR) of unhealthy years due to air particulate matter from 1990 to 2019. Both UY caused by indoor and outdoor air pollution reveal similar trends over the period studied across both regions. For UY resulting from HAP, evident sex disparities were observed across all countries in both APAC and Europe, with females experiencing more unhealthy years than males (SR for UY-HAP between 1.14 and 2.48 in APAC and between1.38 and 2.84 in Europe). Regarding UY caused by APM, many countries in both regions showed that females had a higher UY than males, with SR for UY-APM between 0.68 and 1.68 in APAC and between 0.87 and 1.86 in Europe.

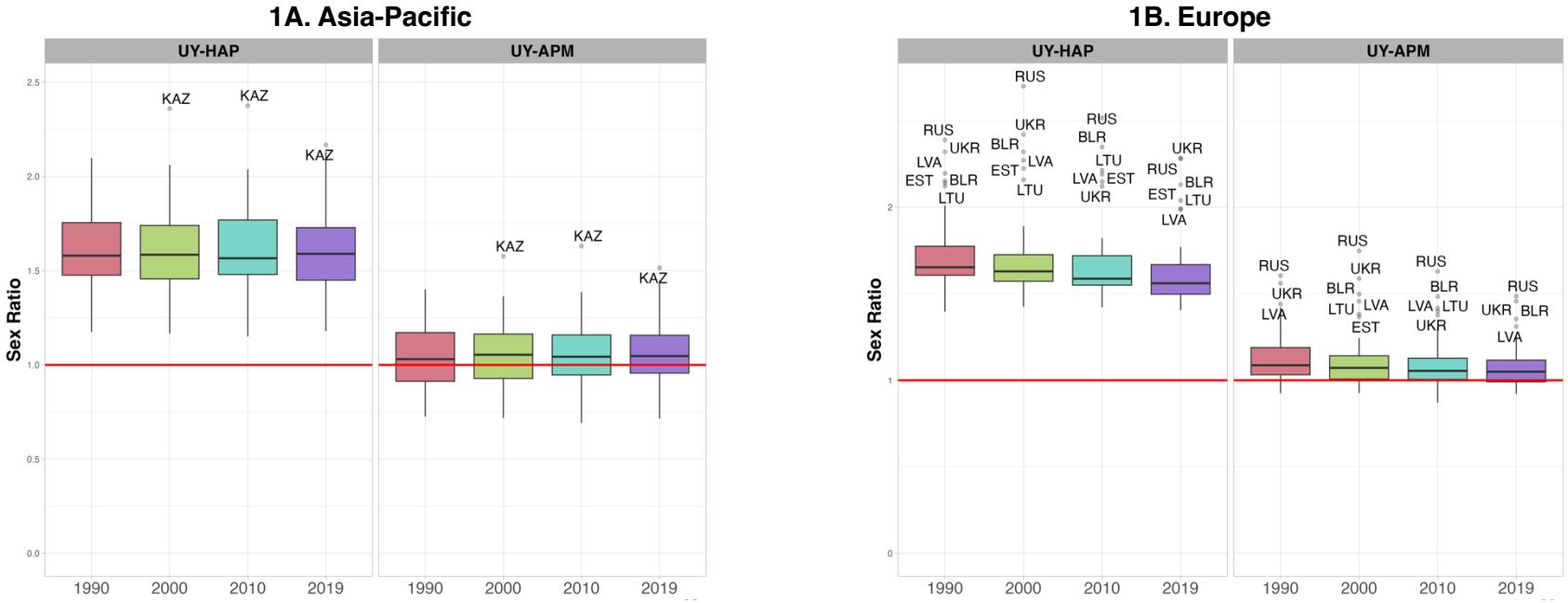

Figure 1. Sex ratios of unhealthy years and life-years lost attributable to household air pollution from solid fuels (HAP) and ambient particulate matter (APM) in 1A: Asia-Pacific countries and 1B: European countries from 1990 to 2019.

Age group-specific unhealthy years and life-years lost caused by air pollution

Figure 2A presents age group-specific unhealthy years for females in 2019 and the changes between 2000-2019 in APAC. Papua New Guinea was the highest UY due to HAP in 2019 among Oceania countries and APAC region, with UY-HAP = 0.59 years, while West and North Asia had lower UY-HAP. Female adults (35-64 years) and older people (65-95 years) experienced more significant UY-HAP. In most APAC nations, the older group had a higher UY-HAP than adults, except in Oceania (e.g., Vanuatu, Solomon Islands, Kiribati and Marshall Islands). UY-HAP decreased among the elderly from 2000 to 2019, except in Oceania, Southeast Asia, and South Asia. Compared to European nations (Figure 2B), Southern Europe, particularly the Balkan region like Bosnia and Herzegovina (UY-HAP=0.12) and Montenegro (UY-HAP=0.08), saw the highest UY from HAP. Western and Northern Europe, such as United Kingdom (UY-HAP< 0.01), had a minimal number of UY due to this pollutant. All European countries reduced their years living in poor health from HAP.

