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UNICEF CHILDREN'S CLIMATE RISK INDEX (CCRI)

Rapid Review: Children and Heat waves

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Introduction

The Children's Climate Risk Index (CCRI) shows that, if current carbon emission levels remain the same, heat waves will become more geographically widespread, frequent, severe, and longer lasting by 2050. Children throughout the world will be at greater risk of the impacts of extreme heat, with children living in particular regions of the world facing the greatest risk. Although heat waves (defined in this review as 3 days + at temperatures >35 degrees C) are known to increase mortality and morbidity across all age groups, children face particular and increased risk owing to their physiology, behavior, and dependency on adult caregivers for their wellbeing and survival (Ebi and Paulson 2007). Children's voices on climate change are currently missing from the National Action Plans demanded by the Paris Agreement and by countries committed to the United Nation's Convention on the Rights of the Child, although this Convention emphasized the importance of children's agency and right to be heard in decisions that affect them. Understanding the risks climate change poses to children is fundamental for meeting the challenges undermining children's future wellbeing. For children's rights to be fully realized, their voices and agencies have a key role to play in how new knowledge is developed and how their understandings of risk and vulnerabilities are incorporated in risk mitigation decision-making. The mitigation of children's vulnerabilities to risks posed by increases in the duration, severity, frequency, and geographic spread of extreme heat events also requires an understanding of the particular risks posed to children by extreme heat, and the ways in which individual, structural, institutional, cultural, policy and wider geographic factors shape children's vulnerability to these risks. Developments designed to mitigate these vulnerabilities must also ensure that children can exercise their rights, and express their own voices, agencies, and decision-making capacities.

A rapid review of the published multidisciplinary academic research literature on heat waves and children was undertaken to identify the known risks, vulnerabilities, and capacities of children to identify priorities for further research and action. This rapid review was undertaken as part of the Children's Climate Risk Index (CCRI) project for UNICEF and consisted of a systematic literature review (SLR) that focused on answering the following six key research questions:

1. What risks are posed to children by extreme heat events?
2. What is known about the factors that influence children's vulnerability to the risks posed by extreme heat (how are the risks differentiated) and the inter-relationships and intersections between these factors?
3. How can children's vulnerability to the particular risks associated with extreme heat be reduced and/or mitigated?

4. How have heat waves been linked to child discrimination and oppression?
5. To what extent does the existing literature focusing on children and heat events capture their differentiated lived experiences, voices, agency, and decision-making capacities?
6. What does the literature say about the particular risks to children associated with increasing heat wave: a) frequency, b) duration and c) severity?

Methodology

The review of the academic literatures combined systematic with narrative techniques to allow the literature search to be conducted in a way that adhered to the key principles of systemic reviewing, while simultaneously allowing for subjective evaluation of the literature to determine relevance (Snilsveit et al., 2012). The systematic aspect involved conducting a database search of the literature. Eight academic databases from which to perform keyword searches were identified and which reflected the multidisciplinary nature of the research problem and enabled consideration of evidence spanning across the social care, social sciences, health and medical sciences, and policy-relevant research contexts. The eight databases chosen were: Web of Science (multidisciplinary, including medical, health and social sciences), Scopus (multidisciplinary), Medline (medical and health sciences), Embase (medical sciences), ProQuest (policy-relevant literature), CINAHL (health sciences), SCIE (social care), and Jstor (Social Sciences, Arts, Humanities). Key words relevant to each of the research questions were identified and to perform keyword searches of the databases.

The searches generated articles of potential relevance to the research questions, with an initial total of 1986 hits of potential relevance being identified. Removal of duplicates and application of a pre-determined inclusionary/exclusionary criteria resulted in the removal of 1690 hits and 296 articles being selected for detailed scrutiny of abstracts and contents to determine relevance. This process resulted in 172 articles being excluded on the basis of not being relevant to the research questions and 124 articles being included in the final pool of articles. Analysis and coding of the articles included in the final sample was undertaken using qualitative descriptive analysis of each of the article abstracts and contents to identify and code for key themes (Sandelowski 2000). Articles were coded according to each of the key research questions.

Findings and Discussion

1. What risks are posed to children by extreme heat events?

All 124 articles included in the final sample explored the risks posed to children by extreme heat. Two broad types of risk to children associated with extreme heat events were identified from the literature. These were the: 1) the risk to health and wellbeing (n=120), and 2) the social and educational risks (n=10).

Five specific types of health risks were identified. These were the risks to physical health, risk to mental health, risk to overall wellbeing, risks in-utero, and the risk of accidents and injuries.

The following particular risks to physical health were identified: increased risk of chronic respiratory conditions (n=45), including increased rates of asthma (n=26), allergies (n=21) and allergic rhinitis (n=7), increase in cardiovascular disease (n=8), cerebrovascular disease (n=2), bacterial enteritis (n=5), diarrhoea (n=19), diabetes (n=9), obesity and weight gain (n=2), undernutrition (n=49) and growth restriction from undernutrition (n=23), dehydration and electrolyte imbalance (n=23), renal failure and kidney disease (n=3), sunburn and skin conditions associated with increased ultraviolet radiation (n=8), low birth weight (n=35), vector-borne disease (n=6), worms and parasitic infections (n=2), otitis media and externa (n=1), encephalopathy (n=2) and increased risk of heat stroke (n=30) heat stress (n=26), and heat exhaustion (n=5). For example, Nosrat et al., (2021) examines the impact of extreme temperature on mosquito abundance and the risk of mosquito-borne diseases in children, including dengue fever, and showed how periods of abnormal temperature can result in increased risk. Anderko et al., (2020), explains that although everyone is vulnerable to the various health impacts associated with climate change, children are disproportionately affected because of their physical and cognitive immaturity. Abian-Vicen and Abian (2012) show that children are at increased risk of dehydration because they have anthropometric and physiological characteristics that make them less effective for dissipating the heat, which places them at a greater risk of heat stroke. The literature also identifies how these risks manifest in increased child morbidity (n=113), mortality (n=98), increased hospital admissions (n=70), hospitalisation (n=23), emergency call outs (n=15), use of emergency medical services (n=61), and increased outpatient visits (n=6). The geographic spread of the evidence exploring the physical health risks associated with heat events in children includes evidence from research focusing on Asia (n=53), Africa (n=40), North America (n=17), South America (n=8), Australasia (n=36) and Europe (n=15), with 40 of these focusing on more than one region.

Nine articles discussed the impacts of heat on children's mental and emotional health. For example, Patz et al., (2014) showed how, in the USA, high temperatures are associated with ozone exceedance days, which are linked to increases of mental ill health in children and adolescents as well as adults, including posttraumatic stress disorder and depression. McMichael (2014) explains that heat waves and other climate induced events are linked to poor child mental health outcomes because, as climate change advances, many adults fret about the losses of livelihood that may result and children, in turn, fret about their parents' worries but may not understand the world's climate and their own futures. In chronically worried or anxious children, blood cortisol levels rise and adverse changes accrue in various organ systems that prefigure adult-life diseases. Children in poorer countries are at greatest risk as warming temperatures threaten life-food sufficiency and availability of safe drinking water, which results in parents and caregivers experiencing a greater sense of fatalism, which in turn impacts children's mental health. Hotz and Hajat (2020), show that increases in emergency hospital admissions and emergency room visits for psychiatric presentations are associated with increased ambient temperatures. Swaminathan et al. (2014) explain that as heat events are associated with increased under nutrition, psychological stress, and exposure to ambient ultraviolet radiation, and how this affects susceptibility to infection, allergy, and autoimmune disease, while Van der Linden et al., (2019) shows that during heat waves those with psychiatric symptoms and pre-existing mental health conditions are more likely to die.

Five articles discuss the risks posed by extreme heat to children's overall wellbeing (rather than incidences of mental ill health and diagnostic conditions). For example, Antoniadis et al., (2020), explore children's thermal comfort during hot ambient conditions and show how children are more sensitive and vulnerable to these conditions compared to adults. They also explain that thermal comfort monitoring tools are mainly developed for adults and that typical urban schoolyards lack shade and thus create conditions that favour the exposure of children to excessive heat.

Heat waves are also associated with increased rates of unintentional injuries and accidents in children (n=8). While children living in the poorest countries of the world experience the greatest risk, Kampe et al., (2016) shows that in children in high-income countries also face an increased the risk of unintentional injuries and accidents during heat events. Children are also at greater risk of exertional heat-related injuries during heat waves (Nelson et al., 2011). Sindall et al., (2022) explain that children also face an increased risk of drowning. Williams and Grundstein (2018) explain that young children are more at risk of vehicular heatstroke accidents on hot days.

Forty-six of the articles mention the risks posed by extreme heat to children in-utero, thus closely linking foetal and child health outcomes to maternal health. Increased temperatures and extreme heat events are associated with greater risks of pre-term birth (n=9), poor in-utero growth (n=5), greater risk of gestational diabetes and associated consequences (n=10), increased risk of stillbirth (n=26).

The second type of risk identified in the literature was the social and educational risks posed to children by extreme heat conditions (n=8). These risks can be both direct and indirect. For example, Hanna and Oliva (2016) argue that the impacts of rising temperatures and extreme heat will affect access to education and educational outcomes amongst children in the poorest countries more than others, because of the impact of excessive heat on crop yields in countries that depend primarily on agriculture. Poor nutrition and economic disruption are linked to lower scholastic achievement and school attendance, and consequently, income and health in adulthood. Children may also face an increased risk of being pushed into the labour force to obtain an income and leave education altogether (Kousky 2016). In turn, those with lower education and literacy are most vulnerable to the acute health impacts of extreme heat events, especially women and girls (Schifano et al., 2013). Children working in agriculture and in other outdoor industries, are especially vulnerable to heat stress due to the strenuous nature of their work (El Khayat et al. 2022). Children's learning in high-, middle- and low-income countries can also be disrupted by periods of extreme heat, with high air temperatures and lower hydration levels affecting children's ability to concentrate (Shortridge et al., 2022, Zivin and Shrader 2016). Children are also less likely to be able to participate in outdoor or physical education during hot days, and when they do, face an increased risk of dehydration and heat stress. Risks are highest for those who are under nourished or overweight (Somboonwong et al. 2012). Carrico et al., (2020) show that heat waves are associated with lower educational participation and increases in early marriage in poorer girls in Bangladesh, and greater risks of adolescent intimate partner violence. A summary of the different types of risk posed to children by extreme heat events is presented in **Table 1** (page 7).

2. What is known about the factors that influence children's vulnerability to the risks posed by extreme heat (how are the risks differentiated) and the inter-relationships and intersections between these factors?

The literature differentiated between the degree of health risk posed to children by extreme heat according to age, with 25 articles exploring the particular risks to children under 5 years of age, with three of these examining the risks to children under 12 months of age. Fourteen articles discussed the risks to children pre-natally, while 7 focused on children between 5 and 13 years. Five articles focused

on the risks to adolescents (13–18 years). For example, O’Sullivan and Chisholm, (2020) found that babies and young children were most at risk of increased heat related mortality and morbidity compared to other age groups. Pan et al., (2019) found that school age children were at greater risk of asthma exacerbations as a result of increased air temperatures compared to pre-school age children. Adolescents were especially vulnerable to exertional heat-related injury (Nelson et al., 2011), and are more likely to require hospital admission for exertional injury compared to younger children (Niu et al., 2022). Adolescents, especially girls, were more vulnerable to the educational and social risks associated with increased heat (Carrico et al., 2020). However, the majority of articles in the sample did not differentiate between the risks posed to children of different ages, focusing instead on all children from 0–18 years.

Very little information was available about how the risks posed by extreme heat were differentiated according to individual level factors, specifically gender, race and ethnicity, disability status or health status (including pre-existing chronic health conditions), amongst children, as well as socio economic and structural factors, cultural factors, political factors, and specific geographic context. Only eight articles explored how risks were differentiated according to gender. For example, Xu et al., (2013) found that males were more likely to be vulnerable to the impacts of heat than females, owing to increased risk taking behaviours and greater exposure to outdoor weather conditions. Four articles examined the impacts of race and ethnicity (Knowlton et al., 2009; Lee et al., 2016, Sheffield et al., 2018, and Smith and Hardeman 2020), showing how Black and Minority Ethnic children were particularly vulnerable to the risks associated with extreme heat. None of the articles differentiated outcomes in children according to disability or pre-existing health conditions. Only 19 articles specifically examined the risks in relation to socio-economic factors, with all 19 finding that the risks were most pronounced in children from lower socio-economic backgrounds. For example, Dong et al., (2020), revealed that in Wuhan, China, children living in the poorest areas with the lowest access to greenspace were more vulnerable to the health risks associated with heat waves. Similarly, Kravchenko et al., (2013), found that children who were from the most socially marginalised backgrounds had the greatest risk of mortality and morbidity. Those living in the poorest communities in the poorest countries of the world face the greatest risk from heat waves and other extreme weather events due to food and physical insecurity, poor housing and infrastructure, inadequate medical care, and poor access to education (Sheffield, and Landrigan 2011). Children from the poorest social economic backgrounds also face an increased risk of drowning accidents from swimming to try to keep cool during heat waves (Sindall et al., 2022).

Only 3 articles discuss the influence of cultural factors in determining the risks and outcomes (Carrico et al., 2020; Shortridge et al., 2022; and Junene et al., 2017). For example, Shortridge et al., (2022), examines how heat safety culture in schools in the US affect the perceptions of those tasked with safeguarding children about the risks of heat for children. Only two articles directly discussed how political factors could influence outcomes associated with extreme heat in children (McMichael 2014; Mueller et al., 2014). Mueller et al., (2014) discussed how political instability in the Eastern Mediterranean and Middle East region has led to greater risks of displacement, food insecurity and violence, which in turn, increases the risks of heat stress, vector-, water- and food-borne diseases associated with increased temperatures. While 89 articles acknowledge that children living in the poorest countries are the most vulnerable to the risks associated with heatwaves, 45 articles focus on the risks to children in high income countries. In both high- and low-income countries, greater risks are associated with living in dense city environments (n=26) and in rural areas (n=33), with the greatest risks being for children living in poor neighbourhoods and in poor quality housing (Flores-Larsen and Filippin 2021).

Although 27 of the articles in the sample discuss how two or more factors influence the risks and outcomes amongst children, only 6 of these discuss five or more factors. None of the articles present a holistic account of how all the different factors interrelate to determine outcomes and none explore how the intersections between all the multi-levelled and multi-scaled factors affect risks and outcomes.

3. How can children's vulnerability to the particular risks associated with extreme heat be reduced and/or mitigated?

Only a small number of articles within the sample (n=36) discussed ways of reducing the risks to children posed by extreme heat. Of these, 6 focused on the role of education, information provision and awareness raising, 2 focused on specific government action, 10 focused on improvements to public health, 10 focused on personal protective measures, including increasing hydrational levels and using skin protection, and 7 focused on improving living conditions through improvements in the built and infrastructural environment. For example, Gribble et al., (2019) explain that current guidance related to heat waves in Australia contained information that could prove dangerous to infants and suggest that Government health authorities should take more action to ensure that children are protected in emergencies. Kenendy et al., (2021) argue that designing thermally comfortable outdoor spaces and upgrading existing guidelines to reduce exposure to the sun and thermal extremes will help to protect children against the risk of heat related illness and injury. Nguyen et al., (2022) argue that a 1% increase in green space can reduce heat-related respiratory hospitalization

risk by 3.8%. Van Graan et al. (2013) suggest that improvements to the accessibility and quality of water could help to reduce the risks of waterborne illness associated with heatwaves. Smith et al., (2016) explain that there is a need to improve situational awareness during heatwaves and suggest that monitoring the effects of heat waves in children is necessary to provide the evidence and information required to improve early warnings and situational awareness. Cuesta et al., (2017) explore the importance of increasing fluid intake and avoiding exposure to the sun for reducing the risks, while Sheffield and Landrigan (2011) argue that climate change preparedness strategies need to be incorporated into public health. While the majority of articles in the sample did not provide or suggest specific mitigatory strategies and actions, 26 articles stated that reducing carbon emissions levels will help reduce the risks associated with extreme heat in children and secure the right to health. For example, Sheffield and Landrigan (2011) argue for greater emphasis on prevention strategies to reduce the health impacts of climate change through the reduction of greenhouse gas emissions. Patz et al., (2014) explain that the health benefits gained from improved air quality and planetary health could offset the cost of carbon policies.

4. How have heat waves been linked to child discrimination, exclusion, and oppression?

Although none of the articles within the sample directly mention how heat waves may be linked to child discrimination, exclusion, and oppression, 23 could be argued to make an *implicit* link between climate-change induced heat events and the exclusion and oppression of children. This is because they mention how the wellbeing of children now and in the future is being placed at risk due to a lack of effective government action to tackle global warming rates and reduce carbon emissions. Of these, 12 argue that children's health and educational outcomes and opportunities are predicted to worsen, with global, regional, and local existing inequalities becoming greater, with 5 articles emphasising how heat jeopardizes children's right to life, right to education, and right to health (Sheffield et al., 2014, Mitchell et al., 2021, Swaminathan et al. 2014; McMichael 2014, Caricco et al., 2020). McMichael (2014) argues that as children face increased risks from heat extremes, many will come to regard their parents' generation and complacency as culpable. The risks posed to children's health and education also mean that young people and future generations cannot develop their skills and talents to their maximum potential.

5. To what extent does the existing literature focusing on children and heat events capture their differentiated lived experiences, voices, agency, and decision-making capacities?

None of the articles drew on children's own experiences or views to critically assess conventional and 'adult' understandings of heat risk or to provide insight

into how children themselves experience and understand heat waves within the context of their daily lives. None of the articles included evidence revealing children's own agency or decision-making capacities. This shows that the voice of children themselves remains absent from this body of research, representing a huge gap in this literature that requires rectification.

6. What does the literature say about the particular risks to children associated with increasing heat wave: a) frequency, b) duration, c) and severity?

While 66 of the articles within the sample acknowledge how children will face an increased risk from heatwave events in the future, only two of the articles directly focused on the particular risks and outcomes associated with actual increases in heat wave frequency, duration, and severity. Acquotta et al., (2017) show that the development of haemolytic-uraemic syndrome from *Escherichia coli* infection in children can be correlated with increases in the duration, number, and frequency of heat waves, while Xu et al., (2014) shows how the impacts heat waves on childhood diarrhoea levels in Brisbane, Australia, increased with intensity and duration. However, it cannot be fully ascertained from the literature how heat wave rates, duration and intensity will affect the degree to which children may face other intensified health risks or risks to their education, suggesting that this is another area requiring further research.

Table 1: Summary of Findings of the Risks to Children Associated with Exposure to Extreme Heat and Heat Wave Events

Risks to Children from Exposure to Extreme Heat and Heat Wave Events	
Type of Risk	Number of Articles (N=124)
<i>Risks to Health and Wellbeing</i>	
<i>n=120</i>	
• Physical Health Risks	n=115
○ <i>Undernutrition</i>	n=49
○ <i>Increased risk of chronic respiratory conditions</i>	n=45
○ <i>Low birth weight</i>	n=35
○ <i>Heat stroke</i>	n=30
○ <i>Heat stress</i>	n=26
○ <i>Growth restriction</i>	n=23
○ <i>Dehydration and electrolyte imbalance</i>	n=23
○ <i>Allergy development</i>	n=21
○ <i>Diarrhoea</i>	n=19
○ <i>Sunburn and skin conditions</i>	n=8
○ <i>Increased risk of cardiovascular disease</i>	n=8
○ <i>Vector borne disease</i>	n=6
○ <i>Bacterial enteritis</i>	n=5
○ <i>Heat exhaustion</i>	n=5
○ <i>Renal failure and kidney disease</i>	n=3
○ <i>Cerebrovascular disease</i>	n=2
○ <i>Obesity and excessive weight gain</i>	n=2
○ <i>Worms and intestinal parasites</i>	n=2
○ <i>Encephalopathy</i>	n=2
○ <i>Otitis media and externa</i>	n=1
• Mental Health Risks	n=9
○ <i>General reduction in mental health</i>	n=6
○ <i>Depression</i>	n=2
○ <i>Anxiety</i>	n=1
○ <i>Psychiatric hospital admissions and emergency room visits</i>	n=1
○ <i>Increased risk of death in those with pre-existing mental health conditions</i>	n=1
• Risks In-Utero	n=46
○ <i>Still birth</i>	n=26
○ <i>Complications from gestational diabetes</i>	n=10
○ <i>Pre-term birth</i>	n=9
○ <i>Poor in-utero growth</i>	n=5
• Risk of Accidents and Injuries	n=6
○ <i>Unintentional injuries and accidents</i>	n=5
○ <i>Exertional heat related injuries</i>	n=4
○ <i>Drowning</i>	n=1
• Risk to Overall (General) Wellbeing	n=5
<i>Risks to Education and Social Development</i>	
<i>n=8</i>	
• Lower Educational Outcomes (General)	n=4
• Access to Education	n=4
• Participation in Physical Education	n=4
• Childhood/Early Employment	n=4
• Access to Outdoor Education	n=3
• Participation in Outdoor Hobbies and Recreation	n=3
• Lower Literacy	n=2
• Lower Income and Poorer Health in Adulthood	n=2
• Early Marriage	n=1
• Intimate Partner Violence in Adolescence	n=1

Conclusion

This review highlights that although a substantial amount of research is available focusing on the risks to children's health posed by heat wave events, research focusing on the social and educational impacts of heat waves remains more limited. Furthermore, while much is known about the risks of heat waves on children's physical health, risk of injuries and risks posed to children in-utero, less is known about how exposure to extreme heat affects children's mental health and overall wellbeing. This suggests that further research should be undertaken to discern the impacts of heat events on children's mental and emotional wellbeing. More research specifically examining the link between mental ill health in adolescents and extreme heat is also required, given that levels of mental ill health are increasing amongst teens. In addition, while children face an increased risk of mortality and morbidity from extreme heat events owing their physiologic susceptibility, behaviour and dependence on caregivers, further research should ascertain how different forms of risk affect children of different ages in different ways, as only a small number of articles currently differentiate between children's vulnerability according to age. The findings also show that limitations persist in our knowledge of the different factors that influence associations between extreme heat and specific outcomes, particularly in how outcomes may vary according to gender, race/ethnicity, disability, pre-existing health conditions, and socio-economic, cultural, and political factors, and in our understandings of the relationships and intersections between them. Future research should endeavour to understand the impacts of increases in the frequency, severity, and duration of heat wave events on the risks to children, as current research examining these actual impacts remains very limited. A lack of differentiation between children of different ages and living in different social, cultural, political, and geographic contexts means that more research is required to enable specific targeting of interventions to mitigate risk. Greater effort should be made to identify appropriate strategies to enable children to adapt to heat wave events, and further research should explore the potential for transferring strategies between different contexts and to help devise new, locally appropriate strategies that are responsive to different social, cultural, political, and geographic contexts. However, as the existing research warns, it is important not to rely on adaptational strategies alone, as reducing global carbon emission levels is fundamental for reducing the level of risk faced by children in the future. Governments and policy makers therefore need to take urgent action to reduce emission levels to safeguard children's futures.

The lack of available research focusing on children's own lived experiences of extreme heat reflects the extent to which research and intervention are not

specifically child centric. Children are the ones who bear the greatest burden of risk from climate change and yet they remain excluded from creating the climate safe futures that they envision for themselves. While understanding the risks that heatwaves pose to children is fundamental for designing interventions to offset the threats posed to children's rights to life, health, and education, children's voices, agency, and decision-making capacities must be incorporated in research and development for children's rights to be fully realized. For this reason, future research conducted in partnership with children focusing on children's real-life experiences needs to be undertaken. Action should follow the insights gained to help safeguard children's futures.

Recommendations for policymakers

The following five recommendations for policymakers can be made on the basis of the findings:

1. Policymakers must act urgently to tackle climate change so that the talents of all children can be developed to benefit children themselves as well as other members of society.
2. Greater action must be taken by governments to safeguard children's current and future health and educational achievements from the risks associated with extreme heat events.
3. Policymakers need to listen to children's own experiences and acknowledge their agency and decision-making capacities, and should work in partnership with children in the designing of policies and interventions aimed at mitigating the risks posed by increased heat.
4. Greater investment in the development of green spaces should be made to help reduce rates of heat related illness and the associated burden on health care, as well as to help improve the health of the planet.
5. Although heat waves can affect everyone, greater acknowledgement needs to be made by policymakers to the specific ways in which they impact on children differently according to specific age, individual level factors (gender, race/ethnicity, and disabilities), differences in social, political, culture and geographic contexts, when developing policy to reduce children's vulnerabilities to the risks associated with extreme heat.

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List of Articles (with Abstracts) Selected for Inclusion in the Final Sample (Total 124)

1. Abian-Vicen, J., and P. Abian, (2012), Dehydration of School-Age Children, *Journal of Sport and Health Research*, 4, 3, 223-232.

Citations: 0

Abstract: The aim of the study was to review the mechanisms that are responsible for regulating the performance of different systems against dehydration in school children and to establish patterns of hydration to be followed when conducting the activity physics in different special situations (such as hot days). Children are at greater risk of dehydration because they have anthropometric and physiological characteristics that make them less effective for dissipating the heat. Considering that thirst is a mechanism that occurs when there is already a hypohydration and that any percentage of dehydration causes a reduction in working capacity becomes important aspect of rehydration. Among the issues that we must take into account for proper rehydration find patterns in fluid intake in both quantity and distribution, CHO concentrations (48%) temperature (8-10 degrees C), metabolite concentrations (18 mmol/l) and the taste of the drink. Hydration is a very important aspect, which we believe should not be taken lightly by groups that are in contact with children in sports such as parents, teachers or coaches. Especially considering that dehydration can have fatal consequences, as lead to heat stroke with all that this entails.

2. Alqahtani, J. M., Asaad, A. M., Awadalla, N. J., and A. A. Mahfouz (2017), Environmental Determinants of Bronchial Asthma among Saudi School Children in Southwestern Saudi Arabia, *International Journal of Environmental Research and Public Health*, 14, 1, 22, DOI: 10.3390/ijerph14010022.

Citations: 11

Abstract: The aim here was to study the possible environmental and dietary determinants of asthma among school-aged children in Southwestern Saudi Arabia. In a cross-sectional study on a representative sample in Najran in Southwestern Saudi Arabia using an Arabic version of the modified ISAAC Phase III, parent-administered questionnaire data were collected. Skin prick tests (SPTs) were performed. The study included 1700 school children, out of them 468 (27.5%) were diagnosed with, cases of bronchial asthma and 20.8% (353) reported a 12-month nocturnal cough (as a proxy of severe asthma). In multivariable analysis, the study identified the following risk factors for having asthma or severe asthma: having dogs in the house, being male, being exposed to dense truck traffic on the

street, using wood as a cooking fuel, conducting vigorous exercise, consuming eggs, consuming vegetables, having an allergic sensitization to dog hair, and being exposed to *Cladosporium*, pigweed, and Bermuda grass. On the other hand, the following food stuffs were found to be protective: seafood, fruit, and dairy products. Comprehensive school educational programs for both children and their parents should be adopted to prevent the use of wood in cooking and heating, to ensure that house pets are properly cared for, and to encourage proper dietary habits. Physicians should be informed of the patterns of allergens in order to improve asthma diagnosis and management.

3. Akerlof, K., DeBono, R., Berry, P., Leiserowitz, A., Roser-Renouf, C., Clarke, K. L., Rogaeva, A., Nisbet, M. C., Weathers, M. R. Maibach, E. W., (2010) Public Perceptions of Climate Change as a Human Health Risk: Surveys of the United States, Canada and Malta, *International Journal of Environmental Research and Public Health*, 7, 6, 2559–2606, DOI: 10.3390/ijerph7062559.

Citations: 78

Abstract: We used data from nationally representative surveys conducted in the United States, Canada and Malta between 2008 and 2009 to answer three questions: Does the public believe that climate change poses human health risks, and if so, are they seen as current or future risks? Whose health does the public think will be harmed? In what specific ways does the public believe climate change will harm human health? When asked directly about the potential impacts of climate change on health and well-being, a majority of people in all three nations said that it poses significant risks; moreover, about one third of Americans, one half of Canadians, and two-thirds of Maltese said that people are already being harmed. About a third or more of people in the United States and Canada saw themselves (United States, 32%; Canada, 67%), their family (United States, 35%; Canada, 46%), and people in their community (United States, 39%; Canada, 76%) as being vulnerable to at least moderate harm from climate change. About one third of Maltese (31%) said they were most concerned about the risk to themselves and their families. Many Canadians said that the elderly (45%) and children (33%) are at heightened risk of harm, while Americans were more likely to see people in developing countries as being at risk than people in their own nation. When prompted, large numbers of Canadians and Maltese said that climate change can cause respiratory problems (78–91%), heat-related problems (75–84%), cancer (61–90%), and infectious diseases (49–62%). Canadians also named sunburn (79%) and injuries from extreme weather events (73%), and Maltese cited allergies (84%). However, climate change appears to lack salience as a health issue in all three countries: relatively few people answered open-ended questions in a manner that indicated clear top-of-mind associations between climate change and human health risks. We recommend

mounting public health communication initiatives that increase the salience of the human health consequences associated with climate change.

