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RISK FACTORS FOR EMERGENCY MEDICAL CARE OR HOSPITALIZATION DUE TO HEAT-RELATED ILLNESS OR INJURY: A SYSTEMATIC REVIEW

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***Background**: Temperatures globally have been predicted to increase due to changes in the climate. As the earth gets warmer, it is expected that heat-related illness will also increase worldwide. An effective and appropriate public health response will be critical. **Purpose**: The aim of this review was to identify risk factors associated with heat-related illness and injury to provide target areas for future interventions. **Methods**: A review of existing literature was analyzed for risk factors that may increase the likelihood of being admitted to an emergency department for a heat related illness or injury. **Results**: Of the included articles in this analysis (n=85), the common risk factors for emergency care or hospitalization from heat exposure were patient's age (n=42), gender or sex (n=33), underlying health conditions or comorbidities (n=12) and time of year (n=24). **Discussion:** Community education and public health messages for prevention with focus on risk factors and common symptoms are important to decrease the rates of emergency care and hospital admissions. Further research is needed to determine mitigation strategies to decrease heat-related illness or injury as well as investments in early warning systems to protect vulnerable populations.*

Introduction | Climate change has been attributed to an almost 1.5-degree average increase in Fahrenheit globally since 1900 and is projected to increase another 2.0 degrees Fahrenheit by 2100.[1] The world's five hottest years on record have occurred since 2015 and nine out of ten of the world's hottest years during the last five decades have occurred since 2005.[2] The Earth is continuing to get warmer due to increasing greenhouse gases like carbon dioxide and methane being released into the atmosphere. These gases build up and trap additional heat which increases average ambient temperatures all over the world.[3] Higher temperatures are linked to higher mortality and in the United States (USA), extreme heat events contribute to more deaths each year than all other extreme weather events combined.[4]

Temperature increases during the last century contribute to negative health impacts for communities.[5-6] Summer months, or the "hot season," are characterized by extreme heat events and overall warmer temperatures when compared to other times of the year. The Centers for Disease Control and Prevention (CDC) predict that as ambient temperatures increase, the average temperature of "hot weather" and "record hot weather" will also continue to grow in severity.[3] Studies have shown that as temperatures in a region increase over time, heat-related-illness (HRI) become more common.[4,7-8] Heat-related illnesses include a wide range of disorders that present from mild to severe. As the human body absorbs large amounts of heat, it often cannot expel that heat at the same rate. This can cause complications like heat cramps, heat exhaustion, heat edema, heat migraines, heat stroke and more.[9] Heat-related illness is a serious complication and can result in death if not treated promptly. With the increase of heat-related illness, hospital admissions and emergency department visits are also expected to rise.[6]

Identifying risk factors that may contribute to extreme heat exposure and subsequent heat-related illness will aid in the prevention of emergency department visits or the need for acute medical response. Reducing

exposures to extreme heat within high-risk or other vulnerable groups can decrease the potential for developing a heat-related illness and medical facility admission or care.[10] Increased knowledge of risk factors for heat-related illness can also help identify vulnerable populations for focused interventions and public health response efforts. The purpose of this review is to identify the risk factors reported globally that contribute to emergency department admission, hospitalization, or other acute medical care for a heat-related illness or injury.

Methods | For this review, six different databases were searched between May 24th and May 28th, 2020 and included PubMed, Science Direct, Web of Science, Nursing and Allied Health Outcomes, CINAHL, and ProQuest: Health and Medicine. The search terms used included "heat related illness," "heat related injury," "hospitalization," "emergency department," and "admission". Boolean Operators AND/OR were also used as applicable to each database. For example, the following search string was used within the Science Direct database: ("heat related illness" OR "heat related injury") AND (hospitalization OR "emergency department" OR admission). A full listing of search strings by database is available (S1).

Studies were included that met the following eligibility criteria: 1) the research identified risk factors and/or specific patient demographics associated with seeking acute care at a medical facility or from emergency medical professional due to a heat-related illness or injury; 2) the publication was a peer-reviewed journal article; 3) the study was published between January 1, 2000 and May 28th, 2020; and 4) the study was conducted on primary data. Included studies were qualitative and quantitative and both domestic and global in scope. Titles were excluded if they were published outside of the date range, were in any format other than peer-reviewed article, written in a language other than English, did not address risk factors or specific case demographics associated with a heat-related illness and emergency care, compared clinical outcomes only, used secondary data analyses or reviews, or conducted analyses on model outputs only. No specific definition of heat-related illness or injury was used in this review and instead this was defined within the individual included studies by the authors. Morbidity and mortality data were both included as long as this outcome was the result of a heat-related illness or injury, and risk factors or specific case characteristics were addressed in the publication.

During full examination of the included studies, risk factors and specific patient demographics were recorded as they were identified in the paper and overall themes were noted. However, not every patient demographic or associate case characteristic was noted unless related to a heat-related illness or injury. The authors utilized broad terms and phrases to represent the included risk factors and their subject matter and categorize the study findings (i.e. socioeconomic status). These categories served to align the findings of multiple studies and synthesize their outcomes in the review. Due to limitations of the co-authors, studies were restricted to English language only.

Results | The initial search yielded a total of 1,133 titles published between the years 2000 and 2020 (Figure 1). The results were further narrowed down to 142 articles upon initial screening of the subject matter in the title and abstract and removal of duplicate publications and non-journal articles. From a full-text examination of these titles by both authors, 85 articles addressed the research question at hand and were selected for inclusion. One research article was admitted as a replacement in the final analysis for a case study published on these findings that was included in the original search results.[11-12]

Each included article was analyzed in depth for risk factors that contributed to an individual seeking care or treatment at a medical facility or emergency department for a heat-related illness or injury. In addition, the study population, location, and purpose were outlined (Table 1). The articles were organized in chronological order by the year they were published.

