The Influence of Heat on Daily Police, Medical, and Fire Dispatches in Boston, Massachusetts: Relative Risk and Time-Series Analyses

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Objectives. To examine the impact of extreme heat on emergency services in Boston, MA.

Methods. We conducted relative risk and time series analyses of 911 dispatches of the Boston Police Department (BPD), Boston Emergency Medical Services (BEMS), and Boston Fire Department (BFD) from November 2010 to April 2014 to assess the impact of extreme heat on emergency services.

Results. During the warm season, there were 2% (95% confidence interval [CI] = 0%, 5%) more BPD dispatches, 9% (95% CI = 7%, 12%) more BEMS dispatches, and 10% (95% CI = 5%, 15%) more BFD dispatches on days when the maximum temperature was 90°F or higher, which remained consistent when we considered multiple days of heat. A 10°F increase in daily maximum temperature, from 80° to 90°F, resulted in 1.016, 1.017, and 1.002 times the expected number of daily BPD, BEMS, and BFD dispatch calls, on average, after adjustment for other predictors.

Conclusions. The burden of extreme heat on local emergency medical and police services may be agency-wide, and impacts on fire departments have not been previously documented.

Public Health Implications. It is important to account for the societal burden of extreme heat impacts to most effectively inform climate change adaptation strategies and planning. (*Am J Public Health.* 2020;110:662–668. doi:10.2105/AJPH.2019.305563)

Extreme heat is a significant public health threat that is increasing in frequency, duration, and severity with climate change.[1] In 1971 through 2000, Boston, Massachusetts, the focus of this study, experienced an average of 11 hot days (at least 90°F) per year, but it could experience up to 40 hot days by 2030 and 90 by 2070, depending on greenhouse gas emission trajectory.[2] Although the definition of heat waves and extreme heat events varies by location and agency, heat has been the leading cause of death of all meteorological phenomena in recent decades in the United States[3] and results in significant morbidity and a myriad of poor health outcomes.[4,5] Recent research has shown that even at lower thresholds than previously thought, heat has the ability to affect public health and societal services[6] and governance.[7] It has been well documented that heat stress–related ambulance calls,[8–12] aggressive behavior (even in normal interactions and situations),[13] and violent crime[14–16] increase on hot days. Extreme heat has been associated with declines in cognitive function[17,18] and sleep.[19,20] Cognitive failures have been associated with increased driving errors in healthy adults.[21] Poor sleep or sleep deprivation has been associated with increased traffic accidents,[22] increased occupational injury,[23] and inhibition of working memory and concentration.[24] Extreme heat may also result in increases in impulsivity, which can escalate otherwise positive or neutral situations into aggressive situations.[13] With these health outcomes, there are many potential pathways to emergency situations when the clinical and subclinical health impacts of extreme heat are being experienced across a large population, like a city.

Despite these many potential outcomes, as of 2016, the only incorporation of emergency services into heat preparedness planning in Boston was through increased awareness of medical practitioners of heat-related illness and increasing onsite power generation and backup for police, ambulance, and fire stations.[2] Even though local first responder groups, public health practitioners, and nonprofit groups were all able to provide anecdotal awareness of these societal impacts on hot days, a lack of quantitative evidence has limited resilience and adaptation planning to date.

The premise of this study was to evaluate agency-wide impacts of extreme heat on emergency services, as these health and behavioral changes that happen during extreme heat periods create pathways to emergency situations. The study's objective was to determine whether emergency services in Boston experienced greater need during extreme heat—through the dispatch of police, ambulance, and fire department services; we assessed this using both relative risk and time series analyses.

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METHODS

Daily counts of emergency dispatch calls for the City of Boston for November 1, 2010, to April 21, 2014, were publicly available from the Boston Department of Innovation and Technology.[25] These calls represented 3 agencies—the Boston Police Department (BPD), Boston Emergency Medical Services (BEMS), and Boston Fire Department (BFD). Major holidays and local events (e.g., the Boston Marathon) were evaluated to determine if they were outliers. We computed descriptive statistics on the distribution of dispatches within agencies across the full year and the warm season (May–September) using a Student *t* test.

