Short Report

Mortality, disease burden, and exposure to main risk factors in Southeastern Europe

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Abstract

Aim: Focused assessments of long-term risk transitions in Southeastern Europe remain limited. We aimed at analyzing temporal trends in age-standardized mortality, disease burden, and summary exposure values (SEVs) attributable to major groups of risk factors in Southeastern European countries between 1990 and 2023, to identify progress achieved and emerging public health challenges.

Methods: A comparative longitudinal analysis was conducted across Albania, Montenegro, North Macedonia, Bosnia and Herzegovina, Serbia, Croatia, and Slovenia. Age-standardized mortality, disease burden, and SEVs attributable to metabolic, behavioral, and environmental and occupational risks were extracted from the Global Burden of Disease (GBD) framework.

Results: Between 1990 and 2023, all-cause mortality and Disability-Adjusted Life Years (DALYs) attributable to major risk factors declined substantially across all countries, with Slovenia consistently exhibiting the lowest levels. Environmental and occupational risks showed the steepest relative reductions, whereas behavioral risks also declined markedly, particularly in Albania and Slovenia. In contrast, SEVs revealed stagnation or increases in population exposure, especially for metabolic risks, which rose consistently across all countries, signaling a growing cardiometabolic burden.

Conclusion: Notwithstanding major reductions in mortality and disease burden, rising metabolic exposures highlight an emerging public health challenge in Southeastern Europe. Sustained progress will require targeted strategies addressing obesity, diet, and sedentary lifestyles alongside continued environmental and behavioral risk reduction.

Keywords*: behavioral risks, environmental and occupational risks, metabolic risks, risk factors, Southeastern Europe.*

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Introduction

Metabolic, behavioral, and environmental risk factors remain the principal drivers of mortality and disability across Europe (1). Countries in Southeastern Europe have experienced rapid demographic and socioeconomic transitions over recent decades, accompanied by substantial shifts in disease patterns and population risk profiles (2). Although overall mortality has declined, the region continues to bear a disproportionately high burden of preventable non-communicable diseases (NCDs) compared with other parts of Europe (3).

The Global Burden of Disease (GBD) studies produced by the Institute for Health Metrics and Evaluation (IHME) provide standardized and comparable estimates of mortality, disability-adjusted life years (DALYs), and population exposure attributable to major risk factors across countries and over time (4,5). Previous GBD analyses have documented marked reductions in environmentally related and cardiovascular mortality in Europe, alongside increasing exposure to metabolic risks such as obesity, hypertension, and hyperglycemia (6).

However, focused assessments of long-term risk transitions in Southeastern Europe remain limited. In this context, we aimed at analyzing temporal trends in age-standardized mortality, disease burden, and summary exposure values (SEVs) attributable to major groups of risk factors in Southeastern European countries between 1990 and 2023, using GBD estimates, to identify progress achieved and emerging public health challenges.

Methods

A comparative longitudinal analysis of age-standardized mortality, disease burden, and population exposure attributable to major groups of risk factors in Southeastern European countries was conducted. More specifically, the countries included in this analysis consisted of Albania, Montenegro, North Macedonia, Bosnia and Herzegovina, Serbia, Croatia, and Slovenia.

Trends were examined between 1990 (first reported estimates) and 2023 (most recent estimates) to assess changes in health outcomes and risk exposure over time.

Data source

This analysis was based on the estimates derived from the GBD studies produced by the Institute for Health Metrics and Evaluation (IHME) (4).

The GBD framework synthesizes data from vital registration systems, household surveys, disease registries, environmental monitoring, and published epidemiological studies using standardized statistical modelling techniques to generate comparable estimates across countries and time periods (4).

Risk factor groups

The following four groups of risk factors were extracted (4) and analyzed:

- All risk factors combined.
- Metabolic risks, including high blood pressure, high fasting plasma glucose, high body mass index, and dyslipidemia.

- Behavioral risks, including tobacco use, alcohol consumption, dietary risks, and physical inactivity.
- Environmental and occupational risks, including air pollution, unsafe water and sanitation, and occupational exposures.

Outcome measures

The following three outcomes were extracted (4) and analyzed:

- Age-standardized all-cause mortality rates attributable to each risk factor group (deaths per 100,000 population).
- Age-standardized DALY rates attributable to each risk group (DALYs per 100,000 population), combining years of life lost due to premature mortality and years lived with disability (4).
- Summary Exposure Values (SEVs), a risk-weighted metric ranging from 0 (no population exposure) to 100 (maximum possible exposure), reflecting both the prevalence and severity (relative harm) of exposure in the population (4,7).

Results

Table 1 presents all-cause mortality and disease burden rates and summary exposure values attributable to selected groups of risk factors in Southeastern European countries in 1990 and in 2023.

