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Do temperature changes cause eczema flares? An English cohort study.

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Abbreviated Abstract

This cohort study of 519 children with eczema, examined the effect of short-term temperature changes on eczema symptoms.

Seasonal variation in symptom scores was observed, suggesting worsening with colder weather in winter and improvements with warmer weather in summer.

We provide evidence to show temperature changes may play a role, specifically that hot weather is protective against flares. Switching emollients in different weather states to try and prevent a flare is unlikely to be helpful.

Title page

Title: Do temperature changes cause eczema flares? An English cohort study.

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Ethical approval: Ethical approval was not required for secondary analysis of the BEE trial dataset; this used baseline and eczema severity data from participants who had given informed written consent for their anonymised data to be used in subsequent future research. The original BEE trial was granted approval by the NHS REC (South West - Central Bristol Research Ethics Committee 17/SW/0089).

Contributors: MJR and JC conceived the study. JC, SJM, BS, YTEL, AR, DM, MJR contributed to the design of the study, acquisition, analysis and interpretation of the data. JC, SJM, BS were responsible for statistical analysis. AR contributed to the design and interpretation of the data. JC drafted the manuscript and all authors have critically revised and approved it. All authors have had final responsibility for the decision to submit for publication and JC takes responsibility for the integrity of the data and the accuracy of the data analysis.

Patient and public involvement: Co-author Amanda Roberts is an expert patient having ran an eczema patient support group for many years and caring for both herself and her children who suffer from eczema. She provided insights into her lived experience of dealing with eczema and factors that matter to patients on a daily basis.

Word Count: 2,675

Table Count: Two (+ two supplementary)

Figure count: Two (+ one supplementary)

Bulleted statements (maximum 70 words per question)

What's already known about this topic?

- People with eczema commonly report that changes in the weather cause disease flares.
- Previous studies have suggested that some patients (such as those with more severe disease) are more susceptible to changes in the weather.
- Some guidelines recommend thicker emollients in winter months.

What does this study add?

- Hot, but not cold, weather was associated with reduced odds of a flare in eczema in children.
- Susceptibility to changes in temperature were not associated with eczema severity or the type of emollient used by the child.
- Specific types of emollients may not protect against changes in temperature.

Summary (Abstract)

Background

It is unclear if ambient temperature changes affect eczema. It is also unclear if people with worse disease are more susceptible to weather-related flares, or specific types of emollient offer protection. Substantiating these links may help inform action plans and patients self-management.

Objective

To investigate the effect of short-term temperature variations on eczema symptoms in children.

Methods

Data from a UK cohort of 519 children (6 months-12 years) with at least mild eczema, participating in a randomised trial comparing four types of emollients on eczema symptoms, were combined with observed temperature data from the Hadley Centre's Integrated Surface Database.

Hot & cold weeks were defined by average regional temperature >75th or <25th percentile, January 2018-February 2020. Eczema flares were defined as ≥3 point change in patient-oriented eczema measure (POEM). Random effects logistic regression models were used to estimate the odds ratios of flares in hot & cold weeks (reference group: temperate weeks). The likelihood ratio test assessed for evidence of effect modification by disease severity and emollient type.

Results

The baseline mean age was 4.9 years (SD 3.2) and POEM score was 9.2 (SD 5.5), indicating moderate eczema. 90% of participants lived within 20km of their nearest weather station. From the 519 participants there were 6,796 consecutively paired POEMs and 1,082 flares.

Seasonal variation in POEM scores was observed, suggesting symptoms worsening with colder weather in winter and improving with warmer weather in summer. Odds ratios of flares were: 1.15 (p=0.136, 95%CI 0.96-1.39) in cold weeks, 0.85 (p=0.045, 95%CI 0.72-1.00) in hot weeks. Likelihood ratio test showed no evidence of this differing by disease severity (p=0.53) or emollient type used (p=0.55).

Conclusions

Our findings are consistent with previous studies demonstrating either improvements in eczema symptoms or reduced flares in hot weather. Worse disease and different emollient types did not increase susceptibility or provide protection against temperature changes. Further work should investigate the role of sunlight, humidity, air pollution and other environmental factors.

Word count: 323/350 words

Introduction

Eczema (atopic eczema/dermatitis) is an inflammatory dry itchy skin condition affecting around 20% of children, commonly persisting into adulthood.[1] Eczema waxes and wanes in severity, with 'flares' caused by different 'triggers'. Identifying triggers can be difficult as there is variation amongst patients, but some of those previously investigated include the climate, weather, diet and clothing.[2, 3] Clarifying triggers is important to patients as it can help inform self-management strategies and reduce the need for rescue treatments.

Weather describes the conditions of the atmosphere over short periods of time, ranging from minute-to-minute changes to periods lasting weeks. This differs from the climate which describes weather patterns on average over the long term, usually years to centuries.

Previous epidemiological studies have primarily focussed on associations between eczema severity/prevalence and climate.[4-7] Some smaller studies in countries with temperate weather similar to the UK, have provided varied findings around short-term effects. An Irish cohort study of 25 children with eczema demonstrated worse scratch scores associated with high outdoor temperature.[8] A follow-on study of 60 children in Nottingham (England) showed an increase in eczema severity with shampoo use (particularly when the outdoor temperature was low).[1] No other associations were seen between eczema and temperature or humidity.

A nationwide questionnaire sent to 1343 Danish outpatient patients with eczema between 2014-2018, reported associations by eczema severity.[9] Of those with mild eczema, 47% reported cold weather and 19% warm weather as causes of worse eczema. In children with severe eczema 62% reported cold weather and 45% warm weather as triggers. A larger proportion of children with severe eczema reported weather as triggers, suggesting they are more prone to weather-related flares. This is possibly due to a greater defect in the functioning of the skin barrier compared to those with milder disease.

Overall there is limited information about the effects of short-term weather on eczema flares in the literature. Exploring this with larger cohorts than previous studies and quantitative methods is important to further our understanding of the potential temperature triggers of eczema, as well as potential mitigatory effects of different emollients. This exploratory study serves as a step towards providing new scientific information about weather-related eczema in the UK.

Methods

We sought to investigate the effect of weather (temperature) related changes on eczema flares in children living in England, which has a temperate climate. Our objectives were to (1) describe the seasonal trend in eczema symptoms; (2) explore associations between changes in temperature and eczema severity; and (3) explore for associations between baseline eczema severity and emollient type used with temperature-related eczema flares.

