

INTRODUCTION

- Residential radon is a Group 1 carcinogen and a well-established environmental contributor to lung cancer mortality, yet global patterns remain incompletely characterized.
- Radon gas and its decay products emit alpha particles that directly damage DNA in the bronchial epithelium, driving the mutations that lead to lung cancer.
- We used Global Burden of Disease (GBD) 2023 data to describe 34-year trends in radon-attributable mortality across the world’s most populous countries, evaluating sex-stratified absolute and relative changes in mortality rate.
- This analysis extends our group’s prior work on tobacco-, air pollution-, and asbestos-attributable lung cancer mortality to radon as a fourth major environmental risk factor.
- To our knowledge, this is among the first analyses to characterize country- and sex-specific radon-attributable lung cancer trends using GBD 2023 estimates.

METHODS

Data source

- Age-standardized mortality rates (ASMR; deaths per 100,000) for radon-attributable tracheal, bronchus, and lung cancer, from GBD 2023 (GBD Results Tool, IHME).
- Global plus the 10 most populous countries (2023 census); years 1990–2023 (all 34 years); sex-stratified (Male, Female, Both).

Analytic scope

- Sex-stratified absolute and relative changes in ASMR were evaluated for each country across the full study period, alongside exploratory analyses of potential shifts in trend slope over time.

Trend summary (AAPC)

- Average Annual Percent Change estimated by single-line log-linear regression of ln(ASMR) on year across the full period, with 95% CI.

Joinpoint analysis

- Continuous piecewise log-linear regression via grid search over candidate joinpoint years (minimum 4-year segment spacing; maximum 3 joinpoints/series).
- Model selection used BIC3, NCI’s documented information-criterion alternative to the permutation test; segment APC considered significant when the 95% CI excluded zero.

Software & validation

- Analyses performed in Python (statsmodels); joinpoint results cross-checked against BIC, BIC3, and Modified BIC for consistency.
- AAPC values reproduce our submitted abstract’s Table 1 to <0.01 precision; the earlier-shift-in-females joinpoint finding held under all three model-selection criteria tested.
- A combined (Both-sex) estimate was pulled independently from GBD rather than derived by averaging male/female rates, avoiding age-standardization bias.

DISCUSSION AND CONCLUSION

Actionable Takeaway

- Radon-attributable lung cancer mortality is declining globally, but almost entirely because of improvement among men. Female trends are flat or worsening in most of the world’s most populous countries.
- This female-lagging pattern mirrors similar trends to the mortality risk of tobacco and air pollution, ranking as a third independent risk factor
- Mortality is declining in countries such as Mexico, USA, and Russia, but increasing in others including Bangladesh, India, Indonesia, Pakistan, and Nigeria, particularly among women.

Regional Highlights — Find Your Country

- N. America / USA: steepest recent male decline (–4.2%/yr); female decline shallower, significant only after 2012.
- E. Europe / Russia: highest absolute male ASMR of any country studied, despite the fastest recent decline.
- Latin America: Mexico shows the fastest overall decline; Brazil’s males decline while females rise the entire period.
- E./SE Asia: China carries the highest absolute ASMR of any country even in 2023; Indonesia is rising in both sexes.
- South Asia & Sub-Saharan Africa: Bangladesh, India, Pakistan, and Nigeria show the sharpest recent acceleration, especially in women.

Conclusion

- These findings highlight the need for expanded radon testing, improved mitigation strategies, and integration of radon exposure into lung cancer prevention and early detection efforts.
- Sex-specific surveillance is essential: aggregate (both-sex) statistics can mask sharply divergent underlying trends, as seen in Pakistan and Brazil.
- Future Directions
 - Expand radon testing/mitigation programs globally, with sex-specific risk communication and integration into national lung cancer screening guidance.
 - Investigate drivers of the earlier trend shift in women — candidates include indoor exposure time and housing construction changes.

