Development of a Surveillance Case Definition for Heat-related Illness Using 911 Medical Dispatch Data

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ABSTRACT

Objectives: The adverse effects of hot weather on public health are of increasing concern. A surveillance system using 911 medical dispatch data for the detection of heat-related illness (HRI) could provide new information on the impact of excessive heat on the population. This paper describes how we identified medical dispatch call codes, called “determinants”, that could represent HRI events.

Methods: Approximately 500 medical dispatch determinants were reviewed in focus groups composed of Emergency Medical Services (EMS) paramedics, dispatchers, physicians, and public health epidemiologists. Each group was asked to select those determinants that might adequately represent HRI. Selections were then assessed empirically using correlations with daily mean temperature over the study period (June 1 – August 31, 2005).

Results: The focus groups identified 12 determinant groupings and ranked them according to specificity for HRI. Of these, “Heat/cold exposure” was deemed the most specific. The call determinant groupings with the clearest positive associations with daily mean temperature empirically were “Heat/cold exposure” (Spearman’s correlation coefficient (SCC) 0.71, p<0.0001) and “Unknown problem (man down)” (SCC 0.21, p=0.04). Within each grouping, the determinant “Unknown status (3rd party caller)” showed significant associations, SCC=0.34 (p=0.001) and SCC=0.22 (p=0.03) respectively.

Conclusions: Clinically-informed expertise and empirical evidence both contributed to identification of a group of 911 medical dispatch call determinants that plausibly represent HRI events. Once evaluated prospectively, these may be used in public health surveillance to better understand environmental health impacts on human populations and inform targeted public health interventions.

Key words: Heat stress disorders; emergency medical services; temperature; environment; public health; surveillance

La traduction du résumé se trouve à la fin de l'article.

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The syndromic surveillance system under development by our research group is based on Emergency Medical Services (EMS) ambulance dispatch data. Emergency medical services are defined as the services needed to provide rapid, appropriate medical care to people in the community who are acutely ill or injured. Toronto EMS operates its own dispatch centre to which all 911 callers reporting medical emergencies are connected for triage and dispatching of an appropriate response. EMS call data created during the process have several advantages. Data are entered in real-time into a computerized database, with a single record created for each call. The automated nature of the system facilitates a timely and relatively simple method of transferring the data for analysis either continuously or in discrete time intervals. Further, this method can be reproduced in comparable EMS data systems and implemented at minimal cost.

There has been some limited work in the development of syndromic surveillance systems for HRI using nurse-helpline and medical dispatch data. An increase in total calls and calls specific for heat-/sunstroke was demonstrated in a time-series analysis of data from the UK National Health Service Direct, a nurse-led helpline, during two summer heat episodes in 2003. Total ambulance response calls were observed to increase with temperatures higher than expected – approximately 10% on heat alert days in earlier Toronto research. However, no studies to date have examined relationships between heat events and HRI-specific ambulance dispatch call volumes, likely because no call category is precise for HRI.

Creating a case definition for HRI using medical dispatch call categories is a challenge. Call questions are designed for triage, assessing resources needed to be dispatched by EMS rather than designed for accurate diagnosis. Hence, our initial objective was to select appropriate call categories and subcategories, counts of which could serve as HRI indicators in our syndromic surveillance system.

**METHODS**

**EMS dispatch system**

All emergency medical services in Toronto are provided by a single municipal government agency, Toronto EMS. EMS dispatchers classify and prioritize calls for service with the Medical Priority Dispatch System (MPDS - Priority Dispatch Corp, Salt Lake City, Utah), a widely used computerized triage algorithm, which scripts the dispatcher’s interview with the 911 caller to identify the nature of the incident and the probable acuity of the patient. Based on the caller’s answers, MPDS’s software assigns the call to one of more than 500 “determinants” and recommends a dispatch priority. MPDS is fully integrated into the EMS Computer-Aided Dispatch (CAD) system which contains a unique record for each incident, including all data from the MPDS interview.

To identify potential HRI-relevant “determinants”, we used a staged combination of clinically informed “expert” opinion and empirical testing, in keeping with others’ approaches to syndrome definition and validation.
Clinical assessment

A clinician group from our research team reviewed all determinants and selected a set which they felt was most likely to include patients suffering from HRI. This selected list was then reviewed in two focus groups. The first included colleagues at Toronto EMS – paramedics, dispatch operators, and emergency room physicians who ranked the categories according to their judgements on specificity in identifying HRI cases. The second comprised public health physicians, epidemiologists, public health managers, and medical residents, who reviewed the ranked and selected list to ensure that all determinants of public health relevance were captured.

For empirical testing, we drew on two datasets – the MPDS call data and meteorological data.

Meteorological data

The average value of mean temperature (°C) was obtained for each day of the study period from Environment Canada for Toronto (measured at Pearson International Airport, 27 km northwest of downtown).