Trends in all-cause mortality attributable to major risk factor groups during 1990-2023 (upper panel)

Across all Southeastern European countries, age-standardized all-cause mortality attributable to all risk factors declined substantially between 1990 and 2023. The largest absolute reductions were observed in Serbia (from 865 to 530 deaths per 100,000), North Macedonia (719 to 472), and Croatia (627 to 365), whereas Slovenia consistently exhibited the lowest mortality rates, decreasing from 492 to 220 per 100,000 population.

Reductions were evident across all major risk categories. Thus, mortality attributable to metabolic risk factors declined markedly in all countries, with decreases ranging from approximately 30% in Montenegro (431 to 306) to over 55% in Slovenia (307 to 134). Furthermore, behavioral risk-attributable mortality exhibited considerable improvement, particularly in Albania (351 to 176) and Slovenia (292 to 122). However, environmental and occupational risks experienced the most pronounced relative declines in all-cause mortality in several countries, especially in Slovenia (from 160 to 52).

Notably, all reported mortality reductions were statistically significant across countries.

Disease burden (DALYs) attributable to risk factors during 1990-2023 (middle panel)

Consistent with mortality trends, the all-cause disease burden attributable to all risk factors, measured in DALYs per 100,000 population, decreased substantially from 1990 to 2023 across the region. Serbia and North Macedonia experienced particularly high baseline burdens in 1990 (≈20,800 and 19,670 DALYs per 100,000, respectively), which declined to ≈12,760 and

≈12,240 by 2023. Slovenia again maintained the lowest burden levels throughout the period, declining from ≈13,850 to ≈7,550 DALYs per 100,000.

Table 1. All-cause mortality and disease burden rates and summary exposure values attributable to selected groups of risk factors in Southeastern European countries in 1990 and in 2023 (4)

Upper panel: age-standardized all-cause mortality rates due to selected groups of risk factors (deaths per 100,000 population)														
Mortality rates	**Albania**		**Montenegro**		**North Macedonia**		**Bosnia and Herzegovina**		**Serbia**		**Croatia**		**Slovenia**	
	1990	**2023**	**1990**	**2023**	**1990**	**2023**	**1990**	**2023**	**1990**	**2023**	**1990**	**2023**	**1990**	**2023**
All risks*	567	311	611	436	719	472	623	417	865	530	627	365	492	220
Metabolic*	320	208	431	306	508	345	411	283	623	382	435	247	307	134
Behavioral*	351	176	357	251	406	250	368	237	481	287	399	218	292	122
Environmental and occupational*	286	118	254	145	318	162	316	164	366	174	215	102	160	52
Middle panel: age-standardized all-cause disease burden attributable to selected groups of risk factors (DALYs per 100,000)														
Burden of disease	**Albania**		**Montenegro**		**North Macedonia**		**Bosnia and Herzegovina**		**Serbia**		**Croatia**		**Slovenia**	
	1990	**2023**	**1990**	**2023**	**1990**	**2023**	**1990**	**2023**	**1990**	**2023**	**1990**	**2023**	**1990**	**2023**
All risks*	18584	8886	16296	11972	19670	12242	17147	11801	20808	12762	16137	10308	13852	7553
Metabolic*	6574	4451	8808	6836	10145	7173	8657	6303	11725	7260	8672	5428	6589	3410
Behavioral*	13295	5504	10978	7716	13243	7398	11254	7442	13514	7886	11464	6767	9304	4601
Environmental and occupational*	8113	2837	5709	3279	7599	3535	7363	3804	7555	3557	4444	2321	3696	1640
Lower panel: age-standardized summary exposure values (SEV) for selected groups of risk factors [SEV range: from 0 (best) to 100 (worst possible level of risk)]														
Summary exposure values*	**Albania**		**Montenegro**		**North Macedonia**		**Bosnia and Herzegovina**		**Serbia**		**Croatia**		**Slovenia**	
	1990	**2023**	**1990**	**2023**	**1990**	**2023**	**1990**	**2023**	**1990**	**2023**	**1990**	**2023**	**1990**	**2023**
All risks†	23.0	23.5	22.9	23.7	22.8	24.7	25.0	25.8	23.2	24.2	21.0	22.7	23.3	24.6
Metabolic*	19.6	24.7	21.3	27.3	20.0	26.5	19.1	24.6	19.1	25.4	20.9	25.7	21.4	27.3
Behavioral	19.6	20.5	25.0	25.4	24.2	24.6	23.3	25.1	23.9	23.9	26.1	24.7	25.2	21.6
Environmental and occupational*	42.0	26.6	35.1	27.0	36.8	27.2	41.3	31.2	36.0	26.4	29.7	22.4	29.7	20.9

* Total percentage change (from 1990 to 2023) was statistically significant in all countries.

† Total percentage change (from 1990 to 2023) was statistically significant only in North Macedonia.