4. Andualem, Z., Taddese, A. A., Azene, Z. N., Azanaw, J., and D. H. Henok, (2020), Respiratory symptoms and associated risk factors among under-five children in Northwest, Ethiopia: community based cross-sectional study. *Multidisciplinary Respiratory Medicine*, 14, 685, DOI: 10.4081/mrm.2020.685.

Citations: 0

Abstract: Introduction: Acute respiratory infections are still a major public health problem resulting in morbidity and mortality among under-five children. This study aims to assess the extent of respiratory symptoms and associated risk factors among under-five children in Gondar city, Northwest Ethiopia. Methods: A community-based cross-sectional study was carried out from February to June 2019. From 792 study participants, data were collected via face to face interviews by using a semi-structured pre-tested questionnaire. Data were entered in Epi Info version 7, then exported to Stata 14.00 for analysis. Binary (Bivariable and Multivariable) logistic regression analysis was used to test the association of explanatory and outcome variables. Variables with $p < 0.05$ were considered as significantly associated with the outcome variable. Results: The prevalence of respiratory symptoms among under-five children was 37.5% at [95% (CI: 34.3-41)]. Uterine irritability during pregnancy [AOR = 1.89 at 95% CI: (1.11-3.23)], physical exercise during pregnancy [AOR = 0.60 at 95% CI: (0.41-0.89)], using wood and coal for heating [AOR = 2.42 at 95% CI: (1.65-3.53)], cockroaches infestation [AOR = 1.95 at 95% CI: (1.36 - 2.90)], presence of new carpets [AOR = 2.38 at 95% CI: (1.33-4.29)], damp stain [AOR = 2.45 at 95% CI: (1.02-2.69)], opening windows during cooking [AOR = 0.58 at 95% CI: (0.36 - 0.93)], living less than 100 m heavy traffic [AOR = 1.94 at 95% CI: (1.16-3.27)], and living less than 100 m (unpaved roads/streets) [AOR=2.89 at 95% CI: (1.89-4.55)] were significantly associated with respiratory symptoms. Conclusion: The prevalence of respiratory symptoms among under-five children was relatively high in the study area. Personal and environmental characteristics influencing symptom occurrence were identified. Respiratory symptoms will be minimized by reducing exposure to indoor and outdoor air pollution and enhancing housing quality.

5. Antoniadis, D., Katsoulas, N., and D. K. Papanastasiou, (2020), Thermal Environment of Urban Schoolyards: Current and Future Design with Respect to Children's Thermal Comfort, *Atmosphere*, 11, 11, 1144, DOI: 10.3390/atmos11111144.

Citations: 9

Abstract: Urban outdoor thermal conditions, and its impacts on the health and well-being for the city inhabitants have reached increased attention among biometeorological studies during the last two decades. Children are considered more sensitive and vulnerable to hot ambient conditions compared to adults, and are affected strongly by their thermal environment. One of the urban outdoor environments that children spend almost one third of their school time is the schoolyard. The aims of the present manuscript were to review studies conducted worldwide, in order to present the biophysical characteristics of the typical design of the urban schoolyard. This was done to assess, in terms of bioclimatology, the interactions between the thermal environment and the children's body, to discuss the adverse effects of thermal environment on children, especially the case of heat stress, and to propose measures that could be applied to improve the thermal environment of schoolyards, focusing on vegetation. Human thermal comfort monitoring tools are mainly developed for adults, thus, further research is needed to adapt them to children. The schemes that are usually followed to design urban schoolyards create conditions that favour the exposure of children to excessive heat, inducing high health risks to them. The literature survey showed that typical urban schoolyard design (i.e., dense surface materials, absence of trees) triggered high surface temperatures (that may exceed 58 degrees C) and increased absorption of radiative heat load (that may exceed 64 degrees C in terms of Mean Radiant Temperature) during a clear day with intense solar radiation. Furthermore, vegetation cover has a positive impact on schoolyard's microclimate, by improving thermal comfort and reducing heat stress perception of children. Design options for urban schoolyards and strategies that can mitigate the adverse effects of heat stress are proposed with focus on vegetation cover that affect positively their thermal environment and improve their aesthetic and functionality.

6. Acquaotta, F., Ardissino, G., Fratianni, S., and M. Perrone, (2017), Role of climate in the spread of shiga toxin-producing *Escherichia coli* infection among children, *International Journal of Biometeorology*, 61, 9, 1647-1655, DOI: 10.1007/s00484-017-1344-y.

Citations: 3

Abstract: Haemolytic-uraemic syndrome (HUS) is a rare disease mainly affecting children that develops as a complication of shiga toxin-producing *Escherichia coli* (STEC) infection. It is characterised by acute kidney injury, platelet consumption and mechanical destruction of red blood cells (haemolysis). In order to test the working hypothesis that the spread of the infection is influenced by specific climatic conditions, we analysed all of the identified cases of infection occurring between June 2010 and December 2013 in four provinces of Lombardy, Italy (Milano, Monza Brianza, Varese and Brescia), in which a STEC surveillance

system has been developed as part of a preventive programme. In the selected provinces, we recorded in few days a great number of cases and clusters which are unrelated for spatially distant or for the disease are caused by different STEC serotypes. In order to investigate a common factor that favoured the onset of infection, we have analysed in detail the weather conditions of the areas. The daily series of temperature, rain and relative humidity were studied to show the common climate peculiarities whilst the correlation coefficient and the principal component analysis (PCA) were used to point out the meteorological variable, maximum temperature, as the principal climate element in the onset of the infection. The use of distributed lag non-linear models (DLNM) and the climate indices characterising heat waves (HWs) has allowed to identify the weather conditions associated with STEC infection. The study highlighted a close temporal correlation between STEC infection in children and the number, duration and frequency of heat waves. In particular, if the maximum temperature is greater than 90th percentile, days classified as very hot, for 3 or more consecutive days, the risk of infection is increasing.

7. Anderko, L., Chalupka, S., Du, M., and M. Hauptman, M. (2020), Climate changes reproductive and children's health: a review of risks, exposures, and impacts, *Pediatric Research*, 87, 2, 414-419. DOI: 10.1038/s41390-019-0654-7.

Citations: 18

Abstract: Our climate has significantly changed, exceeding what the world has experienced over the last 650,000 years, and has been cited as the most significant health threat of the twenty-first century. Climate change is impacting health in unprecedented ways. While everyone is vulnerable to the health impacts associated with climate change, children are disproportionately affected because of their physical and cognitive immaturity. Climate change impacts that include rising temperatures, extreme weather, rising sea levels, and increasing carbon dioxide levels are associated with a wide range of health issues in children such as asthma, allergies, vector-borne diseases, malnutrition, low birth weight, and post-traumatic stress disorder. Pediatric health providers play a critical role in advancing the science and translating findings to improve public understanding about the link between climate changes and children's health, and establishing strategies to address these issues. This review will provide an overview of research exploring the impact of climate change on children's health impacts, as well as provide recommendations for pediatric research moving forward.

8. Babalola, O., Razzaque, A., and Bishai, D., (2018), Temperature extremes and infant mortality in Bangladesh: Hotter months, lower mortality, *PLOS ONE*, 13, 1, e0189252 DOI: 10.1371/journal.pone.0189252

Citations: 13

Abstract: Our study aims to obtain estimates of the size effects of temperature extremes on infant mortality in Bangladesh using monthly time series data.

Methods

Data on temperature, child and infant mortality were obtained for Matlab district of rural Bangladesh for January 1982 to December 2008 encompassing 49,426 infant deaths. To investigate the relationship between mortality and temperature, we adopted a regression with Autoregressive Integrated Moving Average (ARIMA) errors model of seasonally adjusted temperature and mortality data. The relationship between monthly mean and maximum temperature on infant mortality was tested at 0 and 1 month lags respectively. Furthermore, our analysis was stratified to determine if the results differed by gender (boys versus girls) and by age (neonates (≤ 30 days) versus post neonates (>30 days and <153 days)). Dickey Fuller tests were performed to test for stationarity, and since the time series were non-stationary, we conducted the regression analysis based on the first differences of mortality and temperature.

Results

Hotter months were associated with lower infant mortality in Bangladesh. Each degree Celsius increase in mean monthly temperature reduced monthly mortality by 3.672 (SE 1.544, $p < 0.05$) points. A one degree increase in mean monthly temperature one month prior reduced mortality by 0.767 (SE 0.439, $p < 0.1$) for boys and by -0.0764 (SE 0.366, NS) for girls. Beneficial effects of maximum monthly temperature were on the order of 0.623 to -0.712 and statistically significant for girls and boys respectively. Effect sizes of mean monthly temperature were larger for neonates at 1.126 (SE 0.499, $p < 0.05$) than for post-neonates at 0.880 (SE 0.310, $p < 0.05$) reductions in mortality per degree.

Conclusion

There is no evidence that infant survival is adversely affected by monthly temperature extremes in Bangladesh. This may reflect a more heightened sensitivity of infants to hypothermia than hyperthermia in this environment.

9. Balbus, J. M., and C. Malina (2009), Title: Identifying Vulnerable Subpopulations for Climate Change Health Effects in the United States, *Journal of Occupational and Environmental Medicine*, 51, 1, 33-37, DOI: 10.1097/JOM.0b013e318193e12e.

Citations: 195

Abstract: Climate change can be expected to have differential effects on different subpopulations. Biological sensitivity, socioeconomic factors, and geography may each contribute to heightened risk for climate-sensitive health outcomes, which include heat stress, air pollution health 4 weather event health effects, water, food-, and vector-borne illnesses. Particularly vulnerable subpopulations include.

children, Pregnant women, older adults, impoverished Populations, people with chronic conditions and mobility and cognitive constraints, outdoor workers, and those in coastal and low-lying riverine zones. For Public health planning, it is critical to identify populations that may experience synergistic affects of multiple risk factors for health problems, both related to climate change and to other temporal trends, with specific geographic factors that convey climate-related risks.

10. Basu, R., (2009), High ambient temperature and mortality: a review of epidemiologic studies from 2001 to 2008, *Environmental Health*, 8, 40, DOI: 10.1186/1476-069X-8-40.

Citations: 689

Abstract: Background: This review examines recent evidence on mortality from elevated ambient temperature for studies published from January 2001 to December 2008.

Methods: PubMed was used to search for the following keywords: temperature, apparent temperature, heat, heat index, and mortality. The search was limited to the English language and epidemiologic studies. Studies that reported mortality counts or excess deaths following heat waves were excluded so that the focus remained on general ambient temperature and mortality in a variety of locations. Studies focusing on cold temperature effects were also excluded. Results: Thirty-six total studies were presented in three tables: 1) elevated ambient temperature and mortality; 2) air pollutants as confounders and/or effect modifiers of the elevated ambient temperature and mortality association; and 3) vulnerable subgroups of the elevated ambient temperature-mortality association. The evidence suggests that particulate matter with less than 10 um in aerodynamic diameter and ozone may confound the association, while ozone was an effect modifier in the warmer months in some locations. Nonetheless, the independent effect of temperature and mortality was withheld. Elevated temperature was associated with increased risk for those dying from cardiovascular, respiratory, cerebrovascular, and some specific cardiovascular diseases, such as ischemic heart disease, congestive heart failure, and myocardial infarction. Vulnerable subgroups also included: Black racial/ethnic group, women, those with lower socioeconomic status, and several age groups, particularly the elderly over 65 years of age as well as infants and young children. Conclusion: Many of these outcomes and vulnerable subgroups have only been identified in recent studies and varied by location and study population. Thus, region-specific policies, especially in urban areas, are vital to the mitigation of heat-related deaths.

11. Benton, D., (2011), Dehydration Influences Mood and Cognition: A Plausible Hypothesis? *Nutrients*, 3, 5, 555-573, DOI: 10.3390/nu3050555

Citations: 55

Abstract: The hypothesis was considered that a low fluid intake disrupts cognition and mood. Most research has been carried out on young fit adults, who typically have exercised, often in heat. The results of these studies are inconsistent, preventing any conclusion. Even if the findings had been consistent, confounding variables such as fatigue and increased temperature make it unwise to extrapolate these findings. Thus in young adults there is little evidence that under normal living conditions dehydration disrupts cognition, although this may simply reflect a lack of relevant evidence. There remains the possibility that particular populations are at high risk of dehydration. It is known that renal function declines in many older individuals and thirst mechanisms become less effective. Although there are a few reports that more dehydrated older adults perform cognitive tasks less well, the body of information is limited and there have been little attempt to improve functioning by increasing hydration status. Although children are another potentially vulnerable group that have also been subject to little study, they are the group that has produced the only consistent findings in this area. Four intervention studies have found improved performance in children aged 7 to 9 years. In these studies children, eating and drinking as normal, have been tested on occasions when they have and not have consumed a drink. After a drink both memory and attention have been found to be improved.

12. Bernstein, A. S., Sun, S. Z., Weinberger, K. R., Spangler, K. R., Sheffield, P. E., and G. A. Wellenius (2022), Warm Season and Emergency Department Visits to US Children's Hospitals, *Environmental Health Perspectives*, 130, 1, 017001, DOI: 10.1289/EHP8083

Citations: 5

Abstract: **BACKGROUND:** Extreme heat exposures are increasing with climate change. Health effects are well documented in adults, but the risks to children are not well characterized. **OBJECTIVES:** We estimated the association between warm season (May to September) temperatures and cause-specific emergency department (ED) visits among U.S. children and adolescents. **METHODS:** This multicenter time-series study leveraged administrative data on 3.8 million ED visits by children and adolescents ≤ 18 years of age to the EDs of 47 U.S. children's hospitals from May to September from 2016 to 2018. Daily maximum ambient temperature was estimated in the county of the hospital using a spatiotemporal model. We used distributed-lag nonlinear models with a quasi-Poisson distribution to estimate the association between daily maximum temperature and the relative risk (RR) of ED visits, adjusting for temporal trends. We then used a random-effects metaanalytic model to estimate the overall cumulative association. **RESULTS:** Extreme heat was associated with an RR of all-cause ED

visits of 1.17 (95% CI: 1.12, 1.21) relative to hospital-specific minimum morbidity temperature. Associations were more pronounced for ED visits due to heat-related illness including dehydration and electrolyte disorders (RR = 1.83; 95% CI: 1.31, 2.57), bacterial enteritis (1.35; 95% CI: 1.02, 1.79), and otitis media and externa (1.30; 95% CI: 1.11, 1.52). Taken together, temperatures above the minimum morbidity temperature accounted for an estimated 11.8% [95% empirical 95% confidence interval (eCI): 9.9%, 13.3%] of warm season ED visits for any cause and 31.0% (95% eCI: 17.9%, 36.5%) of ED visits for heat-related illnesses. CONCLUSION: During the warm season, days with higher temperatures were associated with higher rates of visits to children's hospital EDs. Higher ambient temperatures may contribute to a significant proportion of ED visits among U.S. children and adolescents.

13. Block, S., Haile, B., You, L., and D. Headey, (2022), Heat shocks, maize yields, and child height in Tanzania *Food Security*, 14, 1: 93-109. DOI: 10.1007/s12571-021-01211-6.

Citations: 1

Abstract: This paper advances previous literature that has posited a climate-nutrition link without identifying a specific pathway via agriculture. We measure the specific effects of exposure to extreme heat on maize yields in Tanzania, and then test whether prenatal heat-induced yield losses predict subsequent child growth outcomes. In the first stage we find that substituting one full day (24 h) exposure to 39 degrees C for a day at 29 degrees reduces predicted yield for the entire growing season by 6-11%. In the second stage we find that in utero exposure to growing degree days greater than 29 degrees C predicts lower postnatal HAZ scores for Tanzanian boys 0-5 years of age, but not girls. Consistent with a maternal malnutrition mechanism, we also find a negative association between maize yields and women's body mass. Insofar as climate change is likely to increase the incidence of heat shocks in much of sub-Saharan Africa, our results suggest a significant risk of adverse nutritional impacts.

14. Blom, S., Ortiz-Bobea, A., Hoddinott, J., Heat exposure and child nutrition: Evidence from West Africa, *Journal of Environmental Economics and Management*, 115, 102698. DOI: 10.1016/j.jeem.2022.102698.

Citations: 0

Abstract: Extreme heat shocks are increasingly linked to poor economic and health outcomes. This paper constructs hour-degree bins of temperature exposure to assess the effects of extreme heat on early child nutrition, a health outcome correlated with educational attainment and income in adulthood. Linking 15 rounds of repeated cross-section data from five West African countries to geo-coded weather data, we find that extreme heat exposure increases the

prevalence of both chronic and acute malnutrition. We find that a 2 degrees C rise in temperature will increase the prevalence of stunting by 7.4 percentage points, reversing the progress made on improving nutrition during our study period.

15. Carrico, A. R., Donato, K. M., Best, K. B., and J. Gilligan, (2020), Extreme weather and marriage among girls and women in Bangladesh, *Global Environmental Change: Human and Policy Dimensions*, 65, 102160, DOI: 10.1016/j.gloenvcha.2020.102160.

Citations: 11

Abstract: Climate change interacts with social, economic, and political forces in ways that can shape demographic behavior. Yet, the link between environmental stress and marriage has received limited attention. Using survey data from 615 Bangladeshi households, we examine the relationship between extreme weather in the form of heat waves and dry spells, and the risk of marriage over the period from 1989 to 2013. We find that girls and women are at an increased risk of marrying in the year of or following heat waves. The link is strongest for women aged 18 to 23, and weakest for those 11 to 14. We also explore the hypothesis that extreme weather leads families to accept less desirable marriage proposals for daughters. We find that those who wed during periods of extreme heat married into poorer households and to husbands with less education. Similarly, those who married during abnormally dry periods married men with less education and who were more supportive of intimate partner violence. Together these results suggest that, when Bangladeshi families face environmental shocks, they cope by hastening the marriage of daughters or accepting less desirable marriage proposals. Such practices are likely to have long-term impacts on the health and well-being of women and children, and underscore the unique vulnerabilities faced by women as climate change intensifies.

16. Chan, E. Y. Y., Goggins, W. B., Yue, J. S. K., and P. Lee, (2013), Hospital admissions as a function of temperature, other weather phenomena and pollution levels in an urban setting in China, *Bulletin of the World Health Organization*, 91, 8, 576–584. DOI: 10.2471/BLT.12.113035

Citations: 60

Abstract: Objective To explore the relationship between weather phenomena and pollution levels and daily hospital admissions (as an approximation to morbidity patterns) in Hong Kong Special Administrative Region (SAR), China, in 1998–2009. Methods Generalized additive models and lag models were constructed with data from official sources on hospital admissions and on mean daily temperature,

mean daily wind speed, mean relative humidity, daily total global solar radiation, total daily rainfall and daily pollution levels.

Findings During the hot season, admissions increased by 4.5% for every increase of 1 C above 29 C; during the cold season, admissions increased by 1.4% for every decrease of 1 degrees C within the 8.2–26.9 degrees C range. In subgroup analyses, admissions for respiratory and infectious diseases increased during extreme heat and cold, but cardiovascular disease admissions increased only during cold temperatures. For every increase of 1 degrees C above 29 degrees C, admissions for unintentional injuries increased by 1.9%. During the cold season, for every decrease of 1 degrees C within the 8.2–26.9 degrees C range, admissions for cardiovascular diseases and intentional injuries rose by 2.1% and 2.4%, respectively. Admission patterns were not sensitive to sex. Admissions for respiratory diseases rose during hot and cold temperatures among children but only during cold temperatures among the elderly. In people aged 75 years or older, admissions for infectious diseases rose during both temperature extremes. Conclusion In Hong Kong SAR, hospitalizations rise during extreme temperatures. Public health interventions should be developed to protect children, the elderly and other vulnerable groups from excessive heat and cold.

17. Chapman, S., Birch, C. E., Marsham, J. H., Part, C., Hajat, S., Chersich, M. F., Ebi, K. L., Luchters, S., Nakstad, B., and S. Kovats, (2022). Past and projected climate change impacts on heat-related child mortality in Africa. *Environmental Research Letters*, 17, 7, 074028, DOI: 10.1088/1748-9326/ac7ac5.

Citations: 1

Abstract: Children (<5 years) are highly vulnerable during hot weather due to their reduced ability to thermoregulate. There has been limited quantification of the burden of climate change on health in sub-Saharan Africa, in part due to a lack of evidence on the impacts of weather extremes on mortality and morbidity. Using a linear threshold model of the relationship between daily temperature and child mortality, we estimated the impact of climate change on annual heat-related child deaths for the current (1995–2020) and future time periods (2020–2050). By 2009, heat-related child mortality was double what it would have been without climate change; this outweighed reductions in heat mortality from improvements associated with development. We estimated future burdens of child mortality for three emission scenarios (SSP119, SSP245 and SSP585), and a single scenario of population growth. Under the high emission scenario (SSP585), including changes to population and mortality rates, heat-related child mortality is projected to double by 2049 compared to 2005–2014. If 2050 temperature increases were kept within the Paris target of 1.5 degrees C (SSP119 scenario), approximately 4000–6000 child deaths per year could be avoided in Africa. The estimates of future heat-related mortality include the assumption of the significant population

growth projected for Africa, and declines in child mortality consistent with Global Burden of Disease estimates of health improvement. Our findings support the need for urgent mitigation and adaptation measures that are focussed on the health of children.

18. Chersich, M. F., Pham, M. D., Areal, A., Haghghi, M. M. Manvuchi, A., Swift, C. P., Wernecke, B., Robinson, M., Hetem, R., Boeckmann, B., and S. Hajat (2020), Associations between high temperatures in pregnancy and risk of preterm birth, low birth weight, and stillbirths: systematic review and meta-analysis, *BMJ British Medical Journal*, 371, m3811 DOI: 10.1136/bmj.m3811

Citations: 53

Abstract: OBJECTIVE: To assess whether exposure to high temperatures in pregnancy is associated with increased risk for preterm birth, low birth weight, and stillbirth.

DESIGN: Systematic review and random effects meta-analysis.

DATA SOURCES: Medline and Web of Science searched up to September 2018, updated in August 2019.

ELIGIBILITY CRITERIA FOR SELECTING STUDIES: Clinical studies on associations between high environmental temperatures, and preterm birth, birth weight, and stillbirths.

RESULTS: 14 880 records and 175 full text articles were screened. 70 studies were included, set in 27 countries, seven of which were countries with low or middle income. In 40 of 47 studies, preterm births were more common at higher than lower temperatures. Exposures were classified as heatwaves, 1 degrees C increments, and temperature threshold cutoff points. In random effects metaanalysis, odds of a preterm birth rose 1.05-fold (95% confidence interval 1.03 to 1.07) per 1 degrees C increase in temperature and 1.16-fold (1.10 to 1.23) during heatwaves. Higher temperature was associated with reduced birth weight in 18 of 28 studies, with considerable statistical heterogeneity. Eight studies on stillbirths all showed associations between temperature and stillbirth, with stillbirths increasing 1.05-fold (1.01 to 1.08) per 1 degrees C rise in temperature. Associations between temperature and outcomes were largest among women in lower socioeconomic groups and at age extremes. The multiple temperature metrics and lag analyses limited comparison between studies and settings.

CONCLUSIONS: Although summary effect sizes are relatively small, heat exposures are common and the outcomes are important determinants of population health. Linkages between socioeconomic status and study outcomes suggest that risks might be largest in low and middle income countries. Temperature rises with global warming could have major implications for child health.

19. Cingi, C., Muluk, N. B., and G. K. Scadding, (2019), Will every child have allergic rhinitis soon? *International Journal of Pediatric Otorhinolaryngology*, 118, 53–58. DOI: 10.1016/j.ijporl.2018.12.019.

Citations: 12

Abstract: Objectives: Given the increasing prevalence of AR amongst children, we aimed to review the literature regarding the future of AR in this population.

Methods: We searched the PubMed, Google and Proquest Central databases at Kirikkale University Library. Search terms used were: "allergic rhinitis", "children", "paediatric", "allergy", "future", "risk factors", "treatment", "pharmacotherapy" and/or "allergen specific immunotherapy". With regard to risk factors for allergic rhinitis, the terms "Environmental factors", "Improved hygiene", "Increased indoor allergen exposure", "Farms, villages, worms, and other parasites", "Environmental toxicants", "Diet", "Lifestyle changes", "Air pollution" and "Climate factors" were searched for.

"Prevention of allergic diseases" and "Allergen-specific immunotherapy in the future" were also included in the search. Results: AR has a high prevalence and causes considerable morbidity, has associated comorbidity and features specific complications. The principal treatments rely on avoiding the allergens responsible, and administering drug treatment or immunotherapy, which targets specific antigens. Genetic drift does not explain the rising prevalence of allergic disorders, but multifactorial environmental factors are likely culprits. Amongst such environmental factors to consider are the rise in caesarean births, decreases in breast feeding, dietary changes resulting in less fresh produce being consumed, the eradication of intestinal worm infestations, alterations in the way homes are aired and heated, children taking less exercise and being outdoors for shorter periods, whilst also having more contact with pollution. Conclusion:

Barring substantial lifestyle alterations, more and more children are likely to develop AR. It may prove feasible to stop allergy developing in the first place through manipulation of the microbiome, but the exact format such a modification should involve remains to be discovered. Molecular allergological techniques do offer the prospect of more precisely targeted immunotherapy, the sole disease modifier at present. However, at present the complexity and cost of such interventions prevents their widespread use and research in this area is still needed. The majority of children with AR are going to be managed using nasal saline sprays, since they are the most straightforward and least risky alternative for first line treatment.

20. Collins, T. W., Grineski, S. E., Ford, P., Aldouri, R., Aguilar, M. D. R., Velazquez-Angulo, G., Fitzgerald, R., and D. J. Lu (2013), Mapping vulnerability to climate change-related hazards: children at risk in a US-Mexico border metropolis, *Population and Environment*, 34, 3: 313–337. DOI: 10.1007/s11111-012-0170-8.

Citations: 11

Abstract: There are significant human impacts associated with climate change. This paper introduces a model for identifying small area risks associated with children's vulnerability to climate change-related hazard exposures, which is transferable to other regions and adaptable to varied population and exposure scenarios. The cross-national El Paso-Ciudad Juarez (US-Mexico) metropolis serves as the study area for model implementation, which involves mapping social vulnerability, hazard exposure, and cumulative climate change-related risks. This study addresses two limitations of extant fine-scale climate change vulnerability mapping studies. First, rather than focusing on one exposure variable, it assesses the combined risks of multiple exposures (extreme heat, peak ozone, and floods) and, thus, offers a model for mapping neighborhood-level cumulative climate change exposure risks. Second, it provides a model for small area spatial analyses of climate change vulnerability within low-/middle-income countries and in contexts where climate change risks (and appropriate responses) are cross-national in scope.

21. Cuesta, G. J., van Loenhout, J. A. F., Colaco, M. D., Guha-Sapir, D., (2017), General Population Knowledge about Extreme Heat: A Cross-Sectional Survey in Lisbon and Madrid, *International Journal of Environmental Research and Public Health*, 14, 2, 122, DOI: 10.3390/ijerph14020122

Citations: 12

Abstract: Extreme heat is associated with an increased mortality and morbidity. National heat plans have been implemented to minimize the effect of extreme heat. The population's awareness and knowledge of national heat plans and extreme heat is essential to improve the community's behavior and adaptation. A general population survey was conducted in Lisbon and in Madrid to assess this knowledge. We used a questionnaire to interview passers-by. Results were compared between Lisbon and Madrid and between locals and foreigners, using Pearson Chi-square tests and Fisher's exact test. We conducted 260 interviews in six locations of different socio-economic backgrounds in each city. The most frequently mentioned extreme heat-related risk groups were the elderly (79.2%), children (49.6%) and babies (21.5%). The most frequently reported protective measures were increased fluid intake (73.1%) and avoiding exposure to the sun (50.8%). Knowledge about the heat plan was higher in Lisbon (37.2%) than in Madrid (25.2%) (p -value = 0.03). Foreigners had less knowledge of risk groups compared to locals. Heat plans were not widely known in Madrid and Lisbon. Nonetheless, knowledge of practical concepts to face extreme heat, such as certain risk groups and protective measures, was found. Our results were similar to comparable surveys where specific respondents' groups were identified as less knowledgeable. This highlighted the importance of addressing these groups when

communicating public health messages on heat. Foreigners should be specifically targeted to increase their awareness.