Meteorological Data and Exposure Assessment

We obtained daily maximum ambient temperature and daily maximum heat index (to assess both temperature and humidity) from Boston Logan International Airport and assessed them as continuous variables. Extreme heat can also be assessed by using temperature thresholds set a priori for a specific location. A common measure of extreme temperature exposure in Boston is when the daily maximum temperature is 90°F or above, and heat advisories are issued beginning at a daily maximum heat index of 95°F or above, both as defined by the local National Weather Service.[26] City agencies use this definition to enact local warnings and responses (e.g., opening of cooling centers). In this study, hot days were those in which the maximum temperature was 90°F or above, and days with a maximum heat index of 95°F or above were considered hot and humid. We examined cumulative impacts of heat as a binary variable indicating 2 consecutive hot or hot and humid days. Data on daily ozone and particulate matter 2.5 microns or smaller in size ($PM_{2.5}$) were available from the US Environmental Protection Agency's Air Quality System for Station 25–025-0042 located in Roxbury, Boston. Summary statistics of the local climate and air pollution can be found in Table 1.

Relative Risk Analysis

We used relative risk analyses to determine an agency's relative risk of dispatch on a hot day compared with nonhot days. We restricted relative risk analyses to the warm season to reduce seasonal confounding and any bias introduced from population fluctuations between the academic year and the warm season. (Analyses on the full study period are in Table A and Figure A, available as supplements to the online version of this article at http://www.ajph.org). The relative risk quasi-Poisson regression model equation is as follows:

$$\log\left(\mu_j\right) = \beta_0 + \beta_1 I_j[HotDay] + \log(Population_k) \quad (1)$$

where μ_j is the expected count of dispatch calls for an agency on day *j*, $I_j[HotDay]$ is a binary indicator of a hot day, and log(*Population*) in year *k* represents the yearly number of permanent residents in Boston. We ran the same model substituting the indicator for hot day with an indicator for hot and humid day, 2 and 3 consecutive hot days, and 2 and 3 consecutive hot and humid days.

Time Series Analysis

We used time series (TS) analyses to assess the relationship between maximum temperature and dispatch call counts for each agency per unit increase in temperature, using a quasi-Poisson regression. TS analyses were also restricted to the warm season, but full-year analyses are in Table A and Figure A. The warm-season-restricted TS models used a nonparametric spline with 1 degree of freedom per year to account for any long-term trends in emergency services (we used 4 degrees of freedom per year in the full-year analysis to account for seasonal trends), and a natural cubic spline with 2 degrees of freedom for maximum temperature or maximum heat index, all determined a priori on the basis of previous research and to optimize the generalized cross validation criteria. Sensitivity analyses on the degree of freedom for maximum temperature or maximum heat index did not influence the main results (not shown). We controlled for day of the week with indicator variables for each day, with reference to Friday. We also inserted linear terms for daily ozone and $PM_{2.5}$ into the model, given ozone and $PM_{2.5}$'s association with both high temperature and relevant health outcomes. The TS model equation is as follows:

$$\begin{aligned} Log(\mu_j) = \beta &+ s(\beta_1(T_{MAX})_j) \\ &+ \beta_2 I(HotDay)_j + \beta_3(Ozone)_j \\ &+ \beta_4(PM_{2.5})_j + \beta_5 I(DayofWeek)_j \\ &+ s(\beta_6(Date)_j) + \log(Population_k) \end{aligned} \quad (2)$$

where μ_j is the expected count of dispatch calls for an agency on day *j*, $I(HotDay)_j$ is a binary indicator of a hot day, $I(DayofWeek)_j$ is an indicator for day of week, and *s* represents splines on variables with nonlinear trends; daily maximum temperature, ozone, and $PM_{2.5}$ were all examined as continuous variables for each day *j*, and log(*Population*) in year *k* represents the yearly number of permanent residents in Boston. We ran the same model substituting maximum temperature for maximum heat index. Results are

TABLE 1—Descriptive Statistics for Warm-Season Meteorological and Atmospheric Conditions: Boston, MA, 2010–2014

	Mean (SD)	Range
Daily maximum temperature, °F	76.15 (10.45)	50–103
Daily minimum temperature, °F	61.18 (8.04)	36–81
Daily mean temperature, °F	68.86 (8.87)	47–92
Daily mean heat index, °F[a]	80.65 (8.27)	68–116
Ozone, ppm	0.03 (0.01)	0.05–0.08
$PM_{2.5}$, µg/m[3]	8.66 (4.49)	0.1–28.0

Note. $PM_{2.5}$ = particulate matter ≤ 2.5 microns; ppm = parts per million. Data are from measurements taken at Boston Logan International Airport and the US Environmental Protection Agency's Air Quality System for Station 25–025-0042. Warm season was defined as May through September.

