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Data Insight

Exploring the effects of hot weather on pregnancy and newborn health — the MAGENTA study

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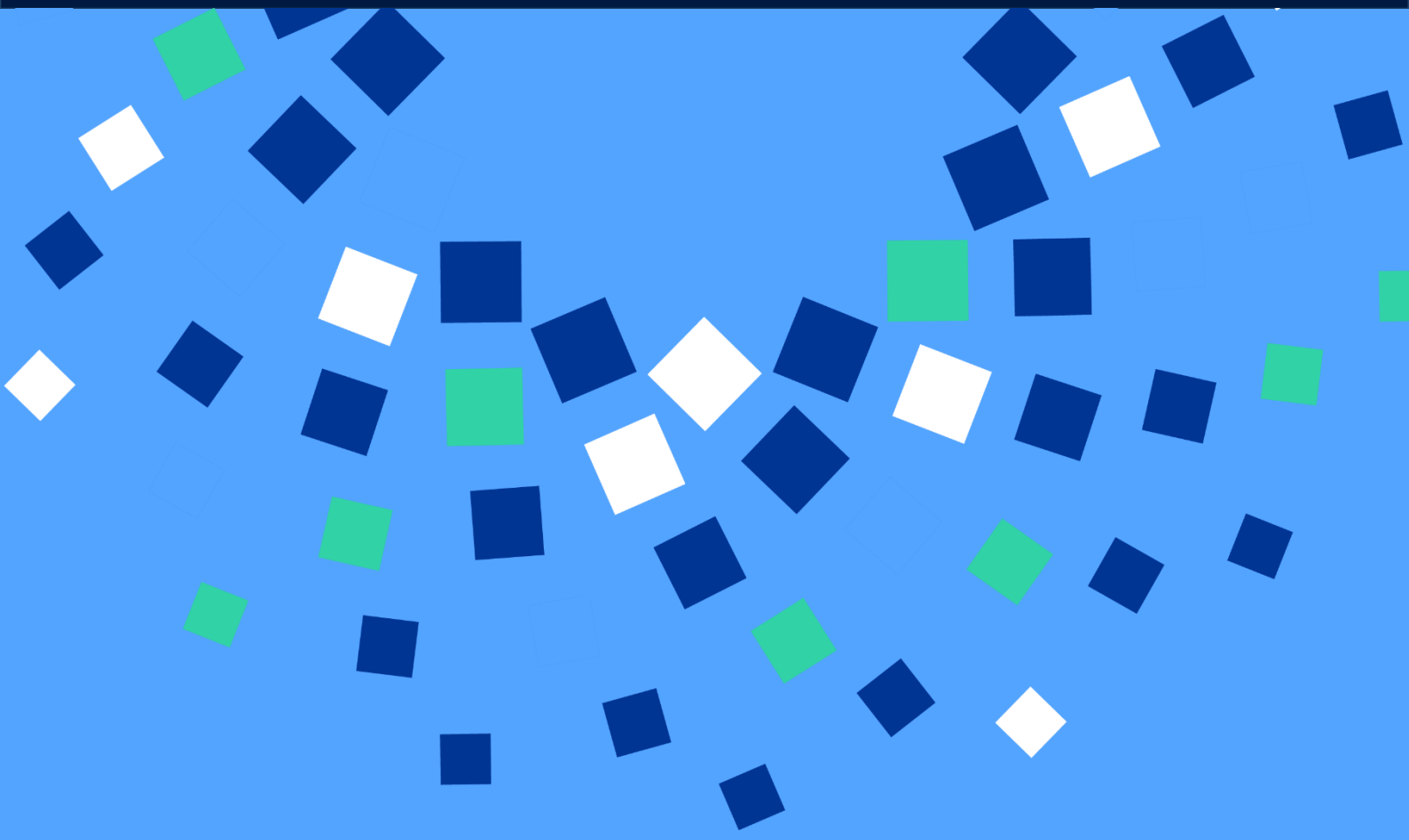


Summary

Climate change is resulting in more frequent, intense and prolonged heat events globally, including here in the UK (1). A comprehensive understanding of the health impacts of these rising temperatures, particularly among vulnerable groups of the population such as pregnant women and infants, is critical to enable the development of evidence-based, effective interventions and policies aimed at adapting and mitigating future climate health risks in a warming world.