22. D'Amato, G., Holgate, S. T., Pawankar, R., Ledford, D. K., Cecchi, L., Al-Ahmed, M., Al-Enezi, F., Al-Muhsen, S., Ansotegui, I., Baena-Cagnani, C. E., Baker, D. J., Bayram, H., Bergmann, K. C., Boulet, L. P., Buters, J. T. M., D'Amato, M., Dorsano, S., Douwes, J., Finlay, S. E., Garrasi, D., Gomez, M., Hahtela, T., Halwani, R., Hassani, Y., Mahboub, B., Marks, G., Mechelozzi, P., Montagni, M., Nunes, C., Oh, J. J. w., Popov, T. A., Portnoy, J., Ridolo, E., Rosario, N., Rottem, M., Sanchez-Borges, M., Sibanda, E., Sienna-Monge, J. J., Vitale, C., Annesi-Maesano, I., (2015), Meteorological conditions, climate change, new emerging factors, and asthma and related allergic disorders. A statement of the World Allergy Organization, *World Allergy Organisation Journal*, 8, 25, DOI: 10.1186/s40413-015-0073-0

Citations 247

Abstract: The prevalence of allergic airway diseases such as asthma and rhinitis has increased dramatically to epidemic proportions worldwide. Besides air pollution from industry derived emissions and motor vehicles, the rising trend can only be explained by gross changes in the environments where we live. The world economy has been transformed over the last 25 years with developing countries being at the core of these changes. Around the planet, in both developed and developing countries, environments are undergoing profound changes. Many of these changes are considered to have negative effects on respiratory health and to enhance the frequency and severity of respiratory diseases such as asthma in the general population. Increased concentrations of greenhouse gases, and especially carbon dioxide (CO₂), in the atmosphere have already warmed the planet substantially, causing more severe and prolonged heat waves, variability in temperature, increased air pollution, forest fires, droughts, and floods - all of which can put the respiratory health of the public at risk. These changes in climate and air quality have a measurable impact not only on the morbidity but also the mortality of patients with asthma and other respiratory diseases. The massive increase in emissions of air pollutants due to economic and industrial growth in the last century has made air quality an environmental problem of the first order in a large number of regions of the world. A body of evidence suggests that major changes to our world are occurring and involve the atmosphere and its associated climate. These changes, including global warming induced by human activity, have an impact on the biosphere, biodiversity, and the human environment. Mitigating this huge health impact and reversing the effects of these changes are major challenges.

This statement of the World Allergy Organization (WAO) raises the importance of this health hazard and highlights the facts on climate-related health impacts, including: deaths and acute morbidity due to heat waves and extreme

meteorological events; increased frequency of acute cardio-respiratory events due to higher concentrations of ground level ozone; changes in the frequency of respiratory diseases due to trans-boundary particle pollution; altered spatial and temporal distribution of allergens (pollens, molds, and mites); and some infectious disease vectors. According to this report, these impacts will not only affect those with current asthma but also increase the incidence and prevalence of allergic respiratory conditions and of asthma. The effects of climate change on respiratory allergy are still not well defined, and more studies addressing this topic are needed. Global warming is expected to affect the start, duration, and intensity of the pollen season on the one hand, and the rate of asthma exacerbations due to air pollution, respiratory infections, and/or cold air inhalation, and other conditions on the other hand.

23. Dimitrova, A., (2021), Seasonal droughts and the risk of childhood undernutrition in Ethiopia, *World Development*, 141, 105417 DOI: 10.1016/j.worlddev.2021.105417.

Citations: 2

Abstract: Chronic seasonal crop and livestock loss due to heat stress and rainfall shortages can pose a serious threat to human health, especially in Sub-Saharan Africa where subsistence and small-scale farming dominate. Young children are particularly susceptible to undernutrition when households experience food insecurity because nutritional deficiencies affect their growth and development. The increase in the frequency of extreme climate events, including droughts, can potentially pose serious health impacts on children. However, the evidence is inconclusive and rather limited to small-scale local contexts. Furthermore, little is known about the differential impacts of droughts on the health of population subgroups. This study contributes to the literature by using data from three nationwide Demographic and Health Surveys (DHS) for Ethiopia conducted in 2005, 2011 and 2016 (n = 21,551). Undernutrition, measured as stunting and wasting among children under five, is used as a health indicator. Droughts are identified using the Standardized Precipitation Evapotranspiration Index (SPEI), a multi-scalar drought index. This study found that drought exposure during the main agricultural season (meher) increased the risk of both chronic undernutrition (stunting) and acute undernutrition (wasting) among under-five children in Ethiopia, however, the impacts vary with population subgroups. Boys, children born to uneducated mothers, and those living in the rural area and whose households are engaged in agricultural activities were more likely to be affected. This suggests that nutritional intervention should target these particularly vulnerable groups of the population.

24. Dominguez-Amarillo, S., Fernandez-Aguera, J., Gonzales, M. M., and T. Cuerdo-Vilches (2020), Overheating in Schools: Factors Determining Children's Perceptions of Overall Comfort Indoors, *Sustainability*, 12, 14, 5772 DOI: 10.3390/su12145772.

Citations: 5

Abstract: Climate change is raising the length and intensity of the warm season in the academic year, with a very significant impact on indoor classroom conditions. Increasingly frequent episodes of extreme heat are having an adverse effect on school activities, whose duration may have to be shortened or pace slackened. Fitting facilities with air conditioning does not always solve the problem and may even contribute to discomfort or worsen health conditions, often as a result of insufficient ventilation. Users have traditionally adopted measures to adapt to these situations, particularly in warm climates where mechanical refrigeration is absent or unavailable. Implementation of such measures or of natural ventilation is not always possible or their efficacy is limited in school environments, however. Such constraints, especially in a context where reasonable energy use and operating costs are a primary concern, inform the need to identify the factors that contribute to users' perceptions of comfort. This study deploys a post-occupancy strategy combined with participatory action to empower occupants as agents actively engaging in their own comfort. It addresses user-identified classroom comfort parameters potentially applicable in the design and layout of thermally suitable spaces meriting occupant acceptance.

25. Dong, J. Q., Peng, J., He, X. R., Corcoran, J., Qiu, S. J., and X. Y. Wang, (2020), Heatwave-induced human health risk assessment in megacities based on heat stress-social vulnerability-human exposure framework, *Landscape and Urban Planning*, 203, 103907, DOI: 10.1016/j.landurbplan.2020.103907.

Citations: 20

Abstract: Assessing heatwave-induced human health risk is of critical importance in order to mitigate hazards caused by extreme environmental events. Air temperature or land surface temperature in previous studies was often used to characterize the severity of heatwaves, and human perception of the thermal environment was neglected as a key component in the heatwave-induced risk assessment. In order to redress this issue, in this study we applied the Universal Thermal Climate Index (UTCI) to represent human thermal comfort perception and embedded the measure within an assessment framework of heat stress-social vulnerability-human exposure. The heatwave-induced human health risk was then evaluated in Wuhan City, China across 177 blocks covering the entire city area and local risk governance measures were also explored based on risk zoning. The results showed that spatial patterns of heatwave-induced human health risk followed a decreasing trend from the city center towards the

surrounding areas, with the average risk of the main urban area being 1.6 times that beyond the metropolitan development area. Through the heatwave-induced human health risk zoning, about 73.45% of the 177 blocks in Wuhan City demonstrated a positive relationship between heat stress and human exposure, and both were opposite with social vulnerability. Multiple linear regression between UTCI and the proportion of greenspace, water body and construction land indicated that, more blue or green infrastructure should be integrated within the urban fabric to help mitigate heat stress particularly in the main urban area, while in the metropolitan development area construction land dominating heat stress should be strictly regulated. Furthermore, protecting vulnerable groups such as left-behind children and elderly people should be a priority in rural areas that were generally associated with higher levels of social vulnerability. This study proposed a new heatwave-induced human health risk framework with a local evidence in Wuhan City, and further emphasized that risk zoning could be used as a basic yet important approach to facilitating more effective urban planning guidelines for risk governance.

26. Ebi, K. L., Paulson, J. A., (2007), Climate change and children, *Pediatric Clinics of North America*, 54, 2, 213. DOI: 10.1016/j.pcl.2007.01.004

Citations: 47

Abstract: Climate change is increasing the burden of climate-sensitive health determinants and outcomes worldwide. Acting through increasing temperature, changes in the hydrologic cycle, and sea level rise, climate change is projected to increase the frequency and intensity of heat events and extreme events (floods and droughts), change the geographic range and incidence of climate-sensitive vector-, food-, and waterborne diseases, and increase diseases associated with air pollution and aeroallergens. Children are particularly vulnerable to these health outcomes because of their potentially greater exposures, greater sensitivity to certain exposures, and their dependence on caregivers.

27. El Khayat, M., Halwani, D. A., Hneiny, L., Alameddine, I., Haider, M. A., and R. R. Habib, (2022), Impacts of Climate Change and Heat Stress on Farmworkers' Health: A Scoping Review, *Frontiers in Public Health*, 10, 782811 DOI: 10.3389/fpubh.2022.782811.

Citations: 0

Abstract: Due to the continuous rise of global temperatures and heatwaves worldwide as a result of climate change, concerns for the health and safety of working populations have increased. Workers in the food production chain, particularly farmworkers, are especially vulnerable to heat stress due to the strenuous nature of their work, which is performed primarily outdoors under poor

working conditions. At the cross-section of climate change and farmworkers' health, a scoping review was undertaken to summarize the existing knowledge regarding the health impacts associated with climate change and heat stress, guide future research toward better understanding current and future climate change risks, and inform policies to protect the health and safety of agricultural workers. A systematic search of 5 electronic databases and gray literature websites was conducted to identify relevant literature published up until December 2021. A total of 9045 records were retrieved from the searches, of which 92 articles were included in the final review. The majority of the reviewed articles focused on heat-related illnesses ($n = 57$) and kidney diseases ($n = 28$). The risk factors identified in the reviewed studies included gender, dehydration, heat strain, wearing inappropriate clothing, workload, piece-rate payment, job decision latitude, and hot environmental conditions. On the other hand, various protective and preventive factors were identified including drinking water, changing work hours and schedule of activities, wearing appropriate clothing, reducing soda consumption, taking breaks in shaded or air-conditioned areas, and increasing electrolyte consumption in addition to improving access to medical care. This review also identified various factors that are unique to vulnerable agricultural populations, including migrant and child farmworkers. Our findings call for an urgent need to expand future research on vulnerable agricultural communities including migrant workers so as to develop effective policies and interventions that can protect these communities from the effects of heat stress.

28. Fang, J. K., Song, J., Wu, R. S., Xie, Y. F., Xu, X., Zeng, Y. P. Zhu, Y. T., Wang, T., Yuan, N. M., Xu, H. B., Song, X. M., Zhang, Q. H., Xu, B. P. and W. Huang, (2021), Association between ambient temperature and childhood respiratory hospital visits in Beijing, China: a time-series study (2013-2017), *Environmental Science and Pollution Research*, 28, 23, 9445-29454 DOI: 10.1007/s11356-021-12817.

Citations: 4

Abstract: Little is known on the potential impact of temperature on respiratory morbidity, especially for children whose respiratory system can be more vulnerable to climate changes. In this time-series study, Poisson generalized additive models combined with distributed lag nonlinear models were used to assess the associations between ambient temperature and childhood respiratory morbidity. The impacts of extreme cold and hot temperatures were calculated as cumulative relative risks (cum.RRs) at the 1st and 99th temperature percentiles relative to the minimum morbidity temperature percentile. Attributable fractions of respiratory morbidity due to cold or heat were calculated for temperatures below or above the minimum morbidity temperature. Effect modifications by air pollution, age, and sex were assessed in stratified analyses. A total of 877,793 respiratory hospital visits of children under 14 years old between 2013 and 2017

were collected from Beijing Children's Hospital. Overall, we observed J-shaped associations with greater respiratory morbidity risks for exposure to lower temperatures, and higher fraction of all-cause respiratory hospital visits was caused by cold (33.1%) than by heat (0.9%). Relative to the minimum morbidity temperature (25 degrees C, except for rhinitis, which is 31 degrees C), the cum.RRs for extreme cold temperature (-6 degrees C) were 2.64 (95%CI: 1.51-4.61) for all-cause respiratory hospital visits, 2.73 (95%CI: 1.44-5.18) for upper respiratory infection, 2.76 (95%CI: 1.56-4.89) for bronchitis, 2.12 (95%CI: 1.30-3.47) for pneumonia, 2.06 (95%CI: 1.27-3.34) for rhinitis, and 4.02 (95%CI: 2.14-7.55) for asthma, whereas the associations between extreme hot temperature (29 degrees C) and respiratory hospital visits were not significant. The impacts of extreme cold temperature on asthma hospital visits were greater at higher levels of ozone (O₃) exposure (> 50th percentile). Our findings suggest significantly increased childhood respiratory morbidity risks at extreme cold temperature, and the impact of extreme cold temperature on asthma hospital visits can be enhanced under higher level exposure to O₃.

29. Flores-Larsen, S., Filippin, C., (2021), Energy efficiency, thermal resilience, and health during extreme heat events in low-income housing in Argentina, *Energy and Buildings*, 231, 110576, DOI: 10.1016/j.enbuild.2020.110576

Citations: 10

Abstract: Extreme heat events result in higher indoor temperatures in buildings, increased energy consumption, and more frequent health problems, mainly between the children, the elderly over 65, and vulnerable low-income people. The indoor environment plays a key role in reducing the effects of extreme heat events. While the benefits of passive cooling measures on thermal and environmental aspects are well known, their effects on resilience are less well explored. This paper aims at studying the indoor environment in low-income housing from the energy and heat resilience points of view, during extreme hot periods, together with possible passive cooling measures to be applied in the houses in order to improve both, heat resilience and energy efficiency. A low-income neighbourhood in La Pampa, central Argentina, was selected as a case study. Transient thermal simulation, electricity consumption bills obtained from the Energy Company, and health statistics from the data-base of the nearby hospital were used. We conclude that the houses are not capable to manage hot/heat wave periods in a resilient way because of their energy inefficient design. Moreover, the cooling equipment is sub-used due to economic reasons. Indoor temperatures exceeded 33 degrees C and Heat Index reached "Extreme caution" health risk level. Sudden changes in the meteorological conditions seems to increase the number of consultations of health disorders previous or after the hot periods. The best set of passive strategies is to favour night ventilation

together with shading of the envelope (i.e., by trees, climbing plants, green walls, or by installing ventilated opaque facades) and an improved roof (light colour coating and addition of thermal insulation). These strategies could both, improve the heat resilience and the thermal behavior of the indoor environment while reducing the electricity consumption in the hottest months of summer

30. Garcia, D. M., and M. C. Sheehan, (2016), Extreme Weather-driven Disasters and Children's Health, *International Journal of Health Services*, 46, 1, 79-105, DOI: 10.1177/0020731415625254.

Citations: 29

Abstracts: Extreme weather events such as heat waves, extreme precipitation, and storm surges are likely to become more frequent and intense with climate change. Extreme weather-driven disasters (EWDDs) cause a substantial burden of childhood mortality and morbidity worldwide. We reviewed the published literature on EWDDs and their health impacts on children, and developed a conceptual model based on complex systems thinking to identify the health risks, vulnerabilities, and capacities of children in the context of EWDDs as a means of informing areas for adaptive intervention. We found that direct and indirect physical and mental impacts of EWDDs on child health are abundant and interrelate in complex ways. The literature review and modeling demonstrated the centrality of resilience at the level of the child and his or her direct environment, suggesting that mental health status may play a key role in a child's experience of numerous other health outcomes of EWDDs. EWDDs interact with environmental and social systems and with individual children and their contexts in complex ways, the impacts of which are nonlinear and difficult to predict. Traditional perspectives on climate change-driven health impacts often overlook complex bio-psychosocial interactions, suggesting a need to work on preventive strategies to reduce vulnerability and build individual child resilience.

31. Ghirardi, L., Bisoffi, G., Mirandola, R., Ricci, G., Baccini, M., (2015), The Impact of Heat on an Emergency Department in Italy: Attributable Visits among Children, Adults, and the Elderly during the Warm Season, *PLOS ONE*, 10, 10, e0141054 DOI: 10.1371/journal.pone.0141054

Citations: 5

Abstract: Recent studies suggest that heat is associated with an increase in the number of ambulance calls and emergency department visits. We investigated the association between heat and daily number of emergency department visits at the University Hospital of Verona during the warm seasons 2011-2012 and we assessed the magnitude of the impact in terms of attributable events, focusing on the role of age and triage codification.

Materials and methods

We used a Poisson model to analyse the association between daily number of visits and daily mean apparent temperature, accounting for air pollution level and seasonality. The analyses were stratified by age group and were performed both on the total number of emergency department visits and on the subsample of high-priority visits. Impact estimates were obtained only for this subsample, using a Monte Carlo approach to account for sampling variability. Number of attributable events and attributable community rate were calculated.

Results

We found a positive and immediate association between event occurrence and mean apparent temperatures exceeding a threshold located around 28–29 degrees C. The estimated percent change in the total number of visits per 1 degrees C increase of exposure above the threshold was equal to 3.75 (90% CI: 3.01; 4.49). Focusing only on high-priority visits, the estimated percent change was larger and the greatest effect was among children. We estimated that apparent temperatures above the threshold were responsible for 1177 high-priority visits during the study period. Due to the record high temperatures observed in 2012 in Italy and in Europe, the impact in 2012 was much larger than in 2011, and consisted in 34 high-priority visits every 10000 children, 30 every 10000 people aged 15–64, and 38 every 10000 people aged 65 and over.

Discussion

Our results indicate that heat affects not only the elderly, but also children and non-elderly adults, stressing the need for developing public health preparedness plans for the entire community.

32. Glass, K., Tait, P. W., Hanna, E. G., and K. Dear, (2015), Estimating Risks of Heat Strain by Age and Sex: A Population-Level Simulation Model. *International Journal of Environmental Research and Public Health*, 12, 5: 5241–5255, DOI: 10.3390/ijerph120505241.

Citations: 14

Abstract: Individuals living in hot climates face health risks from hyperthermia due to excessive heat. Heat strain is influenced by weather exposure and by individual characteristics such as age, sex, body size, and occupation. To explore the population-level drivers of heat strain, we developed a simulation model that scales up individual risks of heat storage (estimated using Myrup and Morgan's man model MANMO) to a large population. Using Australian weather data, we identify high-risk weather conditions together with individual characteristics that increase the risk of heat stress under these conditions. The model identifies elevated risks in children and the elderly, with females aged 75 and older those most likely to experience heat strain. Risk of heat strain in males does not increase as rapidly with age, but is greatest on hot days with high solar radiation. Although

cloudy days are less dangerous for the wider population, older women still have an elevated risk of heat strain on hot cloudy days or when indoors during high temperatures. Simulation models provide a valuable method for exploring population level risks of heat strain, and a tool for evaluating public health and other government policy interventions.

33. Gribble, J., Paterson, M. and D. Brown (2019), Emergency preparedness for infant and young child feeding in emergencies (IYCF-E): an Australian audit of emergency plans and guidance, *BMC Public Health*, 19, 1, 1278, DOI: 10.1186/s12889-019-7528-0

Citations: 10

Abstract: Background Australia experiences a high incidence of natural emergencies and Australian governments have committed significant investment into emergency preparedness and response. Amongst the population groups most vulnerable to emergencies are infants and young children with their vulnerability centering around their specific food and fluid needs. For this reason, the World Health Assembly has urged all member states to develop and implement infant and young child feeding in emergency (IYCF-E) plans in line with international guidance. This study aimed to determine the degree to which Australia has complied with this direction by conducting an audit of Australian emergency plans and guidance. **Methods** Australian Federal, State/Territory and a sample of Local government emergency plans and guidance were located via web searches. Documents were searched for key words to identify content dealing with the needs of infants and young children. Plans and guidance were also searched for content dealing with the needs of animals as a comparison. **Results** While plans and guidance contained numerous pointers to the desirability of having plans that address IYCF-E, there was a dearth of planning at all levels of government for the needs of infants and young children. Guidance related to heat waves contained information that could prove dangerous to infants. No agency at Federal or State/Territory had designated responsibility for IYCF-E or children in general. This was in stark contrast to the situation of animals for which there was widespread and comprehensive planning at all levels of government with clear designation of organisational responsibility. **Conclusions** Lack of planning for IYCF-E in Australia places infants and young children at serious risk of adverse health consequences in emergencies. Australian Federal, State/Territory and Local governments need to take action to ensure that IYCF-E plans and guidance are developed and deployed in line with international standards. The pathway to successful integration of animal welfare plans provides a method for a similar integration of IYCF-E plans. Government health authorities are best placed to lead and be responsible for IYCF-E in Australia. National governments internationally

should similarly take action to ensure that their youngest, most vulnerable citizens are protected in emergencies.

34. Grubenhoff, J. A., du Ford, K., and G. E. Roosevelt, (2007), Heat-Related Illness, *Clinical Pediatric Emergency Medicine*, 8, 1: 59-64. DOI: 10.1016/j.cpem.2007.02.006.

Citations: 18

Abstract: Heat-related illnesses encompass disorders ranging from minor syndromes to life-threatening emergencies. The number of children suffering from heat-related illness is increasing. Because of physiologic differences and unique behavioral characteristics, children are at high risk for suffering heat-related illnesses. This article reviews physiologic responses to heat stress and highlights particular differences and behavioral considerations unique to children. It will address the diagnosis of heat-related illness in the emergency department, including the need for accurate temperature assessment and laboratory diagnostic tests. Management strategies follow a description of each illness. The science surrounding possible treatments for moderate to severe heat-related illness is reviewed.

35. Hajat, S., Gampe, D., Sarsour, A. and S. Abuzerr, (2022), Climate Change and Diarrhoeal Disease Burdens in the Gaza Strip, Palestine: Health Impacts of 1.5 degrees C and 2 degrees C Global Warming Scenarios, *International Journal of Environmental Research and Public Health*, 19, 8, 4898, DOI: 10.3390/ijerph19084898

Citation: 0

Abstract: The Gaza Strip is one of the world's most fragile states and faces substantial public health and development challenges. Climate change is intensifying existing environmental problems, including increased water stress. We provide the first published assessment of climate impacts on diarrhoeal disease in Gaza and project future health burdens under climate change scenarios. Over 1 million acute diarrhoea cases presenting to health facilities during 2009-2020 were linked to weekly temperature and rainfall data and associations assessed using time-series regression analysis employing distributed lag non-linear models (DLNMs). Models were applied to climate projections to estimate future burdens of diarrhoeal disease under 2 degrees C and 1.5 degrees C global warming scenarios. There was a significantly raised risk of diarrhoeal disease associated with both mean weekly temperature above 19 degrees C and total weekly rainfall below 6 mm in children 0-3 years. A heat effect was also present in subjects aged > 3 years. Annual diarrhoea cases attributable to heat and low rainfall was 2209.0 and 4070.3, respectively, in 0-3-year-olds. In both age-groups, heat-related cases could rise by over 10% under a 2 degrees C global warming level compared to baseline, but would be limited to

below 2% under a 1.5 degrees C scenario. Mean rises of 0.9% and 2.7% in diarrhoea cases associated with reduced rainfall are projected for the 1.5 degrees C and 2 degrees C scenarios, respectively, in 0–3-year-olds. Climate change impacts will add to the considerable development challenges already faced by the people of Gaza. Substantial health gains could be achieved if global warming is limited to 1.5 degrees C.

36. Hanna, R., and P. Oliva (2016), Implications of Climate Change for Children in Developing Countries, *Future of Children*, 26, 1, 115–132, DOI: 10.1353/foc.2016.0006.

Citations: 21

Abstract: Climate change may be particularly dangerous for children in developing countries. Even today, many developing countries experience a disproportionate share of extreme weather, and they are predicted to suffer disproportionately from the effects of climate change in the future. Moreover, developing countries often have limited social safety nets, widespread poverty, fragile health care systems, and weak governmental institutions, making it harder for them to adapt or respond to climate change. And the fact that many developing countries have high birth rates and high ratios of children to adults (known as high dependency ratios) means that proportionately more children are at risk there than in the developed world. In this article, Rema Hanna and Paulina Oliva delve into climate change's likely implications for children in developing countries. Such children already face severe challenges, which climate change will likely exacerbate. In particular, most people in developing countries still depend primarily on agriculture as a source of income, and so anything that reduces crop yields such as excessive heat or rain is likely to directly threaten the livelihoods of developing-country families and their ability to feed their children. Poor nutrition and economic disruption are likely to lower children's scholastic achievement or even keep them out of school altogether. Children in developing countries also face more-severe threats from both air and water pollution; from infectious and parasitic diseases carried by insects or contaminated water; and from possible displacement, migration, and violence triggered by climate change. How can we temper the threat to children in developing countries? Hanna and Oliva write that we should design and fund policies to shield children in developing nations from the harm caused by climate change. Such policies might include developing new technologies, inventing more-weather-resistant crops, improving access to clean water, increasing foreign aid during disasters, and offering more assistance to help poor countries expand their safety net programs.

37. Heidenreich, A., Buchner, M., Walz, A., and A. H. Thielen (2021), How to Deal with Heat Stress at an Open-Air Event? Exploring Visitors' Vulnerability, Risk Perception,

and Adaptive Behavior with a Multimethod Approach, *Weather, Climate and Society*, 13, 4, 989–1002, DOI: 10.1175/WCAS-D-21-0027.1

Citations: 0

Abstract: Heat waves are increasingly common in many countries across the globe, and also in Germany, where this study is set. Heat poses severe health risks, especially for vulnerable groups such as the elderly and children. This case study explores visitors' behavior and perceptions during six weekends in the summer of 2018 at a 6-month open-air horticultural show. Data from a face-to-face survey (n = 306) and behavioral observations (n = 2750) were examined by using correlation analyses, ANOVA, and multiple regression analyses. Differences in weather perception, risk awareness, adaptive behavior, and activity level were observed between rainy days (maximum daily temperature, 25 degrees C), warmsummer days (25 degrees–30 degrees C), and hot days (>30 degrees C). Respondents reported a high level of heat risk awareness, but most (90%) were unaware of actual heat warnings. During hot days, more adaptive measures were reported and observed. Older respondents reported taking the highest number of adaptive measures. We observed the highest level of adaptation in children, but they also showed the highest activity level. From our results we discuss how to facilitate individual adaptation to heat stress at open-air events by taking the heterogeneity of visitors into account. To mitigate negative health outcomes for citizens in the future, we argue for tailored risk communication aimed at vulnerable groups.

38. Ho, H. C., Knudby, A., Chi, G. Q., Aminopouri, M., Lai, D. Y. F. (2018), Spatiotemporal analysis of regional socio-economic vulnerability change associated with heat risks in Canada, *Applied Geography*, 95, 61–70, DOI: 10.1016/j.apgeog.2018.04.015

Citations: 31

Abstract: Excess mortality can be caused by extreme hot weather events, which are increasing in severity and frequency in Canada due to climate change. Individual and social vulnerability factors influence the mortality risk associated with a given heat exposure. We constructed heat vulnerability indices using census data from 2006 to 2011 in Canada, developed a novel design to compare spatiotemporal changes of heat vulnerability, and identified locations that may be increasingly vulnerable to heat. The results suggest that 1) urban areas in Canada are particularly vulnerable to heat, 2) suburban areas and satellite cities around major metropolitan areas show the greatest increases in vulnerability, and 3) heat vulnerability changes are driven primarily by changes in the density of older ages and infants. Our approach is applicable to heat vulnerability analyses in other countries.

39. Hotz, I. C., Hajat, S., (2020), The Effects of Temperature on Accident and Emergency Department Attendances in London: A Time-Series Regression Analysis, *International Journal of Environmental Research and Public Health*, 17, 6, 1957, DOI: 10.3390/ijerph17061957.

Citations: 7

Abstract: The epidemiological research relating mortality and hospital admissions to ambient temperature is well established. However, less is known about the effect temperature has on Accident and Emergency (A&E) department attendances. Time-series regression analyses were conducted to investigate the effect of temperature for a range of cause- and age-specific attendances in Greater London (LD) between 2007 to 2012. A seasonally adjusted Poisson regression model was used to estimate the percent change in daily attendances per 1 degrees C increase in temperature. The risk of overall attendance increased by 1.0% (95% CI 0.8, 1.4) for all ages and 1.4% (1.2, 1.5) among 0- to 15-year-olds. A smaller but significant increase in risk was found for cardiac, respiratory, cerebrovascular and psychiatric presentations. Importantly, for fracture-related attendances, the risk rose by 1.1% (0.7, 1.5) per 1 degrees C increase in temperature above the identified temperature threshold of 16 degrees C, with the highest increase of 2.1% (1.5, 3.0) seen among 0- to 15-year-olds. There is a positive association between increasing temperatures and A&E department attendance, with the risk appearing highest in children and the most deprived areas. A&E departments are vulnerable to increased demand during hot weather and therefore need to be adequately prepared to address associated health risks posed by climate change.