[a]Calculated only for days when the temperature (> 80°F) and relative humidity (> 40%) were within the bounds of the National Weather Service heat index calculation.

reported as percentage increase in the relative number of dispatch calls for each agency for a +10°F increase in maximum temperature or maximum heat index. We calculated local inflection points of the nonlinear maximum temperature for maximum heat index term for each agency to evaluate local trends in this exposure with our outcome of interest.

RESULTS

A total of 1268 days were included in this study period, whereas the analyses restricted to just the warm season consisted of 446 days. Forty-one days exceeded 90°F, and there were 22 and 13 days when there were 2- and 3-consecutive-day periods that exceeded this threshold, respectively. A total of 111 days had maximum temperatures exceeding 95°F, and there were 67 and 39 2- and 3-consecutive-day periods that exceeded this threshold, respectively. There was a total of 3 474 332 emergency dispatch calls during the study period (Table 2). Across all agencies, the mean number of dispatches per day was significantly greater during the warm season than during the full year (all $P < .001$; Table 2).

Relative Risk Analyses

The relative risk of dispatch on a hot day, as determined by a binary indicator in which maximum temperature was 90°F or above, compared with a nonhot day, increased for all agencies during the warm season (Table 3; all full-year relative risk analyses can be found in Table A). The magnitude of this increase on single days of high temperatures was greater for BEMS (9%; 95% confidence interval [CI] = 7%, 12%) and BFD dispatch calls (10%; 95% CI = 5%, 15%) than for BPD calls (2%; 95% CI = 0%, 5%). When we considered 2- and 3-day periods when the maximum temperature was 90°F or above, there was still not a significant increase in the relative risk of dispatch for BPD. However, the relative risk of dispatch for BEMS was 10% (95% CI = 6%, 14%) and 10% (95% CI = 5%, 15%) on 2- and 3-day periods of maximum temperatures of 90°F and above, respectively. The relative risk of dispatch for BFD was greatest during 2-day (11%; 95% CI = 4%, 17%) and 3-day (13%; 95% CI = 5%, 22%) periods of high temperatures.

When we also factored in humidity, the relative risk of dispatch on days with a maximum heat index of 95°F or above increased 2% (95% CI = 0%, 4%) for BPD, 7% (95% CI = 5%, 9%) for BEMS, and 7% (95% CI = 4%, 10%) for BFD during the warm season. During 2- and 3-day periods of maximum heat index of 95°F or above, relative risks were slightly attenuated, but still excluded the null (relative risk = 1.0) for BEMS and BFD (Table 3).

Time Series Analyses

The estimated effects of maximum temperature were nonlinear for dispatches from all agencies, with higher relative risk at hot temperatures for BPD and BEMS and higher risks at hot and cold temperatures for BFD (Figure 1). The binary indicator for days with a maximum temperature of 90°F or above, or a maximum heat index of 95°F or above, was not a significant predictor for any agency's dispatch calls in the TS model. However, the continuous values of maximum temperature and maximum heat index were significant predictors in all warm-season TS models. Ozone was a significant predictor of dispatches for BPD and BFD only when we evaluated maximum heat index and maximum temperature, respectively. $PM_{2.5}$ was a significant predictor of dispatches for BPD only when we evaluated maximum heat index.

During the warm season, a 10°F increase in daily maximum temperature—from 80° to 90°F—resulted in 1.016, 1.017, and 1.002 times the expected number of daily BPD, BEMS, and BFD dispatch calls, respectively, on average, after adjustment for the other predictors in the model. Full-year TS estimates can be found in Figure A. When we examined heat index as a continuous, nonlinear variable in the TS model, the same 10°F increase in daily maximum heat index resulted in 1.007, 0.985, and 1.018 times the number of BPD, BEMS, and BFD dispatch calls, respectively (Figure B, available as a supplement to the online version of this article at http://www.ajph.org).