This report presents early findings and plans for the MAGENTA (Maternal And preGnancy hEalth aNd elevaTed heAt - https://magentaresearch.org/) project, a £2.2 million Wellcome Trust-funded research project led by Swansea University and partnered with the Kids' Environment & Health Cohort at University College London. The overarching aim of this project is to provide evidence on whether exposure to higher temperatures during pregnancy is associated with adverse health outcomes for mother and baby. Outcomes of interest include stillbirth or death in the first month of life, gestational age at birth (the primary outcome in our study), birth weight, mode of birth (e.g. vaginal birth or C-section), babies' health immediately after birth, congenital abnormalities (e.g. anomalies of the heart, brain, spine), and whether the mother requires hospital care following delivery. A key objective of the MAGENTA project is to investigate whether socioeconomic disadvantage increases vulnerability to heat during pregnancy.

This report presents findings from the MAGENTA 2022 electronic cohort (MAGENTA22 e-cohort) held in the Secure Anonymised Information Linkage (SAIL) Databank. The e-cohort links birth

Background

Climate change is no longer a future problem, nor a problem restricted to only warmer climates. Five of the ten highest recorded temperatures in the UK occurred in the last decade (2), with provisional Met Office statistics confirming the summer of 2025 as officially the warmest summer on record for the UK (3).

Pregnant women and their newborns are particularly vulnerable to increasing heat. Emerging evidence indicates higher temperatures during pregnancy are associated with increased risk of preterm birth, reduced birthweight, birth defects, neonatal intensive care admissions, still-birth and increased risk of severe maternal health outcomes (4). Furthermore, preterm birth is recognised as the leading cause of death in the first month of life, and even babies born moderately pre-term experience increased risks of respiratory illness, hospital admissions, and poorer educational outcomes compared to babies born term (5). The amount of research in this area is increasing, but there is still much that we do not understand about the impact of heat on mothers and babies, including the magnitude of risk, the range of pregnancy outcomes impacted, periods of greatest vulnerability, factors that increase vulnerability, temperature thresholds that trigger ill health, and the underlying biological mechanisms. Further, only one study to date (6) has explored the impact of heat on pregnancy in the UK, and pregnant women have only been formally recognised as a vulnerable group in UK heat-health alert plans since 2024 (7).

A key challenge facing advancing research and action in this area is the complexity of integrating large-scale climate, environment and health data at the individual level, along with the multidisciplinary expertise required to accurately interpret results both now and under projected future climate change scenarios.

The MAGENTA project attempts to bridge this gap, by bringing together a multidisciplinary team of geographers, epidemiologists, statisticians, clinicians and immunologists. The project provides an exemplar of how large-scale, longitudinal, de-identified administrative and health data can be linked with biological samples from a recruited cohort of pregnant mothers to better understand the association between heat and health and to inform future climate health risks and adaptation policy and practice. Climatically, Wales experiences a changeable maritime climate, whereas Greater London (the UK's largest urban area) is already warmer and is projected to warm the most. This is due to both London's geographical location and the Urban Heat Island (UHI) effect, where dense buildings and roads absorb heat and more limited vegetation reduces natural cooling, resulting in cities often being warmer than surrounding rural areas.

records in Wales during 2022 to maternity and health records and daily temperature exposures during pregnancy. Findings from this cross-sectional analysis are intended to update the policy and research community on the direction of ongoing research, in addition to informing the development of the full MAGENTA e-cohort, which will include all births in London and Wales from 2010 onwards.

Key research questions

RQ1 – How does exposure to elevated temperatures during pregnancy influence mother and baby health in London and Wales?
RQ2 – How do factors such as income, housing conditions and other environmental factors change or influence the effects of heat on mother and baby health?
RQ3 – What are the biological mechanisms through which heat stress impacts mother and baby health during pregnancy?
RQ4 – Can insights into the biological impacts of heat stress during pregnancy be combined with large-scale data analysis to improve understanding of current and future effects of heat on pregnancy in a warming world?

We will answer our research questions using anonymised health and environment data held within the SAIL Databank (8) and the ONS Secure Research Service (SRS), combined with biological samples from a consenting cohort of pregnant women in Wales. MAGENTA is led by Swansea University and is partnered with the Kids' Environment & Health Cohort at University College London. MAGENTA also works in collaboration with the Office for National Statistics and Administrative Data Research Wales. A key strength of the project is the ongoing bi-directional engagement with the public (via the project's Patient and Public Involvement and Engagement [PPIE] group) as well as with policy, practice and communication experts. This ensures the study is co-produced and the findings are communicated as effectively as possible to drive action. Our PPIE group has played an active role in shaping the project, through discussions around variables of interest and potential data sources, highlighting different perspectives and any concerns. The group were very supportive of the proposed work, and their contributions will strengthen our interpretation of the data and support us in providing clear and meaningful communication of findings to the public.

