Establishing an emergency department syndromic surveillance system to support the London 2012 Olympic and Paralympic Games

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ABSTRACT

Background The London 2012 Olympic and Paralympic Games is a mass gathering event that will present a major public health challenge. The Health Protection Agency, in collaboration with the College of Emergency Medicine, has established the Emergency Department Sentinel Syndromic Surveillance System (EDSSS) to support the public health surveillance requirements of the Games.

Methods This feasibility study assesses the usefulness of EDSSS in monitoring indicators of disease in the community. Daily counts of anonymised attendance data from six emergency departments across England were analysed by patient demographics (age, gender, partial postcode), triage coding and diagnosis codes. Generic and specific syndromic indicators were developed using aggregations of diagnosis codes recorded during each attendance.

Results Over 339 000 attendances were recorded (26 July 2010 to 25 July 2011). The highest attendances recorded on weekdays between 10:00 and 11:00 and on weekends between 12:00 and 13:00. The mean daily attendance per emergency department was 257 (range 38–435). Syndromic indicators were developed including: respiratory, gastrointestinal, cardiac, acute respiratory infection, gastroenteritis and myocardial ischaemia. Respiratory and acute respiratory infection indicators peaked during December 2010, concomitant with national influenza activity, as monitored through sentinel systems for the early warning/monitoring of seasonal outbreaks of disease, for example, influenza and norovirus, and responding to national and local incidents where the health of the population is at risk, for example, industrial fires and flooding. Two of the main syndromic systems routinely used are the HPA/National Health Service (NHS) Direct Syndromic Surveillance System, based upon the collection of symptoms from callers using the NHS Direct telephone health help-line, and the HPA/QSurveillance National Surveillance System, a large GP-based morbidity reporting system; both systems are described in detail elsewhere.

Conclusions The EDSSS has been established to provide an enhanced surveillance system for the London 2012 Olympics. Further validation of the data will be required; however, the results from this initial descriptive study demonstrate the potential for identifying unusual and/or severe outbreaks of infectious disease, or other incidents with public health impact, within the community.

INTRODUCTION

Syndromic surveillance

Surveillance is the ‘systematic ongoing collection, collation, and analysis of data, and the timely dissemination of information to those who need to know it in order for action to be taken’. A key principle of disease surveillance is a fundamental understanding of the sensitivity, specificity and timeliness of the systems that comprise the surveillance programme. There is also a growing emphasis on the use of complex statistical methods that interrogate surveillance data, alerting to anomalous signals and thus providing the ability to identify potential public health problems in a timely fashion.

In recent years, syndromic surveillance has become an increasingly important tool for disease surveillance. Syndromic surveillance is the collection, analysis, interpretation and dissemination of health-related data, typically on a real-time (or near real-time) basis, to enable the early identification of the impact (or absence of impact) of potential human or veterinary public health threats which require effective public health action. The data are usually collected for purposes other than surveillance and, where possible, are automatically generated so as not to impose an additional burden on the data providers.

Examples of healthcare and other settings that can provide data for use in syndromic surveillance systems include telephone health helplines; general practitioner (GP)-based networks, emergency departments, over-the-counter drug sales, and absenteeism records. More recently, innovative systems utilising internet-based search queries and social networking data have been developed.

The UK Health Protection Agency (HPA) coordinates several national syndromic surveillance systems for the early warning/monitoring of seasonal outbreaks of disease, for example, influenza and norovirus, and responding to national and local incidents where the health of the population is at risk, for example, industrial fires and flooding. Two of the main syndromic systems routinely used are the HPA/National Health Service (NHS) Direct Syndromic Surveillance System, based upon the collection of symptoms from callers using the NHS Direct telephone health help-line, and the HPA/QSurveillance National Surveillance System, a large GP-based morbidity reporting system; both systems are described in detail elsewhere.

Mass gatherings

Mass gatherings are generally defined as gatherings of more than 1000 persons at a specific location for a specific purpose, although the majority of the available literature defines gatherings exceeding 25 000 persons. The significance of mass gatherings with respect to public health is the increased risk of importation of an infectious disease,
exposure of visitors to endemic diseases, potentially increased transmission across large populations gathered in one place, increased opportunity for transmission of infectious disease (due to close mixing and/or pressures on catering and sanitation systems) and the increased strain on health services (and therefore risk in not responding to an incident) caused by the gathering. The surveillance of mass gatherings therefore provides an opportunity to identify potential problems, enabling a timely public health response. In addition, such events may serve as a potential target for terrorist activity and all the risks associated with chemical, radiological, biological and nuclear threats.