For UY attributable to APM, West Asia led with Qatar reporting the highest UY for this pollutant at 0.60 years in APAC. On the contrary, Oceania showed the lowest UY-APM, Solomon Islands at 0.03 years. UY-APM rose from 2000 to 2019, primarily among the elderly, except for countries like Australia, Philippines and Singapore, which experienced a decrease in UY among the elderly. Comparatively, Southern and Eastern Europe, especially the Balkan countries such as North Macedonia and Bosnia and Herzegovina (UY-APM=0.28 and 0.27, respectively), had higher UY due to APM. Female adults and the elderly faced the highest APM exposure for this region. Most European countries had declined UY from APM, although some nations like Bosnia and Herzegovina and Serbia witnessed an increase. Younger populations (aged 5-34 years) in both regions generally had a lower burden of unhealthy years from HAP and APM.

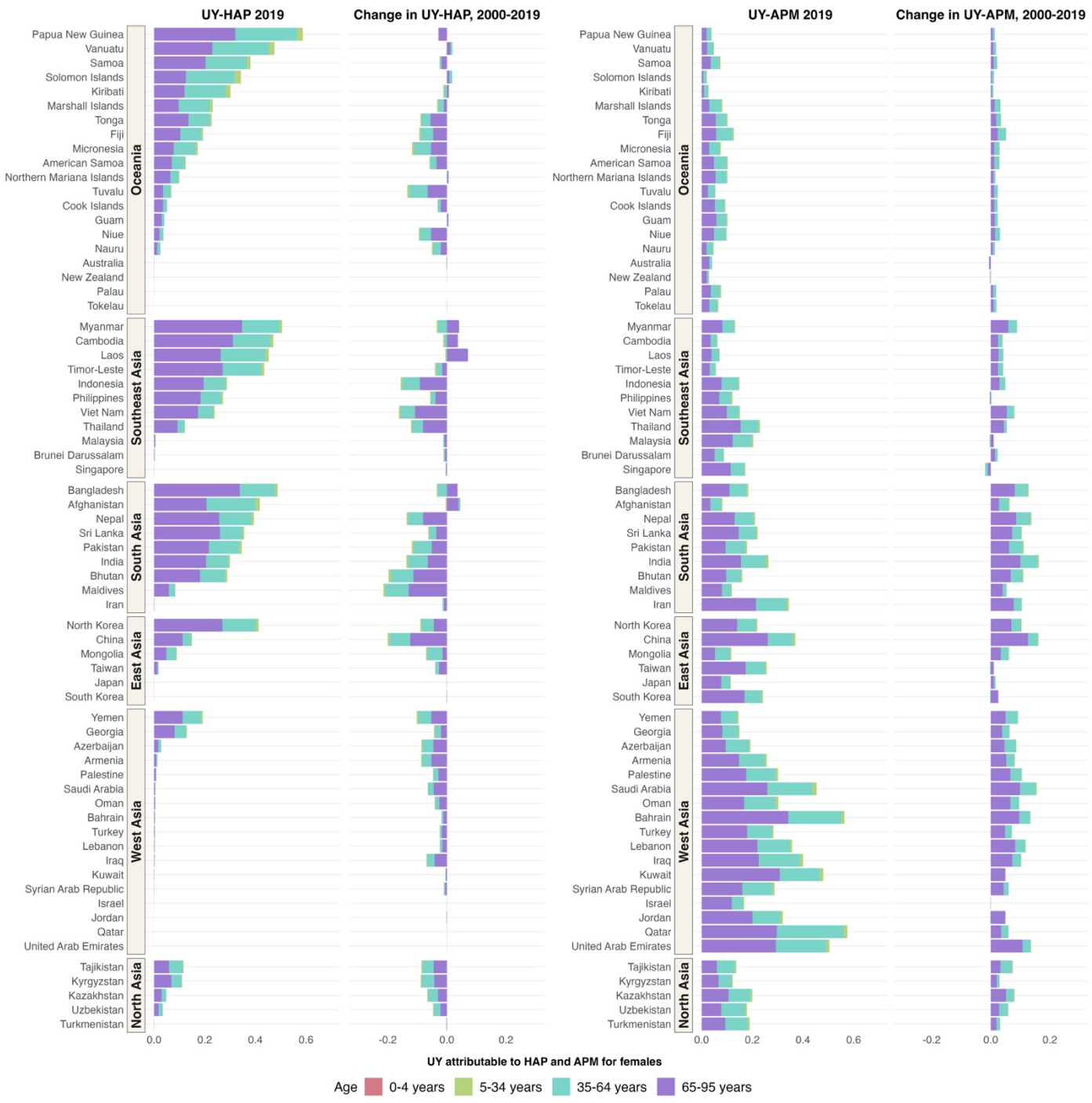

Figure 2A. Age groups specific unhealthy years in 2019 and changes in age groups specific UY attributable to ambient particulate matter (APM) and household air pollution from solid fuels (HAP) between 2000 and 2019 for females in Asia-Pacific countries.