There were multiple risk factors for heat-related illness listed in each article. The prevalent risk factor for seeking acute care for a heat-related illness or injury was an elevation in ambient temperature (n= 25) or an elevated ambient temperature over consecutive days (n= 21).The next most commonly identified risk factors contributing to increased risk of admission to an emergency department for a heat-related illness within these publications were age (n=42), sex (n=33), time of year (warm months/summer based on the study hemisphere) (n=24), outdoor exercise/sports (n= 21), geographical origin (n= 13), and comorbidities (n= 12). Additional risk factors noted in multiple included studies were outdoor mass gathering events (n= 10), medication usage (n= 10), race/ethnicity (n= 9), rural residence (n= 8), socioeconomic status (n= 8), military physical training (n= 7), outdoor work (n= 7), being uninsured (n= 6), weekday (n= 4), urban residence (n= 4), no air conditioning at home/prefer not to use the air conditioning (n= 3), occupation (n= 3), physical labor (n= 3), having a mental illness and/or behavioral disorder (n= 3), event of human smuggling and/or trafficking (n= 3), a lack of heat acclimatization (n= 2), previous heat sensitivity (n= 2), living in a nursing home/institution (n= 2), and being socially isolated (n= 2). Residential crowding, elevated temperature year, heaving clothing use in summer, being immobile, gastrointestinal distress, a lack of sleep,

poor salt intake, travel, and time of day were mentioned in an included study (n= 1).

Specifically, the 65 and over age range (senior) was identified most often as a risk factor for heat-related health care and response (n=21). Males were shown to be at higher risk for heat-related injury or illness than females, although it was dependent upon the study population (n=25 and n=8, respectively). Comorbidities, or underlying illnesses or chronic health conditions, were mentioned as a risk factor for many study participants. Cardiovascular disorders and upper respiratory disease were attributed to higher rates of emergency department admission or hospitalization due to heat exposure (n=9). Seasonality was a common risk factor for heat-related illness and injury with summer months being a more dangerous time of year.

Of the 85 articles included, the majority of studies were conducted within the USA (Figure 2). Most studies were conducted in the United States (n= 44) followed by Australia (n=12), Canada (n=6), China (n=4), Japan (n=3), as well as Israel, Italy, Pakistan, Greece, and Saudi Arabia (n=2 each). England and Wales, India, Oman, Iraq, France, the Republic of Korea, Qatar, and Taiwan each served as the location for a single study in this analysis.

Discussion | Based on this review, a common risk factor for HRI was patient age. This factor was mentioned in 49% of the articles included in this study.[11,13-14,19,24,27,31,33,35,38,41,43,46-47,49,52-53,55-57,59,61,63-65,67-70,72-74,77-78,80-84,88,90,96] However, the age groups at higher risk for heat-related illness and/or follow up health care varied by study design and measure. A quarter of the articles, 25%, found that being over the age of 65 put a person more at risk for being admitted to a medical facility or needing emergency care for an HRI.[11,13,19,24,27,31,33,49,52-43,55-57,59,64,67,69,74,78,84,90] This could be due to higher rates of chronic upper respiratory conditions or chronic cardiovascular conditions in older individuals that could exacerbate the health effects of extreme heat exposure and lead to more dangerous outcomes.[97]

Sex was another risk factor mentioned in many of the included study findings.[11,14,19-20,24,27-28,32-33,35-36,41,46-47,53,56,59,63-65,67,70,72-73,77-78,80-83,86,91,96] Almost 39% of studies listed sex, largely being of male sex (28%), as a condition which put individuals at higher risk for an HRI.[11,27-28,33,35,41,46-47,53,56,59,63-65,67,70,72-73,77,80-83,91,96]

This factor may be intertwined with lifestyle choices, cultural norms, and behavioral factors associated with masculine v. feminine social constructs (gender) rather than biological, physiological, or any other dimension (sex).[98] However experimental investigations have shown females to be more intolerant to higher temperatures and suggest that sex-related physiological and thermoregulatory differences may be the contributing factor to heat-related injury or illness.[99] However, further research needs to be conducted in order to determine the statistical significance of this claim. Some research has found that men have greater participation in yard work, outside recreational activities and occupations that expose workers to higher temperatures- which would be due to gender roles and no sex.[46] For example, in the study by Xiang et al., HRI rates were analyzed by extreme heat and the effect that had on workers compensation claims for HRI in South Australia (2015).[100] Of these claims, 81% were men.[100] The correlation between sex and HRI, based on this review, should be investigated further, particularly surrounding risks surrounding gender and/or gender roles. While there were studies that listed sex as a risk factor, there was not as much of a description of the specifics to the relationship.

As temperatures are generally higher during summer months, 26% of the reviewed studies listed this time of year as a common risk factor.[11,14,20,26,35,38,41,43,45-47,53,56,63,65,68-70,74,78,82,86] Perhaps as expected, most studies included in this analysis reported a direct correlation of increased HRI with exposure to high temperatures or extreme heat events.[11,13,21,23-26,30,31,33-34,36,37,43,45,47,49-51,53,57-59,61,65-66,68-69,74-76,78-79,84-85,87-90,95]

This alone could contribute to advocating for future research and public health policy consideration. However, coupled with higher temperatures during seasonal weather comes outdoor sporting exhibitions and races, exercise regimens, festivals, and mass gatherings.[14-18,27-29,32,38-43,54,60,71,76-77,83,85,88,91-92,94-95]

These large-scale events can bring vast quantities of people together which leads to medical response and emergency care needs that can overwhelm unprepared health care professionals, particularly during high heat days.[101-102]

High temperatures and extreme heat events are routine during summer months.[5] And with the effects of climate change progressing, summer months are anticipated to be hotter globally in the coming years.[3,5] Climate change is expected to contribute to increases in HRI for healthy residents, but specifically among the vulnerable populations mentioned in this review. Yet future research in this topic area may consider examining HRI at different parts of the year to determine if people are seeking emergency medical care across other calendar months.