We used data from a randomised controlled trial of emollients for the treatment of eczema in children, the Best Emollient for Eczema (BEE) study.[10] In BEE, 550 children with eczema were randomised to use a lotion, cream, gel or ointment emollient as their main moisturizer for 16 weeks. No difference was found in the primary outcome of POEM (Patient Oriented Eczema Measure), which captures eczema symptoms for the previous week.[11]

Children were recruited from GP (General Practitioner) surgeries in three regions of England: West of England, East Midlands and Wessex. Eligible participants were aged 6 months - 12 years, with a diagnosis of eczema on their GP record, of at least mild severity (POEM>2) and their parent able to complete the outcome measures. Patients were excluded if they had any allergies to the study emollients. Recruitment began in January 2018 and weekly data (for 16 weeks) collection ended in February 2020.

Temperature data

Daily mean dry bulb temperatures were obtained from HadISD (Met Office Hadley Centre Integrated Surface Database).[12] Dry bulb temperature is defined as ambient air temperature measured using a thermometer shielded from moisture.[13] HadISD weather data is provided daily at the city level, collected from local weather stations and quality controlled by the UK Met Office to be consistent across the whole of the UK. Using the STATA *geodist* command, participants were mapped by their home post codes to their nearest weather station.

Seven day rolling averages for temperature were calculated and linked to participants' corresponding POEM score for that week. We also classified seven day moving averages as either hot, cold or temperate weeks. Hot weeks were defined as those with average temperature greater than the 75th percentile, temperate weeks between the 25th and 75th percentile and cold weeks less than the 25th percentile of the temperature distribution during the total observation period *[Supplementary Table S1]*. These cutoff points were used to ensure a reasonable number of POEMs in each category. This technique has been previously used by other epidemiological studies in this field when comparing continuous variables with a dichotomous outcome.[7]

Definitions of eczema severity and disease flares

Eczema severity categories used in our descriptive analyses are those that Charman et al. have previously described using POEM score cutoffs. These are 0-2 (clear/almost clear); 3-7 (mild); 8-16 (moderate); 17-24 (severe); 25-28 (very severe).[11]

There is no consensus about how best to define an eczema flare.[14] However, studies of POEM have identified a change of 3 as minimally important change (MIC).[15, 16] Therefore, we defined an eczema flare as an increase in POEM score ≥3 from the previous week.

Sample size

The BEE trial was powered to detect a difference of 3 units in POEM scores between treatment arms; full details of the assumptions for the sample size calculation can be found in the published BEE protocol.[17] As an exploratory secondary analysis of a clinical trial this study did not set out to formally test a hypothesis but to explore relationships between variables and so no formal sample size was calculated.

Statistical methods

Descriptive analyses were undertaken of baseline characteristics such as age and eczema severity. This summarised numeric data using means and standard deviations. Categorical data used frequencies and proportions. The weekly measures of flares were studied using univariable and multivariable random effects logistic regression models to estimate the odds ratios of flares in hot and cold weeks using temperate weeks as the reference group. Multivariable analyses adjusted for age at baseline, emollient allocation, baseline severity (POEM at enrolment), gender, ethnicity and socioeconomic status. Sensitivity analyses were performed with varying cutoffs defining hot and cold weeks *[Supplementary Table S1]*.

To explore whether the effect of weather differed according to emollient allocation or by baseline eczema severity, the primary multivariable regression models were run including an interaction term with weather. The likelihood ratio test was then used to compare this model with one excluding the interaction term to assess for evidence of effect modification.

All analysis was performed using the statistical software STATA v17.0.

Ethical approval

The BEE trial was granted approval by the NHS REC (South West - Central Bristol Research Ethics Committee 17/SW/0089). Ethical approval was not required for secondary analysis of the BEE trial dataset. We used baseline and eczema severity data from participants who had given informed written consent for their anonymised data to be used in subsequent future research.

Results

Baseline characteristics

From the 550 participants in the original BEE trial dataset, we restricted our analysis to the cohort of 519 participants who had at least one pair of consecutive POEM measurements, to allow calculation of 'flares'. These 519 children comprised 53% boys, 87% of white ethnicity with a mean age at enrollment of 4.9 years. Our cohort was similar to participants in the trial [Table 1] and a range of eczema severities were represented; clear or mild eczema (42%), moderate eczema (46.8%) and severe or very severe (11%). The majority (90%) of participants were within 20km of their local weather station.

Table 1: Participant characteristics at baseline.

Characteristics	BEE trial	Study cohort
Number of participants	550	519
Age, mean (SD) in years	4.9 (3.20)	4.9 (3.24)
Boys	295 (54%)	275 (53%)
Girls	255 (46%)	244 (47%)
Baseline Eczema severity[†]		
Clear/Almost clear eczema (POEM 0 to 2)	40 (7.3%)	40 (7.7%)
Mild eczema (POEM 3 to 7)	185 (33.6%)	178 (34.3%)
Moderate eczema (POEM 8 to 16)	266 (48.4%)	243 (46.8%)
Severe eczema (POEM 17 to 24)	53 (9.6%)	52 (10%)
Very severe eczema (POEM 25 to 28)	5 (0.9%)	5 (1%)
Missing	1 (0.2%)	1 (0.2%)
Ethnicity		
White	473 (86%)	450 (87%)
Black	18 (3%)	15 (3%)
Asian	16 (3%)	15 (3%)
Mixed	43 (8%)	39 (7%)
Socioeconomic background (IMD quintiles)*		
IMD 1	62 (11%)	57 (11%)
IMD 2	55 (10%)	48 (9%)