The role of emergency medicine in syndromic surveillance
Emergency department syndromic surveillance is based upon the monitoring of patient attendances and presenting symptoms in near real-time. Patients present at emergency departments with more severe acute illness when compared with other sources of syndromic surveillance data, for example, telephone helpline and GP consultations, providing an opportunity to augment the other community-based surveillance systems for common community-based pathogens, for example, influenza and norovirus, environmental incidents such as heat waves, *Escherichia coli* O104 and haemolytic-uraemic syndrome.20 21 In the UK, emergency departments also represent an open access health service that is available to non-residents, and as such provide a potential sentinel health service for monitoring health events among visitors attending mass gatherings. In addition, emergency department syndromic surveillance also provides a unique opportunity for collecting injury/trauma-based data which could provide valuable surveillance information during other incidents such as periods of severe cold weather.

Aims
In this paper we describe the establishment of the Emergency Department Syndromic Surveillance System (EDSSS), the first national emergency department surveillance network in the UK, primarily aimed at supporting an enhanced surveillance national emergency department surveillance network in the UK, and the experience of coordinating several other syndromic surveillance systems within the HPA,17 24 a number of syndromic indicators were developed, based on the diagnosis recorded within the EDSSS during this period. The mean daily attendance data were analysed over the 12-month period from 26 July 2010 (figure 1). Upon joining the EDSSS, each emergency department submitted an automated daily extract of data to the HPA. EDSSS emergency departments were located across England, with three located within London. The location of each emergency department was categorised according to its geographical locality; each emergency department was classified as urban (less sparse, population over 10000) using published scores.22

METHODS

Recruitment of emergency departments to the EDSSS
We initially contacted the UK College of Emergency Medicine (CEM) to gain support for the establishment of the EDSSS. We considered it critical to the success of the EDSSS that the CEM supported the principles of the system. These initial discussions also identified complementary areas of work such as the improvement of emergency department coding and the use of common datasets which would be of benefit for both the EDSSS and the CEM, as well as the UK Department of Health. A CEM representative was appointed to the EDSSS project group to provide emergency medicine expertise to the project and to liaise with emergency department clinicians.

Emergency departments were recruited by initially identifying and engaging with lead emergency medicine clinicians in each emergency department selected for the EDSSS to discuss the requirements and the public health and clinical benefits of the project. Approval was subsequently gained from IT and governance departments within each NHS Trust.

Extraction of data from emergency departments
Each emergency department uses an Emergency Department Information System (EDIS) for the electronic recording and management of patients during their attendance. There are a variety of EDISs available and used in emergency departments in the UK; the EDSSS used one EDIS (Symphony, Ascribe Ltd) during the period reported here due to the extensive coverage across UK emergency departments and the ability of the Symphony system to record patient attendance details electronically and in real-time. At each participating emergency department, the existing EDIS was configured to map existing clinical data to comply with the structure and data format of an standardised EDSSS minimum dataset (MDS) (see online supplementary table 1 for details).23 Data were subsequently extracted from the live hospital database to a virtual server hosted within the hospital network on a daily basis at a predefined time.

Secure transfer of data from emergency departments
Anonymous data were encrypted using 256-bit technology and transferred to the HPA on a daily basis (see online supplementary figure 1 for details). To conform to UK NHS security regulations, data were securely transferred across the NHS N3 network to an encrypted database that was mirrored across a firewall to an encrypted database from which the data were downloaded using encrypted file transfer protocol to a secure server located at the HPA.

Development of syndromic indicators
Using mass gathering surveillance guidance published by the WHO1 and the experience of coordinating several other syndromic surveillance systems within the HPA,17 24 a number of syndromic indicators were developed, based on the diagnosis recorded for each emergency department attendance. Within the UK, emergency departments utilise a number of different coding systems built into the local EDIS. These include SNOMED-CT,23 ICD1026 and a standard commissioning dataset.27 The syndromic indicators were developed by aggregating diagnostic codes, from each coding system, into groups meeting the criteria for each syndromic indicator. Broad generic indicators and more specific indicators (see online supplementary table 2 for details) were developed to provide the means to monitor public health for a number of potential mass gathering/public health scenarios. The underlying principle for developing these aggregations of codes was to ensure that a wide range of potential public health problems could be detected using the EDSSS.