The TS analyses show how there were increases in the predicted number of dispatches for each agency on days when the maximum temperature did not reach 90°F and days when the maximum heat index did not reach 95°F, both of which are thresholds currently used for putting local heat interventions into effect. The nonlinear effect of temperature on dispatch had local inflection points at 75°F for BPD, 85°F for BEMS, and 88°F for BFD, potentially indicating increases in the rate of increase in dispatches above these temperatures for each agency. We used these inflection points at threshold values for a secondary evaluation of relative risk (Table B, available as a supplement to the online version of this article at http://www.ajph.org).

TABLE 2—Number of Dispatch Calls for Boston Police Department (BPD), Boston Emergency Medical Services (BEMS), and Boston Fire Department (BFD) for the Warm Season Versus the Full Year: Boston, MA, 2010–2014

	Full Year, No. or Mean	Warm-Season Restricted, No. or Mean	*P*
Total dispatches			
BPD	2 691 191	1 037 897	
BEMS	494 615	187 284	
BFD	288 526	109 804	
Mean dispatches per d			
BPD	2 122.4	2 261.2	< .001
BEMS	390.1	408.0	<.001
BFD	227.5	239.2	< .001

Note. Warm season was defined as May through September. A Student *t* test evaluated the difference in the mean number of dispatches per day for each agency in the warm season compared with full-year analyses, at $\alpha = 0.05$ significance level.

DISCUSSION

This study offers a comprehensive analysis of the impacts of extreme heat on emergency services in Boston. It assesses the impacts of

TABLE 3—Relative Risk of Dispatch Calls for Each Agency on Days Meeting Specific Temperature or Heat Index Thresholds Compared With All Other Days, Calculated During the Warm Season: Boston, MA, 2010–2014

Temperature Metric	RR (95% CI)
Boston Police Department	
$T_{MAX} \geq 90°F$ (1 d)	1.02 (1.00, 1.05)
$T_{MAX} \geq 90°F$ (2 d)	1.02 (0.99, 1.06)
$T_{MAX} \geq 90°F$ (3 d)	1.01 (0.97, 1.05)
$HI_{MAX} \geq 95°F$ (1 d)	1.02 (1.00, 1.04)
$HI_{MAX} \geq 95°F$ (2 d)	1.02 (1.00, 1.04)
$HI_{MAX} \geq 95°F$ (3 d)	1.01 (0.99, 1.04)
Boston Emergency Medical Services	
$T_{MAX} \geq 90°F$ (1 d)	1.09 (1.07, 1.12)
$T_{MAX} \geq 90°F$ (2 d)	1.10 (1.06, 1.14)
$T_{MAX} \geq 90°F$ (3 d)	1.10 (1.05, 1.15)
$HI_{MAX} \geq 95°F$ (1 d)	1.07 (1.05, 1.09)
$HI_{MAX} \geq 95°F$ (2 d)	1.06 (1.04, 1.09)
$HI_{MAX} \geq 95°F$ (3 d)	1.06 (1.03, 1.09)
Boston Fire Department	
$T_{MAX} \geq 90°F$ (1 d)	1.10 (1.05, 1.15)
$T_{MAX} \geq 90°F$ (2 d)	1.10 (1.04, 1.17)
$T_{MAX} \geq 90°F$ (3 d)	1.13 (1.05, 1.22)
$HI_{MAX} \geq 95°F$ (1 d)	1.07 (1.04, 1.10)
$HI_{MAX} \geq 95°F$ (2 d)	1.06 (1.02, 1.10)
$HI_{MAX} \geq 95°F$ (3 d)	1.06 (1.01, 1.11)

Note. CI = confidence interval; HI_{MAX} = maximum heat index; RR = relative risk; T_{MAX} = maximum temperature. Warm season was defined as May through September. RR analyses for days with $HI_{MAX} \geq 95°F$ were calculated only for days when the temperature (> 80°F) and relative humidity (> 40%) are within the bounds of the National Weather Service heat index calculation.