Statistical analysis

We jointly plotted mean daily temperature (smoothed using Spline) and the percent of the total EMS call volume for all determinant groupings, as well as those selected by the expert groups, for which sufficient call volume existed (determinant groupings with median call volumes of 0 were excluded). For those in which we could visually observe some co-variation, we computed Spearman’s correlations (as distributions were not normal) using SAS 9.1 (SAS Institute, Cary, North Carolina). We hypothesized stronger positive correlations for determinants which represented: greater recognition, labeling or occurrence of HRI per se, aggravation of pre-existing conditions, and decompensation of already vulnerable individuals.

RESULTS

The clinical assessment process led to a list of 12 EMS call determinant groupings deemed to be potentially relevant for a case definition of heat-related illness (Figure 2). Four of these appeared to covary with temperature on visual inspection (Figure 3), and further analysis revealed significant correlations (Table I).

### Table I

<table>
<thead>
<tr>
<th>Call Determinant Groupings</th>
<th>Spearman’s Correlation Coefficient</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat/cold exposure</td>
<td>0.71496</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Unconscious/fainting</td>
<td>0.17776</td>
<td>0.0900</td>
</tr>
<tr>
<td>Cardiac or respiratory arrest/death</td>
<td>-0.00389</td>
<td>0.9706</td>
</tr>
<tr>
<td>Headache</td>
<td>-0.11061</td>
<td>0.2939</td>
</tr>
<tr>
<td>Sick person</td>
<td>0.13904</td>
<td>0.1862</td>
</tr>
<tr>
<td>Stroke/CVA</td>
<td>-0.25627</td>
<td>0.0137</td>
</tr>
<tr>
<td>Breathing problems</td>
<td>0.12344</td>
<td>0.2411</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>0.05096</td>
<td>0.6295</td>
</tr>
<tr>
<td>Psychiatric problems</td>
<td>0.00624</td>
<td>0.9530</td>
</tr>
<tr>
<td>Chest pain</td>
<td>-0.09234</td>
<td>0.3813</td>
</tr>
<tr>
<td>Diabetic problems</td>
<td>-0.00473</td>
<td>0.9643</td>
</tr>
<tr>
<td>Unknown problem (man down)</td>
<td>0.21374</td>
<td>0.0408</td>
</tr>
</tbody>
</table>

* p<0.05 bolded

Figure 3. Percentage of heat-related calls and mean daily temperature, June 1-August 31, 2005 by determinant.

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(One or more images, tables, or figures are not transcribed in this response.)
Including “Heat/cold exposure”, “Breathing problems”, “Unconscious/fainting”, and “Unknown problem (man down)”. Correlation analyses supported this observation (see Table I). “Heat/cold exposure”, the most specific, demonstrated the strongest positive correlation (Spearman’s correlation coefficient (SCC) 0.71, p<0.0001): as daily mean temperature increased, so did the percentage of total daily EMS emergency call volume assigned to this MPDS determinant group. Those determinants more related to pre-existing conditions were either not significant, e.g., breathing problems (SCC=0.12, p=0.24) or negatively correlated, e.g., CVA/stroke (SCC=-0.26, p=0.01). Less specific, but perhaps indicating vulnerable populations, were “Unknown problem (man down)” (SCC=0.21, p=0.04) and “Unconscious/fainting” (SCC=0.18, p=0.09).

Further examination of individual MPDS determinants related to “Heat/cold exposure” indicated that determinants describing patients as “Alert”, having “Change in skin colour”, or being of “Unknown status (3rd party caller)” were most correlated with mean daily temperature. Similarly, calls for determinants related to “Unknown problem (man down)”, or to patients described as “Standing, sitting, moving or talking” or of “Unknown status (3rd party caller)” were positively correlated with daily mean temperature (Table II).

**DISCUSSION**

Heat health impacts

Through a combination of clinically-informed expertise and empirical methods, our research group developed plausible HRI indicators using medical dispatch call determinant codes. While our research was for the summer of 2005, these findings were supported by examination of data for the years 2002-2004. The most specific category, “Heat/cold exposure”, was clearly associated with mean temperature. Such attribution may in part reflect changes in 911 caller behaviour during periods of heat alerts or sustained high temperature, partly prompted by media messages themselves. Nevertheless, the increase in “Unconscious/fainting” determinant calls, though not significant, is consistent with real increases in morbidity. The latter are corroborated by other surveillance work, particularly around events, where increases in morbidity not detected by other methods have been identified.20

Our findings regarding indicators of aggravation of pre-existing conditions were less expected, given the experts’ judgements. Correlations were minimal for cardio-respiratory deaths, and positive but modest for breathing problems. Given the pathophysiological process of dehydration and potential for sludging, the significant negative correlations with CVA/stroke are anomalous.