Comorbidities were listed as a risk factor for heat-related illness in approximately 14% of the included articles.[13,15,24,31,49,52,59,61,63,71,77,83] Examples of comorbidities include cardiovascular disease or upper respiratory conditions such as asthma. These conditions could amplify symptoms of HRI and motivate a person to seek medical care.[97,103] Comorbidities may also be related to increased age, yet another risk factor for HRI. With the help of modern medicine, populations globally are living longer on average. This allows noncommunicable

diseases and disabilities to progress into older age. This can cause seniors to be at higher risk for HRI because they are inherently more likely to have age-related comorbidities.[9,97] Yet even a younger, overall healthy individual who would not normally be effected severely by extreme heat or higher temperatures will be more at risk for seeking medical care for an HRI if they have a pre-existing condition like asthma.[103] Asthma rates across the globe have been mounting with more than 339 million people suffering with the condition. It has also been recognized as one of the most common chronic diseases among children.[104]If comorbidities, like asthma, continue to increase around the globe, it could drive the risk for HRI incidents higher within overall populations. As comorbidities and age were both frequently reported risk factors in this review, it may be helpful to investigate further the relationship between these two topics.

This review highlights the reported global risk factors and specific patient demographics for those seeking emergency health care from HRI with further discussion of several frequently described characteristics. Previous studies have analyzed risk factors in specific geographic locations or with a focus on particular patient characteristics. This review outlines the reported risk factors from multiple locations around the world thus illustrating differences and similarities in HRI drivers among patients. The risks outlined in this review are expected to continue to contribute to the rates of admission to medical facilities or emergency departments for HRI unless proactive action is taken to prevent dangerous heat exposures. The first priority for most communities and municipalities is to conduct an assessment of climate change and temperature-related vulnerability, particularly among marginalized and high-risk groups.[105] The CDC has developed a framework for health departments and similar organizations for performing an assessment and writing a plan of action for climate change adaptation and mitigation efforts. The acronym B.R.A.C.E. is used to exemplify the process of Building Resilience Against Climate Effects.[106] These five sequential steps include 1) identifying potential impacts of climate change and their resulting adverse health outcomes for communities and regions, particularly among overlooked populations; 2) conducting a quantification of the anticipated increased disease burden for these climate change effects; 3) determining the most effective and efficient public health interventions that could be implemented to combat these adverse health outcomes; 4) creating, implementing, revising, and managing a written plan of action for addressing climate effects on health; and 5) conducting continual monitoring and evaluation of the plan and its success and failure.[106]

Already, multiple countries, regions and communities have early warning systems for dangerous temperatures and extreme heat events but there are still many areas that do not utilize similar systems or have an emergency plan in place.[107] A report released by the World Health Organization in Europe showed that only 15 of the 45 countries analyzed in the study had a heat health warning system or an emergency plan in place.[108] In the United States, similar studies have showcased the need for updated emergency plans and/or the implementation of heat health early warning systems.[109] Policy makers should make it a priority that all communities have some sort of public alert procedure or emergency plan in place and available to community members, as well as a method of delivering these warnings to all residents through multiple communication channels.[108-109] For example, New York City, NY, USA, has an advanced warning system in place that not only provides information to the general public about extreme heat, but also provides emergency alerts to organizations that serve populations with disabilities and other special needs. The system advertises cooling centers and allows people to sign up for updates and more information.[110] Public health officials should focus their efforts towards not only awareness and community education on the risks of HRI and prevention measures but also on climate change mitigation and adaptation strategies. Our research has outlined reported risk factors that may increase the likelihood of acquiring a heat-related illness and seeking medical care for an HRI. Future research would benefit from focusing more extensively on additional risk factors such as race/ethnicity, socioeconomic status, occupation, outdoor exercise, etc. This review attempts to outline and explain risk factor data available at this time. Comparing similarities between HRI drivers globally rather than nationally could help uncover more innovative and collaborative ways of preventing HRI incidents. Further research on the statistical significance that each risk factor may be contributing to the severity of HRI is needed.

However, this work is not without limitations. By not utilizing supplementary databases, it is likely that additional journal articles that address the issue were unintentionally omitted from the analysis. Moreover, study findings published in any language other than English are absent but could provide an ancillary understanding to the role of increased heat on care-seeking behaviors worldwide. And finally, the exclusion of articles which discussed broad patient characteristics for emergency care during heat events or mass gathering events, without specific mention to risk factors for heat-related illness or injury, could still be beneficial for public health and clinical response. In fact, case definitions for what constituted heat-related illness and/or injury varied across the studies. The difficulty in teasing out HRI risk factors lead to the

authors to be conservative in their inclusion of titles and subsequent risk factors. However, the risk factors listed in the results table of this paper is not exhaustive and likely does not capture the true breadth of the issue. It is also important to note that while this review discussed only a few of the risk factors identified in the included titles, it does not diminish the importance or prevalence of other risk factors either outlined in the results of this study or reported elsewhere. Common risk factors listed should not be interpreted as more important than others either listed or not. Future research efforts should focus on the needs of the highlighted at-risk, vulnerable populations both domestically and globally but must consider additional groups not listed to further understand the individual and social determinants of health for HRI in order to design interventions and prevention strategies in the face of increased temperature and climate change.

Conclusion | This review compiled the risk factors shown to increase a person's chance of being admitted to a medical facility or emergency department for a heat-related illness. As global temperatures are increasing every year, heat-related illness will continue to be a public health challenge. Efforts to educate communities on risk factors, symptoms, treatment, and prevention strategies can decrease rates of illness and injury from exposure to extreme heat. Further research in determining mitigation strategies to decrease the incidence of seeking medical care for a heat-related illness is needed. Furthermore, investments in early warning systems and municipal and social infrastructure to protect vulnerable populations is critical in our collective response to climate change.