RESULTS

Number of participating emergency departments
Six emergency departments were recruited to the EDSSS during the first 12 months beginning 26 July 2010 (figure 1). Upon joining the EDSSS, each emergency department submitted an automated daily extract of data to the HPA. EDSSS emergency departments were located across England, with three located within London. The location of each emergency department was categorised according to its geographical locality; each emergency department was classified as urban (less sparse, population over 10000) using published scores.22

Emergency department total attendances
Attendance data were analysed over the 12-month period from 26 July 2010 to 25 July 2011. A total of 339 417 attendances were recorded within the EDSSS during this period. The mean daily total attendance increased incrementally as new sites were recruited (figure 1). During the first 4 weeks of the EDSSS (July/August 2010), the mean daily total attendances was 527 (range 458–614); this increased to 1291 (range 1197–1539) during the
final 4 weeks of the time period. The mean daily total attendance per emergency department was 257 with emergency departments 1–6 each recording 330, 225, 253, 327, 93 and 50 mean daily attendances respectively. Analysis of the total daily attendances by hour illustrated a disparity in attendances during the course of a week. During the early hours of each day (00:00–06:00) there were generally low levels of attendance, with the highest levels of early morning attendances observed over weekends; attendances increased sharply over the time period 07:00–10:00, with the highest attendances recorded on weekdays; a decline was then observed throughout the remainder of the day with a small increase recorded at 18:00–19:00; the majority of day time attendances was observed on Mondays (figure 2).

Emergency department triage presentations
The recording of triage data was analysed using two separate triage fields. Triage category is recorded in the emergency department as an initial indicator of the acuity of the patient’s illness in accordance with the UK definitions of triage presentation.29 A numerical value (level 1–6) is recorded representing decreasing urgency of the emergency department resources required to treat the patient (ie, level 1 most urgent, level 5 least urgent)29, level 6 is recorded for deceased patients. To detect changes in the severity of triage presentation within the EDSSS, we devised a triage severity ratio which monitored the number of patients categorised as emergency and urgent (levels 2 and 3) against semiurgent and non-urgent (levels 4 and 5). Monitoring this ratio over the winter period demonstrated an increase in this ratio during December 2010, indicating an increased severity of illness in those attending (see online supplementary figure 2 for details). This coincided with increased influenza activity within the UK.30 In addition to the triage presentation scale, data were also collected on the triage presentation record, where the nature of the patient’s complaint was recorded at the point of triage.29 A number of triage presentation syndromes were selected and monitored for surveillance purposes including asthma, diarrhoea, vomiting and rash; however, the most frequently recorded triage presentations were abdominal pain and cardiac complaints (data not shown).

Emergency department discharge diagnoses
The recorded diagnosis was monitored on a daily basis. The coding system in use at the participating EDSSS sites was mapped to a common set of syndromic indicators (see online supplementary table 2 for details). These comprised broad generic indicators: respiratory, gastrointestinal and cardiac, as well as some more specific groupings: acute respiratory infection (ARI), gastroenteritis, meningitis and myocardial ischaemia. These indicators encompass the requirements of routine syndromic surveillance for infectious diseases and other health protection incidents. Further indicators are currently under development; these will target specific and more specialist areas of health protection including: heat wave indicator, monitoring the health impact of extreme heat; chemicals/poisons indicator, monitoring the impact of major chemical incidents and other possible chemical events, for example, carbon monoxide.
poisoning; and injury indicator, monitoring mass gathering events\(^1\) and the impact of extreme cold weather on public health (including the effect of snow and ice on the incidence of fractures and sprains).

During winter 2010/2011, there were demonstrable increases in the incidence of respiratory and ARI attendances (figure 3). ARI attendances were analysed by age demonstrating individual peaks of ARI in the 5–14 years age group initially, followed by the 15–44 years age group (see online supplementary figure 3 for details).

**Quality of data recording**

The completion of each field recorded was analysed. There was variation in the levels of data recording of the various fields included within the MDS. The basic demographics of each patient visit were recorded to a high level of completion (table 1). The triage category was also recorded to a high level of completion; however, there was more variation in the recording of triage presentation ranging from 0% to 100% completion within each emergency department on a daily basis. The use of triage presentation appeared to be emergency department specific with some emergency departments not using triage codes in this field as a standard. The poorest completion was observed in the diagnostic code field, less than two-thirds overall, ranging from 17% to 89% (table 1).

