Exposure to Extreme Weather Events and Fertility Behaviour: Insights from the UK Household Longitudinal Study.

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Introduction

Extreme weather events, including heatwaves, heavy rainfall, floods and droughts, are becoming more frequent and severe in many regions worldwide as a result of anthropogenic climate change (IPCC 2023). These events have global repercussions, profoundly affecting societies and ecosystems, including demographic outcomes. While there is relatively abundant research on how exposure to extreme climatic events and temperatures influence migration (Hoffmann et al. 2020; 2024) and mortality (Ebi et al. 2021; Watts et al. 2015), evidence on their impact on fertility behaviour remains limited.

This study leverages rich longitudinal data from *Understanding Society* (2009–2023), combined with high-resolution flood and temperature records, to investigate the relationship between exposure to climate-related events and the likelihood of conception in the UK. To our knowledge, this represents a novel contribution to the field of reproductive demography for the following reasons. While previous studies on climate and fertility have mostly relied on macro-level data at the country or subnational level, our use of individual-level longitudinal panel data offers two key advantages. First, it avoids the risk of ecological fallacy by allowing us to analyse fertility behaviour directly at the individual level. Second, it enables us to investigate heterogeneity in responses to climate events e.g. by gender, socio-economic status and attitudinal factors and to assess how these characteristics may moderate the relationship between climate exposure and fertility. Furthermore, existing research using individual-level survey data has primarily focused on the relationship between climate change concerns and fertility intentions. This study contributes to this emerging field of research by observing actual outcomes and matching them with objective climate data, adding an additional perspective to the existing literature. Additionally, most of the existing research observing climate-change related natural hazards in relation to fertility focuses primarily on extreme temperatures. This study brings contribute to the literature by also examining the effects of exposure to floods—an area that has received limited attention.

Theorical Background

The study draws on multiple strands of literature to establish its theoretical foundation, distinguishing between the direct and indirect effects of climate change on fertility behaviours. Direct effects refer primarily to physiological responses to environmental stressors, which may influence reproductive outcomes independently of individual intentions or behaviours. A consistent body of research has documented a decline in fertility eight to ten months after periods of extreme heat. This growing body of research includes regions across the Global North, including the US (Barreca, Deschenes, and Guldi 2018; Lam and Miron 1996), Spain (Conte Keivabu, Cozzani, and Wilde 2024), Hungary (Hajdu and Hajdu 2022) and South Korea (Cho 2020). Similar findings have emerged in the only study examining the Global South, specifically Sub-Saharan Africa (Thiede et al. 2022). Some of these studies suggest that after an initial decline, fertility rates partially rebound in subsequent months, indicating that populations may offset some fertility costs by shifting conception timing (Barreca, Deschenes, and Guldi 2018; Hajdu and Hajdu 2022; Conte Keivabu, Cozzani, and Wilde 2024). This phenomenon contributes to birth seasonality, as extreme heat appears to reduce immediate conception rates and to delay conceptions. While the precise mechanisms remain uncertain, evidence points to physiological responses to heat rather than changes in sexual behaviours as the primary drivers (Barreca, Deschenes, and Guldi 2018).

In contrast, little is known about the direct effects of floods on fertility. To our knowledge, only a few studies have explored this link. For instance, research on the 1997 Red River flood in North Dakota found an increase in certain maternal health risks after the flood, in addition to a moderate decrease in fertility rates (Tong, Zotti, and Hsia 2011). A broader literature review by Lee et al. (2023), focusing on the impacts of natural disasters on fertility behaviours, suggests that physical disasters such as floods and tsunamis influence fertility mainly through behavioural (*indirect*) mechanisms (such as psychological attachment, replacement effects, or changes in partnership dynamics), rather than physiological (Lee et al. 2023). The authors also highlight a strong population heterogeneity in fertility responses to floods and tsunamis. For example, one study on the 2004 Indonesian tsunami conducted in the most severely affected regions found a strong negative effect (Kinoshita et al. 2016), while another cross-regional study found a fertility increase (Nobles, Frankenberg, and Thomas 2015).