The MAGENTA22 e-cohort presented in this report includes data on all births in Wales in 2022, a year marked by consistently above-average temperatures and multiple extreme heat events, including the maximum temperature ever recorded in Wales (37.1 (°C) in Hawarden Airport, Flintshire). Lessons learned from this 2022 cohort will inform the development of the full MAGENTA e-cohort, which includes all births from 2010 onwards in both London and Wales.

What we did

Creating the birth e-cohort

An e-cohort of all singleton births in Wales in 2022 (MAGENTA22 e-cohort) was curated to explore early findings, assess feasibility and refine data linkage methods. The MAGENTA22 e-cohort provided proof-of-concept for the full MAGENTA e-cohort.

Birth datasets were linked and cross-validated to create a comprehensive dataset capturing all births in Wales in 2022. These included two datasets curated by the National Health Service (NHS): the National Community Child Health Dataset (NCCH) and the Maternity Indicators Dataset (MIDS), and a dataset derived from official birth registrations (held by the Office for National Statistics (ONS), the Annual District Births Extract (ADBE). The Welsh Demographic Service Dataset (WDSD), a national dataset containing personal and address details on all individuals registered with a General Practice in Wales, was used to include only mothers who were continuously resident in Wales throughout their pregnancy.

Table 1 includes descriptions of the data sources used in the cohort and the variables derived from each.

Table 1. Data sources used for the MAGENTA22 cohort

Dataset Name (Acronym)	Dataset Description	Variables derived from dataset
Annual District Births Extract (ADBE)	A dataset curated by the ONS based on the legal registration of each birth in Wales	Week of birth, birth weight
Maternity Indicators Dataset (MIDS)	The Maternity Indicators Data Set (MIDS) is another NHS dataset that records initial assessment and birth details for mothers and babies across Wales.	Week of birth, gestational age at birth (in weeks), birth weight, mode of labour onset, mode of delivery
National Community Child Health Dataset (NCCH)	An NHS dataset brings together data from local Child Health System databases which are held by NHS Trusts and used by them to administer child immunisation and health surveillance programmes. The births table contains data on all births that take place in NHS Wales facilities	Week of birth, gestation al age at birth (in weeks), birth weight, mode of labour onset, mode of delivery, maternal ethnicity
Patient Episode Dataset for Wales (PEDW)	A dataset containing records of all inpatient and day case admissions managed by NHS Wales, including Welsh residents treated in English trusts.	Date of delivery (to assign maternal exposure windows)
The 2021 Rural Urban Classification of Statistical Geographies, England and Wales	A geographic dataset that categorises each Lower layer Super Output Area (LSOA) into rural or urban, based on the Office for National Statistics' (ONS) 2021 Rural Urban Classification (RUC) methodology	Urban/Rural LSOA
Welsh Demographic Service Dataset (WDSD)	A dataset that includes administrative information about individuals in Wales that use NHS services	Maternal age, maternal address history
Welsh Index of Multiple Deprivation (WIMD) 2019	The Welsh Government's official measure of relative deprivation for small areas in Wales	WIMD Quintile
Welsh Longitudinal General Practice Dataset (WLGP)	Contains attendance and clinical information for all general practice interactions. The dataset covers 86% of Welsh population and 83% of GP practices in Wales.	Maternal ethnicity

Assigning pregnancy temperature exposures

Daily temperature exposures were assigned to each mother throughout their pregnancy by utilising anonymised maternal address history in the WDSD and historical temperature records from the HadUK dataset (HadUK-Grid - Met Office) (9).