Figure 1: *Screening flowchart for study inclusion.*

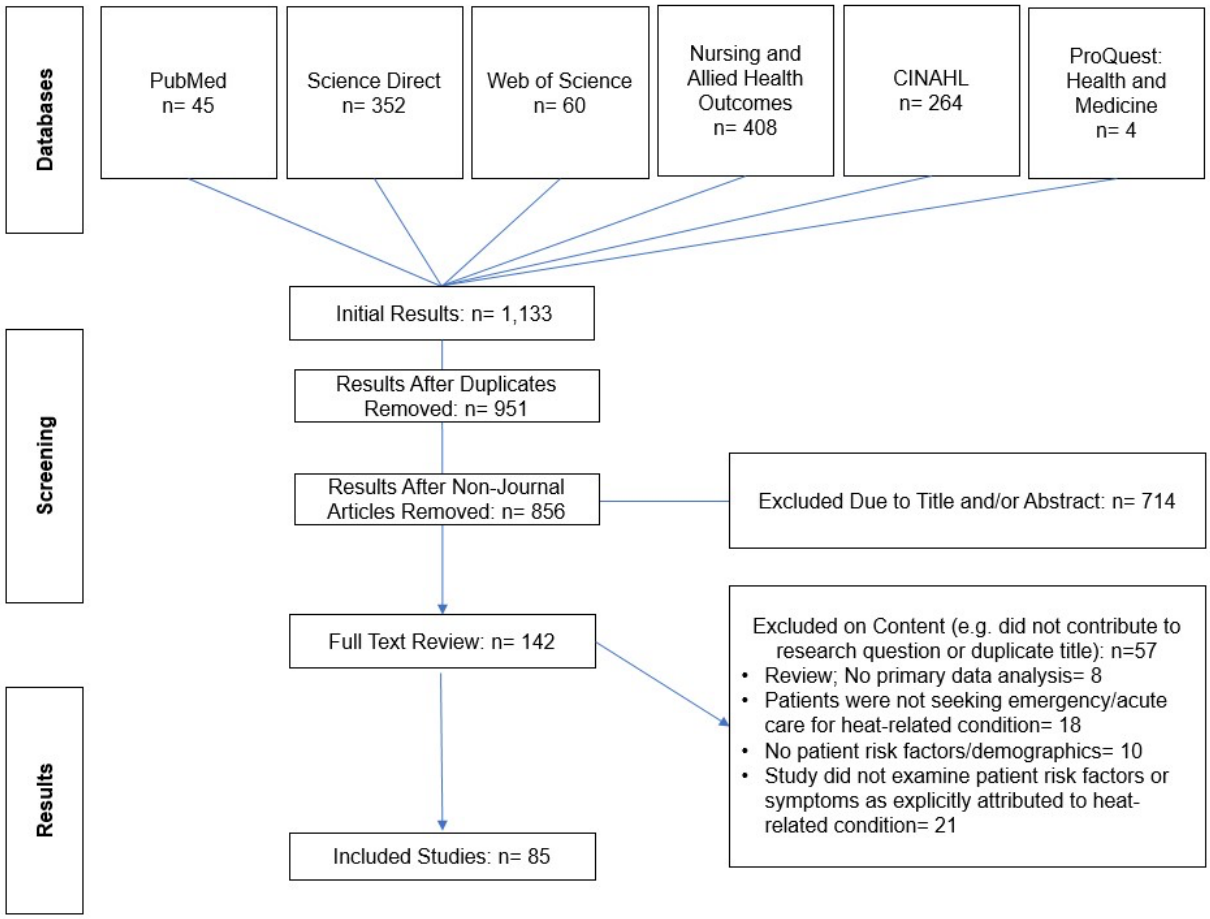


Table 1: *Summary of included studies (n=85) by title, year, location, population, purpose, and identified risk factors for acute care, hospitalization, or emergency response due to heat-related illness or injury in chronological order of publication.*

Citation	Year	Study Location	Study Population	Purpose of Paper	Risk Factors Identified
13	2000	Taiwan	Patients diagnosed with classic heat stroke at Taipei Veterans General Hospital between June to August in 1998	Explore causes of heat stroke	• Age (senior) • Comorbidities • Elevated ambient temperature over consecutive days • Heavy clothing use in summer • Immobile • Medication usage • No air-conditioning in home (or prefer not to use it) • Residential crowding • Urban residence
14	2001	U.S.	89,500 soccer players, ages 9-19	Record the incidence of competition related injuries among players in an international youth soccer tournament and to assess the location and type of injuries by age and sex	• Age (youth) • Outdoor exercise/sports • Sex (female) • Time of year (summer)
15	2001	California, U.S.	Patients that participated in the mentioned event presenting for medical care for heat-related-illness	Identify risk factors for exertional heat-related-illness and whether having human immunodeficiency virus increases your risk of acquiring this outcome	• Comorbidities • Outdoor exercise/sports
16	2001	South Carolina, U.S.	Marine Corps members 1979–1991 at the Parris Island Marine Corps Recruit Depot, SC	Evaluate long-term susceptibility to heat-related-illness in military recruits who had exertional heat illness during basic training	• Military physical training • Outdoor exercise/sports
17	2001	U.S.	Solider/Emergency department patient	Examine the cause of hospitalization and provide recommendations to avoid this incidence in the future	• Military physical training • Outdoor exercise/sports
18	2002	U.S.	All U.S. military personnel on active duty in the four Service branches during 1996-1999	Identify all U.S. military exercise related deaths	• Military physical training • Outdoor exercise/sports
19	2003	Montreal Island, Quebec, Canada	1,802,309 Island residents	Investigate the frequency and determinates of heat-related injury in Montreal Island, Quebec, Canada	• Age (senior) • Sex (female)
20	2005	U.S.	Hospitalization data from 1980 through 2002 of the U.S. Army	Document hospitalizations and death due to heat-related-illness	• Sex (female) • Geographic origin (duty station) • Lack of heat acclimatization • Occupation (military) • Race/ethnicity (White or Caucasian)