40. Iniguez, C., Schifano, P., Asta, F., Michelozzi, P., Vicedo-Cabrera, A., and F. Ballester, (2016), Temperature in summer and children's hospitalizations in two Mediterranean cities, *Environmental Research*, 150, 236-244, DOI: 10.1016/j.envres.2016.06.007.

Citations: 11

Abstract: Background and objective: Children are potentially vulnerable to hot ambient temperature. However, the evidence on heat-related children's morbidity is still scarce. Our aim was to examine the association between temperatures in summer (May to September) and children's hospitalizations in two Mediterranean cities, Rome and Valencia, during the period 2001-2010. Methods: Quasi-Poisson generalised additive models and distributed lag non-linear models were combined to study the relationship between daily mean temperature and hospital admissions for all natural, respiratory and gastrointestinal diseases in children under 15 years of age. Associations were summarised as the percentage of change (Ch%) in admissions at 50th, 75th, 90th, 95th and 98th percentiles of

temperature in summer compared to 1.) the 50th percentile in the whole year (50th(y)) and 2.) the preceding percentile in the previous series. Cumulated risks were obtained for groups of lags showing a similar pattern: 0-1, 2-7, 8-14 and 15-21 days. Results: Almost whatever increase of temperature from 50th(y) was significantly associated with an increase of paediatric hospitalizations by all natural diseases at short term (lag 0-1), while small increases at high temperatures only had a delayed effect on this outcome. The same pattern was observed in Rome for respiratory admissions, while in Valencia only a delayed association (days 8-14) was observed. The increase of temperature from 50th to 75th percentiles was associated at short time to an increase of gastrointestinal admissions in both cities. Conclusion: Children's hospitalizations rose with heat in Rome and Valencia. Patterns of delays and critical windows of exposure mainly varied according the outcome considered.

41. Ito, Y., Akahane, M., and T. Imamura, (2018), Impact of Temperature in Summer on Emergency Transportation for Heat-Related Diseases in Japan, *Chinese Medical Journal*, 131, 5, 574-582.

Citations: 9

Abstract: Background: In Japan, the demand for emergency transportation for people with heat-related illness has recently increased. The purpose of this study was to investigate the relationship between incidents of heat-related illness and the daily maximum temperature.

Methods: The daily maximum temperatures in Japan's 11 districts over the past 10 years were classified into four categories, with cutoff points at the 50th, 95th, and higher than 95th percentiles. We then conducted a logistic regression analysis of emergency transportation demand in each temperature category by age group, using the 50th percentile as the reference category for each area. Results: There were 42,931 cases of emergency transportation due to heat-related diseases during the study period. Classified by age, 12.5%, 43.4%, and 44.1% of cases involved children, adults, and elderly people, respectively. The analysis showed that the number of cases of emergency transportation for people with heat-related diseases (per 100,000 people; corresponding to a 1.0 degrees C increase in the daily maximum temperature) was 0.016-0.106 among children (24.9-169.9 children required emergency transportation for heat-related diseases), from 0.013 to 0.059 among adults (19.8-98.2 adults required emergency transportation), and from 0.045 to 0.159 among elderly persons (30.0-145.4 elderly people required emergency transportation). The risk was highest for elderly persons, followed by children and finally adults. Cases of emergency transportation due to heat-related illness increased by 2.4-8.9 times when the daily maximum temperature was approximately 1.5 degrees C above the mean daily maximum temperature. In fact, the daily maximum temperature had a larger effect than the daily relative

humidity level on emergency transportation for people with heat-related diseases.

Conclusion: Public health organizations and health-care services should support elderly people and children, two high-risk groups for heat-related diseases.

42. Jiang, W., Liu, Z. Y., Ni, B., Xie, W. Q., Zhou, H. Y., and X. L. Li (2021), Independent and interactive effects of air pollutants and ambient heat exposure on congenital heart defects, *Reproductive Toxicology*, 104, 106–113, DOI: 10.1016/j.reprotox.2021.07.007.

Citations: 1

Abstract: Accumulating studies have been focused on the independent effects of air pollutants and ambient heat exposure on congenital heart defects (CHDs) but with inconsistent results, and their interactive effect remains unclear. A case-control study including 921 cases and 9210 controls was conducted in Changsha, China in warm season in 2015–2018. The gravidas were assigned monthly averages of daily air pollutants and daily maximum temperature using the nearest monitoring station method and city-wide average method, respectively, during the first trimester of pregnancy. Multivariate logistic regression models were used to estimate the independent effects of each air pollutant and different ambient heat exposure indicators. Their additive joint effects were quantified using attribute proportions of interaction (API). Increasing SO₂ consistently increased the risk of CHDs in the first trimester of pregnancy, with aORs ranging from 1.78 to 2.04. CO, NO₂ and PM_{2.5} exposure in the first month of pregnancy, and O₃ exposure in the second and third month of pregnancy were also associated with elevated risks of CHDs, with aORs ranging from 1.04 to 1.15. Depending on the ambient heat exposure indicator used, air pollutants showed more apparent synergistic effects (API > 0) with less and moderately intense heat exposure. Maternal exposure to CO, NO₂, SO₂, PM_{2.5} and O₃ during early pregnancy increased risk of CHDs, and ambient heat exposure may enhance these effects. Our findings help to understand the interactive effect of air pollution with ambient heat exposure on CHDs, which is of vital public health significance.

43. Junene, Z., Albers, P. N., Lucas, R. M., Banwell, C., Mathee, A. and C. Y. Wright, (2017), 'My child did not like using sun protection': practices and perceptions of child sun protection among rural black African mothers, *BMC Public Health*, 17, 677, DOI: 10.1186/s12889-017-4688-7

Citations: 4

Abstract: Background: Photodamage is partially mitigated by darker skin pigmentation, but immune suppression, photoaging and cataracts occur among individuals with all skin types.

Methods: To assess practices and acceptability to Black African mothers of sun protection equipment for their children living in a rural area, participants were recruited at the time of their child's 18-month vaccinations. Mothers completed a baseline questionnaire on usual sun behaviours and sun protection practices. They were then provided with sun protection equipment and advice. A follow-up questionnaire was administered two weeks later.

Results: Mothers reported that during the week prior to the baseline questionnaire, children spent on average less than 1 hour of time outdoors (most often spent in the shade). Most mothers (97%) liked the sun protection equipment. However, many (78 of 86) reported that their child did not like any of the sun protection equipment and two-thirds stated that the sun protection equipment was not easy to use. Conclusions: Among Black Africans in rural northern South Africa, we found a mismatch between parental preferences and child acceptance for using sun protection when outdoors. A better understanding of the health risks of incidental excess sun exposure and potential benefits of sun protection is required among Black Africans.

44. Kalimeri, K. K., Saraga, D. E., Lazaridis, V. D., Legkas, N. A., Missia, D. A., Tolis, E. I., and J. G. Bartzis, (2016), Indoor air quality investigation of the school environment and estimated health risks: Two-season measurements in primary schools in Kozani, Greece, *Atmospheric Pollution Research*, 7, 6, 1128-1142.

Citations: 52

Abstract: Two primary schools and one kindergarten were selected in the city of Kozani, Greece in order to investigate the school environment, the indoor air pollutants that children are exposed to and possible health risks at school. In each school three classrooms and one outdoor position were monitored from Monday to Friday, in both non-heating (26/09/2011-14/10/2011) and heating (23/01/2012-10/02/2012) period. Temperature, relative humidity and CO₂, were continuously monitored. Formaldehyde, benzene, trichloroethylene, pinene, limonene, NO₂ and O₃ were measured with diffusive samplers. CO was monitored every day (30 min/day). Radon was measured for four weeks with short term radon detectors. PM_{2.5} was gravimetrically determined while PM_{2.5} and PM₁₀ fractions were measured using the optical light scattering technique. Building material emission testing for VOCs was performed using the Field and Laboratory Emission Cell (FLEC). The ventilation rate for each classroom was calculated based on the CO₂ measurements. Results indicated that indoor air concentrations of the measured pollutants were within accepted limits with indicative ranges 1.5-9.4 $\mu\text{g}/\text{m}^3$ for benzene, 2.3-28.5 $\mu\text{g}/\text{m}^3$ for formaldehyde, 4.6-43 mg/m^3 for NO₂ and 0.1-15.6 $\mu\text{g}/\text{m}^3$ for O₃. Emissions from building materials seem to have a significant contribution to the indoor air quality. Very low ventilation rates (0.1-3.7 L/s per person) were observed,

indicating inadequate ventilation and possible indoor air quality problems requiring intervention measures. The estimated average lifetime cancer risks for benzene, formaldehyde and trichloroethylene were very low.

45. Kampe, E. O. I., Kovats, S., Hajat, S. (2016), Impact of high ambient temperature on unintentional injuries in high-income countries: a narrative systematic literature review. *BMJ Open*, 6, 2, e010399 DOI: 10.1136/bmjopen-2015-010399.

Citations: 43

Abstract: Objectives: Given the likelihood of increased hot weather due to climate change, it is crucial to have prevention measures in place to reduce the health burden of high temperatures and heat waves. The aim of this review is to summarise and evaluate the evidence on the effects of summertime weather on unintentional injuries in high-income countries.

Design: 3 databases (Global Public Health, EMBASE and MEDLINE) were searched by using related keywords and their truncations in the title and abstract, and reference lists of key studies were scanned. Studies reporting heatstroke and intentional injuries were excluded.

Results: 13 studies met our inclusion criteria. 11 out of 13 studies showed that the risk of unintentional injuries increases with increasing ambient temperatures. On days with moderate temperatures, the increased risk varied between 0.4% and 5.3% for each 1 degrees C increase in ambient temperature. On extreme temperature days, the risk of injuries decreased. 2 out of 3 studies on occupational accidents found an increase in work-related accidents during high temperatures. For trauma hospital admissions, 6 studies reported an increase during hot weather, whereas 1 study found no association. The evidence for impacts on injuries by subgroups such as children, the elderly and drug users was limited and inconsistent.

Conclusions: The present review describes a broader range of types of unintentional fatal and non-fatal injuries (occupational, trauma hospital admissions, traffic, fire entrapments, poisoning and drug overdose) than has previously been reported. Our review confirms that hot weather can increase the risk of unintentional injuries and accidents in high-income countries. The results are useful for injury prevention strategies

46. Kanner, J., Williams, A. D., Nobles, C., Ha, S., Ouidir, M., Sherman, S., and P. Mendola, (2020), Ambient temperature and stillbirth: Risks associated with chronic extreme temperature and acute temperature change, *Environmental Research*, 189, 109958, DOI: 10.1016/j.envres.2020.109958.

Citations: 9

Abstract: Background: Ambient temperature events are increasing in frequency and intensity. Our prior work in a U.S. nationwide study suggests a strong association between both chronic and acute temperature extremes and stillbirth risk. Objective: We attempted to replicate our prior study by assessing stillbirth risk associated with average whole-pregnancy temperatures and acute ambient temperature changes in a low-risk U.S. population.

Methods: Singleton deliveries in the NICHD Consecutive Pregnancies Study (Utah, 2002–2010; n = 112,005) were identified using electronic medical records. Ambient temperature was derived from the Weather Research and Forecasting model. Binary logistic regression determined the adjusted odds ratio (aOR) and 95% confidence interval (95% CI) for stillbirth associated with whole-pregnancy exposure to extreme cold (<10th percentile) and hot (>90th percentile) versus moderate (10th–90th percentiles) average temperature, adjusting for maternal demographics, season of conception, hypertensive disorders of pregnancy, and gestational diabetes. In a case-crossover analysis, we estimated the stillbirth aOR and 95% CI for each 1 degrees Celsius increase during the week prior to delivery using conditional logistic regression. In both models, we adjusted for relative humidity, ozone, and fine particulates. **Results:** We observed 500 stillbirth cases among 498 mothers. Compared to moderate temperatures, whole-pregnancy exposure to extreme cold (aOR: 4.42, 95% CI:3.43, 5.69) and hot (aOR: 5.06, 95% CI: 3.34, 7.68) temperatures were associated with stillbirth risk. Case-crossover models observed a 7% increased odds (95% CI: 1.04, 1.10) associated with each 1 degrees Celsius increase during the week prior to delivery.

Discussion: Both chronic and acute ambient temperature were associated with odds of stillbirth in this low-risk population, similar to our prior nationwide findings. Future increases in temperature extremes are likely and the observed risk in a low-risk population suggests this association merits attention.

47. Kennedy, E., Olsen, H., Vanos, J., Vecellio, D. J., Desat, M., Richters, K., Rutledge, A., and G. R. A. Richardson, (2021), Reimagining spaces where children play: developing guidance for thermally comfortable playgrounds in Canada, *Canadian Journal of Public Health–Revue Canadienne De Sante Publique*, 112, 4, S1, 706–713, DOI: 10.17269/s41997-021-00522-7

Citations: 2

Abstract: Setting Planning and designing thermally comfortable outdoor spaces is increasingly important in the context of climate change, particularly as children are more vulnerable than adults to environmental extremes. However, existing playground standards focus on equipment and surfacing to reduce acute injuries, with no mention of potential negative health consequences related to heat illness, sun exposure, and other thermal extremes. The goal of this project was to develop proposed guidelines for designing thermally comfortable playgrounds in Canada

for inclusion within the CAN/CSA-Z614 Children's playground equipment and surfacing standard. Intervention The project to develop guidance for thermally comfortable playgrounds was initiated with a municipal project in Windsor, Ontario, to increase shade, vegetation, and water features at parks and playgrounds to provide more comfortable experiences amid the increased frequency of hot days (≥ 30 degrees C). The lack of available information to best manage environmental conditions led to a collaborative effort to build resources and raise awareness of best practices in the design of thermally comfortable playgrounds. Outcomes A group of multidisciplinary experts developed technical guidance for improving thermal comfort at playgrounds, including a six-page thermal comfort annex adopted within a national playground and equipment standard. The annex has been used by Canadian schools in a competition to design and implement green playgrounds. Implications Both the technical report and the thermal comfort annex provide increased awareness and needed guidance for managing environmental conditions at playgrounds. Thermally safe and comfortable play spaces will help ensure that Canada's playgrounds are designed to minimize environmental health risks for children.

48. Knowlton, K., Rotkin-Ellman, M., King, G., Margolis, H. G., Smith, D., Solomon, G., Trent, R., and P. English (2009), The 2006 California Heat Wave: Impacts on Hospitalizations and Emergency Department Visits, *Environmental Health Perspectives*, 117, 1, 61-67, DOI: 10.1289/ehp.11594

Citations: 465

Abstract: BACKGROUND: Climate models project that heat waves will increase in frequency and severity. Despite many studies of mortality from heat waves, few studies have examined morbidity. OBJECTIVES: In this study we investigated whether any age or race/ethnicity groups experienced increased hospitalizations and emergency department (ED) visits overall or for selected illnesses during the 2006 California heat wave.

METHODS: We aggregated county-level hospitalizations and ED visits for all causes and for 10 cause groups into six geographic regions of California. We calculated excess morbidity and rate ratios (RRs) during the heat wave (15 July to 1 August 2006) and compared these data with those of a reference period (8-14 July and 12-22 August 2006).

RESULTS: During the heat wave, 16,166 excess ED visits and 1,182 excess hospitalizations occurred statewide. ED visits for heat-related causes increased across the state [RR = 6.30; 95% confidence interval (CI), 5.67-7.01], especially in the Central Coast region, which includes San Francisco. Children (0-4 years of age) and the elderly (≥ 65 years of age) were at greatest risk. ED visits also showed significant increases for acute renal failure, cardiovascular diseases, diabetes, electrolyte imbalance, and nephritis. We observed significantly elevated

RRs for hospitalizations for heat-related illnesses (RR = 10.15; 95% CI, 7.79-13.43), acute renal Failure, electrolyte imbalance, and nephritis.

CONCLUSIONS: The 2006 California heat wave had a substantial effect on morbidity, including regions with relatively modest temperatures. This suggests that population acclimatization and adaptive capacity influenced risk. By better understanding these impacts and population vulnerabilities, local communities can improve heat wave preparedness to cope with a globally warming future.

49. Kousky, C. (2016), Impacts of Natural Disasters on Children, *Future of Children*, 26, 1: 73-92. DOI: 10.1353/foc.2016.0004.

Citations: 71

Abstract: We can expect climate change to alter the frequency, magnitude, timing, and location of many natural hazards. For example, heat waves are likely to become more frequent, and heavy downpours and flooding more common and more intense. Hurricanes will likely grow more dangerous, rising sea levels will mean more coastal flooding, and more-frequent and more intense droughts will produce more wildfires. Children, particularly the poor and those in developing countries, are at risk. Carolyn Kousky considers three ways that natural disasters may harm children disproportionately, often with long-lasting effects. First, disasters can damage children's physical health. Children may be injured or killed, but they may also suffer from such things as malnutrition caused by disruptions in food supply or diarrheal illness caused by contaminated water. Moreover, disasters can cut off access to medical care, even for non-disaster-related illnesses. Second, disasters can cause mental health problems. Not only are disasters themselves stressful and frightening, but children can suffer psychological harm from the damage to their homes and possessions; from migration; from the grief of losing loved ones; from seeing parents or caregivers undergo stress; from neglect and abuse; and from breakdowns in social networks, neighborhoods, and local economies. Third, disasters can interrupt children's education by displacing families, destroying schools, and pushing children into the labor force to help their families make ends meet in straitened times. How can we mitigate the dangers to children even as disasters become more powerful and more frequent? For one thing, we can prepare for disasters before they strike, for example, by strengthening school buildings and houses. Kousky also describes actions that have been proven to help children after a disaster, such as quickly reuniting them with parents and caregivers. Finally, a range of policies not designed for disasters can nonetheless help mitigate the harm disasters cause children and their families. In fact, Kousky writes, using existing safety net programs may be easier, faster, and more effective than creating entirely new programs after a disaster occurs.

50. Kravchenko, J., Abernethy, A. P., Fawzy, M., and H. K. Lyerly, (2013), Minimization of Heatwave Morbidity and Mortality, *American Journal of Preventive Medicine*, 44, 3, 274-282 DOI: 10.1016/j.amepre.2012.11.015.

Citations: 105

Abstract: Global climate change is projected to increase the frequency and duration of periods of extremely high temperatures. Both the general populace and public health authorities often underestimate the impact of high temperatures on human health. To highlight the vulnerable populations and illustrate approaches to minimization of health impacts of extreme heat, the authors reviewed the studies of heat-related morbidity and mortality for high-risk populations in the U.S. and Europe from 1958 to 2012.

Heat exposure not only can cause heat exhaustion and heat stroke but also can exacerbate a wide range of medical conditions. Vulnerable populations, such as older adults; children; outdoor laborers; some racial and ethnic subgroups (particularly those with low SES); people with chronic diseases; and those who are socially or geographically isolated, have increased morbidity and mortality during extreme heat. In addition to ambient temperature, heat-related health hazards are exacerbated by air pollution, high humidity, and lack of air-conditioning. Consequently, a comprehensive approach to minimize the health effects of extreme heat is required and must address educating the public of the risks and optimizing heatwave response plans, which include improving access to environmentally controlled public havens, adaptation of social services to address the challenges required during extreme heat, and consistent monitoring of morbidity and mortality during periods of extreme temperatures.

51. Lam, L. T., (2007a), Association between climatic factors and childhood illnesses presented to hospital emergency among young children, *Progress in Environmental Science and Technology*, 1, 1442-1446.

Citations: 0

Abstract: There has been an increasing concern about the effect of climatic change on human health in recent years. It has been suggested that young children are particularly at risk due to the reduced regulating mechanism against extreme climatic changes. However, few studies on the associations between climatic factors and childhood illness, specifically among young children, have been found in the literature. This epidemiological study utilised data collected on all young patients aged less than 6 years who presented to an Emergency Department for a period of two years. Information on climate and outdoor air quality variables was obtained from the Bureau of Meteorology. Data were analysed with various ARIMA time series models for each common childhood illness. Results suggested that maximum daily temperature was a significant risk

factor for fever ($t=5.29$, $p<0.001$) with a regression coefficient of 0.37 (SE=0.07) and gastroenteritis ($t=2.69$, $p=0.007$) with a regression coefficient of 0.10 (SE=0.04). The UV index was also found to be significantly but negatively related to gastroenteritis ($t=-2.37$, $p=0.018$). However, none of the climatic variables were associated with respiratory problems after adjusting for other air quality variables and infectious disease.

52. Lee, M., Shi, L., Zanobetti, A., and J. D. Schwartz, (2016), Study on the association between ambient temperature and mortality using spatially resolved exposure data, *Environmental Research*, 151, 610–617. DOI: 10.1016/j.envres.2016.08.029

Citations: 56

Abstract: There are many studies that have posited an association between extreme temperature and increased mortality. However, most studies use temperature at a single station per city as the reference point to analyze deaths. This leads to exposure misclassification and usually the exclusion of exurban, small town, and rural populations. In addition, few studies control for confounding by PM_{2.5}, which is expected to induce upward bias. The high-resolution temperature and PM_{2.5} data at a resolution of 1 km² were derived from satellite images and other land use sources. To capture the nonlinear association of temperature with mortality we fit a piecewise linear spline function for temperature, with a change in slope at 1 degrees C and 28 degrees C, the temperature threshold at which mortality in Georgia, North Carolina, and South Carolina increases due to cold and heat, respectively. We conducted stratified analyses by age group, sex, race, education, and urban vs nonurban, as well as sensitivity analyses of different temperature threshold and covariate sets. We found a 0.19% (95% CI = -0.98, 1.34%) increase in mortality for each 1 degrees C decrease in temperature below 1 degrees C and a 2.05% (95% CI = 0.87, 3.24%) increase in mortality for each 1 degrees C increase in temperature above 28 degrees C, a 79.8% larger effect size for heat compared to the station-based metric. The effect estimates relying on the monitoring stations were 0.09% (95% CI = -0.79, 0.95%) and 1.14% (95% CI = 0.08, 1.57%) for the equivalent temperature changes. The estimates were not confounded by PM_{2.5}. Children under 15 years of age had the largest percentage increase per 1 degrees C increase in temperature (8.19%, 95% CI = -0.38 to 17.49%) followed by Blacks (4.35%, 95% CI = 2.22 to 6.53%). Higher education was a protective factor for the effect of extreme temperature on mortality. There was a suggestion that people in less urban areas were more susceptible to extreme temperature. The relationship between temperature and mortality was stronger when using exposure data with more spatial variability than using exposure data based on existing monitors alone.

53. Li, M. M., Gu, S. H., Bi, P., Yang, J., and Q. Y. Liu (2015), Heat Waves and Morbidity: Current Knowledge and Further Direction—A Comprehensive Literature Review, *International Journal of Environmental Research and Public Health*, 12, 5, 5256–5283. DOI: 10.3390/ijerph120505256.

Citations: 128

Abstracts: In the past few decades, several devastating heat wave events have significantly challenged public health. As these events are projected to increase in both severity and frequency in the future, it is important to assess the relationship between heat waves and the health indicators that can be used in the early warning systems to guide the public health response. Yet there is a knowledge gap in the impact of heat waves on morbidity. In this study, a comprehensive review was conducted to assess the relationship between heat waves and different morbidity indicators, and to identify the vulnerable populations. The PubMed and ScienceDirect database were used to retrieve published literature in English from 1985 to 2014 on the relationship between heat waves and morbidity, and the following MeSH terms and keywords were used: heat wave, heat wave, morbidity, hospital admission, hospitalization, emergency call, emergency medical services, and outpatient visit. Thirty-three studies were included in the final analysis. Most studies found a short-term negative health impact of heat waves on morbidity. The elderly, children, and males were more vulnerable during heat waves, and the medical care demand increased for those with existing chronic diseases. Some social factors, such as lower socioeconomic status, can contribute to heat-susceptibility. In terms of study methods and heat wave definitions, there remain inconsistencies and uncertainties. Relevant policies and guidelines need to be developed to protect vulnerable populations. Morbidity indicators should be adopted in heat wave early warning systems in order to guide the effective implementation of public health actions.

54. Li, Q., Guo, Y. M., Wei, D. M., Song, Y., Song, J. Y., Ma, J., and H-J. Wang (2016), Does local ambient temperature impact children's blood pressure? A Chinese National Survey, *Environmental Health*, 15, 21, DOI: 10.1186/s12940-016-0119-y.

Citations: 10

Abstract: Background: Several studies demonstrated a short-term association between ambient temperature and blood pressure. However, few studies have assessed the long-term effect of ambient temperature on children's blood pressure. The present study aimed to investigate the association between long-term exposure to local ambient temperature and children's blood pressure in China. Methods: We analyzed the systolic (SBP) and diastolic blood pressure (DBP) data of 71,763 children from 2010 Chinese National Survey on Students' Construction and Health (CHNSCH), and local annual average ambient

temperature, relative humidity, air pollutants data from China Meteorological Administration and Ministry of Environment Protection of China. We used generalized additive model (GAM) with non-linear function to examine the effects of ambient temperature on children's blood pressure. Results: The results showed that decrease of ambient temperature was negatively associated with increase of both SBP and DBP in Chinese children while adjusting for individual characteristics, socioeconomic conditions, air pollutants and relative humidity. The largest alteration of SBP related to the temperature difference was observed from 20.4 to 9.6 degrees C, with 9.0 mmHg (95 % CI: 8.4, 9.5) increase in SBP, while the largest alteration of DBP was observed from 21.7 to 10.2 degrees C, with 6.1 mmHg (95 % CI: 5.6, 6.6) increase in DBP. However, when temperature below 9.6 and 10.2 degrees C, SBP and DBP started to decrease, which might be caused by the use of heating system in the extreme cold areas. Conclusions: Public health policy should be improved for protecting children's cardiovascular health from adverse effects of low temperature. Development of heating system in moderate cold area might be a good solution.

55. Lin, Y. F., Hu, W. J., Xu, J., Luo, Z. C., Ye, X. F., Yan, C. H., Lui, Z. W., and S. L. Tong (2017), Association between temperature and maternal stress during pregnancy, *Environmental Research*, 158, 421-430, DOI: 10.1016/j.envres.2017.06.034

Citations: 23

Abstract: Background: Maternal psychological stress during pregnancy has essentially been conceptualized as a teratogen. However, little is known about the effect of temperature on maternal stress during pregnancy. The aim of this study is to investigate the relationship between temperature and maternal stress during pregnancy. Methods: In 2010, a total of 1931 eligible pregnant women were enrolled across Shanghai from four prenatal care clinics during their mid-to-late pregnancy. Maternal life-event stress and emotional stress levels during pregnancy were assessed by the "Life Event Scale for Pregnant Women" (LESPW) and "Symptom Checklist-90 Revised Scale" (SCL-90-R), respectively. Exposure to ambient temperature was evaluated based on daily regional average in different moving average and lag days. The generalized estimating equations were used to evaluate the relationship between daily average temperature/temperature difference and maternal stress. Results: After adjusting for relevant confounders, an U-shaped relationship was observed between daily average temperature and maternal Global-Severity-Index (GSI) of the SCL-90-R. Cumulative exposures to extremely low temperatures (< P5, 1.4-10.5 degrees C, lag 0-1 days, 0-2 days and 0-5 days) and extremely high temperatures (a P95, 31.2-34.1 degrees C, lag 0-1 days and 0-2 days), and acute exposures to extremely low (lag day 0, 1, 2 and 3) and high (lag day 0, 1) temperatures, all induced higher risks of high GSI (the highest tertile), compared to the risk induced by exposed to an optimal

temperature range (20–25 degrees C) ($P < 0.05$). Increased temperature difference was associated with high maternal GSI ($P < 0.05$). However, non-significant associations were observed between daily average temperatures/temperature differences and maternal log-transferred LESPW scores.

Conclusions: Cumulative and acute exposures to extremely low/high temperatures may both induce emotional stress during pregnancy.

56. Lohrey, S., Chua, M., Gros, C., Faucet, J., and J. K. W. Lee, (2021), Perceptions of heat-health impacts and the effects of knowledge and preventive actions by outdoor workers in Hanoi, Vietnam, *Science of the Total Environment*, 794, 148260, DOI: 10.1016/j.scitotenv.2021.14826.