Much of the existing research on the *indirect impacts* of climate change on fertility behaviours focuses on low- and middle-income countries (see, for example, Grace, 2017), where economies are often more dependent on human interaction with the land and nature, making them especially susceptible to climate shifts. However, even in high-income countries, climate change has already started to exacerbate existing economic vulnerabilities, amplifying prevailing uncertainty that is thought to influence childbearing decisions (Vignoli et al. 2020; Puglisi, Muttarak, and Vignoli 2025). Moreover, natural disasters can generate concrete economic hardships—such as housing damage or financial strain (Botzen, Deschenes, and Sanders 2019)—which may disproportionately affect individuals in precarious economic situations and, in turn, indirectly shape their fertility behaviours. Alongside this pathway, we also consider other possible mechanisms linking exposure to natural hazards and fertility decisions in high-income contexts, drawing on two interrelated strands of literature: (1) the influence of climate change concerns on fertility intentions, and (2) the role of direct exposure to natural hazards in shaping climate-related attitudes and behaviours.

Attention to the impact of climate change concerns on fertility intentions has grown in recent years. As awareness of climate change has increased, people have begun questioning the desirability of having children in such a world. Two key mechanisms drive this trend: fear of the environmental impact of adding another child to the planet, and concerns for the wellbeing of the child in a world impacted by climate change (Schneider-Mayerson 2022). Most studies focusing on fertility intentions reveal that people that are particularly concerned about climate change tend to intend to have fewer children or smaller families (Dillarstone, Brown, and Flores 2023; Powdthavee, Oswald, and Lockwood 2024; Rackin, Gemmill, and Hartnett 2023; Bastianelli 2024; Puglisi, Muttarak, and Vignoli 2025), but the findings are mixed (see, for example, De Rose and Testa (2015)). To our knowledge, only Powdthavee and colleagues (2024) investigated how climate change concerns and attitudes relate to fertility behaviours -rather than intentions. They demonstrate that pro-environmental behaviours (such as closing tap running while brushing teeth or taking fewer flights) are associated with lower chances of having a child six years later (Powdthavee, Oswald, and Lockwood 2024).

Given that the interplay between fertility intentions and concern about climate change is contingent upon individuals being aware of—and concerned about—climate change, this study incorporates the theory of experiential learning in the specific context of how climate-related events—specifically floods and heatwaves—affect attitudes regarding childbearing. This framework is based on the premise that direct, firsthand experiences are more influential than theoretical or abstract knowledge in shaping individuals' perceptions and actions, particularly through emotional involvement (Demski et al. 2017; Whitmarsh 2008). Thus, experiencing extreme weather events can diminish the perceived spatial and temporal distance of climate change. While there is quite robust evidence linking the experience of extreme weather events to increased climate change awareness (Spence et al. 2011; Whitmarsh 2008; Larcom, She, and van Gevelt 2019; Osberghaus and Fugger 2022), the same cannot consistently be said for shifts in behaviours (Rüttenauer 2023; Howe et al. 2019).

Our analysis account for other well-established determinants of entry into first parenthood, including age, partnership status, employment status, and the number of existing children (van Wijk, de Valk, and Liefbroer 2022; Tocchioni et al. 2019; Guzzo and Hayford 2020). Additionally, we control for socio-economic factors at both individual (e.g., employment status) and aggregate levels (e.g., median house prices, unemployment rates) are crucial for understanding how economic uncertainties influence fertility plans.

Research questions and hypothesis

This study aims to address two key research questions: (1) What is the relationship between exposure to climate change-related natural hazards—specifically floods and heatwaves—and the likelihood of having a first child? (2) What are the mechanisms that shape this relationship? To investigate these questions, we propose a set of hypotheses that account for both direct and indirect pathways, as well as potential moderating factors.

First, we hypothesise a decline in the likelihood of conception during the month of a heatwave, followed by a possible partial rebound in subsequent months (H1). This expectation aligns with existing literature on the physiological effects of extreme temperatures on fertility behaviour.

In contrast, formulating hypotheses around the effects of floods is less straightforward due to the limited literature and context-specific nature of such events. Nonetheless, we anticipate a decline in the likelihood of conception during the month of a flood, primarily driven by behavioural mechanisms—for instance, the disruption caused by property damage, displacement, and increased financial and time burdens (H2). We expect this reduced likelihood may persist over the following months, if the flood is particularly severe (H3).