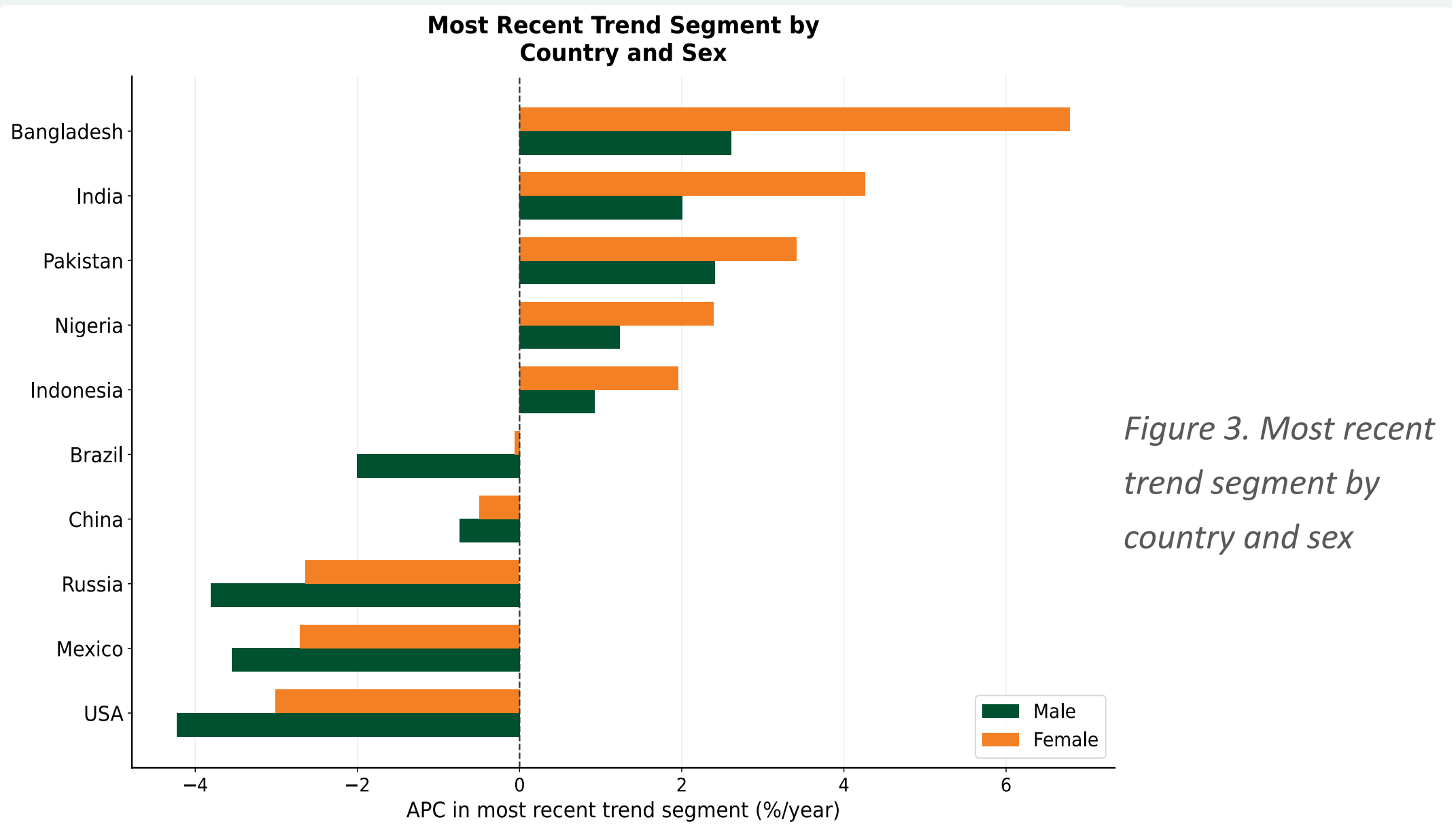


Figure 3. Most recent trend segment by country and sex

AI-Use Disclosure

Artificial intelligence (Claude, Anthropic) was used to assist with generation of data visualizations, and poster layout/formatting. All analytic outputs and figures were reviewed and modified by the authors prior to their final version

Abbreviations: ASMR, age-standardized mortality rate; AAPC, average annual percent change; APC, annual percent change; BIC, Bayesian information criterion; GBD, Global Burden of Disease; IHME, Institute for Health Metrics and Evaluation; TBLC, tracheal, bronchus, and lung cancer.

RESULTS

- Global radon-attributable TBLC deaths rose from an estimated **49,709 (1990) to 83,077 (2023)**, a **67% increase**, driven largely by increases among women.
- Yet age-standardized rates tell a different story: mortality fell for men (Global AAPC **–1.48%/yr**) but was roughly flat for women (**–0.38%/yr**) from 1990–2023 — the rising death count mainly reflects population growth and aging, not rising individual risk.
- In **8 of 11 countries**, the female trend shifted at the same year or earlier than the male trend — and Bangladesh’s female mortality rose **+6.79%/yr** in the most recent segment (2018–2023), the fastest-moving trend in the dataset.