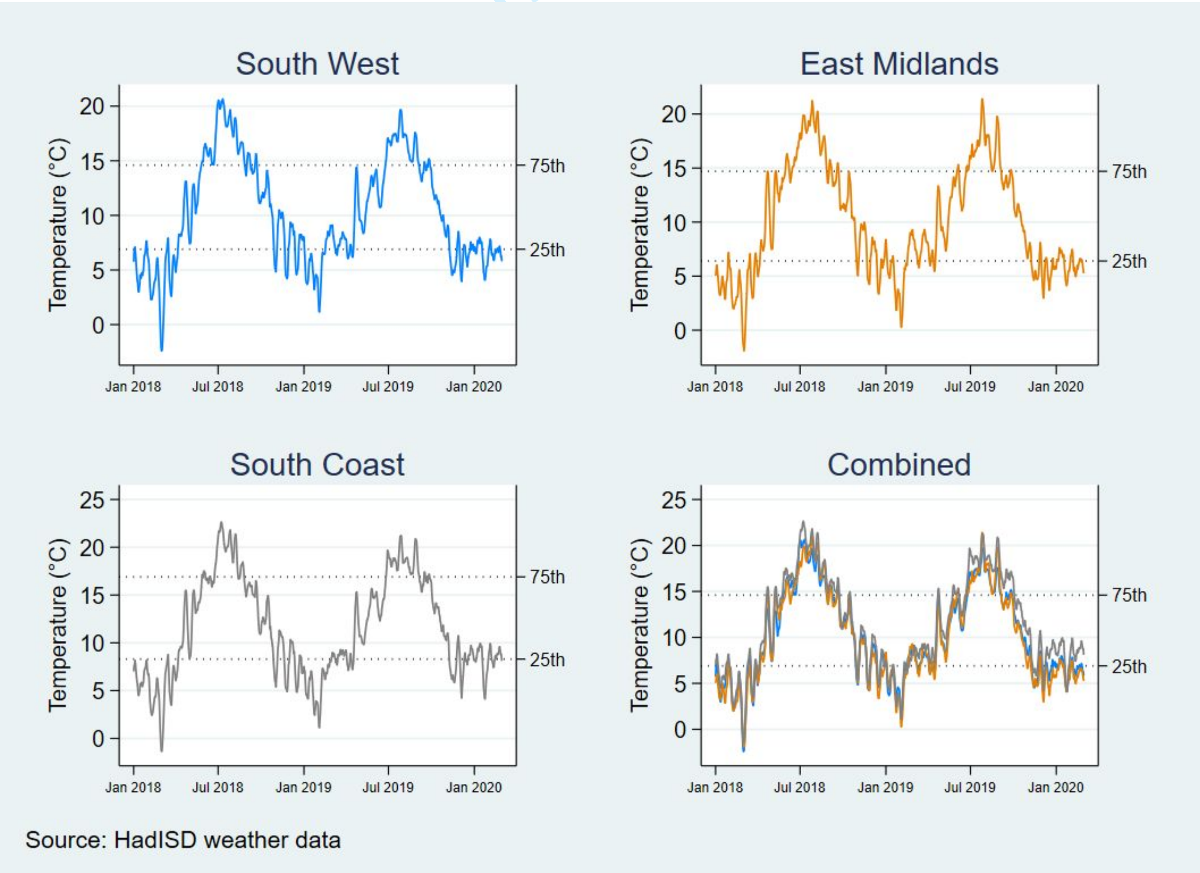
IMD 3	102 (19%)	96 (19%)
IMD 4	111 (20%)	105 (20%)
IMD 5	173 (31%)	169 (33%)
Missing	47 (9%)	44 (8%)
Within 20km of weather station	491 (89%)	466 (90%)
Mean distance to nearest weather station	11.17km (SD 7.4)	11.02km (SD 7.3)

↑categorised POEM score *Index of multiple deprivation, 1 = most deprived.

Weather

During the 25-month study period, the mean rolling seven-day average temperature was between 10.0°C to 11.4°C in the three regions *[Supplementary Table S1]*. The coldest week saw an average temperature of -2.4°C in the southwest, whereas the hottest week had an average high of 22.6°C in the south coast. 2018 had a notably cold winter due to anomalous atmospheric conditions, colloquially known as the 'Beast from the East'. Temperatures were broadly similar across all three regions with similar peaks in summer and dips in winter [Figure 1].

Figure 1: Seven-day rolling average temperatures across three regions of England over the study period.

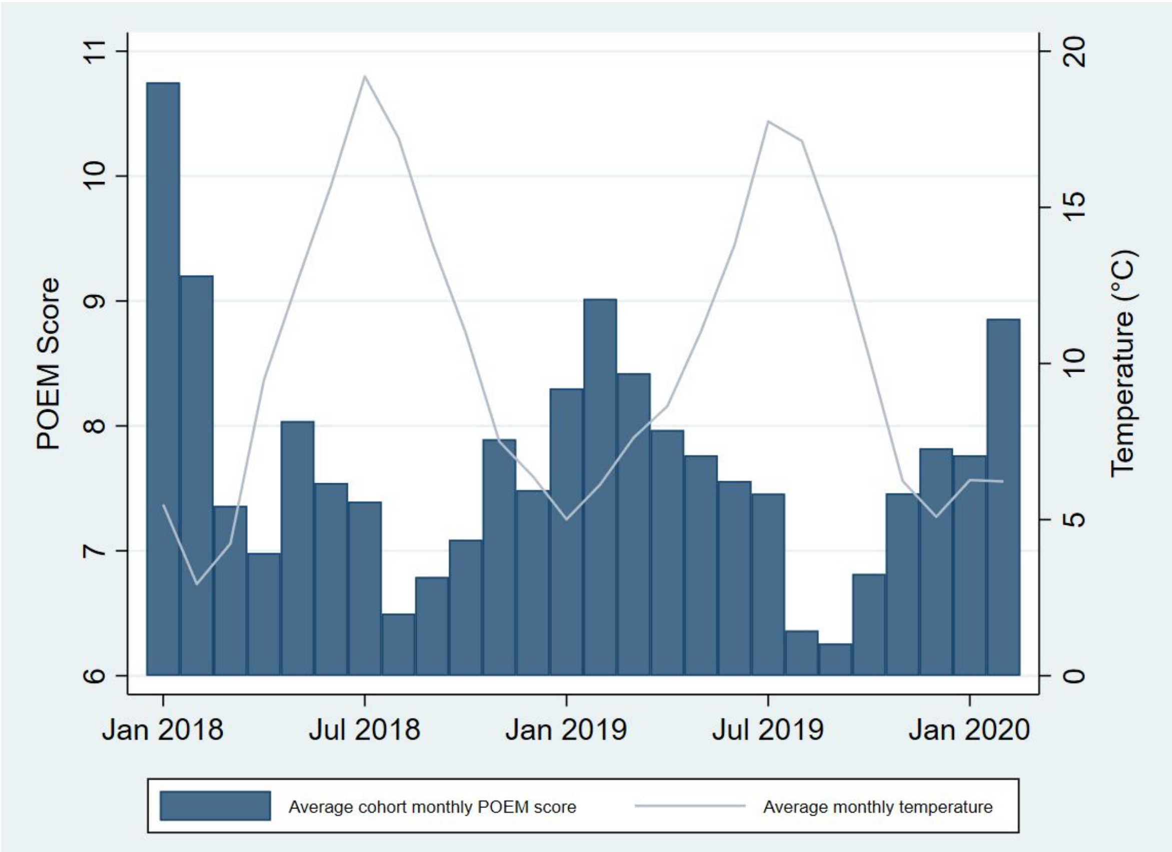


The horizontal dotted lines indicate the 25th and 75th percentiles of the respective temperature distributions. For the combined figure, south west percentiles are used for the dotted lines for demonstrative purposes.