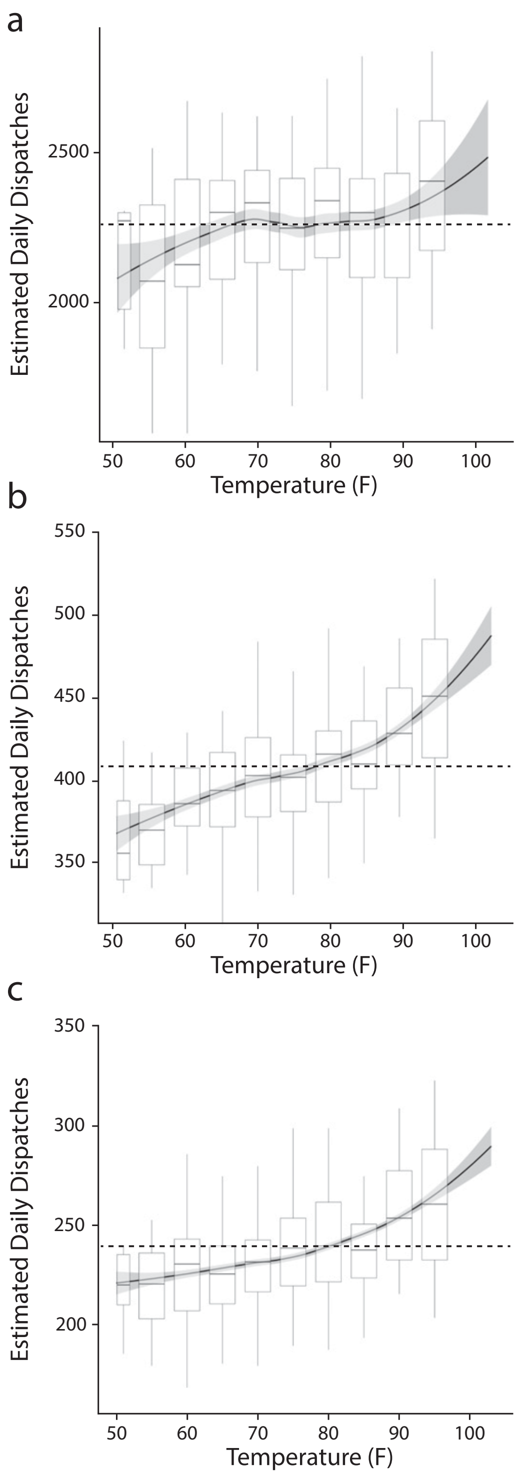
extreme heat and high temperatures on the frequency of emergency dispatch calls across Boston, during the full year and within the warm season. Moreover, the increased demand for police, medical, and fire services reported herein captures an additional public health burden from extreme heat that has not yet been fully captured in research examining the impacts of climate change on public health and societal services. These findings can inform climate change adaptation strategies, for both budgets and institutional preparedness, to ensure the resilience of emergency services as heat waves increase in frequency, severity, and duration in Boston.

During the warm season, there were 2% (95% CI = 0%, 5%) more BPD dispatches, 9% (95% CI = 7%, 12%) more BEMS dispatches, and 10% (95% CI = 5%, 15%) more BFD dispatches on days when the maximum temperature was 90°F or above. There were 2% (95% CI = 0%, 4%), 7% (95% CI = 5%, 9%), and 7% (95% CI = 4%, 10%) more BPD, BEMS, and BFD dispatches, respectively, on days when the maximum heat index was 95°F or above. During the warm season, TS analyses demonstrated that a 10°F increase in daily maximum temperature—from 80°F to 90°F—resulted in 1.016, 1.017, and 1.002 times the expected number of daily BPD, BEMS, and BFD dispatch calls, on average, after adjustment for other predictors.

The nonlinear effect of temperature on dispatch had local inflection points at 75°F for BPD, 85°F for BEMS, and 88°F for BFD, all of which are below current thresholds used for local heat warnings, as well as local heat interventions, such as the opening of cooling centers. This supports previous work that saw increased rates of morbidity and mortality in New England[27] and public health impacts[28] from extreme heat below current heat advisory criteria set by the National Weather Service.

