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COMMENTARY

Weathering Delivery Surges: How Atmospheric Pressure Influences Spontaneous Labour Timing in a Climate-Vulnerable Era

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While adverse health conditions in pregnant persons, including diabetes, preeclampsia, vaginal bleeding and infections are well-established contributors to preterm birth and may account for part of the biological processes involved in labour initiation, they do not fully explain the individual differences in the timing of delivery. Classical factors help explain the initiation of labour; however, some less well-understood elements—such as meteorological conditions—may also influence labour initiation and contribute to fluctuations in delivery rates [1]. For example, previous research has shown that exposure to air pollution and extreme temperatures can increase the risk of preterm birth [2–4]. Additionally, various climatic variables, including atmospheric pressure, relative humidity, duration of sunlight, wind speed and direction, and cyclonic activity, have been hypothesised to affect the daily frequency of spontaneous labour. Fluctuations in atmospheric pressure may pose direct and indirect risks to human health through complex pathophysiological pathways and a combination of external and internal mechanisms [5]. Similarly, variations in daily delivery volume can have broad implications for affected families, hospitals and medical staff, with high delivery days associated with increased maternal and neonatal complications [6]. The impacts of climate change are far-reaching, influencing a wide range of natural processes. As climate change increases the frequency and intensity of extreme weather events, including rapid pressure changes, understanding their potential effects on reproductive outcomes becomes increasingly critical for safeguarding maternal and child health.

In this issue of *Paediatric and Perinatal Epidemiology*, Terada and colleagues [7] present a critical advancement in knowledge by examining the association between drops in atmospheric pressure and spontaneous-onset deliveries, using a large nationwide dataset and applying distributed lag non-linear models (DLNM) to capture delayed and non-linear effects. They analysed data from a Japanese nationwide registry covering 389 obstetrical facilities between 2011 and 2020, which included 1,074,380 spontaneous-onset deliveries. Prefecture-specific lag-cumulative associations were estimated using distributed lag non-linear models and then pooled through a random-effects multivariate meta-analysis to derive the overall effect.

Their findings revealed a clear association between pressure changes between neighbouring days (PCN) and fluctuations in the daily number of spontaneous deliveries. The lag-cumulative curve, derived from a DLNM, summarised the overall effect of atmospheric pressure drops across multiple lag days and showed that the delivery risk increased particularly within the 0–4 days preceding delivery. While the observed risk increases are relatively small at the individual level, they may collectively contribute to a downward shift in the population distribution of gestational age at delivery. Fortunately, this mainly affected women with term pregnancies, with a 6.5% (95% confidence interval [CI] 0.0, 13.8) increased risk of delivery at 38 weeks, an 8.2% (95% CI 2.4, 14.3) increased risk at 39 weeks and a 10.3% (95% CI 2.6, 18.7) at 40 weeks. For preterm births, the relative risk (RR) was estimated for preterm births at 1.04 (95% CI 0.97, 1.13), suggesting a potential but uncertain association between pressure drops and delivery risk in this gestational age. The authors found that adjusting for fine particulate matter ($PM_{2.5}$) and ozone only slightly attenuated the association. Using the daily pressure nadir for PCN calculation

yielded comparable results, as did the inclusion of augmented/induced labours due to weak contractions.

A key challenge in assessing the health impacts of environmental exposures lies in their often-lagged effects and nonlinearity. For example, the association between temperature and health outcomes usually follows a U-, V- or J-shaped curve, indicating that both cold and heat can be harmful, with the risks of illness or death increasing at both ends of the spectrum. Traditional linear models may misestimate or even mischaracterise such relationships, particularly when delayed effects or threshold responses are present. Meteorological exposures frequently exhibit delayed health effects, leading to what is known as a 'harvesting effect', where vulnerable individuals experience adverse outcomes earlier than expected, resulting in an apparent drop in risk during the following days. The distributed lag non-linear model (DLNM) provides a flexible and powerful statistical framework that allows for the simultaneous assessment of non-linear exposure-response relationships and delayed (lagged) effects over time, making it particularly suitable for evaluating the complex and potentially cumulative impacts of environmental exposures on health outcomes [8]. This study used a DLNM to account for both the nonlinear and delayed effects of atmospheric pressure on the risk of spontaneous-onset deliveries, thereby improving the accuracy of effect estimates compared to conventional approaches.