POEM scores

In total 88% (7,727/8,823) of weekly POEMs were completed, with 6,796 pairs of consecutively completed POEMs. The number of completed POEMs varied across the study period, reflecting the number of participants in the trial. Some months therefore had more data available than others *[Supplementary Figure S1].* Plotting average weekly POEM score of the overall cohort by month suggests a seasonal variation in eczema; worse in winter, better in summer [Figure 2].

Figure 2: Plot of average cohort POEM score and South West temperatures by month.



Primary Outcome: odds of eczema flare

1,082 flare episodes were identified with 80% (413/519) of children having at least one flare. When comparing hot weeks with temperate weeks we found that the former were associated with a reduced odds of a flare [unadjusted OR=0.83, p=0.019, 95%CI 0.71-0.97; Table 2]. This association was largely unchanged after adjusting for age, gender, ethnicity, socioeconomic status and baseline POEM in multivariate regression (adjusted OR=0.85, p=0.045, 95%CI 0.72-1.00). Cold weeks, conversely, were associated with increased odds of a flare (adjusted OR=1.15, p=0.136, 95%CI 0.96-1.39), however the confidence interval overlapped with the null.

Sensitivity analyses shows our results were broadly similar when varying definitions of hot/cold weeks were used *[Supplementary Table S2]*. The relationship between flares and hot weeks was strongest when temperatures >95th percentile were considered "hot".

Table 2: Random effects logistic regression - Odds ratio of flare in hot & cold weeks, using temperate weeks as reference group.

	Number of contributing (consecutive) POEMs	Odds ratio	95% CI	p Value	Odds ratio	95% CI	p Value
		Unadjusted			Adjusted↑		
Cold week	1,192	1.13	0.94-1.35	0.192	1.15	0.96-1.39	0.136
Temperate week	3,315	1.00	-	-	1.00	-	-
Hot week	2,289	0.83	0.71-0.97	0.019	0.85	0.72-1.00	0.045

Hot and cold weeks defined by 25th and 75th percentiles for each region *[see Supplementary Table S1].*
↑Adjusted for age at baseline, POEM at baseline, gender, ethnicity and socioeconomic status.

Subgroups

To explore if the effect of weather differed according to the emollient type children were randomised to at baseline, we investigated temperature-emollient interactions. The likelihood ratio test showed no evidence of effect modification (p=0.55). A comparable analysis of baseline eczema severity (measured using POEM) also showed no modification of the effect of weather (p=0.53).

Discussion

Summary

Our study demonstrates a seasonal variation in eczema symptoms in a cohort of UK children, with higher symptom scores in the colder winter and lower scores in the warmer summer. We found a reduced odds of a flare in hot weather compared to temperate weather. There was weak evidence that cold weather was associated with increased odds of a flare. Neither allocated emollient nor baseline eczema severity modified the effect of temperature on odds of a flare.

Strengths and limitations

Our study benefitted from prospectively collected eczema symptom data, in a cohort larger than those previously studied in countries with similar weather. Our sample is more representative of children with eczema in the UK, improving generalisability; previous studies generally recruited children from secondary care settings with more severe eczema. We are also the first to examine whether associations between eczema severity and temperature differed by allocated emollient.

The use of a validated outcome measure (minimally important change in POEM) as a proxy for defining flares is also a strength. There is no consensus on how to define a flare (22 different definitions identified in one systematic review), which is reflected in epidemiological studies that have previously examined associations between weather and eczema.[14, 18] The HOME initiative advises that using either EASI (Eczema Area and Severity Index) or POEM measured regularly through a study for at least three months is a reasonable approach.[19]

This was an exploratory secondary analysis treating data from a trial as a cohort; the original study was not designed or powered to specifically answer our research question. We were limited to the data collected for the purpose of the trial and thus were unable to account for other factors that can cause eczema flares, such as pollen, central heating use and pollution. The use of central heating can create sharp differences between outdoor and indoor temperatures and humidity, which could play a confounding role in our analysis. Improvements seen with warmer temperature may be confounded by UV exposure – light therapy is a recognized treatment for eczema.[20]

Our findings are useful to describe the effect of seasonal weather over weeks, but cannot comment on shorter changes within hours or a few days. This is because POEM scores asked about symptoms over the previous week and we utilised HadISD temperatures (which provides a daily average) converted into 7 day averages. Our weather data could also not account for time spent out of patients' home area. While temperature across the different areas of England was broadly similar, we cannot account for travel further afield.

Utilising an overall measure of eczema symptoms prevented us from looking at the effect of weather on specific parts of the body. Exposed areas such as the face and hands may be more susceptible to changes in temperature than protected areas such as the torso.

Context of wider literature

Previous studies have mainly been outside the UK and focused on demonstrating a link between long term climate and eczema. Global cross-sectional studies show that eczema prevalence increases, as latitude increases (and temperatures decrease).[4] This is corroborated by studies conducted in America, Taiwan and Spain looking at hotter and colder regions.[5, 6, 21] Whilst prevalence and disease severity are different domains, our primary finding that hot weather is associated with fewer flares is consistent with these broad climatic studies.

Our findings are also consistent with the few previous studies examining short term weather effects. Vocks et al. studied 2106 patients being treated at a specialist clinic in the Swiss alps, taking daily weather measurements and eczema measures over an average time of 34 days.[22] Analysis showed itch intensity improved with higher temperatures and sunshine duration. More recently a cohort study of 170 children in the city of Seoul (South Korea) took daily weather recordings and eczema scores, showing that for every 5^{o}C increase in temperature, there was a reduction in risk of eczema present that day.[23]

There have been some studies which show that it may be a change in weather, rather than the absolute conditions, which effect eczema symptoms. Byremo et al. conducted a small RCT involving 56 children, with two trial arms. Those sent to sub-tropical Gran Canary benefited from an improvement in eczema scores, quality of life index, reduction in steroid use and reduction in S. Aureus bacterial skin colonization compared to controls who remained in Norway.[24]

Our findings are in the context of relatively temperate weather of the UK. Given the evidence from studies like the above, we postulate that in countries outside of the UK with harsher extremes of hot and cold temperatures a greater effect would be seen.