Our findings demonstrate increases in BPD and BEMS dispatches as the temperature and heat index increase, establishing evidence that extreme heat events have agency-wide impacts on emergency services for these 2 agencies. Future analyses on the nature of each dispatch call would be necessary to fully understand this and the specific nature of dispatch calls that may be disproportionately increasing on extreme heat days. Ambulance calls[8,10–12] and violent crime[13–15] have been found to increase on hot days, and hospitalizations related to heat stress and other heat-related health outcomes increase during higher ambient temperatures.[29,30] All of these relationships provide potential pathways for heat to result in increased need of BPD and BEMS services; police or emergency medical technicians could be required in emergency situations that involve more than violent crime or heat-stress-related health outcomes. The estimates found within this analysis for BPD and BEMS are similar to those found in previous research on extreme temperatures and ambulance dispatches in other cities around the world. For example, in parts of China, 1 study revealed a 2.6% increase in ambulance dispatches during a heat wave,[8] and another demonstrated a 3% to 5% increase in the relative risk of ambulance dispatch with extreme heat. Similar analyses in the United States have shown a 8% to 14% increase in ambulance calls on hot days in the greater Seattle, Washington, area.[12] During a particularly strong heat wave event in Australia in 2011, all-cause ambulance calls were found to increase 14%,[11] demonstrating perhaps a high-end comparison had local conditions been particularly extreme during this study period. Police agency-wide impacts from extreme heat are less prominent in previous literature; however, a national analysis of various societal governance metrics in the United States demonstrated that police-initiated stops increased up to approximately 29°C (84.2°F) and then decreased beyond this temperature, despite increases in police-related violations (e.g., violence, driver error).[7]

The result demonstrating the largest increase in relative risk in BFD dispatches on extreme heat days is, to our understanding, a novel finding. Most previous research on the influence of weather on fire department services shows strong links between climate change and wildfires,[1] as well as between cold temperatures and residential fires from heating equipment and holiday decorations.[31,32] The cold season was not the primary focus of this study. This is one of the first studies to provide evidence that fire departments, and the services they provide, are affected by extreme heat. Firefighters, including those in Boston, respond to many emergency scenarios across a variety of needs, including medical emergencies. More than 60% of Boston firefighters have an emergency medical technician certification; more than 40% of BFD responses in 2012 were for medical emergencies, whereas fewer than 10% were for actual fires.[33] Thus, we hypothesize that the increase in BFD dispatch calls during days with high temperatures follows pathways similar to those of BPD and BEMS dispatches, but has been underrepresented in the body of scientific evidence highlighting the impact of heat on emergency services and climate adaptation planning. This association warrants more analysis to best understand the drivers of increased BFD dispatches during hot days and what specific call types may be most affected by extreme heat.



Note. Warm season is defined as May through September. Data are after adjustment for binary indicator of hot day (maximum temperature ≥ 90°F), long-term trends, day of week, ozone, $PM_{2.5}$ (particulate matter ≤ 2.5 microns), and population, as estimated in the time series analyses. Ninety-five-percent confidence intervals are shaded in gray, and the mean number of dispatch calls for each agency per day is shown by a dashed line. Box plots display the distribution of observed dispatches per 5°F increments for each agency.

FIGURE 1—Estimated Number of Dispatch Calls per Unit Temperature (°F) During the Warm Season for (a) Boston Police Department, (b) Boston Emergency Medical Services, and (c) Boston Fire Department: Boston, MA, 2010–2014

Limitations

This study has a few limitations. The use of ambient temperature measurements likely introduces a nondifferential exposure misclassification into the analysis, as the temperatures throughout Boston were different than at the airport and varied throughout the city. We also did not have information on those utilizing these emergency services, so we could not do any further analyses on age, gender, other modifiable factors, or the geographic distribution of these services. Additionally, we do not know if multiple emergency agencies (e.g., BPD and BEMS) were dispatched for the same call, which would involve personnel and financial costs for both services. This must be considered when planning appropriate future actions for these services during periods of extreme heat.

Future studies will include additional information on high spatial resolution of urban temperature patterns, and of sociodemographic and environmental parameters, to comprehensively assess vulnerability to these increases in emergency services spatiotemporally, with records on the details of each dispatch call. With the results presented in this article, we plan to work with local emergency service agencies to further evaluate the impact of extreme heat on the specific types of dispatch calls these agencies are receiving. This will allow for a clearer understanding of the causal pathway from extreme heat to emergency services, as well as enhance the financial, personnel, and climate change preparedness of emergency service agencies.

