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Bayesian Detection of Break-Points and Seasonal Patterns for Spontaneous Preterm Birth in Lombardy

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BACKGROUND

Preterm birth (<37 weeks gestation) is the leading cause of death in children under the age of 5 worldwide, accounting for 900k neonatal deaths a year [1]. Preterm birth rates vary widely within and between countries (4-16%) [2], with environmental causes of yet unclear aetiology suspected to be the main drivers [3, 4, 5]. Emerging evidence points to physical environmental factors—such as extreme weather and exposure to air, water, and soil pollutants—that may influence maternal biology, including the microbiome and inflammatory responses, through pathways like infection and nutrition [6]. However, numerous concurrent environmental factors present a challenge for robust inference analysis resulting into weak causal evidence.

OBJECTIVE

This study presents a general method for identifying breakpoints in time series data to help isolate the impact of environmental interventions on health outcomes, illustrated with preterm births in Lombardy.

METHODS

Preterm births were derived from a cohort of nearly 1M pregnancies among 750K women in Lombardy (2012–2023) from linked administrative health data. Monthly and weekly rates of spontaneous singleton births (22–37 weeks) were compiled across 12 provinces and stratified by maternal age (≥35), education, country of origin, and offspring sex. A Bayesian interrupted time series model was used to detect breakpoints—defined as immediate or sustained changes in baseline or slope. A Cauchy prior was applied to shrink the number of potential breakpoints to those with meaningful effects. The model incorporated seasonality to improve validity and provided uncertainty estimates for all parameters, enabling trend and seasonal pattern extraction. This approach was validated through a case study examining the impact of smoking bans in Italy on hospital admissions for cardiovascular events, where the breakpoints were already known.

RESULTS

In Lombardy, nearly 42k (6.3%) children were born preterm between 2012-2023 including 32k (4.8%) due to spontaneous labour. Time series analysis shows a 5.3-4.0% declining trend in spontaneous preterm birth rates. The seasonal component shows the expected biannual peaks in summer and winter, corroborating literature results from other countries. The trends and seasonality patterns are mostly consistent across provinces and socio-demographic risk factors. The model identified 5-10 break-points where an environmental policy might have unintended consequences on preterm birth rates (Fig 1).

CONCLUSION

The Bayesian breakpoint method proved effective in identifying significant changes in the time series. Summer and winter have emerged as high-risk seasons for spontaneous preterm birth over the last 12 years in Lombardy. Future work will explore potential causal drivers by incorporating control time series, detailed characterization of relevant policy changes and concurrent events, and triangulating findings with prior evidence to strengthen causal inference.

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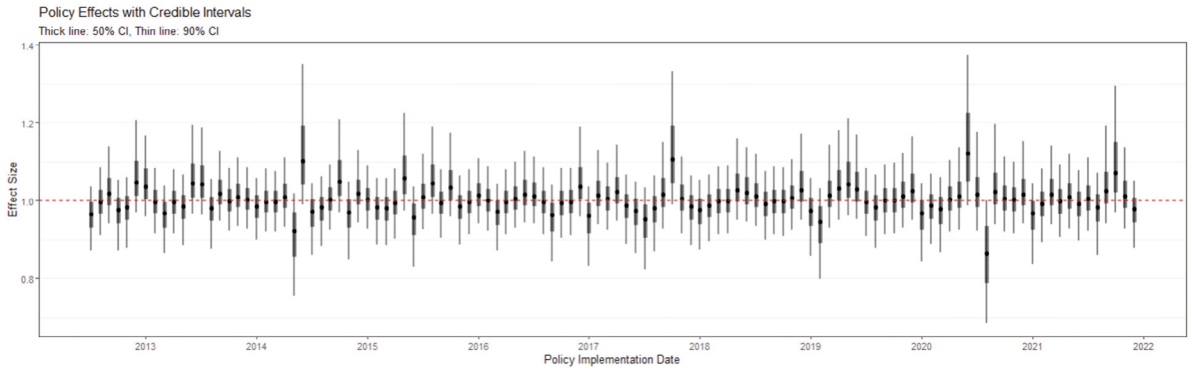

Figure 1. Detection of breakpoints in the time series of preterm birth in Lombardy. Each dot represents the estimated immediate effect of a break-point occurring in that month, with corresponding credible intervals

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