There are likely multiple factors underlying the reasons why flares are less likely in hot weather. Multiple laboratory studies have demonstrated a positive relationship between lower temperatures and decreased skin hydration and transepidermal water loss.[25] It is suggested that as temperature drops, the drier air encourages evaporation of water from the skin surface, which can leave the skin more vulnerable to damage. Silverberg et al. has also demonstrated an association between eczema prevalence and central heating use, which is usually turned on in cold weather.[5] The frequent changes between heated indoors and cold outdoors are postulated to contribute to skin barrier disruption.

Questionnaire studies suggest that more of those with severe eczema perceive extremes of temperature to be triggers of eczema, compared to those with mild disease.[9] Our findings indicate that eczema severity does not influence temperature related flares, but further research in this area is needed to substantiate this.

Guidelines, patient charities and advice guides advocate for the switch to ointments in winter months as the emollient of choice.[26-30] There have been no studies comparing the effectiveness of different emollient types in cold weather. Many advise the use of ointments due to their increased thickness and hydrating properties. However, our study indicates that the type of emollient has no impact on temperature-related eczema flares.

Implications for research and clinical practice

Future research should investigate the differences in body site experiencing flares in different weather and consider the role of other factors including humidity, pollen count and pollution. Meanwhile, parents of children with eczema should be advised a combination of factors contribute to a flare. We provide some evidence to show temperature changes may play a role, specifically that hot weather is protective against flares. Switching emollients in different weather states to try and prevent a flare is unlikely to be helpful.

Word count: 2675/3000

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Table & Figure legend:

7. Table S2 - Random effects logistic regression – Original analysis alongside sensitivity analysis presenting odds ratios of flare in hot & cold weeks, with varying cut-offs for hot and cold week definitions. Temperate weeks used as reference group.

Supplementary data

Table S1: Weather data for study regions in England.

Region	Rolling seven day average temperature (1dp)								
	Mean (SD)	Min	Max	Percentile cutoffs					
				5^{th}	10^{th}	25^{th}	75^{th}	90^{th}	95^{th}
South West	10.2°C (4.8)	-2.4°C	20.7°C	4.1°C	4.9°C	6.9°C	14.6°C	16.8°C	18.1°C
East Midlands	10.0°C (5.1)	-1.9°C	21.4°C	3.4°C	4.7°C	6.4°C	14.7°C	17.2°C	18.6°C
Wessex (south coast)	11.4°C (5.1)	-1.4°C	22.6°C	4.6°C	6.0°C	8.3°C	16.9°C	19.4°C	20.5°C

Percentile cutoffs were calculated using the respective temperature distributions of each region.

Figure S1: Distribution of POEM data across the study period.

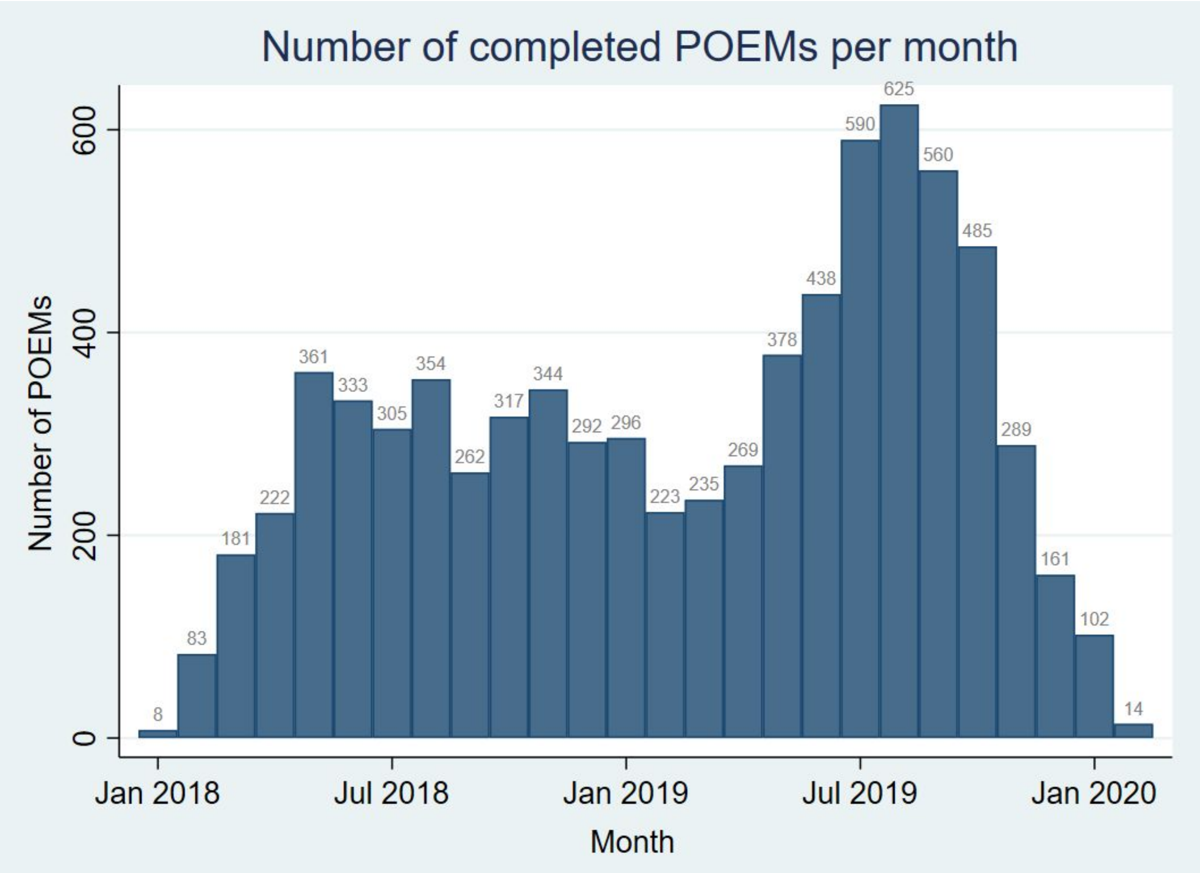

Table S2: Random effects logistic regression – Original analysis alongside sensitivity analysis presenting odds ratios of flare in hot & cold weeks, with varying cut-offs for hot and cold week definitions. Temperate weeks used as reference group.