					• Time of year (June-August)
21	2005	Oman and Iraq	80 patients admitted to the ED for heat-related-illness between 2001 and 2003	Define the distribution and nature of the underlying pathophysiology of heat-related-illness	• Elevated ambient temperature • Gastrointestinal distress • Lack of heat acclimatization • Lack of sleep • Physical labor • Previous heat sensitivity • Poor salt intake • Outdoor work • Travel
22	2005	Hong Kong, China	A 48 old male patient admitted for heat-related-illness	Report a specific case of heat-related-illness in a patient that also uses certain antipsychotic treatment	• Medication usage • Outdoor work
23	2006	Athens, Greece	One patient from East Timor seeking asylum	Describe the case of an asylum-seeking refugee that developed heat stroke	• Elevated ambient temperature • Human smuggling/trafficking using unsafe transportation
24	2007	England and Wales	Daily mortality data for study period	Determine the subgroups of the population that are most vulnerable to heat-related and cold related mortality	• Age (senior) • Comorbidities • Elevated ambient temperature • Living in a nursing home/institution • Sex (female) • Urban residence
25	2007	Italy	Daily count of hospital admissions for people aged ≥75, from June 1 through August 31 in 2002 and 2003	Determine the relationship between hospital admissions and heat waves during the summer months	• Elevated ambient temperature over consecutive days
26	2007	Toronto, Canada	Daily mortality data for study period	Examine and assess patterns and burdens of hot weather experienced over last five decades in Toronto	• Elevated ambient temperature over consecutive days • Time of day (3:00pm) • Time of year (July-August)
27	2008	Australia	Hospital data from 2002-2004 compiled by the Australian Institute of Health and Welfare	Analyze the extent of environmental heat caused illnesses that resulted in hospitalizations	• Age (senior) • Outdoor exercise/sports • Sex (male) • Time of year (December-February)
28	2008	New South Wales, Australia	Data from New South Wales acute hospitals	Present descriptive epidemiology of sport related hospitalization due to heat-related-illness	• Sex (male) • Outdoor exercise/sports • Time of year (November-February)
29	2008	Australia	Runners that presented to medical tents during the event	Survey injury statistics at a sprint triathlon	• Outdoor exercise/sports • Outdoor mass gathering event
30	2009	Toronto, Canada	Emergency department data from the National Ambulatory Care Reporting System	Demonstrate public health applications by monitoring 911 call and dispatch data	• Elevated ambient temperature

31	2009	California, U.S.	County level hospitalization and emergency department visit data	Investigate whether any age or race/ethnicity groups experienced increased hospitalizations and emergency department visits overall during the 2006 California heat wave	• Age (youth and senior) • Comorbidities • Elevated ambient temperature over consecutive days • Geographic origin (region of state) • Race/ethnicity (varied)
32	2010	New York, U.S.	Patients seen over a five-year period at the New York State Infirmary that attended an annual multi-day mass gathering	Identify the nature of illness diagnosed from patrons attending a mass gathering	• Sex (female) • Outdoor mass gathering event
33	2010	Australia	Emergency department admission data from multiple counties	Identify health impacts of extreme heat events	• Age (senior) • Elevated ambient temperature over consecutive days • Sex (male)
34	2012	France	Patients admitted to an urban emergency service in 2003	Compare and contrast between patients who died of heat-related-illness and those who survived	• Elevated ambient temperature over consecutive days • Living in a nursing home/institution • Medication usage • Socially isolated
35	2010	U.S.	Data from 66 hospitals nation-wide on initial visits	Examine incidence and characteristics of people admitted for environmental related reasons with a larger focus on heat-related-illness	• Age (adult) • Sex (male) • Time of year (July-August) • Weekday
36	2010	Athens, Greece	Heat stroke and heat exhaustion patients within public hospitals in the Greek National Health System in 2007	Analyze synoptic conditions, human thermal discomfort through the heat load index, air pollutant concentrations and its relationship with increased heat and the daily air quality stress index	• Elevated ambient temperature over consecutive days • Sex (female)
37	2011	Toronto, Canada	Medical Priority Dispatch System data from Toronto Emergency Medical Services	Describe relationship between temperature and emergency response calls for heat-related-illness	• Elevated ambient temperature • Weekend day
38	2011	U.S.	National Electronic Injury Surveillance System data	Describe the epidemiology of exertional heat-related injuries treated in U.S. emergency departments	• Age (young adult) • Outdoor exercise/sports • Outdoor work • Time of year (June-August)
39	2011	Pennsylvania, U.S.	Admissions from two emergency departments in Pennsylvania during the summer of 2006	Determine the array of reasons for admittance to the emergency department from patients coming from an amusement park	• Outdoor theme park
40	2011	U.S.	15-year-old male seen in clinic for heat-related-illness	Analyze the relationship between the use of methylphenidate and increased risk of heat-related-illness	• Medication usage • Outdoor exercise/sports