Table 1. Age-Standardized Radon-Attributable TBLC Mortality (ASMR), % Change, and AAPC

Country	Male ASMR 1990→2023 (%Δ)	Male AAPC	Female ASMR 1990→2023 (%Δ)	Female AAPC
Global	2.07 → 1.31 (–37.0%)	–1.48	0.60 → 0.56 (–6.7%)	–0.38
USA	3.42 → 1.33 (–61.0%)	–2.80	1.45 → 1.03 (–29.4%)	–1.20
Russia	6.12 → 3.02 (–50.6%)	–2.11	0.66 → 0.50 (–25.1%)	–0.61
Mexico	1.16 → 0.43 (–62.8%)	–3.21	0.47 → 0.26 (–44.9%)	–2.00
China	1.93 → 1.73 (–10.0%)	–0.42	0.87 → 0.74 (–14.8%)	–0.96
Brazil	1.09 → 0.79 (–27.1%)	–0.98	0.36 → 0.50 (+38.8%)	+1.11
Pakistan	0.40 → 0.37 (–5.6%)	–0.61	0.22 → 0.33 (+52.8%)	+1.32
Nigeria	0.39 → 0.47 (+19.6%)	+0.44	0.12 → 0.17 (+41.5%)	+1.02
India	0.39 → 0.49 (+27.0%)	+0.82	0.11 → 0.21 (+95.4%)	+2.05
Indonesia	0.37 → 0.51 (+37.2%)	+0.93	0.11 → 0.18 (+66.4%)	+1.48
Bangladesh	0.37 → 0.60 (+63.2%)	+1.21	0.11 → 0.25 (+122.7%)	+1.39