	Odds ratio	95% CI	p Value	Odds ratio	95% CI	p Value
	Unadjusted			Adjusted↑		
Original definitions of cold/hot weeks based on 25th and 75th percentiles						
Cold week (<25th percentile)	1.13	0.94-1.35	0.192	1.15	0.96-1.39	0.136
Temperate week	1.00	-	-	1.00	-	-
Hot week (>75th percentile)	0.83	0.71-0.97	0.019	0.85	0.72-1.00	0.045
Sensitivity analysis: defining cold and hot weeks based on 10th and 90th percentiles						
Cold week (<10th percentile)	1.20	0.94-1.55	0.146	1.22	0.94-1.59	0.136
Temperate week	1.00	-	-	1.00	-	-
Hot week (>90th percentile)	0.79	0.64-0.97	0.023	0.79	0.64-0.98	0.032
Sensitivity analysis: defining cold and hot weeks based on 5th and 95th percentiles						
Cold week (<5th percentile)	0.98	0.69-1.38	0.888	0.96	0.67-1.38	0.820
Temperate week	1.00	-	-	1.00	-	-
Hot week (>95th percentile)	0.76	0.58-0.99	0.041	0.76	0.58-1.00	0.049

Hot and cold weeks defined by percentiles for each region as seen in [Supplementary Table S1].
↑Adjusted for age, POEM at enrolment, gender, ethnicity and socioeconomic status.

Title: Do temperature changes cause eczema flares? An English cohort study.

Authors: Jonathan Chan[1], Stephanie J MacNeill[1], Beth Stuart[2], Y. T. Eunice Lo[3,4], Amanda Roberts,[5] Dann Mitchell[3], Matthew J Ridd[1].

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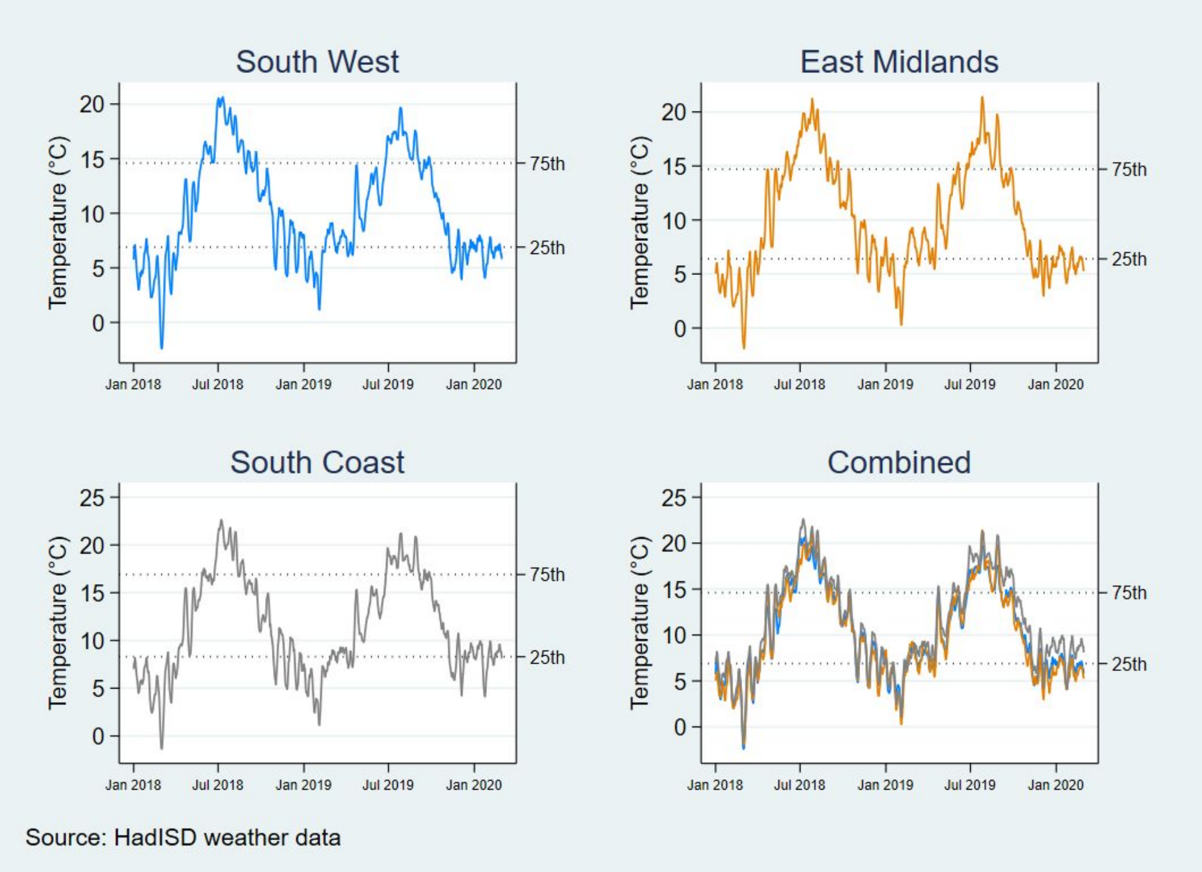
Table & Figure legend:

Table 1: Participant characteristics at baseline.

Characteristics	BEE trial	Study cohort
Number of participants	550	519
Age, mean (SD) in years	4.9 (3.20)	4.9 (3.24)
Boys	295 (54%)	275 (53%)
Girls	255 (46%)	244 (47%)
Baseline Eczema severity[↑]		
Clear/Almost clear eczema (POEM 0 to 2)	40 (7.3%)	40 (7.7%)
Mild eczema (POEM 3 to 7)	185 (33.6%)	178 (34.3%)
Moderate eczema (POEM 8 to 16)	266 (48.4%)	243 (46.8%)
Severe eczema (POEM 17 to 24)	53 (9.6%)	52 (10%)
Very severe eczema (POEM 25 to 28)	5 (0.9%)	5 (1%)
Missing	1 (0.2%)	1 (0.2%)
Ethnicity		
White	473 (86%)	450 (87%)
Black	18 (3%)	15 (3%)
Asian	16 (3%)	15 (3%)
Mixed	43 (8%)	39 (7%)
Socioeconomic background (IMD quintiles)*		
IMD 1	62 (11%)	57 (11%)
IMD 2	55 (10%)	48 (9%)
IMD 3	102 (19%)	96 (19%)
IMD 4	111 (20%)	105 (20%)
IMD 5	173 (31%)	169 (33%)
Missing	47 (9%)	44 (8%)
Within 20km of weather station	491 (89%)	466 (90%)
Mean distance to nearest weather station	11.17km (SD 7.4)	11.02km (SD 7.3)

[↑]categorised POEM score *Index of multiple deprivation, 1 = most deprived.