41	2011	Beersheba, Israel	Eligible patients admitted for exertional heat stroke at Soroka University Medical Center between 1996 and 2006	Identify factors that are associated with poor outcomes of heat-related-illness	• Age (young adult) • Geographic origin (northern region) • Military physical training • Outdoor exercise/sports • Sex (male) • Time of year (May-September)
42	2012	Australia	Archives from 2007 to 2010 of the music festival	To evaluate the public health response to the music festival	• Outdoor mass gathering event
43	2012	North Carolina, U.S.	Statewide heat-related-illness emergency department data between 2008-2010	Analyze heat-related-illness morbidity in order to provide better prevention strategies	• Age (youth and young adult) • Elevated ambient temperature • Outdoor exercise/sports • Outdoor work • Time of year (June)
44	2012	Adelaide, South Australia	Daily maximum and minimum temperatures, daily mortality, ambulance call-outs, emergency department presentations and hospital admissions between 1993 and 2009	Assess heat thresholds and temperature associations between morbidity and mortality	• Elevated ambient temperature
45	2013	U.S.	Emergency call data for Phoenix, Arizona and Chicago, Illinois between 2003 and 2006	Identify relationship between heat and emergency calls	• Elevated ambient temperature over consecutive days • Time of year (June-August) • Urban residence
46	2013	Ontario, Canada	Occupationally active adults aged 15-64 that had emergency department encounters due to heat-related-illness at work	Describe the incidence of occupational heat illness in Ontario	• Age (young adult) • New employee • Occupation • Outdoor work • Physical labor • Sex (male) • Time of year (June-August)
47	2013	North Carolina, U.S.	County-level daily emergency department visit counts for the period 1/1/2007-12/31/2008	Estimate the association between visiting the emergency department for heat-related-illness and environmental temperatures	• Age (young adult and adult) • Elevated ambient temperature • Geographic origin (region of state) • Rural residence • Sex (male) • Time of year (June and August) • Weekday
48	2013	Italy	36-year-old male patient admitted to the emergency room for heat stroke	Assess status of patient that had been exposed to a hot environment for a long period of time and its association to a specific drug treatment for a different diagnosis	• Medication usage • Outdoor work
49	2013	Montreal, Canada	Any resident that utilized health emergency services during the study period	Describe Montreal's heat response plan and application during the heat wave of July 2010	• Age (senior) • Comorbidities • Elevated ambient temperature over consecutive days • Mental illness/behavioral disorders
50	2013	Sydney, Australia	Hospital admissions data between 1991 and 2009	Analyze daily hospital admissions for certain disease groups, including the effects of heat and light between 1991 and 2009	• Elevated ambient temperature over consecutive days

51	2013	Sydney, Australia	Daily mortality and hospital admissions data for greater metropolitan region	Examine the association between unusually high temperature and daily mortality and hospital admissions in the Sydney Greater Metropolitan Region	• Elevated ambient temperature • Elevated ambient temperature over consecutive days
52	2013	South Australia	Medical record data from seven major public hospitals	Investigate the risk factors for the increased heat-related hospital admissions	• Age (senior) • Comorbidities • Living alone • Receiving community assistance • Recent fall • Socially isolated • Socioeconomic status • Uninsured
53	2014	Ningbo, China	All patients diagnosed with heat-related-illness	Examine associations between extreme heat and daily heat-related-illnesses that occurred in the Summers of 2011-2013 in Ningbo	• Age (senior) • Elevated ambient temperature • Elevated ambient temperature over consecutive days • Sex (male) • Time of year (June-August)
54	2014	U.S.	15-year-old male admitted to hospital for heat-related-illness	Identify correlations between heat-related-illness and pre-disposing factors among young athletes that increase risk for heat-related-illness	• Elevated ambient temperature • Medication usage • Outdoor exercise/sports
55	2014	U.S.	Medicare enrollees in 1943 counties	Identify possible causes of admissions to the hospital during heat events and identify their risks using historical data	• Age (senior) • Elevated ambient temperature over consecutive days
56	2014	U.S.	Hospital discharge data	Analyze data on heat-stress-illness hospitalizations from CDC's Environmental Public Health Tracking Program for 2001–2010 to summarize the incidence of heat-stress-illness and examine the trend in the rate of HSI hospitalizations	• Age (senior) • Elevated ambient temperature • Geographic origin (Midwest and Southern region of the country) • Sex (male) • Time of year (May-September)
57	2014	U.S.	Medicare beneficiaries ≥ 65 years of age in 114 cities across five U.S. climate zones	Assess relationships between heat and hospital admissions for non-accidental causes	• Age (senior) • Elevated ambient temperature over consecutive days
11	2014	U.S.	Data from the Nationwide Emergency Department Sample of the Healthcare Cost and Utilization Project	Examine rates of and factors associated with acute heat illness among emergency department patients	• Age (young adult and senior) • Elevated ambient temperature • Elevated temperature year • Geographic origin • Rural residence • Sex (male) • Socioeconomic status • Time of year (May-September) • Uninsured
58	2014	Brisbane, Australia	Hospital admissions data for residents	Quantify spatial variability in heat-related morbidity in Brisbane and highlight areas with higher risk,	• Elevated ambient temperature • Geographic origin (areas of the city) • Population density