To explore the behavioural mechanisms underlying these effects, we include interaction terms between climate variables and key socio-economic and attitudinal factors. Specifically, we test whether the relationship between climate related hazards exposure and fertility is moderated by subjective financial wellbeing, income, and indicators of climate change attitudes and behaviours. These interactions aim to uncover which population subgroups are most affected and through which channels climate-related events might influence reproductive behaviour. We expect that economical vulnerabilities (e.g. a lower subjective financial status or income) will be associated with a stronger decrease in the likelihood of conception during and after exposure to a flood (H4). Based on the existing evidence on the relation between climate change concerns and fertility intentions, and the evidence about experiential learning, we also expect a stronger decrease of the likelihood of conception after exposure to both heatwaves and floods among people that are more concerned about climate change (H5).

Data and Sample

Our primary data source is the "Understanding Society: Waves 1-14, 2009-2024" dataset, which offers comprehensive longitudinal socio-economic and demographic information for approximately 40,000 households (University of Essex, Institute for Social and Economic Research n.d.). Geographical location for each respondent indicates which Lower Layer Super Output Areas (LSOA) the individual lives within - each LSOA typically encompasses around 1,400 individuals. Geographic data from the "Understanding Society" dataset is linked with two external data sources. For data on floods, we use firstly the Environment Agency's Recorded Flood Outlines data for England sourced from the UK Government (n.d.), which includes dates and geographic information on floods from various sources (river, sea, groundwater, and surface water); and secondly the Recorded Flood Extents – Natural Resources Wales, for floods occurred in Wales ('Recorded Flood Extents | DataMapWales', n.d.). Flood data is interpolated by creating 5 km buffers centred around each LSOA. For data on daily temperature, we use the HadUK (Hollis et al. 2019). Following previous studies (Larcom, She, and van Gevelt 2019; Rüttenauer 2023), an LSOA is defined as having experienced a heatwave when the daily maximum temperature equals or exceeds 29°C for at least three consecutive days.

The study sample comprises respondents followed until the occurrence of a childbirth event. Respondents enter the sample at the first survey interview and are tracked until one of the following conditions is met: 1) the birth of their (next) child; 2) attrition from the survey or the end of the observation period; 3) the month preceding their 45th birthday (for women) or 55th birthday (for men). Using this population, we construct a person-month dataset that includes both time-constant and time-varying covariates, following the methodological approach outlined by Allison (1982). Longitudinal weights are employed.

Methods

We employ a multilevel logistic discrete-time event-history model (Barber et al. 2000), which takes into account the hierarchical structure of our data with person-years nested within LSOAs. This approach enables us to model the probability of conception over time while considering the nested nature of individuals within geographical areas. We compute the analysis separately for men and women and focus on childless individuals in the first step of the analysis.

The key predictors are two monthly time-varying measures capturing exposure to heatwaves and floods. The heatwave variable is categorized as: 0) not exposed; 1) exposed in the current month; 2) exposed in the past 2 to 5 months; 3) exposed in the past 6 to 12 months. Flood exposure is categorized as: 0) not exposed; 1) exposed in the current or past month; 2) exposed in the past 3 to 12 months. This structure allows us to assess whether the effects of exposure vary depending on the time elapsed since the event. Alternative operationalisations of these predictors will be tested for robustness.

We control for a range of socio-economic and demographic covariates, including age group, ethnic group, partnership status, educational attainment (interacted with age), as well as economic activity status (employed, unemployed, inactive/family carer, or full-time student). Additionally, we include subjective measures such as self-reported financial wellbeing, mental health, and three variables reflecting climate change-related attitudes, behaviours, and beliefs—derived using principal factor analysis (PFA) from a battery of survey items. We adjust for aggregate level confounders including local unemployment rates and median house prices at LSOA level or local authority level, depending on data availability. To account for seasonal patterns in conception, month of observation is included as a control variable.

Additional models including interaction terms are estimated to conduct moderation analyses, aimed at exploring whether the effects of exposure to climate shocks on fertility behaviours vary by key economic conditions (subjective financial wellbeing, income, and economic activity) and by climate change-related concerns, attitudes, and beliefs.