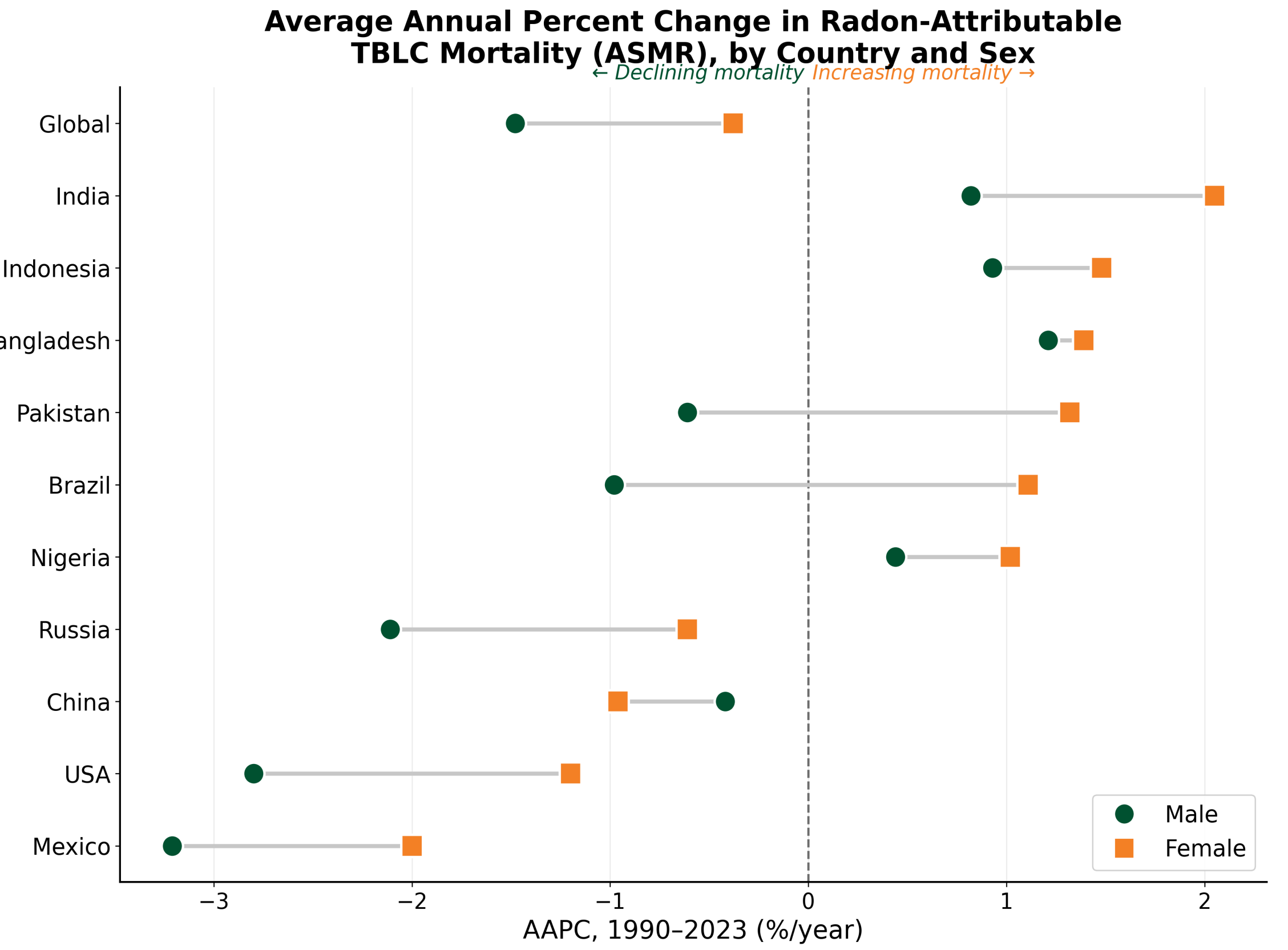


Figure 1. AAPC by country and sex, 1990–2023. Longer connecting lines indicate greater sex divergence.

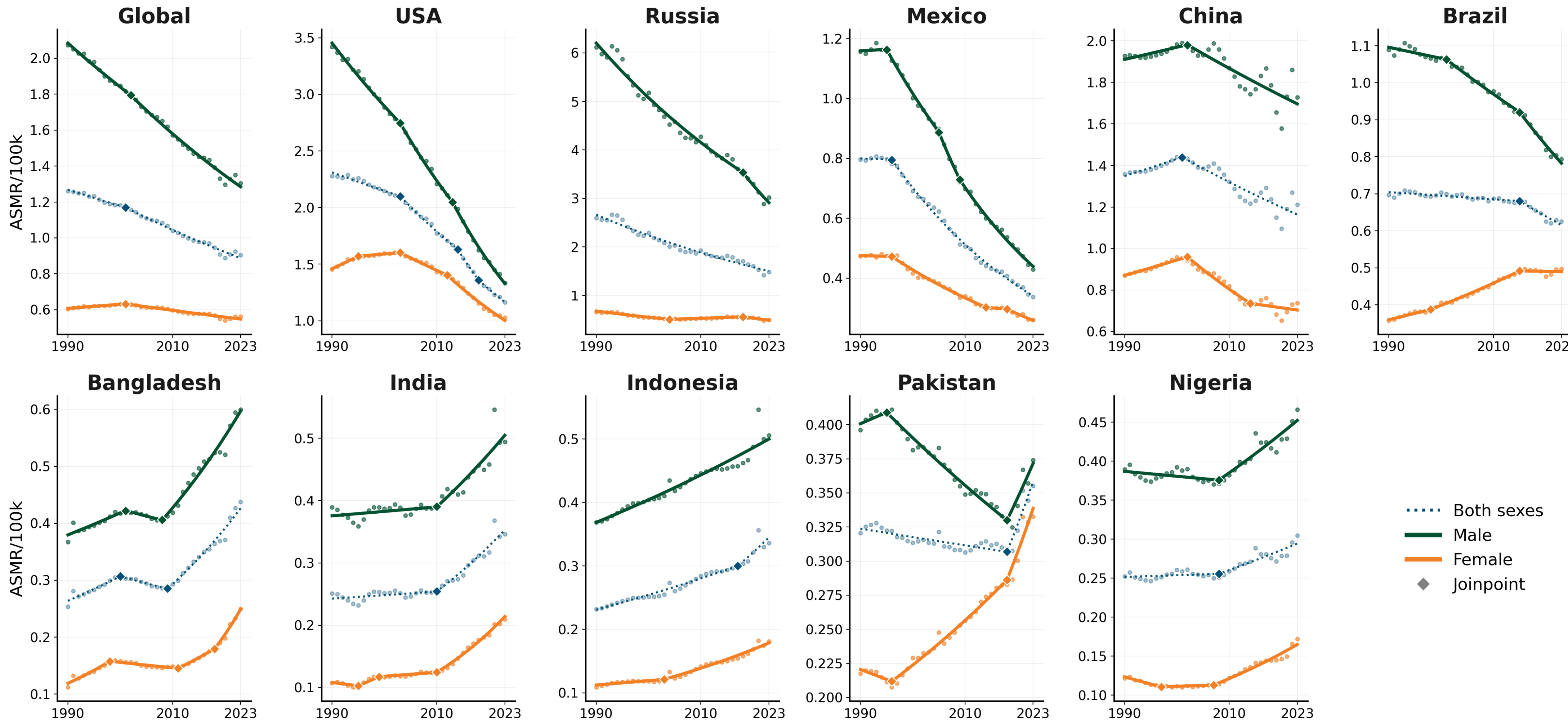


Figure 2. Country- and sex-specific radon-attributable TBLC mortality, 1990–2023, with joinpoint-fitted trend segments (diamonds = joinpoints).

REFERENCES & ACKNOWLEDGEMENTS

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