Figure 1: Seven-day rolling average temperatures across three regions of England over the study period.



The horizontal dotted lines indicate the 25th and 75th percentiles of the respective temperature distributions. For the combined figure, south west percentiles are used for the dotted lines for demonstrative purposes.

Figure 2: Plot of average cohort POEM score and South West temperatures by month.

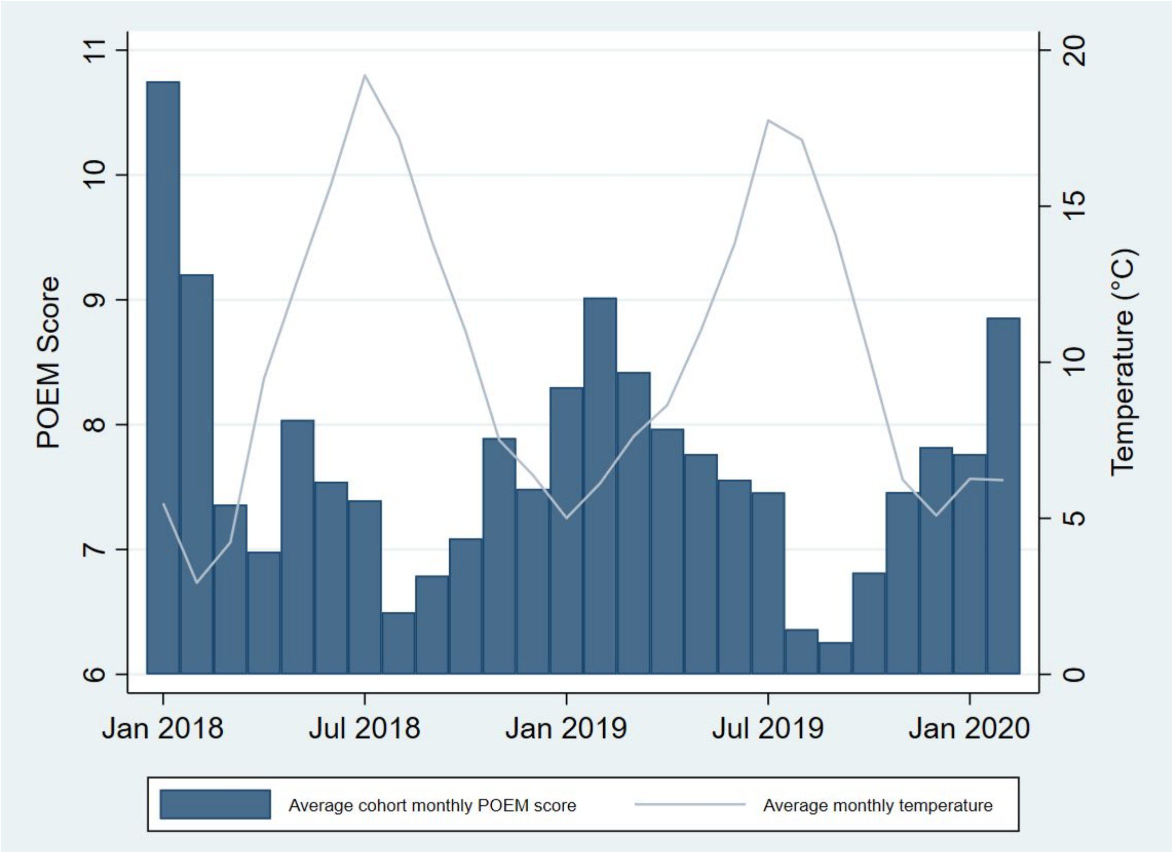


Table 2: Random effects logistic regression - Odds ratio of flare in hot & cold weeks, using temperate weeks as reference group.

	Number of contributing (consecutive) POEMs	Odds ratio	95% CI	p Value	Odds ratio	95% CI	p Value
		Unadjusted			Adjusted[↑]		
Cold week	1,192	1.13	0.94-1.35	0.192	1.15	0.96-1.39	0.136
Temperate week	3,315	1.00	-	-	1.00	-	-
Hot week	2,289	0.83	0.71-0.97	0.019	0.85	0.72-1.00	0.045

Hot and cold weeks defined by 25th and 75th percentiles for each region *[see Supplementary Table S1].*
[↑]Adjusted for age at baseline, POEM at baseline, gender, ethnicity and socioeconomic status.

Supplementary data

Table S1: Weather data for study regions in England.

Region	Rolling seven day average temperature (1dp)								
	Mean (SD)	Min	Max	Percentile cutoffs					
				5th	10th	25th	75th	90th	95th
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Percentile cutoffs were calculated using the respective temperature distributions of each region.

Figure S1: Distribution of POEM data across the study period.