The positive correlation between temperature and subcategories of the “Unknown problem (man down)” call group are consistent with impacts of heat upon the most socially vulnerable, as these determinants largely refer to patients, such as the homeless, observed in public places. The increased proportions of calls ascribed to these determinants may be due to heightened public awareness and concern about the risks of unprotected heat exposure. However, given the increases in mortality observed during heat waves among the socially vulnerable, they likely also represent real increases in morbidity.21-23

**Challenges in constructing case definitions/indicators**

There are a number of challenges using medical dispatch data. The precision of EMS dispatch data is limited as 911 callers are usually not medically trained and often are reporting patients or events to whom or which they have no direct connection but have only observed. For these reasons, many EMS calls do not produce an actual “patient” in the usual sense of the term. Validation of the applied determinant codes with sign and symptom data recorded once a patient is picked up and assessed by paramedics has the potential to improve clinical validity. Hand-held devices that may record this information should be able to provide additional near-real-time data in future studies.

Nevertheless, inherent trade-offs exist between sensitivity and specificity when developing a case definition or selecting indicators for any syndrome.24,25 For HRI, codes like “Breathing problems” may include calls for many medical reasons including heat-related aggravation of existing cardio-respiratory disorders. In contrast, limiting calls to only those in the “Heat/cold exposure” category would not capture calls that may truly be related to temperature increases, e.g., “Unknown problem (man down)”. Corresponding over- and underestimates of the heat-related burden of illness would occur, misleading both our understanding of heat impacts and prioritization activities by public health authorities.

For public health surveillance purposes, focusing on a broader set of MPDS determinants would increase sensitivity and potentially generate more “false alarms”, but focusing on the more specific ones will result in more “false negatives”, missing many cases of HRI that might benefit from interventions. Unfortunately, not having a “gold standard” for an environmental exposure-related syndrome, as understood by the most ample understanding of HRI, means that formal testing of sensitivity and specificity is not possible. Rather, use of different sets of determinant codes will result in different amounts and types of heat-relevant morbidity.

**TABLE II**

<table>
<thead>
<tr>
<th>Call Determinants</th>
<th>Spearman’s Correlation Coefficient</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat/cold exposure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alert</td>
<td>0.45212</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Change in skin colour</td>
<td>0.48380</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Cardiac history</td>
<td>-0.15476</td>
<td>0.1408</td>
</tr>
<tr>
<td>Not alert</td>
<td>0.06167</td>
<td>0.5952</td>
</tr>
<tr>
<td>Unconscious/fainting</td>
<td>0.25644</td>
<td>0.0136</td>
</tr>
<tr>
<td>Life status questionable</td>
<td>-0.03368</td>
<td>0.7499</td>
</tr>
</tbody>
</table>

* p<0.05 bolded
Future directions

Based on our work, further evaluation of the use of 911 medical dispatch electronic data sets for surveillance appears appropriate not only for HRI but for other syndromes. Use of both expert group and empirical validation approaches are warranted for important conditions like influenza. Use of this relatively untapped health-related administrative data source should also be used to improve our understanding of the relationships between increasingly common heat episodes and the full range of human health impacts.

REFERENCES


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RÉSUMÉ

Objectifs : On se préoccupe de plus en plus des effets indésirables du temps chaud sur la santé publique. Un système de surveillance qui détecterait les maladies associées à la chaleur (MAC) d’après les données du service d’urgence 911 pourrait fournir de nouvelles informations sur l’impact de la chaleur excessive dans la population. Nous décrivons ici la méthode que nous avons employée pour sélectionner les codes d’appel aux secours médicaux (que nous appelons les “déterminants”) qui pourraient correspondre à des MAC.


Résultats : Les participants ont sélectionné 12 groupes de déterminants et les ont classés selon leur degré de correspondance spécifique aux MAC. De ces groupes, « Exposition au froid/à la chaleur » a été jugé le plus spécifique. Les groupes qui, expérimentalement, présentaient les associations positives les plus claires avec la température moyenne quotidienne étaient « Exposition au froid/à la chaleur » (coefficient de corrélation de Spearman (CCS) de 0,71, p<0,0001) et « Problème inconnu (appelant tierce personne) » présentait une association significative, soit CCS=0,34 (p=0,001) et CCS=0,22 (p=0,03), respectivement.

Conclusion : L’expérience d’experts et les données empiriques ont toutes deux contribué à la sélection d’un groupe de déterminants pour la répartition des secours médicaux d’urgence du service 911 pouvant raisonnablement servir d’indicateurs de MAC. Lorsqu’ils auront fait l’objet d’une évaluation prospective, ces déterminants pourront être utilisés à des fins de surveillance de la santé publique pour mieux comprendre les effets de l’environnement sur la santé des populations humaines et pour étayer des mesures d’intervention ciblées en santé publique.

Mots clés : troubles liés au stress thermique; secours médicaux d’urgence; température; environnement; santé publique; surveillance