Additionally, Terada and colleagues effectively addressed a significant source of heterogeneity that has limited most previous studies. Prior research on this topic often relied on small sample sizes or data from single hospitals or regions, reducing statistical power and introducing potential selection bias due to geographic differences, such as variations in climate, population demographics or healthcare access. In contrast, Terada and colleagues incorporated nationwide multi-source data and applied random-effects multivariate meta-analysis techniques to combine lag-specific estimates across prefectures, enabling a more robust and comprehensive assessment. This approach enhances generalisability and minimises the influence of localised confounding factors, strengthening the validity of the observed associations.

Nonetheless, limitations remain regarding the use of atmospheric pressure data from ground-based stations, typically at the county level. These measurements may be affected by various factors that can introduce exposure misclassification, such as variations in living floor height, acute changes in local meteorological conditions and indoor environmental buffering [9]. Moreover, the underlying mechanisms through which atmospheric pressure fluctuations influence labour onset remain unclear, particularly concerning differences by gestational week and time of day.

Reliable clinical and animal studies are still needed to elucidate whether and how changes in atmospheric pressure affect uterine sensitivity, the timing of labour initiation or other physiological triggers, especially considering maternal factors such as age, health status or previous pregnancies [10]. Future studies could benefit from finer spatial resolution of atmospheric data or individual-level exposure assessment to reduce misclassification. Additionally, integrating biomarkers or wearable technology might help to clarify individual physiological responses to pressure fluctuations. This study highlights the potential role of environmental factors—specifically atmospheric pressure changes—in predicting daily fluctuations in delivery rates. By examining the lagged effects of pressure drops on spontaneous labour, the authors contribute valuable insight into the growing literature on climate change and reproductive health. The findings suggest that short-term meteorological changes may act as environmental triggers for labour initiation. Obstetrical care systems may benefit from incorporating meteorological forecasting into planning processes, enabling better preparedness through the proactive allocation of staff and resources.

Author Contributions

S.S. was invited to write the commentary. J.L. wrote the first draft of the article with input from W.C. and S.S.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The authors have nothing to report.

Disclosure

The authors have nothing to report.

References

1. B. Dehdashti, N. Bagheri, M. M. Amin, et al., "Impacts of Climate Changes on Pregnancy and Birth Outcomes: A Review," *International Journal of Environmental Health Engineering* 9, no. 1 (2020): 24.

2. T. Ye, Y. Guo, W. Huang, Y. Zhang, M. J. Abramson, and S. Li, "Heat Exposure, Preterm Birth, and the Role of Greenness in Australia," *JAMA Pediatrics* 178, no. 4 (2024): 376–383.

3. N. W. Heatwaves, "PM2.5: Sometimes-Surprising Associations With Preterm Birth," *Environmental Health Perspectives* 128, no. 9 (2020): 94002.

4. S. Sun, K. R. Weinberger, K. R. Spangler, M. N. Eliot, J. M. Braun, and G. A. Wellenius, "Ambient Temperature and Preterm Birth: A Retrospective Study of 32 Million US Singleton Births," *Environment International* 126 (2019): 7–13.

5. M. Denda, "Keratinocytes at the Uppermost Layer of Epidermis Might Act as Sensors of Atmospheric Pressure Change," *Extreme Physiology & Medicine* 5 (2016): 11.

6. J. M. Snowden, K. B. Kozhimannil, I. Muoto, A. B. Caughey, and K. J. McConnell, "A 'Busy Day' Effect on Perinatal Complications of Delivery on Weekends: A Retrospective Cohort Study," *BMJ Quality and Safety* 26, no. 1 (2017): e1.

7. S. Terada, H. Nishimura, N. Miyasaka, and T. Fujiwara, "Drops in Atmospheric Pressure and Subsequent Fluctuations in Daily Delivery Volume: A Case-Crossover Study," *Paediatric and Perinatal Epidemiology* (2025), https://doi.org/10.1111/ppe.70012.

8. A. Gasparrini, "Distributed Lag Linear and Non-Linear Models in R: The Package Dlnm," *Journal of Statistical Software* 43, no. 8 (2011): 1–20.

9. K. L. Ebi, A. Capon, P. Berry, et al., "Hot Weather and Heat Extremes: Health Risks," *Lancet (London, England)* 398, no. 10301 (2021): 698–708, https://doi.org/10.1016/S0140-6736(21)01208-3.

10. K. Ravanos, T. Dagklis, S. Petousis, C. Margioula-Siarkou, Y. Prapas, and N. Prapas, "Factors Implicated in the Initiation of Human Parturition in Term and Preterm Labor: A Review," *Gynecological Endocrinology* 31, no. 9 (2015): 679–683.