Citations: 1

Abstract: Extreme heat is an increasing climate threat, most pronounced in urban areas where poor populations are at particular risk. We analyzed heat impacts and vulnerabilities of 1027 outdoor workers who participated in a KAP survey in Hanoi, Vietnam in 2018, and the influence of their mitigation actions, their knowledge of heat-risks, and access to early warnings. We grouped respondents by their main income (vendors, builders, shippers, others, multiple jobs, and nonworking) and analyzed their reported heat-health impacts, taking into consideration socioeconomics, knowledge of heat impacts and preventive measures, actions taken, access to air-conditioning, drinking amounts and use of weather forecasts. We applied linear and logistic regression analyses using R. Construction workers were younger and had less knowledge of heat-health impacts, but also reported fewer symptoms. Older females were more likely to report symptoms and visit a doctor. Access to air-conditioning in the bedroom depended on age and house ownership, but did not influence heat impacts as cooling was too expensive. Respondents who knew more heat exhaustion symptoms were more likely to report impacts ($p < 0.01$) or consult a doctor ($p < 0.05$). Similarly, those who checked weather updates were more likely to report heat impacts ($p < 0.01$) and experienced about 0.6 more symptoms ($p < 0.01$). Even though occupation type did not explain heat illness, builders knew considerably less (40%; $p < 0.05$) about heat than other groups but were twice as likely to consult a doctor than street vendors ($p < 0.01$). Knowledge of preventive actions and taking these actions both correlated positively with reporting of heat-health symptoms, while drinking water did not reduce these symptoms ($p < 0.01$). Child carers and homeowners experienced income losses in heatwaves ($p < 0.01$). The differences support directed actions, such as dissemination of educational materials and weather forecasts for construction workers. The Red Cross assisted all groups with cooling tents, provision of drinks and health advice.

57. Malmquist, A., Lundgren, T., H., Hjerpe, M., Glaas, E., Turner, E., and S. Storbjork. Vulnerability and adaptation to heat waves in preschools: Experiences, impacts and responses by unit heads, educators and parents, *Climate Risk Management*, 31, 100271 DOI: 10.1016/j.crm.2020.100271.

Citations: 4

Abstract: With global warming, heat waves are becoming more frequent and intense, particularly in northern latitudes, where the pace of warming is faster. Due to its northern location, Swedish society has been built primarily to manage a cold climate, and is less prepared to manage heat, which the 2018 heat wave demonstrated. While young children are recognized as vulnerable to heat, and are reliant on preschool care, few studies have examined how the young and vulnerable people are cared for during heat waves in the institutional preschool setting. This exploratory study demonstrates how children in preschool environments are vulnerable to heat, in order to identify management needs by assessing experienced impacts and responses to the 2018 heat wave in Sweden. Empirically, the study builds on a survey completed by 33 unit heads responsible for 77 preschools in the focused municipality, and qualitative interviews with five educators and five parents, as well as temperature measurements in three selected preschools. This study shows that: (i) children and educators are exposed to both high indoor and outdoor temperatures in the preschools; (ii) both children and educators were affected by the heat wave in the preschools, and their sensitivity is deeply intertwined due to their dependency relationship, rendering a form of double sensitivity to heat; and (iii) the preschool heads and educators were unprepared to sufficiently cope with the heat wave, and organizational strategies for managing heat were lacking, indicating weak adaptive capacity. The significant exposure to heat in preschool environments, the dual sensitivity of children and preschool educators, and the low organizational readiness resulting in uncoordinated responses to reduce heat stress suggest a pronounced vulnerability to heat waves in preschools.

58. Margolis, H. G., (2014), Heat Waves and Rising Temperatures: Human Health Impacts and the Determinants of Vulnerability, *Climate Change and Public Health*, 7, 85-120, DOI: 10.1007/978-1-4614-8417-2_6

Citations: 11

Abstract: Globally, heat waves account for dramatic increases in mortality and morbidity; however, there is increasing awareness that day-to-day increases in temperature contribute to a significant risk of heat-related morbidity and mortality (HRMM) that over one or more warm seasons may exceed the public health burden of heat waves. Climate change has already and will continue to increase both average ambient temperatures and the frequency and intensity of

excursions above those averages (i.e., heat waves or extreme heat events) and will thereby lead directly and indirectly to amplification of the risk of HRMM. This chapter provides a brief synopsis of our current knowledge about thermoregulation, thermotolerance and the pathophysiology of heat stroke, and the multiple determinants of health and illness that influence the risk of HRMM and that collectively define vulnerability. A particular focus is on two vulnerable populations, older adults and children. An Environmental Health Multiple-Determinant Model of Vulnerability is presented as a conceptual framework to integrate that knowledge, with the intent of providing a tool that can facilitate compilation and translation of the information to interventions and adaptation strategies relevant at the individual level and/or subpopulation and population levels and at one or more geopolitical scales in developing and/or developed nations. Three overarching strategies for HRMM risk reduction are discussed, including Extreme Heat Event and Warm Season Heat Preparedness and Response Action Plans, Promote Good Health and Access to Quality Healthcare (reduces risk and increases resiliency), and Reduce/Manage Potential Exposure(s) (individual, community) to Ambient Heat and Other Physical Environmental Stressors. A key focus of this chapter is on integration and translation of knowledge.

59. Martin-Conty, J. L., Martin-Rodriguez, F., Criado-Alvarez, J. J., Castillo-Sarmiento, C. A., Maestre-Miquel, C., Mohedano-Moriano, A., Polonio-Lopez, B., Durantez-Fernandez, C., Castro-Villamor, M. A., and A. Vinuela, (2020), How Health Habits Influence the Physiological Response During a Physical Activity in Extreme Temperatures? *International Journal of Environmental Research and Public Health*, 17, 1, 6374 DOI: 10.3390/ijerph17176374.

Citations: 0

Abstract: Background: The purpose of the study was to determine to what degree the health habits of university students influence their physiological response during a 10-min high-intensity exercise. Methods: We conducted a cross-sectional cohort study with 59 health science students, in which we analyzed their adherence to a Mediterranean and low-fat diet, as well as their activity levels. We correlated these factors with the physiological response (lactic acid and heart rate) and a series of anthropometric parameters in intense physical activity (cardiopulmonary resuscitation (CPR) for 10 min) in three scenarios: extreme cold, extreme heat and a control situation at room temperature. Results: The results of this study demonstrate that in university students, a greater adherence to the Mediterranean diet was associated with a better response to physical exercise, in this case, 10-min CPR, in hostile environments. Conclusions: Following healthy eating guidelines improves physical performance and delays the appearance of fatigue; both are important aspects for a better performance of CPR.

60. Mason, H., King, J. C., Peden, A. E., and R. C. Franklin, (2022), Systematic review of the impact of heatwaves on health service demand in Australia, *BMC Health Services Research*, 22, 1, 960, DOI: 10.1186/s12913-022-08341-3.

Citations: 0

Abstract: Objectives: Heatwaves have been linked to increased levels of health service demand in Australia. This systematic literature review aimed to explore health service demand during Australian heatwaves for hospital admissions, emergency department presentations, ambulance call-outs, and risk of mortality. Study design: A systematic review to explore peer-reviewed heatwave literature published from 2000 to 2020. Data sources: Articles were reviewed from six databases (MEDLINE, Scopus, Web of Science, PsychINFO, ProQuest, Science Direct). Search terms included: heatwave, extreme heat, ambulance, emergency department, and hospital. Studies were included if they explored heat for a period of two or more consecutive days. Studies were excluded if they did not define a threshold for extreme heat or if they explored data only from workers compensation claims and major events. Data synthesis: This review was prospectively registered with PROSPERO (#CRD42021227395). Forty-five papers were included in the final review following full-text screening. Following a quality assessment using the GRADE approach, data were extracted to a spreadsheet and compared. Significant increases in mortality, as well as hospital, emergency, and ambulance demand, were found across Australia during heatwave periods. Admissions for cardiovascular, renal, respiratory, mental and behavioural conditions exhibited increases during heatwaves. The most vulnerable groups during heatwaves were children (< 18 years) and the elderly (60+). Conclusions: Heatwaves in Australia will continue to increase in duration and frequency due to the effects of climate change. Health planning is essential at the community, state, and federal levels to mitigate the impacts of heatwaves on health and health service delivery especially for vulnerable populations. However, understanding the true impact of heatwaves on health service demand is complicated by differing definitions and methodology in the literature. The Excess Heat Factor (EHF) is the preferred approach to defining heatwaves given its consideration of local climate variability and acclimatisation. Future research should explore evidence-based and spatially relevant heatwave prevention programs. An enhanced understanding of heatwave health impacts including service demand will inform the development of such programs which are necessary to promote population and health system resilience.

61. Mathew, S., Mathur, D., Chang, A. B. McDonald, E., Singh, G., R., and D. Nur (2017), Examining the Effects of Ambient Temperature on Pre-Term Birth in Central

Australia, *International Journal of Environmental Research and Public Health*, 14, 2, 147, DOI: 10.3390/ijerph14020147.

Citations: 18

Abstract: Preterm birth (born before 37 completed weeks of gestation) is one of the leading causes of death among children under 5 years of age. Several recent studies have examined the association between extreme temperature and preterm births, but there have been almost no such studies in arid Australia. In this paper, we explore the potential association between exposures to extreme temperatures during the last 3 weeks of pregnancy in a Central Australian town. An immediate effect of temperature exposure is observed with an increased relative risk of 1%-2% when the maximum temperature exceeded the 90th percentile of the summer season maximum temperature data. Delayed effects are also observed closer to 3 weeks before delivery when the relative risks tend to increase exponentially. Immediate risks to preterm birth are also observed for cold temperature exposures (0 to -6 degrees C), with an increased relative risk of up to 10%. In the future, Central Australia will face more hot days and less cold days due to climate change and hence the risks posed by extreme heat is of particular relevance to the community and health practitioners.

62. McMahon, K., and C. Gray, (2021), Climate change, social vulnerability and child nutrition in South Asia, *Global Environmental Change: Human and Policy Dimensions*, 71, 102414, DOI: 10.1016/j.gloenvcha.2021.102414.

Citations: 1

Abstract: Despite recent advancements in global population well-being and food security, climate change threatens to undermine child nutritional health, particularly for marginalized populations in tropical low- and middle-income countries. South Asia is at particular risk for climate-driven undernutrition due to a combination of historical weather exposures, existing nutritional deficits, and a lack of sanitation access. Previous studies have established that precipitation extremes increase rates of undernutrition in this region, but the existing literature lacks adequate consideration of temperature anomalies, mediating social factors, and the developmentally-relevant timing of exposure. We combine high-resolution temperature and precipitation data with large-sample survey data on household demographics and child anthropometry, using an approach that incorporates three key developmental periods and a rigorous fixed effects design. We find that precipitation extremes in the first year of life significantly decrease children's height-for-age (HAZ) in South Asia. The detrimental effects of extreme precipitation are especially concentrated in under-resourced households, such as those lacking access to proper sanitation and education for women, while anomalous heat is particularly harmful for children in Pakistan, though it tends to

benefit children in some demographic groups. These results indicate that nutritional status in South Asia is highly responsive to climate exposures, and that addressing sanitation infrastructure and other development priorities is a pathway towards reducing this vulnerability.

63. McMichael, A. J. (2014), Climate Change and Children: Health Risks of Abatement Inaction, Health Gains from Action. *Children-Basel*, 1, 2, 99–106 DOI: 10.3390/children1020099.

Citations: 10

Abstract: As human-driven climate change advances, many adults fret about the losses of livelihoods, houses and farms that may result. Children fret about their parents' worries and about information they hear, but do not really understand about the world's climate and perhaps about their own futures. In chronically worried or anxious children, blood cortisol levels rise and adverse changes accrue in various organ systems that prefigure adult-life diseases. Meanwhile, for many millions of children in poor countries who hear little news and live with day-to-day fatalism, climate change threatens the fundamentals of life—food sufficiency, safe drinking water and physical security—and heightens the risks of diarrhoeal disease, malaria and other climate-sensitive infections. Poor and disadvantaged populations, and especially their children, will bear the brunt of climate-related trauma, disease and premature death over the next few decades and, less directly, from social disruption, impoverishment and displacement. The recent droughts in Somalia as the Indian Ocean warmed and monsoonal rains failed, on top of chronic civil war, forced hundreds of thousands of Somali families into north-eastern Kenya's vast Dadaab refugee camps, where, for children, shortages of food, water, hygiene and schooling has endangered physical, emotional and mental health. Children warrant special concern, both as children per se and as the coming generation likely to face ever more extreme climate conditions later this century. As children, they face diverse risks, from violent weather, proliferating aeroallergens, heat extremes and mobilised microbes, through to reduced recreational facilities, chronic anxieties about the future and health hazards of displacement and local resource conflict. Many will come to regard their parents' generation and complacency as culpable.

64. Mirsaeidi, M., Motahair, H., Khamesi, M. T., Sharifi, A., Campos, M., Schraufnagel, D. E., (2016), Climate Change and Respiratory Infections, *Annals of the American Thoracic Society*, 13, 8, 1223–1230, DOI: 10.1513/AnnalsATS.201511-729PS

Citations: 73

Abstract: The rate of global warming has accelerated over the past 50 years. Increasing surface temperature is melting glaciers and raising the sea level. More

flooding, droughts, hurricanes, and heat waves are being reported. Accelerated changes in climate are already affecting human health, in part by altering the epidemiology of climate-sensitive pathogens. In particular, climate change may alter the incidence and severity of respiratory infections by affecting vectors and host immune responses. Certain respiratory infections, such as avian influenza and coccidioidomycosis, are occurring in locations previously unaffected, apparently because of global warming. Young children and older adults appear to be particularly vulnerable to rapid fluctuations in ambient temperature. For example, an increase in the incidence in childhood pneumonia in Australia has been associated with sharp temperature drops from one day to the next. Extreme weather events, such as heat waves, floods, major storms, drought, and wildfires, are also believed to change the incidence of respiratory infections. An outbreak of aspergillosis among Japanese survivors of the 2011 tsunami is one such well-documented example. Changes in temperature, precipitation, relative humidity, and air pollution influence viral activity and transmission. For example, in early 2000, an outbreak of Hantavirus respiratory disease was linked to a local increase in the rodent population, which in turn was attributed to a two-to threefold increase in rainfall before the outbreak. Climate-sensitive respiratory pathogens present challenges to respiratory health that may be far greater in the foreseeable future.

65. Mitchell, B. C., Chakraborty, J., and B. Pratyusha, (2021), Social Inequities in Urban Heat and Greenspace: Analyzing Climate Justice in Delhi, India, *International Journal of Environmental Research and Public Health*, 18, 9, 4800, DOI: 10.3390/ijerph18094800.

Citations: 2

Abstract: Climate change and rapid urbanization currently pose major challenges for equitable development in megacities of the Global South, such as Delhi, India. This study considers how urban social inequities are distributed in terms of burdens and benefits by quantifying exposure through an urban heat risk index (UHRI), and proximity to greenspace through the normalized difference vegetation index (NDVI), at the ward level in Delhi. Landsat derived remote sensing imagery for May and September 2011 is used in a sensitivity analysis of varying seasonal exposure. Multivariable models based on generalized estimating equations (GEEs) reveal significant statistical associations ($p < 0.05$) between UHRI/NDVI and several indicators of social vulnerability. For example, the proportions of children ($\beta = 0.922$, $p = 0.024$) and agricultural workers ($\beta = 0.394$, $p = 0.016$) are positively associated with the May UHRI, while the proportions of households with assets ($\beta = -1.978$, $p = 0.017$) and households with electricity ($\beta = -0.605$, $p = 0.010$) are negatively associated with the May UHRI. In contrast, the proportions of children ($\beta = 0.001$, $p = 0.633$) and agricultural workers (β

= 0.002, $p = 0.356$) are not significantly associated with the May NDVI, while the proportions of households with assets ($\beta = 0.013$, $p = 0.010$) and those with electricity ($\beta = 0.008$, $p = 0.006$) are positively associated with the May NDVI. Our findings emphasize the need for future research and policies to consider how socially vulnerable groups are inequitably exposed to the impact of climate change-related urban heat without the mitigating effects of greenspace.

66. Mueller, V., Gray, C., Kosec, K. (2014), Heat stress increases long-term human migration in rural Pakistan, *Nature Climate Change*, 4, 3, 182-185, DOI: 10.1038/NCLIMATE2103.

Citations: 194

Abstract: The Eastern Mediterranean and Middle East (EMME) region has rapid population growth, large differences in socio-economic levels between developed and developing countries, migration, increased water demand, and ecosystems degradation. The region is experiencing a significant warming trend with longer and warmer summers, increased frequency and severity of heat waves, and a drier climate. While climate change plays an important role in contributing to political instability in the region through displacement of people, food insecurity, and increased violence, it also increases the risks of vector-, water-, and food-borne diseases. Poorer and less educated people, young children and the elderly, migrants, and those with long-term health problems are at highest risk. A result of the inequalities among EMME countries is an inconsistency in the availability of reliable evidence about the impacts on infectious diseases. To help address this gap, a search of the literature was conducted as a basis for related recommended responses and suggested actions for preparedness and prevention. Since climate change already impacts the health of vulnerable populations in the EMME and will have a greater impact in future years, risk assessment and timely design and implementation of health preparedness and adaptation strategies are essential. Joint national and cross-border infectious diseases management systems for more effective preparedness and prevention are needed, supported by interventions that improve the environment. Without such cooperation and effective interventions, climate change will lead to an increasing morbidity and mortality in the EMME from infectious diseases, with a higher risk for the most vulnerable populations.

67. Nelson, N. G., Collins, C. L., Comstock, D., and L. B. McKenzie (2011), Exertional Heat-Related Injuries Treated in Emergency Departments in the U.S., 1997-2006, *American Journal of Preventive Medicine*, 40, 1, 54-60, DOI: 10.1016/j.amepre.2010.09.031

Citations: 71

Abstract: Background: Exertional heat-related injuries are a risk to all physically active individuals in warm or hot environments. Unlike classic heat-related injury, exertional heat-related injuries do not require extreme ambient temperatures to cause injury. Still, exertional heat-related injuries, including heat cramps, heat syncope, heat exhaustion, heat stress, and heat stroke, can result in injuries causing a range of outcomes from minimal discomfort to death. Purpose: The purpose of this paper was to describe the epidemiology of exertional heat-related injuries treated in U. S. emergency departments. Methods: A retrospective analysis was conducted using data from the National Electronic Injury Surveillance System of the U. S. Consumer Product Safety Commission for all ages from 1997 through 2006. Data provided by the National Electronic Injury Surveillance System were used to calculate national estimates of exertional heat-related injuries. Trends of exertional heat-related injuries over time were analyzed using linear regression. Results: Nationally, an estimated 54,983 (95% CI = 39995, 69970) patients were treated in U. S. emergency departments for exertional heat-related injuries from 1997 to 2006. The number of exertional heat-related injuries increased significantly from 3192 in 1997 to 7452 in 2006 ($p = 0.002$), representing a 133.5% increase. The overall exertional heat-related injury rate per 100,000 U. S. population more than doubled from 1.2 in 1997 to 2.5 in 2006 ($p = 0.005$). Patients aged ≤ 19 years accounted for the largest proportion of exertional heat-related injuries (47.6%). The majority of exertional heat-related injuries were associated with performing a sport or exercising (75.5%) and yard work (11.0%). The majority of patients (90.4%) were treated and released from the emergency department. Patients aged ≤ 19 years sustained a larger proportion of sports and recreation exertional heat-related injuries, whereas patients aged 40–59 years and ≥ 60 years sustained a larger proportion of exertional heat-related injuries from yard work. Conclusions: This study confirms that although there is a risk of exertional heat-related injury among all physically active individuals, sports pose a specific risk for people of all ages especially among children and adolescents playing football. Many "everyday" activities such as yard work and home maintenance also pose risks of exertional heat-related injury, particularly to those aged ≥ 40 years. Further research on risk factors of exertional heat-related injuries during home maintenance and yard work as well as appropriate prevention practices is needed

68. Nguyen, V. T., Doan, Q. V., Tran, N. N., Luong, L. T. M., Chinh, P. M., Thai, P. K., Phung, D., Le, H. H. T. C., and T. N. Dang, (2022), The protective effect of green space on heat-related respiratory hospitalization among children under 5 years of age in Hanoi, Vietnam. *Environmental Science and Pollution Research*, DOI: 10.1007/s11356-022-21064-6.

Citations: 0

Abstract: Combined effects of global warming and rapid urbanization replace green spaces with urban facilities. Children in urban areas are at a higher risk of heat-related adverse health effects. Our study aimed to examine the protective effect of urban green space on heat-related respiratory hospitalization among children under 5 years of age in Hanoi, the capital city of Vietnam. We estimated district-specific meteorological conditions from 2010 to 2014 by using a dynamic downscaling approach with a fine-resolution numerical climate model. The green space in each district was calculated using satellite data. The attributable fraction of heat-related respiratory hospitalization was estimated using a two-stage model, including a distributed lag non-linear model (DLNM) coupled with multivariate meta-analysis. The association between heat-related respiratory hospitalization and green spaces at the district level was explored using a linear regression model. The central districts were more crowded and hotter, with less green spaces than the outer districts. At temperatures >34 degrees C (extreme heat threshold), the hospitalizations in the central districts increased significantly; however, in the outer districts, the hospitalization rate was insignificant. On average, extreme heat attributed 0.33% to citywide hospitalization, 0.35% in the center, and 0.32% in the outer region. Every 1% increase in the green space fraction will reduce heat-related respiratory hospitalization risk by 3.8%. Heat significantly increased the risk of respiratory hospitalization among children under 5 years in Hanoi, Vietnam. These findings are valuable for authorities to consider strategies to protect children's health against the effects of heat, including increasing green space.

69. Niu, L., Herrera, M. T., Girma, B., Liu, B. A., Schinasi, L., Clougherty, J. E., and P. E. Sheffield, High ambient temperature and child emergency and hospital visits in New York City, *Paediatric and Perinatal Epidemiology*, 36, 1: 36-44. DOI: 10.1111/ppe.12793.

Citations: 3

Abstract: Background Emerging literature has documented heat-related impacts on child health, yet few studies have evaluated the effects of heat among children of different age groups and comparing emergency department (ED) and hospitalisation risks. Objectives To examine the differing associations between high ambient temperatures and risk of ED visits and hospitalisations among children by age group in New York City (NYC). Methods We used New York Statewide Planning and Research Cooperative System (SPARCS) data on children aged 0-18 years admitted to NYC EDs ($n = 2\ 252\ 550$) and hospitals ($n = 228\ 006$) during the warm months (May-September) between 2005 and 2011. Using a time-stratified, case-crossover design, we estimated the risk of ED visits and hospitalisations associated with daily maximum temperature (T_{max}) for children of all ages and by age group. Results The average T_{max} over the study period

was 80.3 degrees F (range 50 degrees, 104 degrees F). Tmax conferred the greatest risk of ED visits for children aged 0–4, with a 6–day cumulative excess risk of 2.4% (95% confidence interval [CI] 1.7, 3.0) per 13 degrees F (ie interquartile range) increase in temperature. Children and adolescents 5–12 years (0.8%, 95% CI 0.1, 1.6) and 13–18 years (1.4%, 95% CI 0.6, 2.3) are also sensitive to heat. For hospitalisations, only adolescents 13–18 years had increased heat-related risk, with a cumulative excess risk of 7.9% (95% CI 2.0, 14.2) per 13 degrees F increase in Tmax over 85 degrees F. Conclusions This urban study in NYC reinforces that young children are particularly vulnerable to effects of heat, but also demonstrates the sensitivity of older children and adolescents as well. These findings underscore the importance of focussing on children and adolescents in targeting heat illness prevention and emergency response activities, especially as global temperatures continue to rise.

70. Noelke, C., McGovern, M., Corsi, D. J., Jiminez, M. P., Stern, A., Wing, I. S., and L. Berkman, (2016), Increasing ambient temperature reduces emotional well-being, *Environmental Research*, 151, 124–129, DOI: 10.1016/j.envres.2016.06.045.

Citations: 50

Abstract: This study examines the impact of ambient temperature on emotional well-being in the U.S. population aged 18+. The U.S. is an interesting test case because of its resources, technology and variation in climate across different areas, which also allows us to examine whether adaptation to different climates could weaken or even eliminate the impact of heat on well-being. Using survey responses from 1.9 million Americans over the period from 2008 to 2013, we estimate the effect of temperature on well-being from exogenous day-to-day temperature variation within respondents' area of residence and test whether this effect varies across areas with different climates. We find that increasing temperatures significantly reduce well-being. Compared to average daily temperatures in the 50–60 degrees F (10–16 degrees C) range, temperatures above 70 degrees F (21 degrees C) reduce positive emotions (e.g. joy, happiness), increase negative emotions (e.g. stress, anger), and increase fatigue (feeling tired, low energy). These effects are particularly strong among less educated and older Americans. However, there is no consistent evidence that heat effects on wellbeing differ across areas with mild and hot summers, suggesting limited variation in heat adaptation.

71. Nosrat, C., Altamirano, J., Anyamba, A., Caldwell, J. M., Damoah, R., Mutuku, F., Ndonga, B., LaBeaud, A. D., (2021), Impact of recent climate extremes on mosquito-borne disease transmission in Kenya, *PLOS Neglected Tropical Diseases*, 15, 3, e0009182 DOI: 10.1371/journal.pntd.0009182

Citations: 9

Abstract: Climate change and variability influence temperature and rainfall, which impact vector abundance and the dynamics of vector-borne disease transmission. Climate change is projected to increase the frequency and intensity of extreme climate events. Mosquito-borne diseases, such as dengue fever, are primarily transmitted by *Aedes aegypti* mosquitoes. Freshwater availability and temperature affect dengue vector populations via a variety of biological processes and thus influence the ability of mosquitoes to effectively transmit disease. However, the effect of droughts, floods, heat waves, and cold waves is not well understood. Using vector, climate, and dengue disease data collected between 2013 and 2019 in Kenya, this retrospective cohort study aims to elucidate the impact of extreme rainfall and temperature on mosquito abundance and the risk of arboviral infections. To define extreme periods of rainfall and land surface temperature (LST), we calculated monthly anomalies as deviations from long-term means (1983–2019 for rainfall, 2000–2019 for LST) across four study locations in Kenya. We classified extreme climate events as the upper and lower 10% of these calculated LST or rainfall deviations. Monthly *Ae. aegypti* abundance was recorded in Kenya using four trapping methods. Blood samples were also collected from children with febrile illness presenting to four field sites and tested for dengue virus using an IgG enzyme-linked immunosorbent assay (ELISA) and polymerase chain reaction (PCR). We found that mosquito eggs and adults were significantly more abundant one month following an abnormally wet month. The relationship between mosquito abundance and dengue risk follows a non-linear association. Our findings suggest that early warnings and targeted interventions during periods of abnormal rainfall and temperature, especially flooding, can potentially contribute to reductions in risk of viral transmission.

72. O'Neill, M. S., and K. L. Ebi (2009), Temperature Extremes and Health: Impacts of Climate Variability and Change in the United States, *Journal of Occupational and Environmental Medicine*, 51, 1, 13–25, DOI: 10.1097/JOM.0b013e318173e122

Citations: 207

Abstract: **Objective:** Vile evaluated temperature-related morbidity and mortality for the 2007 U.S. national assessment on impacts of climate change and variability on human health. **Methods:** We assessed literature published since the 2000 national assessment, evaluating epidemiologic studies, surveys, and studies projecting future impacts. **Results:** Under current climate change projections, heat waves and hot weather are likely to increase in frequency, with the over chill temperature distribution shifting away from the colder extremes. Vulnerable subgroups include communities in the northeastern and Midwestern U.S.; urban populations, the poor, the elderly, children, and those with impaired health or limited mobility. **Conclusions:** Temperature extremes and variability will remain

important determinants of health in the United States under climate change. Research needs include estimating exposure to temperature extremes; studying nonfatal temperature-related illness; uniform criteria for reporting heat-related health outcomes; and improving effectiveness of urban heat island reduction and extreme weather response plans.

73. O'Sullivan, K. C., and E. Chisholm, (2020), Baby it's hot outside: Balancing health risks and energy efficiency when parenting during extreme heat events, *Energy Research and Social Science*, 66, 101480, DOI: 10.1016/j.erss.2020.201480.

Citations: 6

Abstract: In an increasingly heating global climate, parents find themselves charged with managing the health risks of young children during more frequent and extreme heat events. We outline heat health risks posed to children, contrast our experiences and highlight health promotion policy tools and advice available to parents caring for children during extreme heat events in three cities in the United States of America, Germany, and New Zealand. We argue that balancing health and energy needs requires a variety of policy approaches and communication of these to parents to ensure child health protection during extreme heat events.