Preliminary Findings

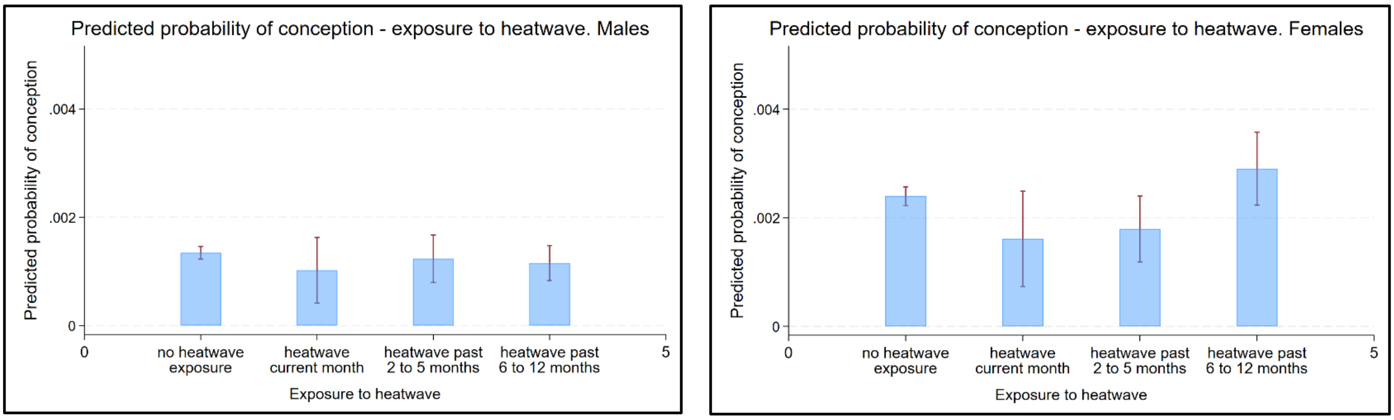
The results reported here are based on the full models, which incorporate all individual-level covariates described previously, alongside controls for seasonality and relevant contextual confounders. Results are presented as predicted probabilities calculated using average adjusted predictions (AAPs) with 83.55% confidence intervals, following MacGregor-Fors and Payton (2013). Given the data structure, which is long-format person-month, the probability of conception is a rare event, with predicted probabilities ranging from 0.0013 to 0.0025 across the different models. To improve interpretability, the results are rescaled by a factor of 100 and expressed as percentages (for example, 0.0013 becomes a 0.13% probability of conceiving a child).

Table 1 and Figure 1 summarize the findings related to the exposure to heatwaves. The probability of conceiving a child appears to decline during months when a heatwave occurs, although this difference does not reach statistical significance. It is important to note that the wide confidence intervals observed reflect the combination of a rare event and the small number of observations falling in some categories of the predictor (only approximately 3% of person-months are classified as 'exposed to a heatwave in the current month'), which reduces statistical power and increases uncertainty around the estimates. While this limitation calls for cautious interpretation, the results, which we nonetheless discuss despite the lack of statistical significance -at this stage, suggest a pattern that is directionally consistent with H1. The pattern of reduced conception probability during heatwave months is consistent for both men and women, with a more pronounced decrease observed among women. The predicted probability of conception decreases from 0.134% to 0.102% for men, and from 0.240% to 0.161% for women. This corresponds to an absolute reduction of 0.032 and 0.079 percentage points, respectively, or approximately 24% and 33% relative declines. For women, we also observe an increase of 0.050 percentage points in the probability of conception observed six to twelve months following a heatwave, compared to periods without exposure. Although this result does not reach statistical significance, the direction of the effect may suggest a compensatory or recovery mechanism in fertility intentions after experiencing extreme heat. This finding aligns with those of Barreca et al. (2018), Conte Keivabu et al. (2024) and Hajdu and Hajdu (2022), who observed a rebound in births occurring somewhat earlier, between two and six months after exposure.

Table 1– Predicted probabilities of experiencing a conception leading to a first birth by exposure to heatwaves. Childless males on the left-hand side (*N* = 249,715 person-months) and females on the right-hand side (*N* = 193,499 person-months). Predicted probabilities are multiplied by 100 and are expressed as percentages to enhance interpretability. 83.55% confidence intervals shown.