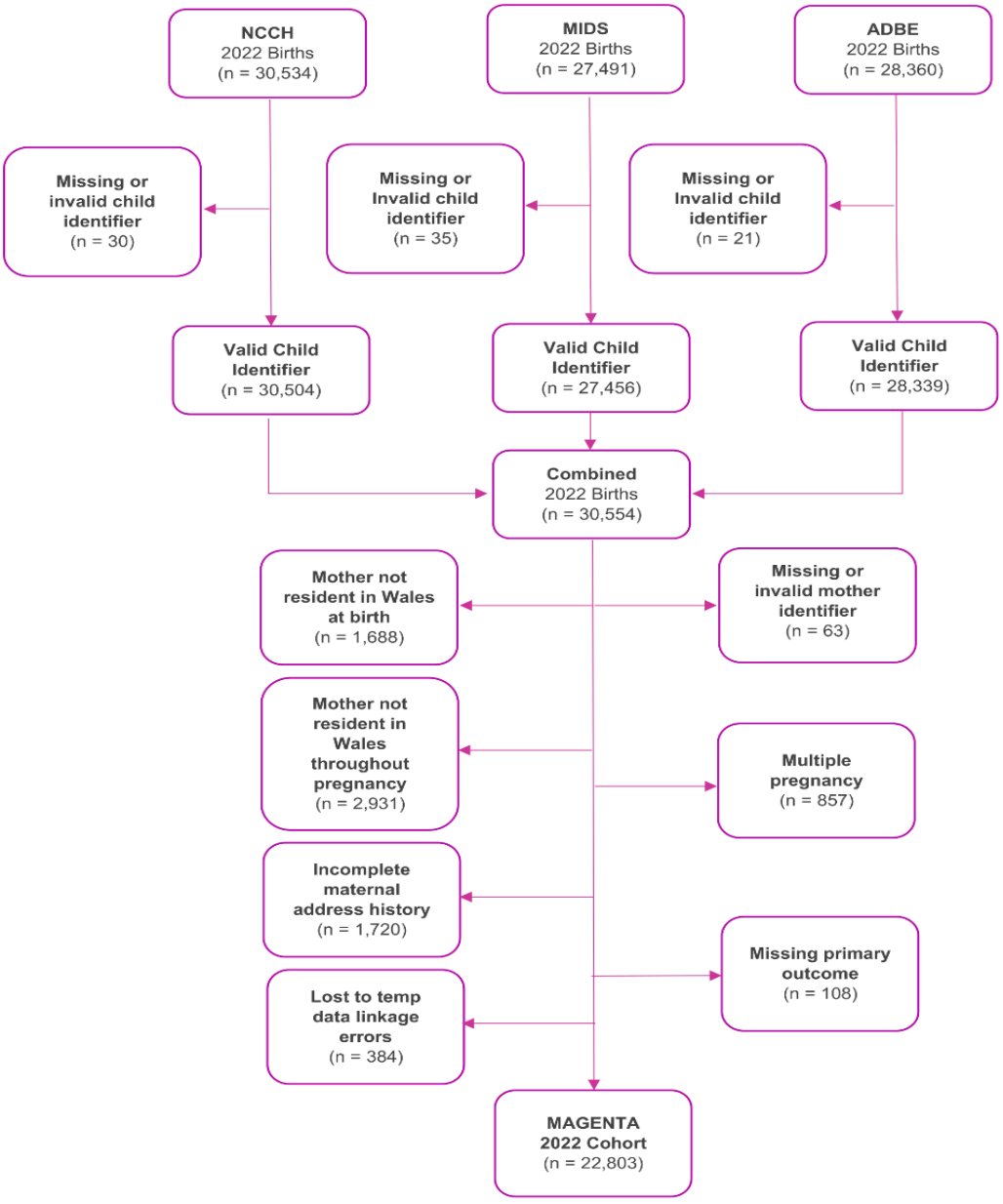
The HadUK-Grid temperature dataset was used to provide gridded UK climate observations at 1 km resolution. The dataset is produced by interpolating quality-controlled station measurements, incorporating geographic factors such as altitude and coastal influence. Daily maximum and minimum temperatures are available from 1960. These data offer spatially continuous temperature estimates with low interpolation error, suitable for analysing climate variability and

long-term temperature trends across the UK. Each household point location within a given 1km grid square was assigned the temperature values for that grid square.