**Public health surveillance outputs**

An EDSSS public health surveillance bulletin was established to enable the routine reporting of trends in syndromic indicators to be distributed to a wide health protection audience. This bulletin followed a similar format to other HPA syndromic surveillance bulletins, with a key messages section highlighting important observations and conclusions based on the analysis of a selection of key graphs in the bulletin illustrating the current trends of the syndromic indicators and providing interpretation of the data.\(^24\)

**DISCUSSION**

We present the development and preliminary data analyses of a new national sentinel emergency department surveillance system, the EDSSS. The success of this system thus far has been primarily due to the underlying aim to maintain a passive syndromic surveillance system, thus, not imposing any additional requirements on the participating clinicians. In order to gain the support of the participating emergency departments this was critical to the success of the system and, in general, is an overarching principle of all syndromic surveillance systems.

The London 2012 Olympic and Paralympic Games provided a challenge to the HPA with respect to mounting an enhanced surveillance programme to monitor the health of the population for any unusual outbreaks of disease. Within the HPA national syndromic surveillance programme, the HPA/NHS Direct and HPA/QSSurveillance syndromic surveillance systems monitor diseases of mild and moderate severity in the community.\(^5\)\(^7\)

However, it had been recognised that there was a deficiency in the surveillance of more severe disease presentation such as that seen globally during the severe acute respiratory syndrome (SARS) and avian influenza outbreaks.\(^31\)\(^32\) This, in addition to the surveillance challenges presented by the London 2012 Games, emphasised the requirement for a UK-based EDSSS as developed and used by other countries.\(^8\)\(^–\)\(^11\)\(^33\)

Another key area in the development of the EDSSS was the establishment of a standardised emergency care MDS.\(^23\) Within the UK, there are a number of different EDISs available (including commercial applications and bespoke in-house systems) resulting in differing standards of automation, electronic data capture, real-time monitoring of data and coding of triage and discharge entries specific to each system. This posed a problem for the standardisation of the collection and analysis of emergency department data, and also highlighted variation in the quality and consistency of recording clinical records within emergency medicine in the UK. The MDS was developed by emergency department clinicians with the support of the CEM to enable the use of existing data fields recorded within each emergency department by mapping them to a common set of fields. The ultimate intention of the MDS is to mandate the standardisation of data collection across all EDIS and emergency departments.

**Comparison with other studies**

Across the USA, there are many examples of subnational, but few national, emergency department surveillance systems, which have...
been successfully used for monitoring public health. In a vast number of these emergency department systems, text recognition systems linked to the recorded disposal symptom are used to monitor syndromic indicators. Established emergency department surveillance systems have developed sophisticated statistical alerting systems that improve the sensitivity of the surveillance.\textsuperscript{8} \textsuperscript{9} \textsuperscript{21} \textsuperscript{34} Across Europe, the Oscour and SIDARTHa networks have been developed in recent years and have been used in responding to public health incidents.\textsuperscript{10} \textsuperscript{33} During Summer 2003, parts of Europe experienced an extreme heat wave that had major public health consequences. France was particularly affected where, overall, 15,000 excess deaths were recorded during a 16-day period.\textsuperscript{35} In 2004, an emergency department surveillance network was established across France (Oscour) as a direct response to the 2003 heat wave.\textsuperscript{36} The Oscour system has been used during subsequent heat waves, demonstrating the ability to provide early warning and a quantitative measure of public health impact of high temperatures.\textsuperscript{21} The SIDARTHa network, a European pilot study analysing prehospital emergency dispatch and emergency department data, provided real-time surveillance in response to the 2010 Eyjafjallajökull volcanic eruption and the resulting ash cloud.\textsuperscript{37}

Emergency department surveillance has previously provided the basis for the surveillance of mass gatherings, including previous Olympic and Winter Olympic Games.\textsuperscript{19} \textsuperscript{38}–\textsuperscript{40} In the majority of these events, syndromic surveillance provided reassurance to local and national public health authorities by demonstrating the absence of increased activity/outbreaks of infectious diseases. However, in some instances emergency department surveillance has provided clearly defined active benefit. During the 2000 Sydney Olympics, sentinel emergency department surveillance identified an increase in presentations for glass-related injuries at an emergency department close to an Olympic entertainment site; the public health action and outcome of these observations was the replacement of glass with plastic drinks containers at the site thus reducing the occurrence of injuries.\textsuperscript{39} During the 2004 Athens Games, syndromic surveillance provided early warning of an increase in gastroenteritis cases, which was linked to an outbreak of Salmonella spp., thus alerting infectious disease control teams

\begin{table}
\centering
\caption{Data quality of CEM MDS fields including triage and diagnosis codes: mean % completion of relevant fields across the EDSSS illustrated.} \label{tab:1}
\begin{tabular}{|c|c|c|}
\hline
MDS field & Mean % completion & Range (daily min %, max %) \\
\hline
Patient sex & 100 & 98.4, 100.0 \\
Patient partial postcode & 98.8 & 82.1, 100.0 \\
Patient age & 99.9 & 96.4, 100.0 \\
Triage category & 95.8 & 72.0, 100.0 \\
Triage presentation* & 95.0 & 65.0, 100.0 \\
Diagnosis & 65.4 & 16.9, 89.0 \\
\hline
\end{tabular}
\end{table}