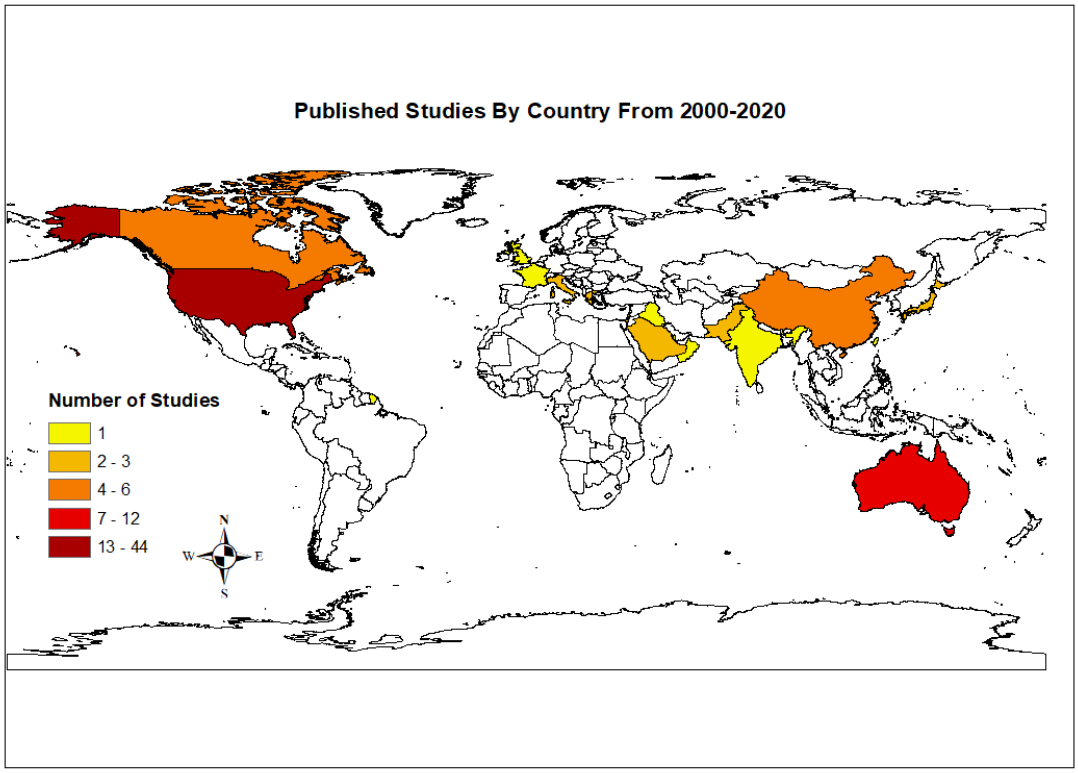
				specifically social and environmental	• Socioeconomic status
59	2014	Georgia, U.S.	Emergency department visit and hospital discharge data	Determine characteristics predicting hospitalization versus emergency department discharge using demographic characteristics, comorbid conditions, socioeconomic status, public health district residence and the presence of an extreme heat event	• Age (adult and senior) • Comorbidities • Elevated ambient temperature over consecutive days • Geographic origin (public health district) • Sex (male) • Socioeconomic status
60	2014	Israel	All long-distance race data from March 2007 to November 2013	Identify what percentage of life-threatening events are due to heat stroke and cardiac issues	• Outdoor exercise/sports • Outdoor mass gathering event
61	2015	India	Patients admitted to an ICU	Identify the profile and outcomes of patients admitted to the intensive care unit with heat-related-illness	• Age (adult) • Comorbidities • Elevated ambient temperature • Medication usage
62	2015	North Carolina, U.S.	Emergency department visit data	Identify area-level risk factors for heat-related-illness at the ZIP code level for urban and rural locations	• Geographic origin (regions of the state) • Rural residence
63	2015	U.S.	Emergency department and inpatient hospitalization data from 2007-2011 in nine states	Identify heat-related-illness numbers as well as demographics and characteristics of patients	• Age (varied) • Comorbidities • Geographic origin (southeastern region of the country) • Occupation • Race/ethnicity (Non-white) • Sex (male) • Time of year (June-August) • Weekday
64	2015	U.S.	Hospital data from Nationwide In-patient Sample	Identify individual and environmental risk factors for hospitalizations and document patterns of household cooling	• Age (adult and senior) • Geographic origin (western region of country) • Mental illness/behavioral disorders • Neurological disorder • Race/ethnicity (Black or African American) • Rural residence • Sex (male) • Socioeconomic status • Uninsured • Urban residence (small clusters)
65	2015	North Carolina, U.S.	Data on emergency department visits obtained from the North Carolina Disease Event Tracking and Epidemiologic Collection Tool	Identify associations between heat and morbidity across warm seasons	• Age (young adult and adult) • Elevated ambient temperature • Geographic origin (region of the state) • Rural residence • Sex (male) • Time of year (May-September)

66	2016	King County, Washington, U.S.	County residents that placed emergency medical service calls	Build on current assessment on mortality and hospitalizations in King County, Washington using emergency medical service calls associated with extreme heat over a six-year period	• Elevated ambient temperature
67	2016	Australia	6700 veterans with incident hospital admission for dehydration or heat-related illness between 2001 and 2013	Assess risk relationship between heat-related-illness and initiation of certain medicines	• Age (senior) • Medication usage • Sex (male)
68	2016	North Carolina, U.S.	Daily emergency department visit data	Gather data on emergency department visits for heat-related illness during three heat events across North Carolina from 2007 to 2011. Visits during these events were compared to the expected number of emergency department visits during several control periods to determine excess morbidity resulting from extreme heat	• Age (varied) • Elevated ambient temperature over consecutive days • Time of year (June-August)
69	2016	Karachi, Pakistan	Mortality data from seven public hospitals and private clinics	Investigate potential risk factors for excess mortality associated with the heat wave of June 2015 in Karachi	• Age (senior) • Elevated ambient temperature over consecutive days • No air-conditioning in home (or prefer not to use it) • Time of year (June-July)
70	2016	Florida, U.S.	Emergency department and hospital discharge data	Describe the burden of severe HRI morbidity and mortality among residents of a humid subtropical climate	• Age (youth and adult) • Geographic origin (county of residence) • Race/ethnicity (Non-White) • Rural residence • Sex (male) • Time of year (May-October)
71	2016	U.S.	19-year-old patient being treated for heat stroke	Assess relationship between hyperthermia and exertional heat stroke	• Comorbidities • Outdoor exercise/sports
72	2016	U.S.	The United States 2001 to 2010 Nationwide Inpatient Sample	Determine and explore expenses for hospitalizations for heat-related-illness	• Age (adult) • Race/ethnicity (White or Caucasian) • Rural residence • Sex (male) • Socioeconomic status • Uninsured
73	2016	U.S.	The United States 2001 to 2010 Nationwide Inpatient Sample.	Compare inpatients with heat-related-illness and inpatients without heat-related-illness and the resources they use	• Age (adult) • Race/ethnicity (White or Caucasian) • Sex (male) • Socioeconomic status • Uninsured
74	2016	U.S.	Medicare beneficiaries who were aged 65 years or older for study period	Evaluate spatiotemporal variation of heat stroke admissions during heat waves and what factors modify the adverse effects	• Age (senior) • Elevated ambient temperature over consecutive days • No air-conditioning in home (or prefer not to use it) • Time of year (June-July)