Final 2022 cohort

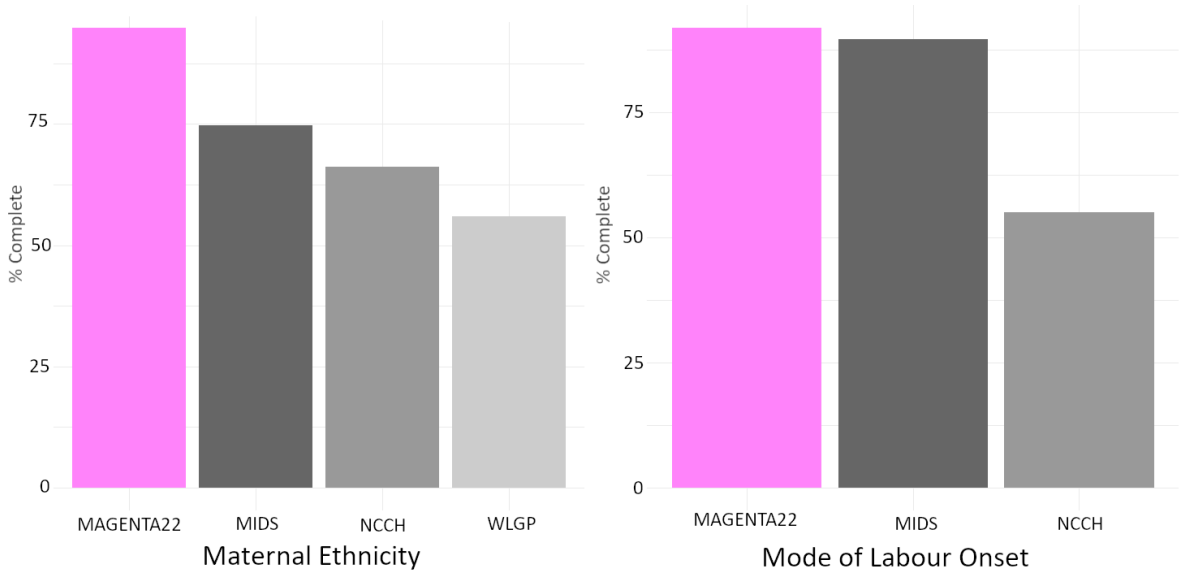
The CONSORT flow diagram (Fig. 1) shows that using multiple data sources for birth records increased the number of cases eligible for inclusion in the 2022 cohort compared with any single source (30,554 births in the combined cohort). After excluding births due to ineligibility or incomplete data, 22,803 births (75%) remained in the final cohort.

Fig. 1. CONSORT diagram depicting the derivation of the MAGENTA22 e-cohort. NCCH: National Community Child Health dataset, MIDS: Maternity Indicators Dataset, ADBE: Annual District Births Extract.



The use of multiple data sources also helped us to minimise the number of cases excluded due to missing data and improve the completeness of cohort variables.

Fig. 2. Percent of complete records by data variable



What we found

Cohort description

A total of 22,803 births to Welsh resident mothers were anonymously linked to birth, maternal and address-based daily temperature exposures in the MAGENTA22 e-cohort. Table 2 shows the breakdown of the MAGENTA22 e-cohort by child sex, mother's age, deprivation (as measured by the Welsh Index of Multiple Deprivation (WIMD) 2019 quintiles), mother's ethnic group and whether maternal address at birth was classified either urban/rural (as specified by Rural Urban Classification 2011 (10)).

Table 2. Breakdown of the MAGENTA22 cohort by demographic factors

MAGENTA22	N = 22,803 (100%)[1]
Child Sex	
Male	11,820 (51.8%)
Female	10,983 (48.2%)
Mother's Age	
<20	707 (3.1%)
20-24	3,490 (15.3%)
25-29	6,615 (29.0%)
30-35	7,339 (32.2%)
35+	4,652 (20.4%)
WIMD Quintile	
1 (most deprived)	6,001 (26.3%)
2	4,966 (21.8%)
3	4,277 (18.8%)
4	3,925 (17.2%)
5 (least deprived)	3,634 (15.9%)
Mother Ethnic Group	
White	19,951 (92.3%)
Asian	775 (3.6%)
Other	275 (1.3%)
Black	283 (1.3%)
Mixed	332 (1.5%)
RUC 2011	
Urban city and town	16,674 (73.1%)
Rural town and fringe	3,728 (16.3%)
Rural village and dispersed	2,401 (10.5%)

[1] n (%)