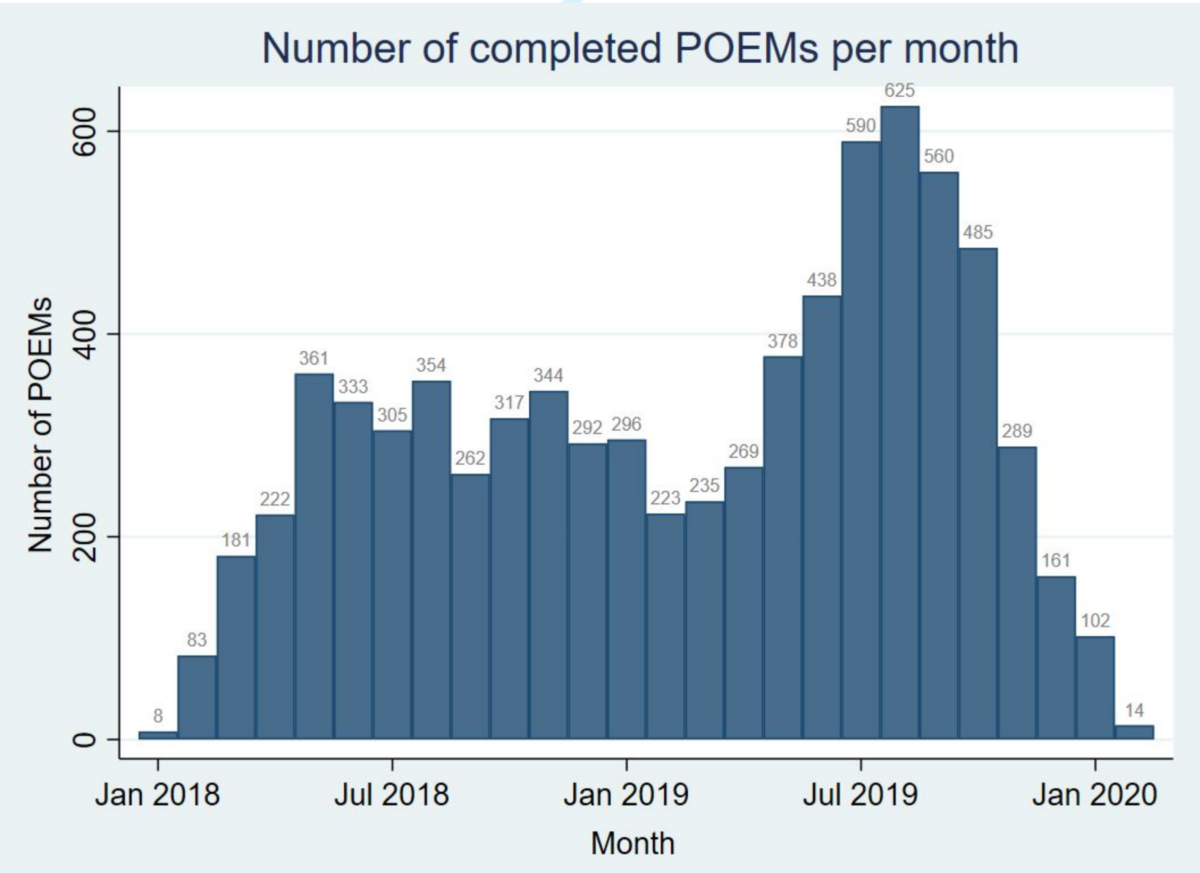

Table S2: Random effects logistic regression – Original analysis alongside sensitivity analysis presenting odds ratios of flare in hot & cold weeks, with varying cut-offs for hot and cold week definitions. Temperate weeks used as reference group.

	Odds ratio	95% CI	p Value	Odds ratio	95% CI	p Value
	Unadjusted			Adjusted↑		
Original definitions of cold/hot weeks based on 25th and 75th percentiles						
Cold week (<25th percentile)	1.13	0.94-1.35	0.192	1.15	0.96-1.39	0.136
Temperate week	1.00	-	-	1.00	-	-
Hot week (>75th percentile)	0.83	0.71-0.97	0.019	0.85	0.72-1.00	0.045
Sensitivity analysis: defining cold and hot weeks based on 10th and 90th percentiles						
Cold week (<10th percentile)	1.20	0.94-1.55	0.146	1.22	0.94-1.59	0.136
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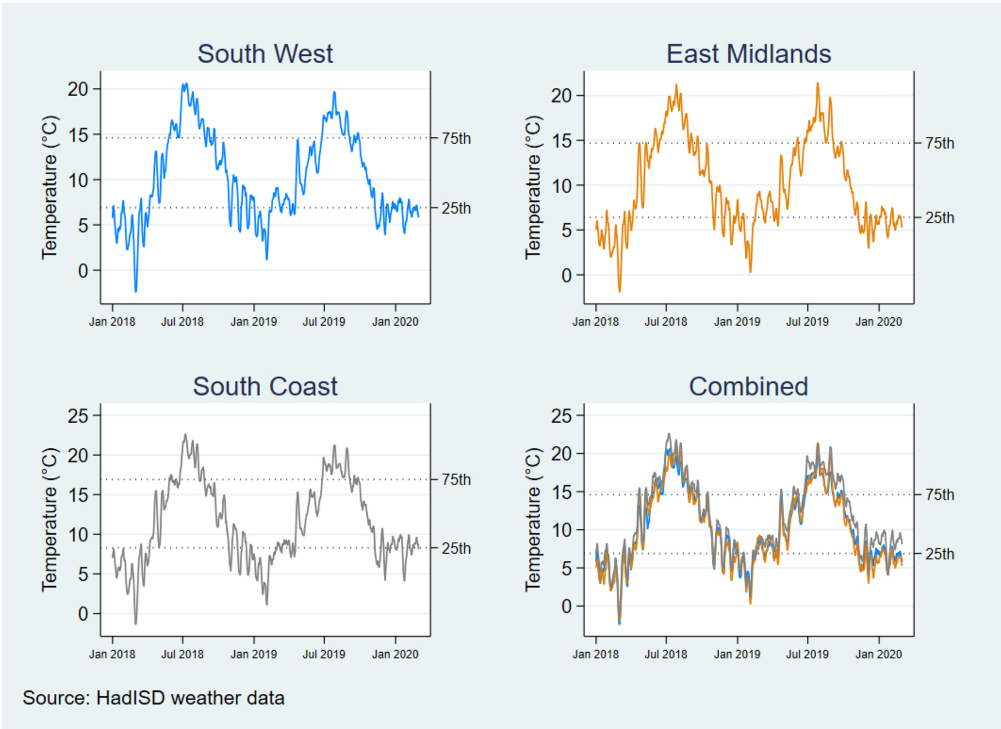

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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Completed	Page of main document
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Yes	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Yes	3
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes	4
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes	3, 4
Methods				
Study design	4	Present key elements of study design early in the paper	Yes	4, 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes	4, 5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Yes	4, 5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Yes	4, 5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Yes	4, 5
Bias	9	Describe any efforts to address potential sources of bias	Yes	5
Study size	10	Explain how the study size was arrived at	Yes	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Yes	5
		(*b*) Describe any methods used to examine subgroups and interactions	Yes	5, 6
		(*c*) Explain how missing data were addressed	Yes	4, 5
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a	n/a
		(*e*) Describe any sensitivity analyses	Yes	5, 6
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Yes	6
		(b) Give reasons for non-participation at each stage	Yes	6
		(c) Consider use of a flow diagram	n/a	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Yes	6
		(b) Indicate number of participants with missing data for each variable of interest	Yes	6
		(c) Summarise follow-up time (eg, average and total amount)	Yes	4, 5, 8

Outcome data	15*	Report numbers of outcome events or summary measures over time	Yes	8
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Yes	8, 9
		(*b*) Report category boundaries when continuous variables were categorized	Yes	5, 14
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Yes	8, 9
Discussion				
Key results	18	Summarise key results with reference to study objectives	Yes	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Yes	9, 10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Yes	10, 11
Generalisability	21	Discuss the generalisability (external validity) of the study results	Yes	9, 10, 11
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Yes	1

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.