74. Oppenheimer, M., and J. K. Anttila-Hughes, (2016), *The Science of Climate Change*, *Future of Children*, 26, 1, 11-30, DOI: 10.1353/foc.2016.0001

Citations: 10

Abstract: Michael Oppenheimer and Jesse Anttila-Hughes begin with a primer on how the greenhouse effect works, how we know that Earth is rapidly getting warmer, and how we know that the recent warming is caused by human activity. They explain the sources of scientific knowledge about climate change as well as the basis for the models scientists use to predict how the climate will behave in the future. Although they acknowledge the large degree of uncertainty that surrounds predictions of what will happen decades or even centuries in the future, they also emphasize the near certainty that climate change has the potential to be extremely harmful to children. Most children around the world will face hotter, more extreme temperatures more frequently. Higher temperatures will directly affect children's health by increasing the rates of heatstroke, heat exhaustion, and heat-related mortality. Excessive heat is also likely to affect children indirectly by disrupting agricultural systems, driving up prices, and increasing food scarcity. Many of the world's children may see local demand for water outstrip supply, as shifting precipitation patterns dry out some regions of the world, make other regions wetter, and increase the frequency of both unusually dry periods and unusually severe rains. Mountain glaciers will recede further, significantly reducing

storage of winter snows and thus springtime runoff, which has traditionally been used to water fields and recharge reservoirs. Melting ice will also raise sea levels, triggering direct physical threats to children through flooding and erosion and indirect threats through migration and expensive adaptation. Climate change is also expected to make weather-based disasters more frequent and more damaging. This is particularly worrisome for children, not only because of the physical peril disasters pose but also because disasters can have debilitating long-term indirect effects on children. Damage to ecosystems from climate change may also harm children; for example, acidification of the world's oceans will reduce food supplies, and disease-carrying insects will invade new areas in response to changing rains and temperatures. In the face of such dire forecasts, Oppenheimer and Ant-Lila-Hughes argue, climate change forces us to directly confront the value we put on future children's wellbeing. Fortunately, we have reason for hope as well as for concern: "History," they write, "has demonstrated time and again that humans can tackle uncertain threats in times of need."

75. Pan, R. B., Gao, J. J., Wang, X., Bai, L. J., Wei, Q. N., Yi, W. Z., Xu, S. H., Duan, J., Cheng, Q., Zhang, Y. W., and H. Su. (2019), Impacts of exposure to humidex on the risk of childhood asthma hospitalizations in Hefei, China: Effect modification by gender and age, *Science of the Total Environment*, 691, 296–305. DOI: 10.1016/j.scitotenv.2019.07.026.

Citations: 14

Abstract: background: With global climate change, there is growing concern about the effects of temperature changes on childhood asthma. However, current research only focuses on the effects of temperature, while ignoring the adverse effects of humidity on children.

Objectives: Our study aimed to quantify the impact of humidex on childhood asthma hospitalizations, which combined temperature and humidity, and further to assess how the effect is modified by individual-factors, such as age and gender. **Methods:** Poisson generalized linear models combined with distributed lag nonlinear models were used to estimate the association between daily childhood asthma hospitalizations and humidex from 2013 to 2016. Air pollutants (CO, O₃, and NO₂) and wind velocity were modelled simultaneously using DLNM, as well as day of week, seasonality and long-term trend.

Results: Low humidex was associated with an increased risk of admissions for asthma in children. The adverse effect appeared on the 4th day, with the RR of 1.045 (95% CI: 1.007–1.084) and lasted until the 7th day (RR: 1.045, 95%CI: 1.006–1.085). Compared with the male, there was an immediate effect on female exposed to low humidex. And the female seems to be more sensitive to low humidex. Besides, the significant effects of humidex on children asthma were detected in the children with preschool and school-age, whereas not for the

subgroup of infants. And the school-age children are most sensitive to low humidex.

Conclusions: Low humidex was associated with the increased risk of admissions for childhood asthma in Hefei. Children suffering from asthma should avoid exposure to the low humidex environment, especially in female and school-age children. In addition, the index of humidex was more significant for disease prevention and public health than the average temperature. These findings may provide epidemiology evidence for formulating precaution guidelines to reduce the risk of childhood asthma hospitalizations.

76. Paterson, S. K., and C. N. Godsmark, (2020), Heat-health vulnerability in temperate climates: lessons and response options from Ireland, *Globalisation and Health*, 16, 1, 29, DOI: 10.1186/s12992-020-00554-7.

Citations: 7

Abstract: Background In Ireland, rising temperatures remains the climate projection that national climate scientists associate with the highest degree of confidence. However, the health challenge of heat has been largely absent from Ireland's public health sector. This is epitomised by the lack of a comprehensive public health-focused heat-health action plan or country-specific codes of practice for heat-health when working outdoors. Our objective is to highlight the anticipated heat-health challenges in Ireland, and other temperate regions, through analysing vulnerable groups and systems, reinforcing the need to respond. Methods A scoping literature review was conducted to determine how heat affects health of the vulnerable in temperate climatic regions, with a focus on Ireland. Additionally, national Google Trends data was coarsely analysed to determine whether heat is a growing societal concern. Results and discussion The heat-vulnerable include: older people; chronically ill; infants, pregnant women, children; outdoor workers; socio-economically disadvantaged; urban dwellers; food systems and the health sector. Google Trends data suggest an increase in heat-related health searches over time, demonstrating rising levels of concern to temperature increases, reinforcing a gap in national policy associated with communication of, and response to, the heat-health challenge. Specific, actionable recommendations for adaptation and mitigation strategies are proposed. Conclusion Heat poses a public and occupational health challenge, receiving limited attention in Ireland. Lack of a co-ordinated effort, places vulnerable populations at risk. Our recommendations, with reference to vulnerable groups and acknowledging the multi-sectoral nature of heat-health and climate change, advocate for the adoption of a "health and climate change in all policies" approach and the development of a public health-focused heat-health action plan.

77. Patz, J. A., Frumkin, H., Holloway, T., Vimont, D. J., and A. Haines, (2014), Climate Change Challenges and Opportunities for Global Health, JAMA – Journal of the American Medical Association, 312, 15, 1565–1580, DOI: 10.1001/jama.2014.13186.

Citations: 244

Abstract: IMPORTANCE Health is inextricably linked to climate change. It is important for clinicians to understand this relationship in order to discuss associated health risks with their patients and to inform public policy. OBJECTIVES

To provide new US-based temperature projections from downscaled climate modeling and to review recent studies on health risks related to climate change and the cobenefits of efforts to mitigate greenhouse gas emissions.

DATA SOURCES, STUDY SELECTION, AND DATA SYNTHESIS We searched PubMed and Google Scholar from 2009 to 2014 for articles related to climate change and health, focused on governmental reports, predictive models, and empirical epidemiological studies. Of the more than 250 abstracts reviewed, 56 articles were selected. In addition, we analyzed climate data averaged over 13 climate models and based future projections on downscaled probability distributions of the daily maximum temperature for 2046–2065. We also compared maximum daily 8-hour average ozone with air temperature data taken from the National Oceanic and Atmospheric Administration, National Climate Data Center.

RESULTS By 2050, many US cities may experience more frequent extreme heat days. For example, New York and Milwaukee may have 3 times their current average number of days hotter than 32 degrees C (90 degrees F). High temperatures are also strongly associated with ozone exceedance days, for example, in Chicago, Illinois. The adverse health aspects related to climate change may include heat-related disorders, such as heat stress and economic consequences of reduced work capacity; respiratory disorders, including those exacerbated by air pollution and aeroallergens, such as asthma; infectious diseases, including vectorborne diseases and waterborne diseases, such as childhood gastrointestinal diseases; food insecurity, including reduced crop yields and an increase in plant diseases; and mental health disorders, such as posttraumatic stress disorder and depression, that are associated with natural disasters. Substantial health and economic cobenefits could be associated with reductions in fossil fuel combustion. For example, greenhouse gas emission policies may yield net economic benefit, with health benefits from air quality improvements potentially offsetting the cost of US and international carbon policies. **CONCLUSIONS AND RELEVANCE** Evidence over the past 20 years indicates that climate change can be associated with adverse health outcomes. Health care professionals have an important role in understanding and communicating the related potential health concerns and the cobenefits from policies to reduce greenhouse gas emissions. Copyright 2014 American Medical Association. All rights reserved.

78. Paz, S., Majeed, A., and G. K. Christophides, (2021), Climate change impacts on infectious diseases in the Eastern Mediterranean and the Middle East (EMME)–risks and recommendations, *Climatic Change*, 169, 3–4, 40 DOI: 10.1007/s10584-021-03300-z.

Citations: 0

Abstract: The Eastern Mediterranean and Middle East (EMME) region has rapid population growth, large differences in socio-economic levels between developed and developing countries, migration, increased water demand, and ecosystems degradation. The region is experiencing a significant warming trend with longer and warmer summers, increased frequency and severity of heat waves, and a drier climate. While climate change plays an important role in contributing to political instability in the region through displacement of people, food insecurity, and increased violence, it also increases the risks of vector-, water-, and food-borne diseases. Poorer and less educated people, young children and the elderly, migrants, and those with long-term health problems are at highest risk. A result of the inequalities among EMME countries is an inconsistency in the availability of reliable evidence about the impacts on infectious diseases. To help address this gap, a search of the literature was conducted as a basis for related recommended responses and suggested actions for preparedness and prevention. Since climate change already impacts the health of vulnerable populations in the EMME and will have a greater impact in future years, risk assessment and timely design and implementation of health preparedness and adaptation strategies are essential. Joint national and cross-border infectious diseases management systems for more effective preparedness and prevention are needed, supported by interventions that improve the environment. Without such cooperation and effective interventions, climate change will lead to an increasing morbidity and mortality in the EMME from infectious diseases, with a higher risk for the most vulnerable populations.

79. Perera, F. P. (2008), Children are likely to suffer most from our fossil fuel addiction, *Environmental Health Perspectives*, 116, 8, 987–990, DOI: 10.1289/ehp.11173.

Citations: 48

Abstract: BACKGROUND: The periods of fetal and child development arguably represent the stages of greatest vulnerability to the dual impacts of fossil fuel combustion: the multiple toxic effects of emitted pollutants (polycyclic aromatic hydrocarbons, particles, sulfur oxides, nitrogen oxides, metals) and the broad health impacts of global climate change attributable in large part to carbon dioxide released by fossil fuel burning.

OBJECTIVES: In this commentary I highlight current scientific evidence indicating that the fetus and young child are at heightened risk of developmental impairment, asthma, and cancer from fossil fuel pollutants and from the predicted effects of climate disruption such as heat waves, flooding, infectious disease, malnutrition, and trauma. Increased risk during early development derives from the inherently greater biologic vulnerability of the developing fetus and child and from their long future lifetime, during which early insults can potentially manifest as adult as well as childhood disease. I cite recent reports concluding that reducing dependence on fossil fuel and promoting clean and sustainable energy is economically feasible. **DISCUSSION:** Although much has been written separately about the toxicity of fossil fuel burning emissions and the effects of climate change on health, these two faces of the problem have not been viewed together with a focus on the developing fetus and child. Adolescence and old age are also periods of vulnerability, but the potential for both immediate and long-term adverse effects is greatest when exposure occurs prenatally or in the early years. **CONCLUSIONS:** Consideration of the full spectrum of health risks to children from fossil fuel combustion underscores the urgent need for environmental and energy policies to reduce fossil fuel dependence and maximize the health benefits to this susceptible population. We do not have to leave our children a double legacy of ill health and ecologic disaster.

80. Phung, D., Rutherford, S., Chu, C., Wang, X. M., Nguyen, M., Nguyen H. H., Do, C. M., Ngguyen, T. H. and C. R. Huang, (2015), Temperature as a risk factor for hospitalisations among young children in the Mekong Delta area, Vietnam, *Occupational and Environmental Medicine*, 72, 7, 529–535 DOI: 10.1136/oemed-2014-102629.

Citations: 15

Abstract: Background The Mekong Delta is the most vulnerable region to climate change in South-East Asia; however, the association between climate and children's health has rarely been studied in this region. Objective We examined the short-term association between daily temperature and hospital admissions for all causes, gastrointestinal and respiratory infection, among young children in the Mekong Delta area in Vietnam. Methods Daily paediatric hospital admissions and meteorological data were obtained from January 2008 to December 2012. A time-series approach was used with a combination of a Poisson regression and constrained distributed lag models to analyse the data. The long-term and seasonal trends, as well as other time-varying covariates, were adjusted using spline functions. Temperature-pediatric admission relationship was evaluated by age-specific (0-2 and 3-5-year-olds) and cause of admission groupings. Results A 1 degrees C increase in the 2-day moving average temperature was significantly associated with a 3.4% (95% CI 1.2% to 5.5%), 4.6% (95% CI 2.2% to

7.3%), 2.6% (95% CI 0.6% to 4.6%), 4.4% (95% CI 0.6% to 8.2%) and 3.8% (95% CI 0.4% to 7.2%) increase in hospital admissions with 0–2-year-old children, 3–5-year-old children, all causes, gastrointestinal infection and respiratory infection, respectively. The cumulative effects from 1-day to 6-day moving average temperature on hospital admissions were greater for 3–5-year-old children and gastrointestinal infection than for 0–2-year-old children and other causes. Conclusions Temperature was found to be significantly associated with hospital admissions in young children with the highest association between temperature and gastrointestinal infection. The government agencies of Mekong Delta should implement measures to protect children from the changing temperature conditions related to climate change.

81. Rahman, J., Fakhruddin, S. H. M. Rahman, A. K. M. F., and M. A. Halim, Environmental Heat Stress Among Young Working Women: A Pilot Study, *Annals of Global Health*, 82, 5, 760–767. DOI: 10.1016/j.aogh.2016.07.007

Citations: 7

Abstract: BACKGROUND Heat waves are increasing significantly in frequency and severity and threaten the health and income of outdoor workers. Pregnant women workers are particularly at risk due to their delicate physiological systems and accountabilities to future generations. Animal and human studies propose that elevated body temperatures during pregnancy can induce adverse pregnancy outcomes. OBJECTIVE To measure the change in internal body temperature (T_{core}) in young working women before, after, and during work (both outdoor and indoor) on hot humid days and relate threshold temperature to the upshot adverse effects of pregnancy (teratogenicity and related miscarriage). METHODS Tympanic temperatures were measured using infrared ear thermometers and workplace temperatures were collected using Lascar Data Logger. Brief exploratory interviews were conducted to gather qualitative data, and content analysis was also carried out. FINDINGS Body temperatures were found elevated among outdoor women workers compared with that of indoor women workers. CONCLUSIONS The present study found that outdoor work during pregnancy in hot, humid days might increase body temperature up to levels that could induce fetal destruction or anomaly.

82. Rao, C. S., Gopinath, K. A., Prasad, J. V. N. S., and A. K. Singh (2016), Climate Resilient Villages for Sustainable Food Security in Tropical India: Concept, Process, Technologies, Institutions, and Impacts, *Advances in Agronomy*, 140, 101–214, DOI: 10.1016/bs.agron.2016.06.003.

Citations: 38

Abstract: The world population is expected to increase by a further three billion by 2050 and 90% of the three billion will be from developing countries that rely on existing land, water, and ecology for food and well-being of human kind. The Intergovernmental Panel on Climate Change (IPCC) in its fifth assessment report (AR5) stated that warming of the climate system is unequivocal and is more pronounced since the 1950s. The atmosphere and oceans have warmed, the amounts of snow and ice have diminished, and sea level has risen. Each of the last three decades has been successively warmer at the earth's surface than any preceding decade since 1850 and the globally averaged combined land and ocean surface temperature data as calculated by a linear trend show a warming of 0.85 degrees C (0.65–1.06 degrees C) over the period of 1880–2012. World Meteorological Organization (WMO) ranked 2015 as the hottest year on record. Climate change poses many challenges to growth and development in South Asia. The Indian agriculture production system faces the daunting task of feeding 17.5% of the global population with only 2.4% of land and 4% of water resources at its disposal. India is more vulnerable to climate change in view of the dependence of huge population on agriculture, excessive pressure on natural resources, and relatively weak coping mechanisms. The warming trend in India over the past 100 years has indicated an increase of 0.6 degrees C, which is likely to impact many crops, negatively impacting food and livelihood security of millions of farmers. There are already evidences of negative impacts on yield of wheat and paddy in some parts of India due to increased temperature, water stress, and reduction in number of rainy days. Significant negative impacts have been projected under medium-term (2020–39) climate change scenario, for example, yield reduction by 4.5–9%, depending on the magnitude and distribution of warming. Since agriculture currently contributes about 15% of India's gross domestic product (GDP), a negative impact on production implies cost of climate change to roughly range from 0.7% to 1.35% of GDP per year.

83. Rathi, S. K., and P. R. Sodani, (2021) Summer Temperature and all Cause Mortality from 2006 to 2015 for Hyderabad, India, *African Health Sciences*, 21, 3, 1474–1481 DOI: 10.4314/ahs.v21i3.59.

Citations: 0

Abstract: Background: Studies have documented a significant association between temperature and all-cause mortality for various cities but such data are unavailable for Hyderabad City. Objective: The objective of this work was to assess the association between the extreme heat and all-cause mortality for summer months (March to June) from 2006 to 2015 for Hyderabad city population. Methods: We obtained the data on temperature and all-cause mortality for at least ten years for summer months. Descriptive and Bivariate analysis were conducted. Pearson correlation coefficient was used to study the

relationship between heat and all-cause mortality for lag time effect. Results: A total of 122,117 deaths for 1,220 summer days (2006 to 2015) were analyzed with mean daily all-cause mortality was 100.1 +/- 21.5. There is an increase of 16% and 17% per day mean all-cause mortality at the maximum temperature of >= 40 degrees C and for extreme danger days (Heat Index >54 degrees C) respectively. The mean daily all-cause mortality shows a significant association with maximum temperature (P < 0.001) and Heat Index from caution to extreme danger risk days (P < 0.0183). The lag effect of extreme heat on all-cause mortality for the study period (2006 to 2015) was at peak on same day of the maximum temperature (r = 0.273 at p<0.01).

Conclusion: The study concludes that the impact of ambient heat in the rise of all-cause mortality is clearly evident (16% mean deaths/day). There was no lag effect from the effect of extreme heat on all-cause mortality as the peak period was the same as the maximum temperature. Hence heat action plans are needed. However, extreme heat-related mortality merits further analysis.

84. Ries, M., Zielonka, M., Ries, N., Breil, T., Garbade, S., and K. Mechler, (2019), Disasters in Germany and France: An Analysis of the Emergency Events Database From a Pediatric Perspective, *Disaster Medicine and Public Health Preparedness*, 13, 5-6, 958-965, DOI: 10.1017/dmp.2019.24

Citations: 63

Abstract: Objective: The objective of this study was to conduct comprehensive analyses of disaster patterns for Germany and France from a pediatric perspective. Methods: An analysis of the Emergency Events Database (EM-DAT), epidemiological database with standard methods of descriptive and comparative statistics respecting the strengthening the reporting of observational studies in epidemiology (STROBE) criteria, was performed. Results: Between 2006 and 2016, there were 41 and 42 disasters in Germany and France claiming 259 and 4973 lives, respectively. Ages of afflicted individuals were not specified in EM-DAT. In Germany, most events were storms (37%), extreme temperatures (17%), floods (17%), and transport accidents (17%). In France, most events were storms (45%), extreme temperatures (17%), floods (19%), and transport accidents (14%). In Germany, most lives (96) were lost in transport accidents. In France, most casualties were due to the heat waves of 2006 and 2015 (1388 and 3275). Reported event types in Germany and France were similar, but heat waves struck France more significantly than Germany. Conclusions: Pediatric data are not explicitly captured in EM-DAT, but reported disaster patterns suggest that exposures to heat and cold, storms, trauma, chemicals, water, and infectious agents are possible mechanisms of injury. Age-stratified disaster data are needed to enable a timely, transparent, coordinated, and sustained data-driven approach to pediatric disaster resilience.

85. Riojas-Rodriguez, H., Quezada-Jimenez, M. L., Zuniga-Bello, P., and M. Hurtado-Diaz (2018), *Climate Change and Potential Health Effects in Mexican Children*, *Annals of Global Health*, 84, 2, 281-284, DOI: 10.29024/aogh.915.

Citations: 2

Abstract: Climate change (CC) is the most important challenge of our time, a long-term global problem and one of the most serious global threats to human health in the future. CC is the expression of changes in temperature and water cycle, floods and drought events, extreme heat waves and sea level rise. Children are particularly vulnerable because they are highly sensitive to climate changes. The main environmental hazards affecting children's health are poor household drinking water quality and availability, lack access to adequate sanitary facilities, poor hygiene practices, outdoor and indoor air pollution, vector-borne diseases, chemical hazards, and unintentional injuries. Except for some unintentional injuries, these environmental hazards are associated to CC.

86. Rublee, C., Dresser, C., Guidice, C., Lemery, J., and C. Sorenson, (2021), *Evidence-Based Heatstroke Management in the Emergency Department*, *Western Journal of Emergency Medicine*, 22, 1, 186-195, DOI: 10.5811/westjem.2020.11.49007.

Citations: 2

Abstract: Introduction: Climate change is causing an increase in the frequency and intensity of extreme heat events, which disproportionately impact the health of vulnerable populations. Heatstroke, the most serious heat-related illness, is a medical emergency that causes multiorgan failure and death without intervention. Rapid recognition and aggressive early treatment are essential to reduce morbidity and mortality. The objective of this study was to evaluate current standards of care for the emergent management of heatstroke and propose an evidence-based algorithm to expedite care.

Methods: We systematically searched PubMed, Embase, and key journals, and reviewed bibliographies. Original research articles, including case studies, were selected if they specifically addressed the recognition and management of heatstroke in any prehospital, emergency department (ED), or intensive care unit population. Reviewers evaluated study quality and abstracted information regarding demographics, scenario, management, and outcome. Results: In total, 63 articles met full inclusion criteria after full-text review and were included for analysis. Three key themes identified during the qualitative review process included recognition, rapid cooling, and supportive care. Rapid recognition and expedited external or internal cooling methods coupled with multidisciplinary management were associated with improved outcomes. Delays in care are associated with adverse outcomes. We found no current scalable ED alert process

to expedite early goal-directed therapies. Conclusion: Given the increased risk of exposure to heat waves and the time-sensitivity of the condition, EDs and healthcare systems should adopt processes for rapid recognition and management of heatstroke. This study proposes an evidence-based prehospital and ED heat alert pathway to improve early diagnosis and resource mobilization. We also provide an evidence-based treatment pathway to facilitate efficient patient cooling. It is hoped that this protocol will improve care and help healthcare systems adapt to changing environmental conditions.

87. Schifano, P., Lallo, A., Asta, F., De Sario, M., Davoli, M., and P. Michelozzi, (2013), Effect of ambient temperature and air pollutants on the risk of preterm birth, Rome 2001-2010, *Environment International*, 61, 77-87, DOI: 10.1016/j.envint.2013.09.005.

Citations: 114

Abstract: Introduction: Although the prevalence of preterm births ranges from 5 to 13% and represents the leading cause of perinatal mortality and morbidity in developed countries, the etiology of preterm birth remains uncertain. We aimed to evaluate the effect of short-term exposure to high and low temperatures and air pollution on preterm delivery and to identify socio-demographic and clinical maternal risk factors enhancing individual susceptibility.

Methods: We analyzed all singleton live births by natural delivery that occurred in Rome in 2001-2010. A time-series approach was used to estimate the effect of exposure to minimum temperature, maximum apparent temperature, heat waves, particulate matter with an aerodynamic diameter of 10 μm or less (PM10), ozone, and nitrogen dioxide in the month preceding delivery; the analysis was conducted separately for cold and warm seasons. Socio-demographic and clinical risk factors were included as interaction terms. **Results:** Preterm births comprised nearly 6% of our cohort. An increase of 1.9% (95% confidence interval (CI) 0.86-2.87) in daily preterm births per 1 degrees C increase in maximum apparent temperature in the 2 days preceding delivery was estimated for the warm season. Older women, women with higher education levels, and women with obstetric or chronic pathologies reported during delivery had a lower effect of temperature on the risk of preterm birth, while women with a chronic disease in the two years before delivery and mothers < 20 years showed a higher effect. A + 19% (95% CI 7.91-31.69) increase in preterm births was observed during heat waves. Temperature had no effect during the cold season. We detected a significant effect of PM10 on preterm-birth risk at a lag period of 12-22 days during the warm season (+ 0.69%; 95% CI 0.23-1.15, for 1 $\mu\text{g}/\text{m}^3$ increase of pollutant); women with obstetric pathologies and with a higher education level showed a higher risk.

Conclusions: Our results suggest a possible short-term effect of heat and a more delayed and prolonged effect of PM10 exposure on preterm-birth risk, as well as the existence of more susceptible subgroups of women. Our observations support the few reported investigations, and may help to increase awareness among public-health stakeholders and clinicians regarding the role of these environmental exposures as risk factors for premature birth and health consequences for children later in life.

88. Shankar, H. M. and M. B. Rice (2020), Update on Climate Change Its Impact on Respiratory Health at Work, Home, and at Play, *Clinics in Chest Medicine*, 41, 4, 753, DOI: 10.1016/j.ccm.2020.08.004.

Citations: 1

Abstract: Climate change is a crisis of vast proportions that has serious implications for pulmonary health. Increasing global temperatures influence respiratory health through extreme weather events, wildfires, prolonged allergy seasons, and worsening air pollution. Children, elderly patients, and patients with underlying lung disease are at elevated risk of complications from these effects of climate change. This paper summarizes the myriad ways in which climate change affects the respiratory health of patients at home and in outdoor environments and outlines measures for patients to protect themselves

89. Shea, K. M., Truckner, R. T., Weber, R. w., and D. B. Peden (2008), Climate change and allergic disease, *Journal of Allergy and Clinical Immunology*, 122, 3, 443-453, Doi: 10.1016/j.jaci.2008.06.032.

Citations: 209

Abstract: Climate change is potentially the largest global threat to human health ever encountered. The earth is warming, the warming is accelerating, and human actions are largely responsible. If current emissions and land use trends continue unchecked, the next generations will face more injury, disease, and death related to natural disasters and heat waves, higher rates of climate-related infections, and wide-spread malnutrition, as well as more allergic and air pollution-related morbidity and mortality. This review highlights links between global climate change and anticipated increases in prevalence and severity of asthma and related allergic disease mediated through worsening ambient air pollution and altered local and regional pollen production. The pattern of change will vary regionally depending on latitude, altitude, rainfall and storms, land-use patterns, urbanization, transportation, and energy production. The magnitude of climate change and related increases in allergic disease will be affected by how aggressively greenhouse gas mitigation strategies are pursued, but at best an average warming of 1 to 2 degrees C is certain this century. Thus, anticipation of a

higher allergic disease burden will affect clinical practice as well as public health planning. A number of practical primary and secondary prevention strategies are suggested at the end of the review to assist in meeting this unprecedented public health challenge.

90. Sheffield, P. E., Durante, K. T., Rahona, E., Zarcadoolas, C., (2014), Emerging Roles of Health Care Providers to Mitigate Climate Change Impacts: A Perspective from East Harlem, New York, *Health and Human Rights*, 16, 1, 113-121.

Citations: 5

Abstract: Professional associations of health care workers are issuing policy statements on climate change and health with greater frequency, calling on their members to act in their duty to protect and fulfill the right to health. These health care providers' perceptions of their roles in the intersection of climate and health, however, have not been well-studied. This article presents results from a qualitative study using focus groups conducted with health care providers serving the low-income, ethnic minority population in East Harlem, New York. The focus groups sought to identify and explore providers' perceived health threats of climate change, as well as their perceived role as frontline disseminators of information and detectors of disease for their patients. Extreme heat events were used to frame the discussion in each group. Three major themes emerged: 1) environmental awareness, 2) an "ecohealth" lens, and 3) heat and health vulnerability. The participants demonstrated their interest in playing a role in climate change adaptation by identifying at-risk patients and helping to tailor clinical care to better serve these individuals.

91. Sheffield, P. E., Herrera, M. T., Kinnee, E. J., and J. E. Clougherty, (2018), Not so little differences: variation in hot weather risk to young children in New York City, *Public Health*, 161, SI, 119-126, DOI: 10.1016/j.puhe.2018.06.004.