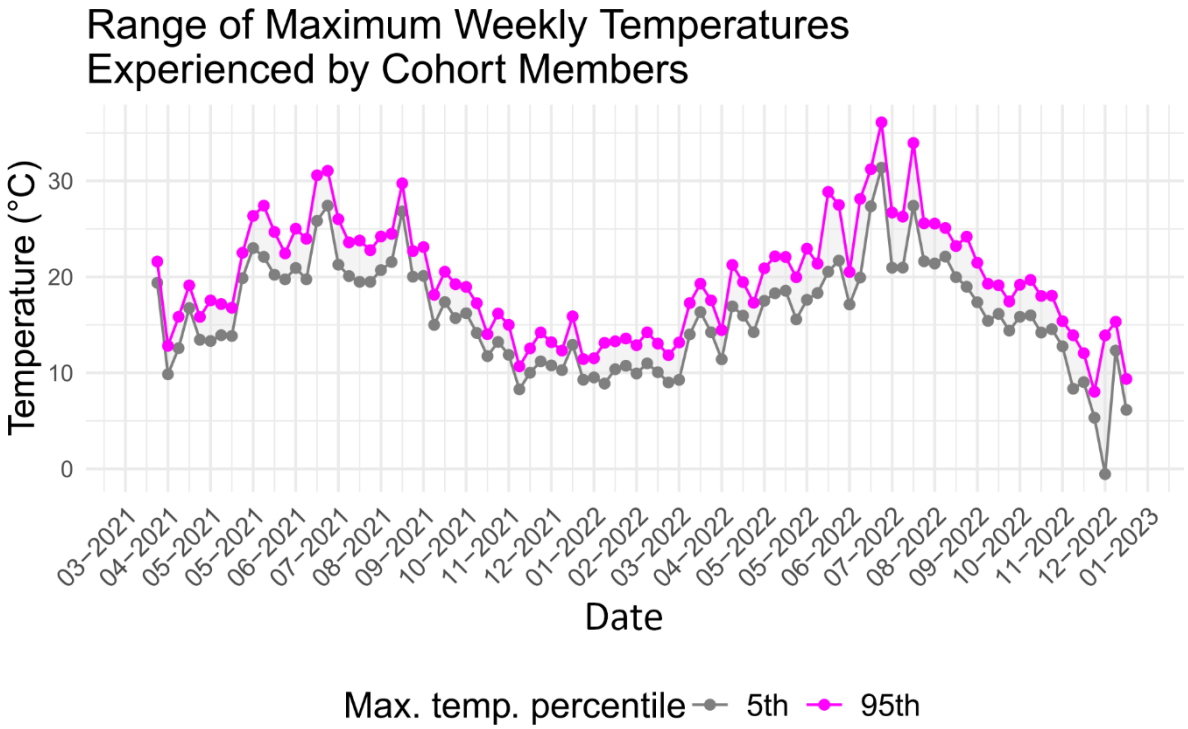
As a birth cohort, MAGENTA22 shows overrepresentation of the most deprived quintiles, consistent with previous research (11). The majority of mothers in the cohort were of White ethnicity, consistent with the demographics of the Welsh population (12,13). This is an expected limitation which will be mitigated by a London-based cohort in the full MAGENTA study, which will include substantially higher ethnic variation (14). Almost three-quarters of the mothers in

the cohort lived in an urban setting at the time of birth, thus enabling examination of Urban Heat Island (UHI) effects discussed in following sections.