		Males			**Females**	
		Predicted Probabilities (%)	83.55% confidence intervals (%)		Predicted Probabilities (%)	83.55% confidence intervals (%)
Heatwave exposure						
No exposure		0.134	0.123 – 0.146		0.240	0.223 – 0.257
Current month		0.102	0.041 – 0.163		0.161	0.073 – 0.249
Past 2 to 5 months		0.123	0.080 – 0.167		0.179	0.119 – 0.240
Past 6 to 12 months		0.115	0.083 – 0.148		0.290	0.223 – 0.358

Figure 1 – Predicted probabilities of conception conditioned on the key predictor 'Heatwave exposure'. Childless males subpopulation on the left-hand side (*N* = 249,715 person-months). Childless females subpopulation on the right-hand side (*N* = 193,499 person-months).

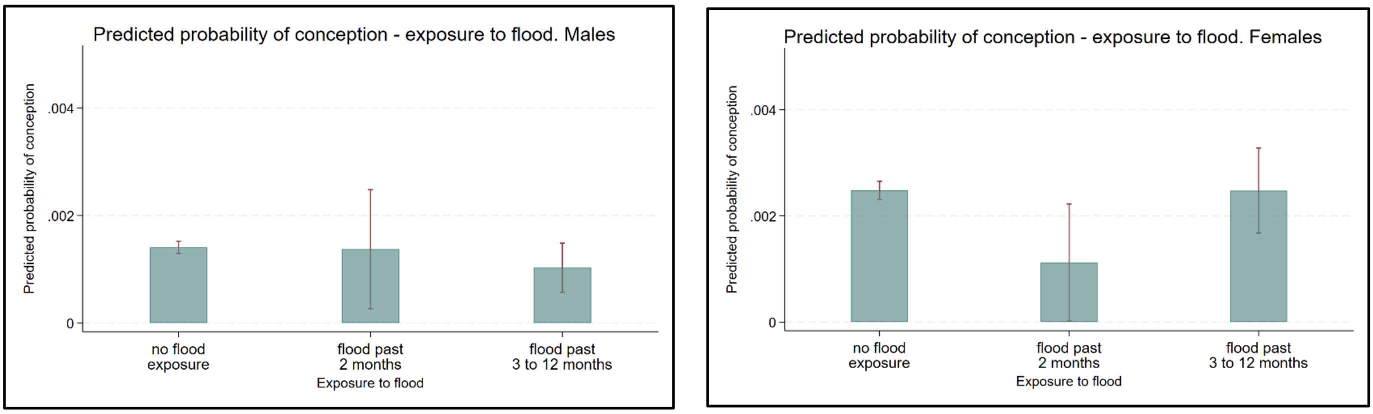


Regarding flood exposure, our results indicate a significant decrease in the likelihood of conception during the month of flood exposure among females, where the effect size is larger and statistically significant despite the wide confidence interval. The predicted probability drops from 0.248% to 0.112%, corresponding to a reduction of 0.136 percentage points, or approximately a 55% relative decline. This result is in line with H2, while H3 is not confirmed by the statistical analysis: in the subsequent 3 to 13 months following the flood event, probabilities of conception return to levels comparable to those observed in unexposed periods (see Table 2 and Figure 2).

Table 2 – Predicted probabilities of experiencing a conception leading to a first birth by exposure to floods. Childless males on the left-hand side (*N* = 218,685 person-months) and females on the right-hand side (*N* = 170,733 person-months). Probabilities have been multiplied by 100 and are expressed as percentages to enhance interpretability. 83.55% confidence intervals shown.