Citations: 20

Abstract: Objectives: High ambient temperatures are associated with significant health risk in the United States. The risk to children has been minimally explored, and often young children are considered as a single age group despite marked physiologic and social variation among this population from infancy through preschool. This study explored the heterogeneity of risk of heat among young children. Study design: Using a time-stratified, case-crossover design, we evaluated associations-between maximum daily temperature (Tmax) and ED visits (n = 1,002,951) to New York City (NYC) metropolitan area hospitals for children aged 0-4 years in May-September, 2005-2011. Methods: Conditional logistic regression analysis estimated risks for an interquartile range of Tmax for

0–6 lag days. Stratified analyses explored age strata by year, race/ethnic groups, and diagnostic codes. Sensitivity analyses controlled for same day ambient ozone, particulate matter <2.5 microns, and relative humidity and, separately, explored race groups without ethnicity and different diagnostic code groupings. Results: Children ages 0–4 years had increased risk of emergency department visits with increased Tmax on lag days 0, 1, and 3. The association was strongest on lag day 0, when an increase in Tmax of 13 degrees F conferred an excess risk of 2.6% (95% confidence interval [CI]: 2.2–3.0). Stratifying by age, we observed significant positive associations for same-day exposures, for 1–4 year olds. Children less than 1 year of age showed a significant positive association with Tmax only on lag day 3. The race/ethnicity stratified analysis revealed a similar lag pattern for all subgroups. The diagnostic group analysis showed percent excess risk for heat-specific diagnoses (16.6% [95% CI: 3.0–31.9]); general symptoms (10.1% [95% CI: 8.2–11.9]); infectious (4.9% [95% CI: 3.9–5.9]); and injury (5.1% [95% CI: 3.8–6.4]) diagnoses. Conclusion: We found a significant risk of ED visits in young children with elevated Tmax. Risk patterns vary based on age with infants showing delayed risk and toddlers and pre-schoolers with same day risk. In addition, the finding of increased risk of injury associated with higher temperatures is novel. Altogether, these findings suggest a need for a tailored public health response, such as different messages to caregivers of different age children, to protect children from the effects of heat. Next steps include examining specific sub-categories of diagnoses to develop protective strategies and better anticipate the needs of population health in future scenarios of climate change.

92. Sheffield, P. E., and P. J. Landrigan, (2011), Global Climate Change and Children's Health: Threats and Strategies for Prevention, *Environmental Health Perspectives*, 119, 3, 291–298. DOI: 10.1289/ehp.1002233.

Citations: 190

Abstract: BACKGROUND: Global climate change will have multiple effects on human health. Vulnerable populations—children, the elderly, and the poor—will be disproportionately affected. OBJECTIVE: We reviewed projected impacts of climate change on children's health, the pathways involved in these effects, and prevention strategies. DATA SOURCES: We assessed primary studies, review articles, and organizational reports. DATA SYNTHESIS: Climate change is increasing the global burden of disease and in the year 2000 was responsible for > 150,000 deaths worldwide. Of this disease burden, 88% fell upon children. Documented health effects include changing ranges of vector-borne diseases such as malaria and dengue; increased diarrheal and respiratory disease; increased morbidity and mortality from extreme weather; changed exposures to toxic chemicals; worsened poverty; food and physical insecurity; and threats to human habitation. Heat-related health effects for which research is emerging include diminished

school performance, increased rates of pregnancy complications, and renal effects. Stark variation in these outcomes is evident by geographic region and socioeconomic status, and these impacts will exacerbate health disparities. Prevention strategies to reduce health impacts of climate change include reduction of greenhouse gas emissions and adaptation through multiple public health interventions. CONCLUSIONS: Further quantification of the effects of climate change on children's health is needed globally and also at regional and local levels through enhanced monitoring of children's environmental health and by tracking selected indicators. Climate change preparedness strategies need to be incorporated into public health programs.

93. Shortridge, A., Walker, W., White, D. D., Guardaro, M. M., Hondula, D. M., and J. K. Vanos (2022), HeatReady schools: A novel approach to enhance adaptive capacity to heat through school community experiences, risks, and perceptions. *Climate Risk Management*, 36, 100437, DOI: 10.1016/j.crm.2022.100437

Citations: 0

Abstract: The current landscape of heat safety culture in schools has received little attention in the literature. HeatReady Schools are those that are increasingly able to identify, prepare for, mitigate, track, and respond to the negative impacts of schoolground heat. This study set out to 1) improve our understanding of heat perceptions, reactions and actions, and heat safety recommendations of key stakeholders, and 2) identify themes from expert stakeholder responses to gauge the effectiveness of their heat preparedness levels in their current school environment. These objectives are focused on school heat readiness and child heat vulnerability in Phoenix, Arizona, USA. An exploratory sequential mixed-methods case study approach was used. Methods focused on acquiring new insight into heat perceptions at elementary schools through semi-structured interviews using thematic analysis and a repeatable Delphi panel approach. Participants included public health professionals and school community members in Central City South (CCS) and South Mountain Village (SMV) in Phoenix, Arizona. Findings demonstrate that 1) heat safety resources are available but not fully utilized within the schools, 2) expert opinions support extreme heat readiness plans accounting for site-specific needs, particularly education, and 3) students are negatively impacted by extreme heat, whether direct or indirect, both inside and outside the classroom. Thirty final recommendations were developed as important school "HeatReady" actions that can be applied or adapted for other school contexts and/or climate regions. Future work will apply these recommendations in a HeatReady School Growth Tool that schools can tailor to their individual needs for heat safety, risk management, and adaptive capacity.

94. Sinclair, W. H., Crowe, M. J., Spinks, W. L., and A. S. Leicht, (2007), Pre-pubertal children and exercise in hot and humid environments: A brief review, *Journal of Sports Science and Medicine*, 6, 4, 385–392.

Citations: 7

Abstract: The ability of pre-pubertal children to regulate their body temperature under thermoneutral environments is similar to that of an adult albeit via differing routes. However, this ability is challenged when exposed to extreme environments. Thermoregulatory responses of pre-pubertal children differ from adults via adaptations that occur during growth and maturation and disadvantage children when exercising in hot and humid environments. When ambient temperatures exceed that of the skin, an influx of thermal energy from the environment increases thermal stress. When coupled with exercise, the increased thermal stress results in reduced physical performance and an increased risk of developing heat-related illness. Evidence suggesting the severity of heat-related illness is greater in prepubertal children than adults is inconclusive because age-related differences in thermoregulatory responses are attributed to either morphologic or functional changes. Additionally, the majority of research on pre-pubertal children exercising in the heat has been maturational or comparative studies with adults conducted in the near absence of convective cooling, complicating extrapolation to field-based environments. However, current consensus is that pre-pubertal children are disadvantaged when exercising in extreme temperatures and that care should be taken in preparing for and conducting sporting activities in hot and humid environments for pre-pubertal children.

95. Sindall, R., Mecrow, T., Queiroga, A. C., Boyer, C., Koon, W., and A. E. Peden, (2022), *Injury Prevention*, 22, 2, 185–191, DOI: 10.1136/injuryprev-2021-044486

Citations: 1

Abstract: Drowning and climate change are both significant global health threats, yet little research links climate change to drowning risk. Research into the epidemiology, risk factors and preventive strategies for unintentional drowning in high-income and in low-income and middle-income countries has expanded understanding, but understanding of disaster and extreme weather-related drowning needs research focus. As nation states and researchers call for action on climate change, its impact on drowning has been largely ignored. This state-of-the-art review considers existing literature on climate change as a contributor to changes in drowning risks globally. Using selected climate change-related risks identified by the World Meteorological Organization and key risks to the Sustainable Development Goals as a framework, we consider the drowning risks

associated with heat waves, hydrometeorological hazards, drought and water scarcity, damaged infrastructure, marine ecosystem collapse, displacement, and rising poverty and inequality. Although the degree of atmospheric warming remains uncertain, the impact of climate change on drowning risk is already taking place and can no longer be ignored. Greater evidence characterising the links between drowning and climate change across both high-income and low-income and middle-income contexts is required, and the implementation and evaluation of drowning interventions must reflect climate change risks at a local level, accounting for both geographical variation and the consequences of inequality. Furthermore, collaboration between the injury prevention, disaster risk reduction and climate change mitigation sectors is crucial to both prevent climate change from stalling progress on preventing drowning and further advocate for climate change mitigation as a drowning risk reduction mechanism.

96. Singh, A. K., Shahi, S. K., Kumar, B., and M. K. Das, (2022), Is Ambient Weather a Risk Factor for Acute Encephalopathy Outbreaks in Children in Muzaffarpur, Bihar, India? Insight from a 9-Year Analysis, *Journal of Tropical Pediatrics*, 68, 1: fmab111. DOI: 10.1093/tropej/fmab111

Citations: 0

Abstract: Objectives Despite periodic outbreaks, the causes and risk factors of acute encephalitis syndrome (AES) in children of Muzaffarpur, Bihar, India, remain unknown. We explored the correlation between AES caseload and the climate parameters. Methods Data for 1318 hospitalized children with AES during 2012–20 were used. The correlation between AES cases and daily climate parameters (temperature, sunshine, rainfall, humidity and wind speed) for the previous 24, 48 and 72 h were examined using Pearson's and Spearman's rank-order correlation and Poisson regression or negative binomial regression analyses. Results Most (91.8%) of the AES cases occurred during the summer season (May–July months), especially June month. Pearson's and Spearman's rank-order correlation analyses revealed that AES caseload had positive correlations with maximum ($r = 0.275$, $\rho = 0.293$) and minimum ($r = 0.306$, $\rho = 0.306$) temperatures during past 24 h and heat index ($r = 0.325$, $\rho = 0.325$) and negative correlation with humidity ($r = -0.222$, $\rho = -0.222$) and rainfall ($r = -0.183$, $\rho = -0.183$) (all $p < 0.05$). The correlation was consistent for the climate parameters for the past 24, 48 and 72 h. Regression analysis also documented a significant association of AES cases with daily maximum (beta: 0.32–0.36) and minimum (beta: 0.53–0.62) temperatures and heat index (beta: 0.92–1.03) over past 24, 48 and 72 h (all $p < 0.01$). The number of AES cases exponentially increased when the daily maximum and minimum temperatures crossed 40 degrees C and 31 degrees C, respectively. Conclusions The climate parameters, especially temperature appears to be a risk

factor for AES in children. The definite aetiological role of heat for AES in children needs further exploration.

Lay Summary Repeated seasonal outbreaks of acute encephalitis syndrome (AES) in children have been observed in Muzaffarpur, Bihar (India), since 1995. These children mostly present during the summer months (May–June) of the year with sudden early morning onset of seizures, altered sensorium, hypoglycaemia, with or without fever. A high fatality (27–63%) or sequels among those who survive have been observed. Large outbreaks were observed in 2005, 2009, 2011, 2012, 2014 and 2019. Despite periodic outbreaks, the causes and risk factors of AES in these children remain mostly unknown. We explored the correlation between the AES caseload (data for 1318 hospitalized children with AES during 2012–2020) and the daily climate parameters (temperature, heat index, sunshine, rainfall, humidity and wind speed) for the previous 24, 48 and 72 h using various statistical tests. Most (91.8%) of the AES cases occurred during the summer season (May–July months), especially June month. The AES caseload had significant positive correlation with maximum and minimum temperatures and heat index and negative correlation with humidity and rainfall. The number of AES cases exponentially increased when the daily maximum and minimum temperatures crossed 40 degrees C and 31 degrees C, respectively.

97. Smith, C. J., (2019), Pediatric Thermoregulation: Considerations in the Face of Global Climate Change, *Nutrients*, 11, 9, 2019, DOI: 10.3390/nu11092010.

Citations: 23

Abstract: Predicted global climate change, including rising average temperatures, increasing airborne pollution, and ultraviolet radiation exposure, presents multiple environmental stressors contributing to increased morbidity and mortality.

Extreme temperatures and more frequent and severe heat events will increase the risk of heat-related illness and associated complications in vulnerable populations, including infants and children. Historically, children have been viewed to possess inferior thermoregulatory capabilities, owing to lower sweat rates and higher core temperature responses compared to adults. Accumulating evidence counters this notion, with limited child–adult differences in thermoregulation evident during mild and moderate heat exposure, with increased risk of heat illness only at environmental extremes. In the context of predicted global climate change, extreme environmental temperatures will be encountered more frequently, placing children at increased risk.

Thermoregulatory and overall physiological strain in high temperatures may be further exacerbated by exposure to/presence of physiological and environmental stressors including pollution, ultraviolet radiation, obesity, diabetes, associated comorbidities, and polypharmacy that are more commonly occurring at younger ages. The aim of this review is to revisit fundamental differences in child–adult

thermoregulation in the face of these multifaceted climate challenges, address emerging concerns, and emphasize risk reduction strategies for the health and performance of children in the heat.

98. Smith, M. L., and R. R. Hardeman, (2020), Association of Summer Heat Waves and the Probability of Preterm Birth in Minnesota: An Exploration of the Intersection of Race and Education, *International Journal of Environmental Research and Public Health*, 17, 17, 6391, DOI: 10.3390/ijerph17176391.

Citations: 7

Abstract: Preterm birth (PTB) is common and has negative impacts on infant health. While some maternal risk factors have been identified, including age under 20 or over 40, substance abuse, low BMI, and racism, less is known about the impact of environmental exposures like high heat. We combined 154,157 records of live births occurring in Minnesota between 2009 and 2015 with hourly weather records collected from the Minneapolis–St. Paul airport. We tested if maternal heat wave exposure (a seven-day period with a mean daily high temp of 37 degrees C) immediately prior to birth leads to a higher risk of preterm birth. Additional covariates included maternal age, race/ethnicity, educational status, and residence in the seven-county Minneapolis–St. Paul metro area. Pregnant women exposed to a seven-day heat wave of 37 degrees C or higher experienced a higher relative risk of PTB compared to women who did not experience a heat wave (1.14 risk ratio (RR), 1.0–1.3 95% confidence interval (CI)). The result is robust to controls for a woman's age, race/ethnicity, educational attainment, place of residence, and year of the birth. Children born to Black women with college degrees who are exposed to heat waves experience a higher relative risk of PTB compared to White women with college degrees in a heat wave (2.97 RR, 1.5–6.1 95% CI). Summer heat waves are associated with higher risk of PTB in late-term pregnancies in Minnesota.

99. Smith, S., Elliot, A. J., Hajat, S., Bone, A., Smith, G. E., and S. Kovats, (2016), Estimating the burden of heat illness in England during the 2013 summer heatwave using syndromic surveillance, *Journal of Epidemiology and Community Health*, 70, 5, 459–465. DOI: 10.1136/jech-2015-206079

Citations: 27

Abstract: Background The burden of heat illness on health systems is not well described in the UK. Although the UK generally experiences mild summers, the frequency and intensity of hot weather is likely to increase due to climate change, particularly in Southern England. We investigated the impact of the moderate heatwave in 2013 on primary care and emergency department (ED) visits using syndromic surveillance data in England.

Methods General practitioner in hours (GPIH), GP out of hours (GPOOH) and ED syndromic surveillance systems were used to monitor the health impact of heat/sun stroke symptoms (heat illness). Data were stratified by age group and compared between heatwave and non-heatwave years. Incidence rate ratios were calculated for GPIH heat illness consultations.

Results GP consultations and ED attendances for heat illness increased during the heatwave period; GPIH consultations increased across all age groups, but the highest rates were in school children and those aged ≥ 75 years, with the latter persisting beyond the end of the heatwave. Extrapolating to the English population, we estimated that the number of GPIH consultations for heat illness during the whole summer (May to September) 2013 was 1166 (95% CI 1064 to 1268). This was double the rate observed during non-heatwave years.

Conclusions These findings support the monitoring of heat illness (symptoms of heat/sun stroke) as part of the Heatwave Plan for England, but also suggest that specifically monitoring heat illness in children, especially those of school age, would provide additional early warning of, and situation awareness during heatwaves.

100. Somboonwong, J., Sanguanrungsirikul, S., and C. Pitayanon, (2012), Heat illness surveillance in schoolboys participating in physical education class in tropical climate: an analytical prospective descriptive study, *BMJ Open*, 2, 4, e000741 DOI: 10.1136/bmjopen-2011-000741.

Citations: 10

Abstract: Objectives: This study aimed to determine thermoregulatory and cardiovascular responses as well as the occurrence of heat illness in children exercising outdoors in physical education class under hot and humid climate. Little information regarding this issue under real-life situation is available, especially in the Southeast Asia. Design: Analytical, prospective descriptive study. Setting: A primary school in Bangkok, Thailand.

Participants: A total of 457 schoolboys (aged 5.5e12 years) were observed while exercising outdoors during their physical education classes throughout the academic year of 2009, including semester 1 (between July and September 2009) and semester 2 (between November 2009 and February 2010). Primary and secondary outcome measures: Primary outcome measure was tympanic temperature. Secondary outcome measures included blood pressure, heart rate, hydration status and the occurrence of heat-related illness. Results: Outdoor physical activity consisted of skill practice (duration 24.11+/-11.04 min, intensity <3 metabolic equivalent of tasks) and playing sports (duration 11.48+/-5.53 min, intensity 2.6-8.8 metabolic equivalent of tasks). After exercise, tympanic temperature increased by 0.66+/-0.41 degrees C. There were 20 (4.4%) students whose ear temperature exceeded 38 degrees C, 18 of whom did not consume

water. The RR of increasing body temperature up to 38 degrees C in overweight students was 2.1-fold higher than normal-weight students. The per cent change in mean arterial pressure and heart rate increased by 20.16+/-15.34% and 23.94+/-19.78%, respectively. Sweat and dehydration rates were 391.16+/-186.75 ml/h and 0.63+/-0.26%, respectively. No evidence of heat illness was found. Wet bulb globe temperatures of semesters 1 and 2 were 29.95+/-1.87 degrees C and 28.32+/-2.39 degrees C, respectively. Conclusions: There is an increased risk for heat illness during outdoor activities in physical education class in primary school children, especially those who are overweight and have poor hydration status.

101. Swaminathan, A., Lucas, R. M., Harley, D., and A. J. McMichael, (2014), Will Global Climate Change Alter Fundamental Human Immune Reactivity: Implications for Child Health? *Children-Basel*, 1, 3, 403-423, DOI: 10.3390/children1030403.

Citations: 7

Abstract: The human immune system is an interface across which many climate change sensitive exposures can affect health outcomes. Gaining an understanding of the range of potential effects that climate change could have on immune function will be of considerable importance, particularly for child health, but has, as yet, received minimal research attention. We postulate several mechanisms whereby climate change sensitive exposures and conditions will subtly impair aspects of the human immune response, thereby altering the distribution of vulnerability within populations-particularly for children-to infection and disease. Key climate change-sensitive pathways include under-nutrition, psychological stress and exposure to ambient ultraviolet radiation, with effects on susceptibility to infection, allergy and autoimmune diseases. Other climate change sensitive exposures may also be important and interact, either additively or synergistically, to alter health risks. Conducting directed research in this area is imperative as the potential public health implications of climate change-induced weakening of the immune system at both individual and population levels are profound. This is particularly relevant for the already vulnerable children of the developing world, who will bear a disproportionate burden of future adverse environmental and geopolitical consequences of climate change.

102. Szabados, M., Csako, Z., Kotlik, B., Kazmarova, H., Kozaida, A., Jutraz, A., Kukec, A., Otorepec, P., Dongiovanni, A., Di Maggio, A., Fraire, S., and T. Szigeti, (2021), Indoor air quality and the associated health risk in primary school buildings in Central Europe - The InAirQ study, *Indoor Air*, 31, 4, 989-1003, DOI: 10.1111/ina.12802.

Citations: 4

Abstract: The indoor air quality (IAQ) was investigated in sixty-four primary school buildings in five Central European countries (Czech Republic, Hungary, Italy,

Poland, and Slovenia). The concentration of volatile organic compounds, aldehydes, PM_{2.5} mass, carbon dioxide, radon, as well as physical parameters were investigated during the heating period of 2017/2018. Significant differences were identified for the majority of the investigated IAQ parameters across the countries. The median indoor/outdoor ratios varied considerably. A comprehensive evaluation of IAQ in terms of potential health effects and comfort perception was performed. Hazard quotient values were below the threshold value of 1 with one exception. In contrast, 31% of the school buildings were characterized by hazard index values higher than 1. The maximum cumulative ratio approach highlighted that the concern for non-carcinogenic health effects was either low or the health risk was driven by more substances. The median excess lifetime cancer risk values exceeded the acceptable value of 1×10^{-6} in the case of radon and formaldehyde. PM_{2.5} mass concentration values exceeded the 24 h and annual guideline values set by the World Health Organization in 56 and 85% of the cases, respectively. About 80% of the schools could not manage to comply with the recommended concentration value for carbon dioxide (1000 ppm).

103. Tripp, B. L., Eberman, L. E., and M. S. Smith (2015), Exertional Heat Illnesses and Environmental Conditions During High School Football Practices, *American Journal of Sports Medicine*, 43, 10, 2490–2495. DOI: 10.1177/0363546515593947.

Citations: 23

Abstracts: Background: Guidelines for preventing exertional heat illnesses (EHIs) during extreme heat stress should be specific to regional environments, age, and sport and should be based on evidence of reducing the risk. Each year in the United States, over 1 million high school football players practice in the August heat; however, no published data describe the incidence of EHIs in these athletes. Purpose: To describe the environmental conditions and incidence of EHIs during high school football practices over a 3-month period.

Study Design: Descriptive epidemiology study. Methods: For a 3-month period (August–October), athletic trainers at 12 high schools in North Central Florida recorded the practice time and length, environmental conditions (wet-bulb globe temperature), and incidences of EHIs in varsity football athletes. Results: Athletes suffered 57 total EHIs during 29,759 athlete-exposures (AEs) for the 3-month data collection period (rate = 1.92/1000 AEs). August accounted for the majority of all EHIs, with 82.5% (47/57) and the highest rate (4.35/1000 AEs). Of total heat illnesses, heat cramps accounted for 70.2% (40/57), heat exhaustion 22.8% (13/57), and heat syncope 7.0% (4/57). The odds ratio indicated that athletes in August practices that lasted longer than the recommended 3 hours were 9.84 times more likely to suffer a heat illness than those in practices lasting 3 hours.

Conclusion: The highest rate of EHIs was during August. Practices in August that

exceeded the recommended 3 hours were associated with a greater risk of heat illnesses. The overall rate of EHIs was lower for the high school football athletes observed in the study compared with that reported for collegiate football athletes in the region. The low rates of EHIs recorded suggest that the prevention guidelines employed by sports medicine teams are appropriate for the region and population. Clinical Relevance: Team physicians and athletic trainers should employ evidence-based, region- and population-specific EHI prevention guidelines. Sports medicine teams, coaches, and athletes should be aware of the increased risk of EHIs during August practices and the risk of prolonged practices during August.

104. Uibel, D., Sharma, R., Piontkowski, D., Sheffield, P. E., and J. E. Clougherty, (2022), Association of ambient extreme heat with pediatric morbidity: a scoping review, *International Journal of Biometeorology*, 66, 8, 1683-1698. DOI: 10.1007/s00484-022-02310-5

Citations: 0

Abstract: Global climate change is leading to higher ambient temperatures and more frequent heatwaves. To date, impacts of ambient extreme heat on childhood morbidity have been understudied, although—given children's physiologic susceptibility, with smaller body surface-to-mass ratios, and many years of increasing temperatures ahead—there is an urgent need for better information to inform public health policies and clinical approaches. In this review, we aim to (1) identify pediatric morbidity outcomes previously associated with extreme heat, (2) to identify predisposing co-morbidities which may make children more susceptible to heat-related outcomes, and (3) to map the current body of available literature. A scoping review of the current full-text literature was conducted using the Arksey and O'Malley framework *Int J Soc Res Methodol* 8:19-32, (2015). Search terms for (1) pediatric population, (2) heat exposures, (3) ambient conditions, and (4) adverse outcomes were combined into a comprehensive PubMed and Medline literature search. Of the 1753 publications identified, a total of 20 relevant studies were ultimately selected based on selection criteria of relevance to US urban populations. Most identified studies supported positive associations between high extreme temperature exposures and heat-related illness, dehydration/electrolyte imbalance, general symptoms, diarrhea and digestion disorders, infectious diseases/infections, asthma/wheeze, and injury. Most studies found no association with renal disease, cardiovascular diseases, or diabetes mellitus. Results were mixed for other respiratory diseases and mental health/psychological disorders. Very few of the identified studies examined susceptibility to pre-existing conditions; Cystic Fibrosis was the only co-morbidity for which we found significant evidence. Further research is needed to understand the nuances of associations between extreme heat and specific

outcomes—particularly how associations may vary by child age, sex, race/ethnicity, community characteristics, and other pre-existing conditions.

105. Upperman, C. R., Parker, J., Jiang, C. S., He, X., and A. Sapkota (2015), Frequency of Extreme Heat Event as a Surrogate Exposure Metric for Examining the Human Health Effects of Climate Change, PLOS ONE, 10, 12: e0144202 DOI: 10.1371/journal.pone.0144202

Citations: 15

Abstract: Epidemiological investigation of the impact of climate change on human health, particularly chronic diseases, is hindered by the lack of exposure metrics that can be used as a marker of climate change that are compatible with health data. Here, we present a surrogate exposure metric created using a 30-year baseline (1960–1989) that allows users to quantify long-term changes in exposure to frequency of extreme heat events with near unabridged spatial coverage in a scale that is compatible with national/state health outcome data. We evaluate the exposure metric by decade, seasonality, area of the country, and its ability to capture long-term changes in weather (climate), including natural climate modes. Our findings show that this generic exposure metric is potentially useful to monitor trends in the frequency of extreme heat events across varying regions because it captures long-term changes; is sensitive to the natural climate modes (ENSO events); responds well to spatial variability, and; is amenable to spatial/temporal aggregation, making it useful for epidemiological studies.

106. Van der Linden, N., Longden, T., Richards, J. R., Khursheed, M., Goddijn, W. M. T., van der Linden, M. C., (2019), The use of an 'acclimatisation' heatwave measure to compare temperature-related demand for emergency services in Australia, Botswana, Netherlands, Pakistan, and USA. PLOS ONE, 14, 3, e0214242 DOI: 10.1371/journal.pone.0214242

Citations: 7

Abstract: Heatwaves have been linked to increased risk of mortality and morbidity and are projected to increase in frequency and intensity due to climate change. The current study uses emergency department (ED) data from Australia, Botswana, Netherlands, Pakistan, and the United States of America to evaluate the impact of heatwaves on ED attendances, admissions and mortality. Methods: Routinely collected time series data were obtained from 18 hospitals. Two separate thresholds (≥ 4 and ≥ 7) of the acclimatisation excess heat index (EHI_{accl}) were used to define "hot days". Analyses included descriptive statistics, independent samples T-tests to determine differences in case mix between hot days and other days, and threshold regression to determine which temperature

thresholds correspond to large increases in ED attendances. Findings: In all regions, increases in temperature that did not coincide with time to acclimatise resulted in increases in ED attendances, and the EHLaccl performed in a similar manner. During hot days in California and The Netherlands, significantly more children ended up in the ED, while in Pakistan more elderly people attended. Hot days were associated with more patient admissions in the ages 5–11 in California, 65–74 in Karachi, and 75–84 in The Hague. During hot days in The Hague, patients with psychiatric symptoms were more likely to die. The current study did not identify a threshold temperature associated with particularly large increases in ED demand. Interpretation- The association between heat and ED demand differs between regions. A limitation of the current study is that it does not consider delayed effects or influences of other environmental factors. Given the association between heat and ED use, hospitals and governmental authorities should recognise the demands that heat can place on local health care systems. These demands differ substantially between regions, with Pakistan being the most heavily affected within our study sample.

107. Van Graan, A. E., Bopape, M. Phooko, D., Bourne, L., and H. H. Wright (2013), Drink lots of clean, safe water: a food-based dietary guideline for South Africa, *South African Journal of Clinical Nutrition*, S77–S86.

Citations: 4

Abstract: The purpose of this review is to summarise the literature that supports the importance of the food-based dietary guideline on water consumption. General recommendations for total daily water intake are between 2 and 3.7 l for women and men, 0.7 l for infants aged 0–6 months, 0.8 l for infants aged 7–12 months, 1.3 l for children aged 1–3 years, and 1.7 l for children aged 4–8 years. Water recommendations for the elderly and people who are involved in exercise or hard physical labour may be higher and might need special consideration. Water remains one of the primary sources of fluoride, and in areas with low levels, the fluoridation of drinking water is recommended. Defluoridation of water is suggested in areas where water fluoride levels exceed 3 mg/l. There is a paucity of South African data on general fluid intake, but some evidence suggests an increase in the intake of energy-containing beverages and in the demand for bottled water, posing unique challenges relating to weight gain and diabetes incidence, and effects on the environment and chemical leaching, respectively. Water quality remains a concern. Low rainfall, declining fresh water sources and the impact of industrial activity, urbanisation, climate change, deforestation, mining and agriculture add pressure on water bodies. This effect on water quality could lead to water-borne illnesses and disease. Managing the quality of drinking water is of utmost importance, and pertains to the microbiological and chemical

safety of water, as well as to the physical and organoleptic qualities of drinking water, which is an important cornerstone for health.