Heat exposure

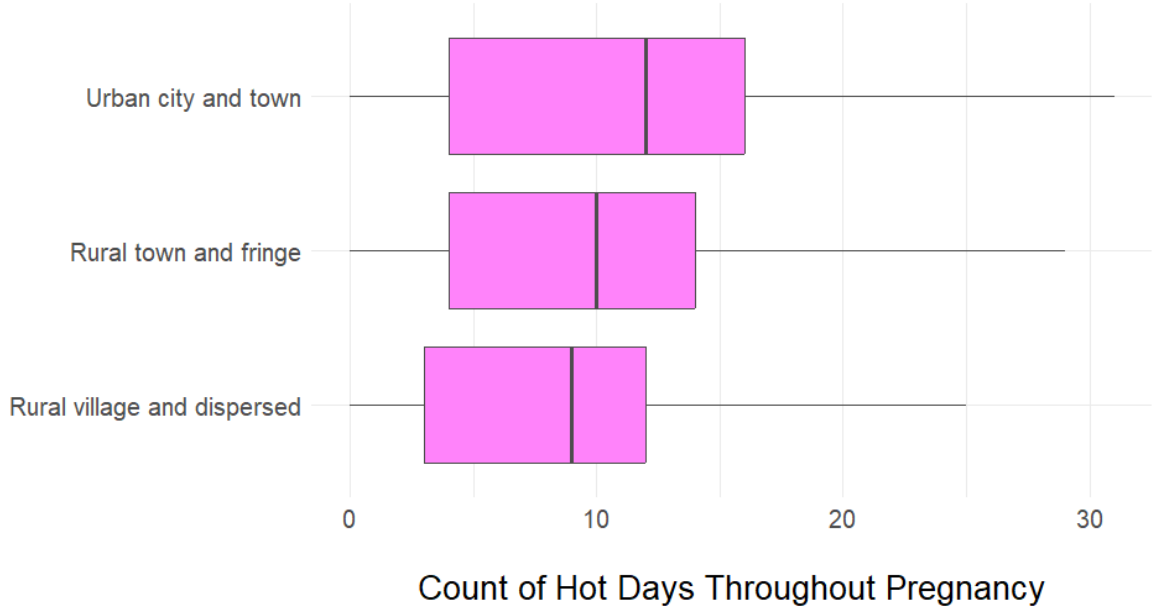
Initial exploration of maternal heat exposure patterns by residential area revealed notable spatial heterogeneity within the cohort. Figure 3 illustrates the weekly 5th and 95th percentiles of maximum temperatures experienced by participants, with the differences between percentiles ranging from 2°C to 14.5°C. This considerable variability in temperature exposure, even within the relatively temperate climate of Wales, underscores the importance of assigning exposures at the individual rather than aggregate level.

Fig. 3. Weekly 5th and 95th percentiles of maximum temperature experienced by mothers in the MAGENTA22 e-cohort during their pregnancy.



Analysis of temperature exposures by urban/rural residence defined using the 2011 Rural-Urban Classification (10) revealed notable differences between settings. As shown in Figure 4, mothers residing in urban areas experienced a greater number of days during pregnancy when maximum temperatures exceeded 25°C (the cut-off level used by the Met Office to define heatwaves (15) for the great majority of counties in Wales) compared with those in rural areas. This disparity may reflect the influence of the urban heat island effect, which will be examined in more detail in subsequent analyses.

Fig. 4. Count of days when temperature exceeded 25°C throughout the pregnancy by a mother in the MAGENTA22 cohort broken down by urbanicity.



Outcome measures

Four outcome measures in this 2022 cohort were examined: gestational age at birth as measured by completed weeks of gestation, maturity category, birth weight in grams and birth size category based on birth weight percentile. Median gestational age at birth for the entire cohort was 39 weeks (IQR 38-40) while median birth weight was 3400 g (IQR 3050-3730). Table 3 shows the breakdown of the cohort by maturity category and birth size category.

Table 3. Breakdown of the MAGENTA22 cohort by maturity category and size category. Weeks refer to completed weeks of gestation at birth.

MAGENTA22	N = 22,803 (100%)[1]
Maturity Category	
Term (>= 37 weeks)	21,205 (93.0%)
Moderate to Late Preterm (32 - < 37 weeks) 25-29	1,317 (5.8%)
Very Preterm (28 - < 32 weeks)	174 (0.8%)
Extremely Preterm (< 28 weeks)	107 (0.5%)
Size Category	
Small for gestational age (SGA)	1,853 (8.1%)
Appropriate for gestational age (AGA)	18,128 (79.5%)
Large for gestational age (LGA)	2,592 (11.4%)
Unknown	230 (1.0%)

[1] n (%). Percentages may sum to greater than 100 due to rounding

Table 4 presents the distribution of maturity categories across deprivation quintiles. Initial analyses indicate that mothers living in more deprived areas were more likely to have a moderate to late preterm birth compared with those living in less deprived areas (chi-square test for trend, $p < 0.001$). This observation is consistent with evidence from national datasets (16), which report increased preterm birth rates in more deprived populations. Including this table helps illustrate baseline inequalities in preterm birth, providing context for MAGENTA's key objective of investigating whether socioeconomic disadvantage increases vulnerability to heat during pregnancy.

Table 4. Breakdown of the MAGENTA22 cohort by maturity category by WIMD quintile (1: most deprived, 5: least deprived). Term: gestational age > 37 weeks, moderate to late preterm: gestational age 32 - <37 weeks, very preterm: gestational age 28 - < 32 weeks, extremely preterm: gestational age < 28 weeks.