Note: the region is classified by United Nations.

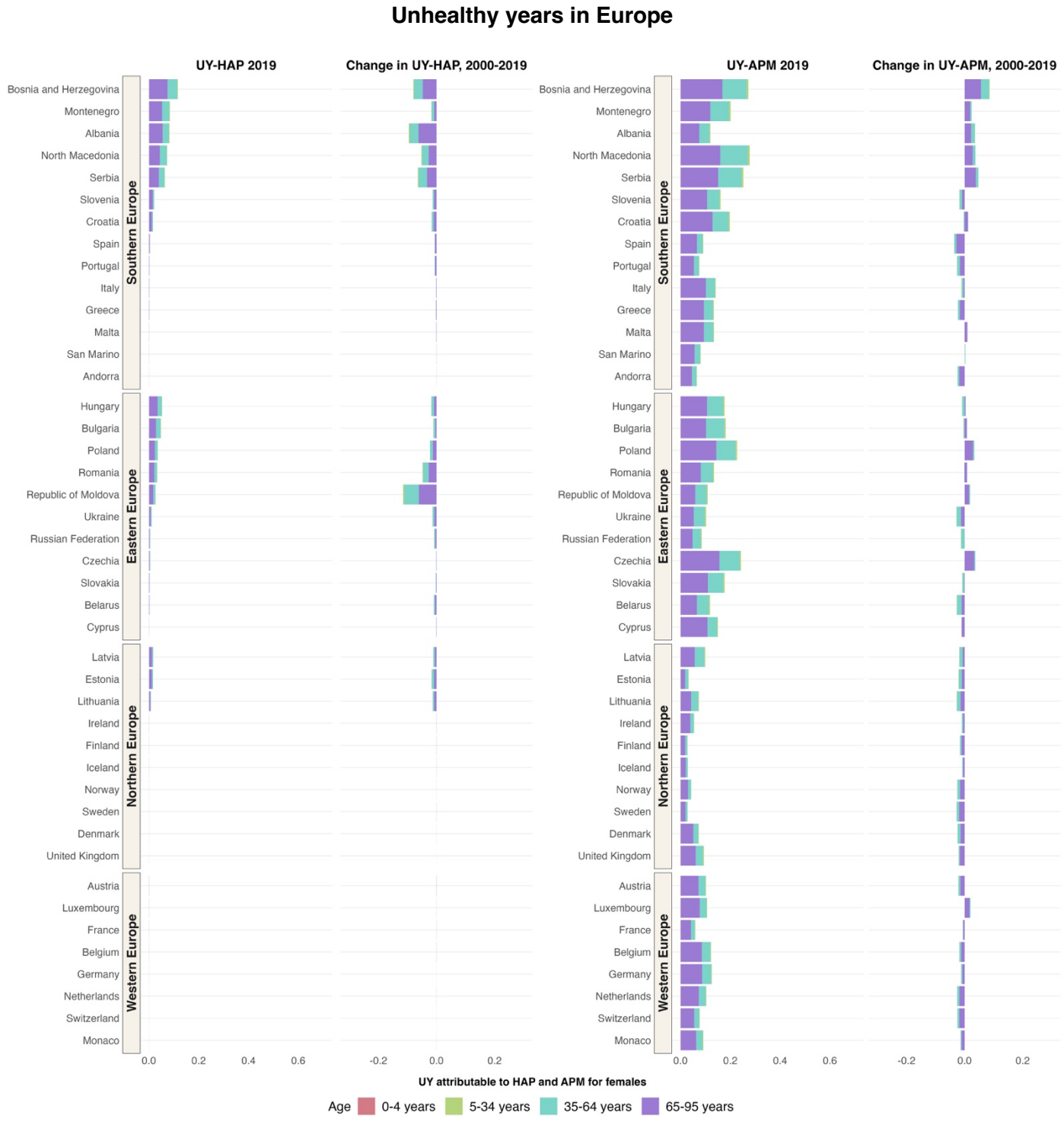

Figure 2B. Age groups specific unhealthy years in 2019 and changes in age groups specific UY attributable to ambient particulate matter (APM) and household air pollution from solid fuels (HAP) between 2000 and 2019 for females in European countries.

Note: the region is classified by United Nations.

Conclusion and next steps

This extended abstract presented some preliminary findings of the burden of unhealthy years (UY) attributable to PM in APAC and European countries between 1990 and 2019 across genders and age groups. UY attributable to ambient particulate matter and household air pollution from solid fuels in APAC were significantly higher than in Europe. Sex disparities were observed across all countries in the APAC and Europe, with females generally experiencing more unhealthy years than males, especially from HAP. APAC showed a more significant decline in HAP-related UY but an increase in APM-related UY compared to Europe. The primary age groups affected were adults and the elderly in both regions, who generally had higher UY compared to younger individuals. Further analysis will include multilevel modelling of variables at the national level that could help explain the disparities between sexes found (pollution, female empowerment, demographic and economic variables).

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