108. Vicedo-Cabrera, A. M., Iniguez, C., and F. Ballester, (2014), Exposure to elevated temperatures and risk of preterm birth in Valencia, Spain, *Environmental Research*, 134, S1, 210–217, DOI: 10.1016/j.envres.2014.07.021

Citations: 43

Abstract: Background: Prematurity is the second-leading cause of death in children under the age of 5 worldwide. It is predicted that the future climate will have more intense, longer lasting and frequent extreme heat episodes, and so the temperature effect on the risk of preterm birth is generating considerable interest in the public health field. Our aim was to explore the potential short-term effects of elevated temperatures on the risk of preterm birth in Valencia (Spain).

Methods: All singleton natural births born in the metropolitan area of Valencia during the warm season (May–September, 2006–2010) were included (N=20,148). We applied time-series quasi-Poisson generalized additive models to evaluate the risk of preterm birth at different maximum apparent and minimum temperature values (50th, 90th and 99th percentiles of the warm season) up to 3 weeks before delivery (reference: overall annual median value). In addition, three temperature-interval-specific estimates were obtained for changes between each of these temperature values. We took into account the pregnancies at risk adjusted by the gestational age distribution of the set in each day. We used distributed-lag nonlinear models with a flexible function in the shape of the relationship and lag structure. Results: Risk of preterm birth increased up to 20% when maximum apparent temperature exceeded the 90th percentile two days before delivery and 5% when minimum temperature rose to the 90th percentile in the last week. Differences between interval-specific risk estimates across lags were observed. Conclusion: Exposure to elevated temperatures was associated with an increased risk of preterm birth in the following three weeks

109. Wang, X. Y., Barnett, A., Guo, Y. M., Yu, W. W., Shen, X. M., and S. L. Tong, (2014), Increased risk of emergency hospital admissions for children with renal diseases during heatwaves in Brisbane, Australia, *World Journal of Pediatrics*, 10, 4, 330–335, DOI: 10.1007/s12519-014-0469-x

Citations: 11

Abstract: Background: Heatwaves have a significant impact on population health including both morbidity and mortality. In this study we examined the association between heatwaves and emergency hospital admissions (EHAs) for renal diseases in children (aged 0–14 years) in Brisbane, Australia. Methods: Daily data on EHAs for renal diseases in children and exposure to temperature and air

pollution were obtained for Brisbane city from January 1, 1996, to December 31, 2005. A time-stratified case-crossover design was used to compare the risks for renal diseases between heatwave and non-heatwave periods. Results: There were 1565 EHAs for renal diseases in children during the study period. Heatwaves exhibited a significant impact on EHAs for renal diseases in children after adjusting for confounding factors (odds ratio: 3.6; 95% confidence interval: 1.4-9.5). The risk estimates differed with lags and the use of different heatwave definitions. Conclusions: There was a significant increase in EHAs for renal diseases in children during heatwaves in Brisbane, a subtropical city where people are well accustomed to warm weather. This finding may have significant implications for pediatric renal care, particularly in subtropical and tropical regions.

110. Wilk, P., Gunz, A., Maltby, A., Ravichakaravarthy, T., Clemens, K. K., Lavigne, E., Lim, R., and A. M. Vicedo-Cabrera, (2021), Extreme heat and paediatric emergency department visits in Southwestern Ontario. *Paediatrics and Child Health*, 26, 5: 305-309, DOI: 10.1093/pch/pxaa096.

Citations: 1

Abstract: Objective: The risk of adverse health events is expected to increase with hotter temperatures, particularly among the most vulnerable groups such as elderly persons and children. The objective of this study was to assess the association between extreme heat and daily emergency department visits among children (0 to 17 years) in Southwestern Ontario.

Methods: We examined the average maximum temperature, relative humidity, and daily paediatric emergency department visits in June through August of 2002 to 2019. We reviewed emergency department visits from two academic hospitals. Daily meteorological data from the local weather station were obtained from Environment and Climate Change Canada. Results: Extreme heat, defined as the 99th percentile of the maximum temperature distribution, occurred at 33.1 degrees C and was associated with an overall 22% increase in emergency department visits, compared to the reference temperature of 21 degrees C. This association was mostly found between the second and fifth day after the exposure, suggesting a slightly delayed effect. The results of the sub-group analysis indicate that the risk of an emergency department visit due to infectious disease increases by 35% and the most pronounced association was noted in children aged 1 to 12 years. Conclusions: Extreme heat is associated with an increased incidence of emergency department visits in children. As temperatures continue to increase, strategies to mitigate heat-related health risks among children should be developed.

111. Williams, C. A., Grundstein, A. J., (2018), Children forgotten in hot cars: a mental models approach for improving public health messaging, *Injury Prevention*, 24, 5, 279–287. DOI: 10.1136/injuryprev-2016-042261.

Citations: 3

Abstract: Introduction On average, in the USA, 37 young children die every year due to vehicular heatstroke. Additionally, over half of these incidents occur when a parent/caregiver forgets a child in a vehicle. While various governmental and child safety advocacy groups have worked to raise awareness about these tragedies, rigorous studies have yet to be conducted that examine the current understanding and effectiveness of this public health messaging. **Methods** This study will employ a mental models approach in order to identify differences that exist between experts' and parents'/caregivers' knowledge and beliefs surrounding the topic of children forgotten in hot cars. We interviewed a diverse set of 25 parents/caregivers and seven experts in order to construct and explore these mental models.

Results A comparative analysis was conducted, and three key differences were observed between these mental models. Unlike the experts, the parents/caregivers in the study emphasised perceived lifestyle factors (eg, low-income parent) as important elements in increasing an individual's likelihood of forgetting a child in a car. Importantly, the parents/caregivers primarily obtained information from news reports, while experts believed public health campaigns would reach more parents/caregivers. Lastly, while experts stressed that this tragedy could happen to anyone, most parents/caregivers failed to acknowledge that they could forget their own child in a car. **Conclusions** To confront this denial, future public health messaging must strive to engage and reach all parents/caregivers. This can be accomplished using a multifaceted messaging strategy that includes personalising core messaging, providing additional resources to media outlets and building rapport between key partners.

112. Wright, C. Y., Dominick, F., Kapwata, T., Bidassey-Manilal, S., Engelbrecht, J. C., Such, H., Methee, A., and M. Matooane, (2019), Socio-economic, infrastructural and health-related risk factors associated with adverse heat-health effects reportedly experienced during hot weather in South Africa. *Pan African Medical Journal*, 34, 40, Doi: 10.11604/pamj.2019.34.40.17569

Citations: 2

Abstract: Introduction: poor urban communities are likely to bear the brunt of climate change impacts on health and well-being. The City of Johannesburg, South Africa, is predicted to experience an average increase in ambient temperature of 4 degrees C by 2100. Focusing on the urban environment, this study aimed to determine socio-economic, infrastructural and health-related risk

factors for heat-related adverse health effects. Methods: this was a cross-sectional study. Data of interest were collected using a pretested and validated questionnaire administered to parents of children attending schools participating in a school heat study. Information related to demographic, socio-economic and household-level determinants of health, which has an impact on the individual prevalence of adverse heat-health effects associated with hot weather, was collected for 136 households and 580 individuals. Results: sweating (n = 208 individuals; 35%), headache and nausea (n = 111; 19%) and weakness, fatigue and dizziness (n = 87; 15%) were the most common heat-health effects reportedly experienced by individuals (n = 580) during hot weather. Individuals who suffered from hypertension (OR = 2.32, 95% CI: 1.34 - 4.05, p = 0.003) and individuals older than 60 years (OR = 1.81, 95% CI: 1.27-1.99, p < 0.001) compared to other age groups were more likely to experience 'any heat-health effects'. Living in government-sponsored detached housing and in houses with asbestos roofs were associated with an increase in reported experience of 'any heat-health effects' compared to living in other housing types. Conclusion: heat-health awareness campaigns should target people suffering from pre-existing diseases and the elderly, as these groups are especially vulnerable to heat. Focus should also be given to appropriate roofing and insulation in government-sponsored housing since summertime temperatures are projected to increase.

113. Wright, C. Y., Street, R. A., Cele, N., Kunene, Z., Balakrishna, Y., Alberts, P. N., and A. Mathee, (2017), Indoor Temperatures in Patient Waiting Rooms in Eight Rural Primary Health Care Centers in Northern South Africa and the Related Potential Risks to Human Health and Wellbeing, *International Journal of Environmental Research and Public Health*, 14, 1, 43, DOI: 10.3390/ijerph14010043

Citations: 11

Abstract: Increased temperatures affect human health and vulnerable groups including infants, children, the elderly and people with pre-existing diseases. In the southern African region climate models predict increases in ambient temperature twice that of the global average temperature increase. Poor ventilation and lack of air conditioning in primary health care clinics, where duration of waiting time may be as long as several hours, pose a possible threat to patients seeking primary health care. Drawing on information measured by temperature loggers installed in eight clinics in Giyani, Limpopo Province of South Africa, we were able to determine indoor temperatures of waiting rooms in eight rural primary health care facilities. Mean monthly temperature measurements inside the clinics were warmer during the summer months of December, January and February, and cooler during the autumn months of March, April and May. The highest mean monthly temperature of 31.4 +/- 2.7 degrees C was recorded in one clinic during February 2016. Maximum daily indoor clinic temperatures exceeded

38 degrees C in some clinics. Indoor temperatures were compared to ambient (outdoor) temperatures and the mean difference between the two showed clinic waiting room temperatures were higher by 2-4 degrees C on average. Apparent temperature (AT) incorporating relative humidity readings made in the clinics showed 'realfeel' temperatures were > 4 degrees C higher than measured indoor temperature, suggesting a feeling of 'stuffiness' and discomfort may have been experienced in the waiting room areas. During typical clinic operational hours of 8h00 to 16h00, mean ATs fell into temperature ranges associated with heat-health impact warning categories of 'caution' and 'extreme caution'.

114. Xiao, J. G., Spicer, T., Jian, L., Yun, G. Y., Shao, C. Y., Nairn, J., Fawcett, R. J. B., Robertson, A., and T. S. Weeramanthri, (2017), Variation in Population Vulnerability to Heat Wave in Western Australia, *Frontiers in Public Health*, 5, DOI: 10.3389/fpubh.2017.00064.

Citations: 24

Abstract: Heat waves (HWs) have killed more people in Australia than all other natural hazards combined. Climate change is expected to increase the frequency, duration, and intensity of HWs and leads to a doubling of heat-related deaths over the next 40 years. Despite being a significant public health issue, HWs do not attract the same level of attention from researchers, policy makers, and emergency management agencies compared to other natural hazards. The purpose of the study was to identify risk factors that might lead to population vulnerability to HW in Western Australia (WA). HW vulnerability and resilience among the population of the state of WA were investigated by using time series analysis. The health impacts of HWs were assessed by comparing the associations between hospital emergency department (ED) presentations, hospital admissions and mortality data, and intensities of HW. Risk factors including age, gender, socioeconomic status (SES), remoteness, and geographical locations were examined to determine whether certain population groups were more at risk of adverse health impacts due to extreme heat. We found that hospital admissions due to heat-related conditions and kidney diseases, and overall ED attendances, were sensitive indicators of HW. Children aged 14 years or less and those aged 60 years or over were identified as the most vulnerable populations to HWs as shown in ED attendance data. Females had more ED attendances and hospital admissions due to kidney diseases; while males had more heat-related hospital admissions than females. There were significant dose-response relationships between HW intensity and SES, remoteness, and health service usage. The more disadvantaged and remotely located the population, the higher the health service usage during HWs. Our study also found that some population groups and locations were resilient to extreme heat. We produced a mapping tool, which indicated geographic areas

throughout WA with various vulnerability and resilience levels to HW. The findings from this study will allow local government, community service organizations, and agencies in health, housing, and education to better identify and understand the degree of vulnerability to HW throughout the state, better target preparatory strategies, and allocate limited resources to those most in need.

115. Xu, Z. W., Etzel, R. A., Su, H., Huang, C. R., Guo, Y. M., and S. L. Tong (2012), Impact of ambient temperature on children's health: A systematic review, *Environmental Research*, 117, 120-131, DOI: 10.1016/j.envres.2012.07.002.

Citations: 149

Abstract: Children are vulnerable to temperature extremes. This paper aimed to review the literature regarding the relationship between ambient temperature and children's health and to propose future research directions. A literature search was conducted in February 2012 using the databases including PubMed, ProQuest, ScienceDirect, Scopus and Web of Science. Empirical studies regarding the impact of ambient temperature on children's mortality and morbidity were included. The existing literature indicates that very young children, especially children under one year of age, are particularly vulnerable to heat-related deaths. Hot and cold temperatures mainly affect cases of infectious diseases among children, including gastrointestinal diseases, malaria, hand, foot and mouse disease, and respiratory diseases. Pediatric allergic diseases, like eczema, are also sensitive to temperature extremes. During heat waves, the incidences of renal disease, fever and electrolyte imbalance among children increase significantly. Future research is needed to examine the balance between hot- and cold-temperature related mortality and morbidity among children; evaluate the impacts of cold spells on cause-specific mortality in children; identify the most sensitive temperature exposure and health outcomes to quantify the impact of temperature extremes on children; elucidate the possible modifiers of the temperature and children's health relationship; and project children's disease burden under different climate change scenarios.

116. Xu, Z. W., Huang, C. R., Hu, W. B., Turner, L. R., Su, H., and S. L. Tong, (2013), Extreme temperatures and emergency department admissions for childhood asthma in Brisbane, Australia, *Occupational and Environmental Medicine*, 70, 10, 730-735. DOI: 10.1136/oemed-2013-101538.

Citations: 65

Abstract: Objectives - To examine the effect of extreme temperatures on emergency department admissions (EDAs) for childhood asthma. Methods - An ecological design was used in this study. A Poisson linear regression model combined with a distributed lag non-linear model was used to quantify the effect

of temperature on EDAs for asthma among children aged 0–14 years in Brisbane, Australia, during January 2003–December 2009, while controlling for air pollution, relative humidity, day of the week, season and long-term trends. The model residuals were checked to identify whether there was an added effect due to heat waves or cold spells. Results – There were 13 324 EDAs for childhood asthma during the study period. Both hot and cold temperatures were associated with increases in EDAs for childhood asthma, and their effects both appeared to be acute. An added effect of heat waves on EDAs for childhood asthma was observed, but no added effect of cold spells was found. Male children and children aged 0–4 years were most vulnerable to heat effects, while children aged 10–14 years were most vulnerable to cold effects. Conclusions – Both hot and cold temperatures seemed to affect EDAs for childhood asthma. As climate change continues, children aged 0–4 years are at particular risk for asthma.

117. Xu, Z. W., Liu, Y., Ma, Z., Toloo, g., Hu, W. B., and S. L. Tong (2014), Assessment of the temperature effect on childhood diarrhea using satellite imagery, *Scientific Reports*, 4, 5389 DOI: 10.1038/srep05389

Citations: 27

Abstract: A quasi-Poisson generalized linear model combined with a distributed lag non-linear model was used to quantify the main effect of temperature on emergency department visits (EDVs) for childhood diarrhea in Brisbane from 2001 to 2010. Residual of the model was checked to examine whether there was an added effect due to heat waves. The change over time in temperature–diarrhea relation was also assessed. Both low and high temperatures had significant impact on childhood diarrhea. Heat waves had an added effect on childhood diarrhea, and this effect increased with intensity and duration of heat waves. There was a decreasing trend in the main effect of heat on childhood diarrhea in Brisbane across the study period. Brisbane children appeared to have gradually adapted to mild heat, but they are still very sensitive to persistent extreme heat. Development of future heat alert systems should take the change in temperature–diarrhea relation over time into account.

118. Xu, Z. W., Sheffield, P. E., Su. H., Wang, X. Y., Bi, Y. and S. L. Tong (2014), The impact of heat waves on children's health: a systematic review, *International Journal of Biometeorology*, 58, 2, S1, 239–247, DOI: 10.1007/s00484-013-0655.

Citations: 86

Abstract: Young children are thought to be particularly sensitive to heat waves, but relatively less research attention has been paid to this field to date. A systematic review was conducted to elucidate the relationship between heat waves and children's health. Literature published up to August 2012 were identified

using the following MeSH terms and keywords: "heatwave", "heat wave", "child health", "morbidity", "hospital admission", "emergency department visit", "family practice", "primary health care", "death" and "mortality". Of the 628 publications identified, 12 met the selection criteria. The existing literature does not consistently suggest that mortality among children increases significantly during heat waves, even though infants were associated with more heat-related deaths. Exposure to heat waves in the perinatal period may pose a threat to children's health. Pediatric diseases or conditions associated with heat waves include renal disease, respiratory disease, electrolyte imbalance and fever. Future research should focus on how to develop a consistent definition of a heat wave from a children's health perspective, identifying the best measure of children's exposure to heat waves, exploring sensitive outcome measures to quantify the impact of heat waves on children, evaluating the possible impacts of heat waves on children's birth outcomes, and understanding the differences in vulnerability to heat waves among children of different ages and from different income countries. Projection of the children's disease burden caused by heat waves under climate change scenarios, and development of effective heat wave mitigation and adaptation strategies that incorporate other child protective health measures, are also strongly recommended.

119. Xu, Z. W., Sheffield, P. E., Hu, W. B., Su, H., Yu, W. W., Qi, X., and S. L. Tong (2012), Climate Change and Children's Health—A Call for Research on What Works to Protect Children, *International Journal of Environmental Research and Public Health*, 9, 9, 3298–3316. DOI: 10.3390/ijerph9093298

Citations: 61

Abstract: Climate change is affecting and will increasingly influence human health and wellbeing. Children are particularly vulnerable to the impact of climate change. An extensive literature review regarding the impact of climate change on children's health was conducted in April 2012 by searching electronic databases PubMed, Scopus, ProQuest, ScienceDirect, and Web of Science, as well as relevant websites, such as IPCC and WHO. Climate change affects children's health through increased air pollution, more weather-related disasters, more frequent and intense heat waves, decreased water quality and quantity, food shortage and greater exposure to toxicants. As a result, children experience greater risk of mental disorders, malnutrition, infectious diseases, allergic diseases and respiratory diseases. Mitigation measures like reducing carbon pollution emissions, and adaptation measures such as early warning systems and post-disaster counseling are strongly needed. Future health research directions should focus on: (1) identifying whether climate change impacts on children will be modified by gender, age and socioeconomic status; (2) refining outcome measures of children's vulnerability to climate change; (3) projecting children's

disease burden under climate change scenarios; (4) exploring children's disease burden related to climate change in low-income countries; and (5) identifying the most cost-effective mitigation and adaptation actions from a children's health perspective.

120. Yu, G. Q., Li, Y. H., Cai, J. S., Yu, D. M., Tang, J. X., Zhai, W. W., Wei, Y., Chen, S. Y., Chen, Q. H., and J. Qin, (2019). Short-term effects of meteorological factors and air pollution on childhood hand-foot-mouth disease in Guilin, China. *Science of the Total Environment*, 646, 460-470, DOI: 10.1016/j.scitotenv.2018.07.329

Citations: 57

Abstract: Background: Previous studies have always focused on the impact of various meteorological factors on Hand-foot-mouth disease (HFMD). However, only few studies have investigated the simultaneous effects of climate and air pollution on HFMD incidence.

Methods: Daily HFMD counts among children aged 0-14 years in Guilin city were collected from 2014 to 2016. Distributed lag nonlinear models (DLNM) were used to assess the effects of extreme meteorological factors and air pollution indicators, as well as the effects of different lag days on HFMD incidence. Furthermore, this study explored the variability across gender and age groups. **Results:** Extreme temperatures, high precipitation and low-O₃ concentration increased the risk of HFMD. Hot effect was stronger and longer lasting than cold effect. Risks of rainy effect and low-O₃ effect continued to increase as lag days extended, with the maximum RR values: 1.60 (1.38, 1.86) (90th vs median) and 1.48 (1.16, 1.89) (1th vs median) at 0-14 lag days, respectively. By contrast, extremely high wind speed, low precipitation, low PM_{2.5} and high O₃ exerted a certain protective effect on HFMD incidence. The corresponding minimum RR values were: 0.85 (0.74, 0.98) (90th vs median) at 0-14 lag days, 0.98 (0.97, 0.99) (10th vs median) at 0-14 lag days, 0.73 (0.61, 0.88) (1th vs median) at 0-14 lag days and 0.81 (0.73, 0.90) (99th vs median) at 0-7 lag days, respectively. Male children and children aged 0-1 years (followed by 1-3 years) were the most susceptible subgroups to extreme climatic effects and air pollution. **Conclusions:** Our results indicated that daily meteorological factors and air pollution exert non-linear and delayed effects on pediatric HFMD, and such effects vary depending on gender and age. These findings may serve as a reference for the development of an early warning system and for the adoption of specific interventions for vulnerable groups

121. Yoon, S. J., Oh, I. H., Seo, H. y., and E. J. Kim (2014), Measuring the burden of disease due to climate change and developing a forecast model in South Korea, *Public Health*, 128, 8, 725-733. DOI: 10.1016/j.puhe.2014.06.008 Published: AUG 2014

Citations: 21

Abstract: Objectives: Climate change influences human health in various ways, and quantitative assessments of the effect of climate change on health at national level are becoming essential for environmental health management. Study design: This study quantified the burden of disease attributable to climate change in Korea using disability-adjusted life years (DALY), and projected how this would change over time. Methods: Diseases related to climate change in Korea were selected, and meteorological data for each risk factor of climate change were collected. Mortality was calculated, and a database of incidence and prevalence was established. After measuring the burden of each disease, the total burden of disease related to climate change was assessed by multiplying population-attributable fractions. Finally, an estimation model for the burden of disease was built based on Korean climate data. Results: The total burden of disease related to climate change in Korea was 6.85 DALY/1000 population in 2008. Cerebrovascular diseases induced by heat waves accounted for 72.1% of the total burden of disease (hypertensive disease 1.82 DALY/1000 population, ischaemic heart disease 1.56 DALY/1000 population, cerebrovascular disease 1.56 DALY/1000 population). According to the estimation model, the total burden of disease will be 11.48 DALY/1000 population in 2100, which is twice the total burden of disease in 2008. Conclusions: This study quantified the burden of disease caused by climate change in Korea, and provides valuable information for determining the priorities of environmental health policy in East Asian countries with similar climates.

122. Zhao, Q., Li, S. S., Coelho, M. S. Z. S., Saldiva, P. H. N., Hu, K. J., Abramson, M. J., Huxley, R. R., and Y. M. Guo (2019), Assessment of Intraseasonal Variation in Hospitalization Associated With Heat Exposure in Brazil, *Jama Network Open*, 2, 2, e187901. DOI: 10.1001/jamanetworkopen.2018.7901

Citations: 10

Abstract: IMPORTANCE The onset of the hot season is known to be adversely associated with a range of health outcomes. However, little is known about whether the association is constant over the course of the hot season. OBJECTIVE To quantify the change in the association between heat exposure and hospitalization from the early to late hot season in the Brazilian population. DESIGN, SETTING, AND PARTICIPANTS This time-stratified case-crossover study used daily data on hospitalization and weather conditions during the 2000 to 2015 hot seasons in 1814 Brazilian cities. There were 49 145 997 admissions during the study period. Data analysis was conducted between May 12, 2018, and July 2, 2018. EXPOSURES Increase in daily mean temperature. MAIN OUTCOMES AND MEASURES Daily hospitalizations were recorded. Conditional quasi-Poisson regression with time-varying constrained distributed lag model was used to examine the city-specific association between heat and hospitalization in the early or late hot

season. City-specific estimates were then pooled at the national level using random-effect-meta-analysis. Stratified analyses were conducted by 5 regions, sex, 10 age groups, and 7 cause-specific categories. RESULTS Of the 49 145 997 admissions (59% women), the median (interquartile range) age was 33.3 (19.8–55.7) years. At the national level, the risk of hospitalization increased by 4.6% (95% CI, 4.3%–4.9%) and 2.3% (95% CI, 1.9%–2.6%) for every 5 degrees C increase in daily mean temperature in the early and late hot season, respectively. Exposure to early heat was associated with greater risk of hospitalization for residents in the northeast (6.4%; 95% CI, 5.5%–7.3%) and central west (7.1%; 95% CI, 6.1%–8.2%) compared with other regions. Children aged 0 to 9 years and elderly individuals (aged \geq 80 years) were most susceptible. Admissions due to endocrine, nutritional, and metabolic diseases were most strongly associated with heat exposure. There was an attenuation in the heat-associated risk of hospitalization from the early to late hot season for all subgroups except young children and patients with hospitalization caused by respiratory illness. CONCLUSIONS AND RELEVANCE In this study, the association between heat exposure and hospitalization attenuated temporally for most of the Brazilian population. Preventive strategies to mitigate the association of high temperature with population health should focus in particular on the first few days of heat exposure.

123. Zhang, W. J., Du, Z. C., Zhang, D. M., Yu, S. C. and Y. T., Hao (2016), Quantifying the adverse effect of excessive heat on children: An elevated risk of hand, foot and mouth disease in hot days. *Science of the Total Environment*, 541, 194–199. DOI: 10.1016/j.scitotenv.2015.09.089.

Citations: 25

Abstract: Background: Hand, foot and mouth disease (HFMD) is a common childhood infection and has become a major public health issue in China. Considerable research has focused on the role of meteorological factors such as temperature and relative humidity in HFMD development. However, no studies have specifically quantified the impact of another major environmental agent, excessive heat, on HFMD. The current study was designed to help address this research gap. Methods: Case-based HFMD surveillance data and daily meteorological data collected between 2010 and 2012 was obtained from China CDC and the National Meteorological Information Center, respectively. Distributed lag nonlinear models were applied to assess the impact of excessive heat on HFMD and its variability across social-economic status and age groups. Results: After controlling the effects of several potential confounders, the commonly hot days were found to positively affect the HFMD burdens with the relative risk (RR) peaking at around 6 days of lag. The RR of HFMD in the Pearl-River Delta Region was generally higher and persisted longer than that in the remaining developing areas. Regarding the inter-age group discrepancy, children aged 3–6 years old

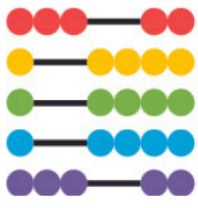
had the highest risk of HFMD under conditions of excessive heat where as those greater than 6 years old had the lowest. The lag structure of the impact of the extremely hot days was quite similar to that of the commonly hot days, although the relative effect of these two kinds of conditions of excessive heat might vary across regions. Conclusions: This study indicated significantly facilitating effects of excessive heat on HFMD especially among those aged 3-6 and from developed areas. Results from the current study were particularly practical and important for developing area-and-age-targeted control programs in the context of climate change and urbanization. (C) 2015 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

124. Zivin, J. G., and J. Shrader (2016), *Temperature Extremes, Health, and Human Capital*, *Future of Children*, 26, 1: 31-50, DOI: 10.1353/foc.2016.0002.

Citations: 31

Abstract: The extreme temperatures expected under climate change may be especially harmful to children. Children are more vulnerable to heat partly because of their physiological features, but, perhaps more important, because they behave and respond differently than adults do. Children are less likely to manage their own heat risk and may have fewer ways to avoid heat; for example, because they don't plan their own schedules, they typically can't avoid activity during hot portions of the day. And very young children may not be able to tell adults that they're feeling heat's effects.

Joshua Graff Zivin and Jeffrey Shrader zero in on how rising temperatures from global warming can be expected to affect children. They review evidence that high temperatures would mean more deaths, especially among fetuses and young children (as well as the elderly). When combined with other conditions such as high humidity, diseases, or pollution-heat can be even deadlier. Even when it doesn't kill, high heat directly causes heat-related illnesses such as heat exhaustion; worsens other conditions, such as asthma, by increasing smog and ozone pollution; and harms fetuses in the womb, often with long-term consequences. High temperatures can also make learning more difficult, affecting children's adult job prospects. What can we do to protect children from a hotter climate? Graff Zivin and Shrader discuss a range of policies that could help. Such policies include requiring air conditioning in schools; heat wave warning systems coupled with public infrastructure that helps people stay indoors and stay cool; and readjusting schedules so that, for example, children are mostly indoors during the hottest time of day or the hottest season of the year.



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