Metabolic risk factors remained major contributors to disease burden in all countries, though significant reductions were observed, especially in Slovenia (≈6,590 to ≈3,400 DALYs per 100,000) and Albania (≈6,570 to ≈4,450). Behavioral risks accounted for the largest DALY burden across most settings in 1990 and continued to represent a substantial share in 2023, despite marked declines, most notably in Albania (≈13,300 to ≈5,500) and Slovenia (≈9,300 to ≈4,600). Environmental and occupational risks exhibited the steepest relative reductions, falling by more than 50% in most countries over the study period.

All changes in DALYs attributable to the major risk groups were statistically significant too.

Patterns in population exposure to risk factors (SEV) during 1990-2023 (lower panel)

In contrast to the pronounced declines in mortality and disease burden, trends in summary exposure values (SEVs) revealed a more complex and less favorable pattern. Overall exposure to all risks increased modestly in most countries between 1990 and 2023, with statistically

significant change observed only in North Macedonia (22.8 to 24.7). Other countries experienced small upward shifts, suggesting stagnation or worsening in population-level risk exposure despite health outcome improvements.

Notably, SEVs for metabolic risk factors increased consistently across all countries, rising from approximately 19-21 in 1990 to 24-27 in 2023, indicating a growing burden of cardiometabolic risk exposure throughout the region. Behavioral risk exposure remained relatively stable or increased slightly in several countries, although Slovenia exhibited a notable decline (25.2 to 21.6).

In contrast, exposure to environmental and occupational risks declined substantially in every country, with SEVs dropping from high baseline levels (e.g., Albania ≈42, Bosnia and Herzegovina ≈41) to markedly lower values by 2023 (≈27 and ≈31, respectively), reflecting major improvements in environmental and workplace conditions over time.

Discussion

Overall, findings of this analysis indicate a profound reduction in premature mortality and disease burden attributable to major modifiable risk factors across Southeastern Europe over the past three decades. However, the discordance between declining health outcomes and rising or stagnant SEVs, particularly for metabolic risks, suggests that improvements in healthcare access, treatment, and survival may be counter-balanced by the worsening of population risk profiles.

The consistent decline in environmental and occupational exposures appears to be a key driver of health gains, whereas the increasing exposure to metabolic risks signals an emerging public health challenge, likely linked to obesity, dietary shifts, and sedentary lifestyles.

The observed trends in Southeastern European region are in line with global trends, which point to a large decrease in many environmental and behavioral risk factors, contrasted by increases in disease burden attributable to metabolic risk factors and NCDs (7). Indeed, analyses based on GBD risk factors data have indicated large relative declines in DALYs attributable to environmental and behavioral risks (including air pollution and tobacco), whereas DALYs attributable to metabolic risks have increased substantially, reflecting rising exposure and epidemiological transitions (6,7). More specifically, at a global scale, the GBD results indicate decreases in DALYs attributable to behavioral and environmental risks respectively from about -21% and -22% from 2000-2021, alongside an increase of around 49% in the burden of disease attributable to metabolic risks (6).

Our analysis has several limitations, as all estimates were derived from the GBD modelling framework, which synthesizes multiple data sources of varying quality and relies on statistical assumptions where primary data are sparse, particularly for earlier years and for some Southeastern European countries (4,5). Furthermore, risk factors were analyzed in broad groups, which may obscure important heterogeneity among individual exposures (e.g., specific dietary components or occupational hazards). Additionally, the ecological and aggregate nature of the data precludes causal inference and masks important within-country inequalities by socioeconomic status, sex, or subnational region. Also, while SEVs provide a useful combined population-level metric, they do not capture changes in clinical management, health system

performance, or interaction between risks, which likely contributed to declining mortality despite rising metabolic exposure.

Conclusion

This analysis highlights substantial progress in reducing premature mortality and disease burden attributable to major risk factors across Southeastern Europe, largely driven by declines in environmental and occupational exposures. Yet, the persistence or rise of metabolic risk exposures underscores an emerging public health challenge that threatens to counterweight these gains, reflecting broader global epidemiological transitions toward NCDs. These findings emphasize the dual importance of sustaining environmental and behavioral risk reductions while urgently addressing metabolic determinants through prevention, policy, and health system innovation.

Nevertheless, considering the reliance on modeled estimates, broad risk groupings, and ecological data, future research should prioritize more granular, country-specific evidence to capture heterogeneity and inequalities, thereby informing targeted interventions that can consolidate health gains and mitigate the growing burden of metabolic risks in the Southeastern European region.

In conclusion, notwithstanding major reductions in mortality and disease burden, rising metabolic exposures highlight an emerging public health challenge in Southeastern Europe. Sustained progress will require targeted strategies addressing obesity, diet, and sedentary lifestyles alongside continued environmental and behavioral risk reduction.

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