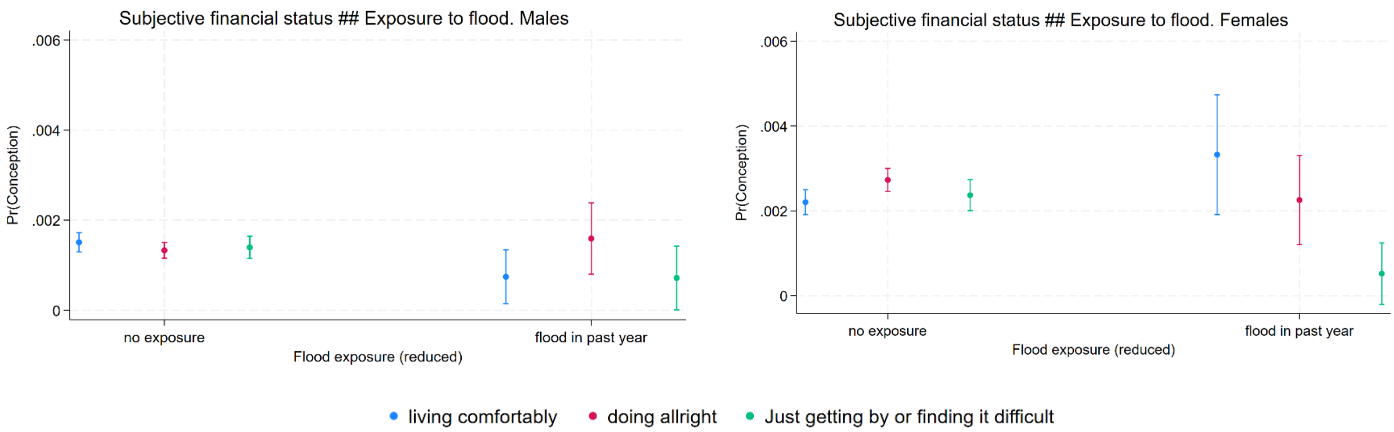
		Males			**Females**	
		Predicted Probabilities (%)	83.55% confidence intervals (%)		Predicted Probabilities (%)	83.55% confidence intervals (%)
Flood exposure						
(base) No exposure		0.141	0.129 – 0.152		0.248	0.231 – 0.265
Past 2 months		0.137	0.027 – 0.248		0.112	0.002 – 0.222
Past 3 to 12 months		0.103	0.057 – 0.149		0.248	0.168 – 0.328

Figure 2 – Predicted probabilities of conception conditioned on the key predictor 'Flood exposure'. Childless males subpopulation on the left-hand side (*N* = 218,685 person-months). Childless females subpopulation on the right-hand side (*N* = 170,733 person-months).



To explore the mechanisms underlying these findings, we examine potential moderation effects of selected covariates, with a particular focus on economic conditions and climate change-related beliefs, behaviours, and attitudes. Due to limited observations in some interaction categories, the climate-related variables are recoded as binary indicators to preserve model stability. In several instances, however, the small number of observations in certain interacted categories leads to issues of perfect prediction or collinearity. As a result, we are unable to fully investigate moderation effects for some covariates. Overall, most of the estimated interaction effects do not reach statistical significance, with the exception of the interaction between subjective financial wellbeing and flood exposure (Figure 3). Among women who experienced a flood in the past year, those reporting financial difficulties have a lower predicted probability of conception (0.052%) than those living in comfortable conditions (0.333%), with a difference of 0.281 percentage points. This finding suggests that economic vulnerability may represent a key mechanism through which environmental shocks influence fertility behaviour, in line with Hypothesis 4.

Figure 3 – Predicted probabilities of conception: interaction between flood exposure and subjective financial status. Childless males subpopulation on the left-hand side (*N* = 218,685). Childless females subpopulation on the right-hand side (*N* = 170,733).



Discussion and next steps

This study provides preliminary evidence on how exposure to extreme weather events may influence fertility behaviour, highlighting the potential role of timing and individual-level vulnerability in shaping these effects. We find that, among women, flood exposure is associated with a lower likelihood of conception during the month of the event. This negative association appears to be more pronounced among women who report financial difficulties, suggesting that economic vulnerability may moderate the impact of environmental shocks on fertility behaviour.

In the analysis of heatwave exposure, the results obtained were not statistically significant. This lack of significance may be attributed to the rarity of both the exposure and the outcome within the dataset, which consequently limits statistical power and results in wide confidence intervals. Despite the absence of statistical significance, the direction of the estimates aligns with findings from prior research, indicating temporary disruptions in conception rates concurrent with heatwave events, followed by a small rebound 6 to 12 months after exposure in the female subpopulation.

To advance this research, future work will explore alternative methodological strategies to address data sparsity and improve model precision. Further moderation analyses will also be conducted to explore the role of additional individual characteristics (e.g. age, ethnicity, education). Finally, we plan to extend the analysis to include other parities, to assess whether the effects vary by previous childbearing experience.

These findings have important implications for understanding how climate stressors may shape demographic behaviours. As climate extremes become more frequent and severe, fertility intentions and outcomes may increasingly reflect both physiological constraints and broader life disruptions caused by such events. This can have a significant impact on population dynamics, particularly in a low fertility setting.

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