75	2016	Atlanta, Georgia, U.S.	Emergency department patients within one of the 20 counties in the Atlanta metropolitan area.	Assess associations between warm-season ambient temperature and emergency department visits across ages in Atlanta during 1993–2012	• Elevated ambient temperature
76	2017	China	Runner that presented to the Accident and Emergency Department of Ruttonjee and Tang Shiu Kin Hospital	Evaluate characteristics and outcomes of marathon runners that presented to the local ED	• Elevated ambient temperature • Outdoor exercise/sports • Outdoor mass gathering event
77	2017	Saudi Arabia	88 patients effected by heat that were brought to central tent clinics	Asses the medical response of the Indian Hajj Medical Mission during the 2016 Hajj	• Age (adult) • Comorbidities • Outdoor exercise/sports • Outdoor mass gathering event • Sex (male)
78	2017	Republic of Korea	Patient data from the National Health Insurance Service database.	Assess the relationship between heat and heat-related-illness	• Age (senior) • Elevated ambient temperature • Rural residence • Sex (female) • Time of year (May-September)
79	2017	New York City, U.S.	Statewide emergency medical system and emergency department data related to heat illness	Examine the capabilities of the heat illness syndromic surveillance data to predict non external deaths	• Elevated ambient temperature over consecutive days • Weekday
80	2017	Karachi, Pakistan	Patient data from the Indus Hospital in Karachi	Identify risk factors of heat-related-illness during the June 2015 heat wave	• Age (adult) • Sex (male)
81	2017	U.S.	Hospitalization data from the Nationwide Inpatient Sample (2001-2010)	Identify risk factors associated with mental illnesses and/or behavioral disorders with a heat-related-illness diagnosis	• Age (adult) • Medication usage • Mental illness/behavioral disorders • Race/ethnicity (varied) • Sex (male) • Socioeconomic status • Uninsured
82	2017	Maricopa county, Arizona, U.S.	Emergency department and inpatient hospital data from 2015	Evaluate a new surveillance query system that identifies new cases of heat-related-illness in real time	• Age (adult) • Sex (male) • Time of year (May-September)
83	2018	Saudi Arabia	Hajj participants admitted to emergency departments in 2016	Recognize heat illness associated with certain clinical characteristics, morbidity, management, and mortality	• Age (adult) • Comorbidities • Outdoor mass gathering event • Sex (male)
84	2018	U.S.	Medicare enrollees during study period	Estimate risks of cause-specific hospitalizations during heat waves	• Age (senior) • Elevated ambient temperature over consecutive days
85	2018	Japan	Three members of military personnel suffering from heatstroke	Multiple patients with heatstroke air evacuated by collaborative agreement	• Elevated ambient temperature • Military physical training • Outdoor exercise/sports
86	2018	U.S.	U.S. army enlistees between 2011 and 2014	Determine predictors for heat-related-illness among study population	• BMI • Marital status • Medication usage • Military physical training • Previous heat sensitivity

					• Race/ethnicity (Black or African American) • Sex (female) • Tobacco use • Time of year (summer)
87	2018	New York City, U.S.	Emergency Department visits to New York City metropolitan area hospitals for children aged 0-4 years in May-September, 2005-2011	Explore risk of high heat temperatures among children	• Elevated ambient temperature
88	2018	Japan	Medical records from world scout jamboree medical center were obtained for that Summer	Examine medical records from campers that sought care at the medical center and identify preventive measures	• Age (youth) • Elevated ambient temperature • Outdoor mass gathering event
89	2018	Brisbane, Australia	Ambulance service uses, emergency department attendances and hospitalization data for heat and/or dehydration	Asses the relationship between temperature observation time and type and the impact on evaluating morbidity and mortality due to heatwaves as well as the effect of heatwaves duration on the impact of morbidity and mortality	• Elevated ambient temperature over consecutive days
90	2018	Japan	Emergency transportation demand data	Analyze relationship between heat-related-illness and emergency transportation	• Age (senior) • Elevated ambient temperature
91	2019	U.S.	medical encounter data from nineteen 10-km road races	Identify common medical problems in the medical tent used for the 10-km road races and to point out resources for future use in minimizing impact of these races on the community	• Outdoor exercise/sports • Outdoor mass gathering event • Sex (male)
92	2019	Doha, Qatar	Participants of the para-athletics track and field world championships	Survey the championships statistics and report on any heat-related-illness data	• Outdoor exercise/sports • Outdoor mass gathering event
93	2019	Texas, U.S.	39 migrants admitted to an emergency department teaching hospital	Evaluate characteristics and outcomes of heat stroke victims from a mass casualty	• Human smuggling/trafficking using unsafe transportation
94	2019	U.S.	27-year-old combat basic trainee	Evaluate patient characteristics to prevent liver failure associated with heat injury	• Military physical training • Outdoor exercise/sports
95	2020	Mississippi, U.S.	25-year-old male that presented with heat-related-illness to a county hospital	Explore the case report of migrant worker that presented to the emergency department for heat-related-illness	• Elevated ambient temperature • Human trafficking • Outdoor work • Physical labor
96	2020	China	Hospital admissions data from June 2013 and September 2018	Evaluate the effectiveness of a quick sequential organ failure assessment (qSOFA) on patients with heat-related illness	• Age (adult) • Sex (male)

Figure 2: *Global map with locations of included studies (n=85). Shading represents the volume of published works by country. Countries without included studies are not shaded.*



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