\textsuperscript{*}Triage presentation is not routinely completed in some of the emergency departments and therefore only the sites recording triage presentation as standard are included within the table.

CEM, UK College of Emergency Medicine; EDSSS, Emergency Department Syndromic Surveillance System; MDS, minimum dataset.

Figure 3  Emergency department syndromic indicator presentation by specific syndromic indicators. Trend data illustrated as syndromic indicators as a daily percentage of all daily attendances with a recorded diagnosis (weekends and bank holidays are illustrated by vertical grey lines). This figure is produced in colour in the online journal—please visit the website to view the colour figure.

before traditional surveillance systems had detected significant signals.19

**Strengths and limitations of the study**

The EDSSS is the first passive national sentinel real-time emergency department surveillance system to be established in the UK; the data monitored will benefit the national surveillance activities of the HPA by providing data from patients presenting at the emergency departments including those who are acutely and severely ill. Currently, all syndromic surveillance activities within the HPA are limited to monitoring mild to moderate disease presentation (telephone health helplines and GP consultations); the introduction of emergency department data will now improve the spectrum of surveillance for infections/diseases that present with severe symptoms, for example, avian flu and severe acute respiratory syndrome. The EDSSS is also able to monitor an additional, unique set of syndromic indicators with the potential to provide added benefit to surveillance activities. Injury data can be monitored routinely and will be used during mass gathering events. Additionally, attendances due to severe illness from exposure to extreme hot or cold weather conditions will also aid the assessment of the impact of severe weather on public health.

The major benefits of the EDSSS will be realised during the 2012 London Olympics. The EDSSS will provide daily reports during the Games informing emergency response teams of any potential public health issues. However, benefits from this project will be generated for many years beyond the conclusion of the games and form part of the Olympic legacy.

Our preliminary analyses of the emergency department data have provided an initial validation of the EDSSS. During the winter 2010/2011, the UK experienced a heightened level of severe weather on public health.

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CONCLUSION

This initial descriptive study was limited to six sentinel emergency departments across England although the proactive recruitment of further emergency departments is continuing during 2011 (at time of writing, nine emergency departments had been recruited). The early development of the EDSSS has used a single EDIS (Symphony); we aim to develop the EDSSS to enable collection of data from a range of different EDIS, which could be implemented into the EDIS at each emergency department to ensure that all coding systems map to a coding commonality.44 When widely implemented, this will also benefit the EDSSS as all coding extracted from emergency departments will be mapped to a common coding dataset thus facilitating easier analysis of the data.

Emergency departments are collecting an increasing amount of data to drive internal business processes, generate revenue via payment by results and communicate effectively with other parts of the health economy such as the patient’s GP. As EDIS becomes increasingly sophisticated, it is becoming quicker and easier to collect such data, minimising the staff cost associated with its collection. The EDSSS has demonstrated that by standardising the way in which such data are collected, it can be put to other uses that considerably increase its value, especially when aggregated from a number of departments. Of note, no additional data items have been collected specifically for the purposes of EDSSS.
We acknowledge the support of the College of Emergency Medicine, all participating emergency departments in the EDSSS and staff within the respective NHS Trusts; without their support the EDSSS would not be possible. Ascrite Ltd and L2S Ltd undertook the configuration of emergency department patient management software systems (Ascrite); and the secure collection, encryption and transfer of data to the HPA (L2S2). We are also thankful to Nigel Brayley (CEM) for continuing expertise and support, Paul Loveridge, Jane Fletcher and Amardeep Bhans (HPA) for technical assistance and Tina Endrickus (HPA) for developmental support.

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Competing interests None.

Ethics approval Information governance approval was obtained at the NHS Trust of each emergency department involved in the EDSSS project.

Contributors AJE, TCD, HEH and GES designed the study; they are the guarantors. All authors have contributed to design and steer of the EDSSS. AJE drafted the original manuscript. All authors contributed to drafting and have seen and approved the final version of the manuscript.

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