	WIMD Quintile					
	1 (Most Deprived)	2	3	4	5 (Least Deprived)	Total
Maturity Category						
Term	5,504 (91.7%)	4,613 (92.9%)	3,984 (93.1%)	3,686 (93.9%)	3,418 (94.1%)	21,205 (93.0%)
Moderate to Late Preterm	409 (6.8%)	290 (5.8%)	246 (5.8%)	194 (4.9%)	178 (4.9%)	1,317 (5.8%)
Very Preterm	54 (0.9%)	41 (0.8%)	26 (0.6%)	28 (0.7%)	25 (0.7%)	174 (0.8%)
Extremely Preterm	34 (0.6%)	22 (0.4%)	21 (0.5%)	17 (0.4%)	13 (0.4%)	107 (0.5%)
Total	6,001 (100%)	4,966 (100%)	4,277 (100%)	3,925 (100%)	3,634 (100%)	22,803 (100%)

Why it matters

Human-induced climate change is contributing to a warmer world, and the UK is already experiencing more frequent and prolonged episodes of high heat, with negative consequences for public health (17). Understanding the impact of increasing heat on pregnancy is particularly important, as adverse pregnancy outcomes can have lifelong health impacts for both mothers and their children.

The MAGENTA22 e-cohort presented in this report represents an important feasibility step in the overall MAGENTA project, successfully demonstrating the linkage of anonymised birth records to daily temperature exposures for mothers throughout their pregnancy. Early insights from the MAGENTA22 e-cohort will inform the development of the full MAGENTA e-cohort, which will include all births from 2010 onwards in both London and Wales alongside enhanced bespoke land-surface temperature modelling to better approximate household-level temperature exposures.

With active public and stakeholder engagement throughout the project through our research midwives, established PPIE group, steering committee and ADR network; MAGENTA will produce actionable recommendations for the public, policy makers and practice to inform future climate health risks and recommendations for adaptation policy and practice.

What next?

The next phase of the project will focus on establishing the full MAGENTA cohort for Wales and London. As well as covering a substantially longer period (2010-2024), the full cohort will incorporate a wider range of pregnancy outcomes (e.g. mode of delivery, stillbirth, neonatal mortality, congenital anomalies and maternal hospital stay) and covariates (e.g. pollution exposure during pregnancy, maternal history of smoking and alcohol and/or drug misuse, maternal history of chronic disease, mode of labour onset and type of prenatal care) and will include enhanced bespoke land-surface temperature modelling to better approximate household-level temperature exposures. Rigorous statistical analyses will quantify the impact of increasing heat on different pregnancy outcomes in the UK. Analyses will explore critical windows of vulnerability during pregnancy and the extent to which individual, household and area-level factors modify the observed associations between heat and pregnancy outcomes. The MAGENTA project will also utilise a Bayesian framework capturing full-parameter and data uncertainty. This framework will enable exploration of the impact on pregnancy outcomes of future temperature projections for the UK, based on climate change models (18) using simulation-based approaches. These approaches will enable policymakers to explore anticipated healthcare resource use of future heat events as well as the impact of mitigation and adaptation strategies under decision uncertainty. We will co-produce all communication and dissemination materials with stakeholders and PPIE partners to ensure the translation of findings into actionable policies and practices.

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Contribution statements

Professor Richard Fry made substantial contributions to the MAGENTA project, including the conceptualisation, coordination, and submission of the grant application. He led the project as Principal Investigator from January 2024 to November 2025 and served as Co-Lead for Work Package 1 (Environmental Data) and Work Package 2 (Electronic Health Data). His leadership and intellectual input during the mobilisation and core research phases were integral to establishing the project's scientific direction and methodological framework.

We would also like to acknowledge Dr Behzad Valipour, who served as the Environmental Modelling Research Officer between August 2024 to August 2025 and was involved in the methodology, data curation and formal analysis of the temperature data.

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This study uses anonymised data held in the Secure Anonymised Information Linkage (SAIL) Databank, which is part of the national population data research infrastructure for Wales. We would like to acknowledge all the data providers who make anonymised data available for research.

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This Data Insight provides a snapshot of informative research currently underway but is not intended to provide a complete picture of work undertaken within this field or the ADR Wales programme of work. The information presented in this Data Insight has been reviewed by ADR Wales colleagues with expertise within this area and accepted to be accurate at the point of publication. Views expressed in this Data Insight are those of the researchers and not necessarily those of ADR Wales partner organisations.

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