Conclusions

Despite these limitations, to our knowledge this was the first study to document the impact of heat on local fire department dispatches, as well as one of the first to examine the impacts of heat on agency-wide BPD and BEMS dispatches in Boston, thus expanding the scientific understanding beyond violent crime and heat-stress-related ambulance calls. Strong and significant effects were seen across all agencies in both a relative risk and a TS analysis, even in analyses limited only to the warm-season months. Although summers in Boston are getting hotter, its climate is more moderate than that of many other urban centers in the United States, given its proximity to the ocean, and sea breezes influenced by the concavity of its coast, and the topography that allows summer temperatures to remain cooler than they otherwise might.[34] Additionally, Boston's rate of some emergency situations, such as violent crime, may differ from those of other cities across the United States. The analysis framework used in this study will allow evaluation of extreme heat impacts on emergency services in other cities to inform local adaptation strategies. Effects may be even stronger in other cities with either heat exposure or emergency scenarios that are more extreme than in Boston, and we are currently working to explore this issue.

The impacts of hot days on increased emergency dispatch calls may result in significant financial and personnel burdens that warrant further consideration. An additional area of consideration that must be accounted for is the occupational heat stress experienced by these first responders on hot days,[35] which would likely increase in the future as heat becomes more pervasive. Despite research demonstrating the impact of extreme temperatures on health and societal services, climate adaptation plans more often account for mitigating the health impacts of extreme heat than planning for the increased need of a broad number of societal services. In Boston, the impacts of storm-related flooding and sea level rise on emergency services are well documented: increased stormwater flooding at fire and police stations will impede access and response; high tide flooding events will expose property valued at $1.3 billion occupied by essential facilities, including fire, emergency medical services, and police infrastructure; and low-probability flood events have the potential to inundate approximately 25% of police stations, which has led to Boston prioritizing flood-related adaptation for emergency service facilities.[2] When it comes to extreme heat, despite the vast range of demonstrated societal impacts (e.g., negative health impacts, increased stress on electricity grid for air conditioning, expansion of roads and rails, poorer air quality), municipal services are only recommended to install backup power generation systems to adapt to extreme heat in the future.[2] It is also vital to consider these societal burdens when planning for future emergency services.

Public Health Implications

This study expands scientific understanding of the many ways extreme heat influences public health and society, demonstrating that heat affects the agency-wide dispatch services of police, emergency medical, and fire department services. During the warm season, there were 2% (95% CI = 1.00%, 1.05%) more BPD, 9% (95% CI = 1.07%, 1.12%) more BEMS, and 10% (95% CI = 1.05%, 1.15%) more BFD dispatches on days with a maximum temperature of 90°F or above. There were 2% (95% CI = 1.00%, 1.04%), 7% (95% CI = 1.05%, 1.09%), and 7% (95% CI = 1.04%, 1.10%) BPD, BEMS, and BFD dispatches, respectively, on days with a maximum heat index of 95°F or above. However, when examining this with continuous temperature and heat index variables, we found that there are significant increases in the relative risk of dispatches on days well below 90°F. A local reexamination of extreme heat warning criteria and the associated social services that are provided once these thresholds are met (e.g., opening of cooling centers, transportation to cooling centers) may better protect the population and reduce negative societal consequences of extreme heat.

Climate change risk assessments and adaptation plans often account for the significant mortality and morbidity health impacts attributed to extreme heat. However, it is important to account for these societal burdens of extreme heat impacts on emergency services. Although this will be beneficial to ensuring the provision of services, the increase in first responders and budgets needed to meet a higher demand for services at higher temperatures should also be considered to allow Boston, and other cities around the United States, to most effectively, sustainably, and equitably implement climate change adaptation strategies. AJPH

CONTRIBUTORS

A. A. Williams served as the lead analyst and author. J. G. Allen, P. J. Catalano, and J. D. Spengler assisted with study design and analysis. A. A. Williams, J. G. Allen, and J. J. Buonocore obtained funding for the research. All authors contributed to the writing and editing of the article.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

HUMAN PARTICIPANT PROTECTION

No personal data or human participants were used in this study, so no approval was required by the university's institutional review board.

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