Resuscitation 96 (2015) 156–162

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical Paper

The daily incidence of out-of-hospital cardiac arrest unexpectedly increases around New Year's Day in Japan☆

Kunihiko Takahashi[a,*], Hideyasu Shimadzu[b]

[a] Department of Biostatistics, Nagoya University Graduate School of Medicine, Nagoya, Japan
[b] Centre for Biological Diversity and Scottish Oceans Institute, University of St Andrews, UK

ARTICLE INFO

Article history:
Received 8 June 2015
Received in revised form 3 August 2015
Accepted 4 August 2015

Keywords:
Cardiac arrest
Out-of-hospital
Time series
Temporal clustering
New Year's Day

ABSTRACT

Background: Over 100,000 patients are diagnosed every year as out-of-hospital cardiac arrest (OHCA) cases in Japan and their number has continued to rise for the last decade, presenting a challenge for preventive public health research as well as emergency medical care. The purpose of this study was to identify whether there are any temporal patterns in daily OHCA presentations in Japan.

Methods: Records of OHCA patients ($n = 701{,}651$) transported by ambulance over the course of six years (1st January 2005 to 10th March 2011) in Japan were obtained from the All-Japan Utstein registry data of cardiopulmonary arrest patients. Time periods within which the incidence of OHCA significantly increased were identified by a temporal cluster detection test using scan statistics. The risk ratios of OHCA for the detected periods were calculated and adjusted according to a Poisson regression model accounting for effects of other factors.

Results: The risk of OHCA significantly rises 1.3–1.6 times around New Year's Day in Japan.

Conclusions: Our analysis revealed the increased daily incidence of OHCA around every New Year's Day in Japan.

Introduction

Over 100,000 patients are diagnosed every year as out-of-hospital cardiac arrest (OHCA) cases in Japan and their number continues to rise, with a 20% increase between 2005 and 2013. These cases account for 2.0–2.3% of emergency cases transported by ambulance, as reported by the Fire and Disaster Management Agency (FDMA) of the Ministry of Internal Affairs, Communications, Japan.[1] OHCA cases have become a major public health issue in Japan, a challenge facing preventive public health research as well as emergency medical care.

From a public health perspective, it is important to understand factors that can be potential hazards contributing to the incidence of OHCA. For example, the incidence of cardiac arrests is known to be related to ambient climate conditions, namely low temperatures, which consequently increase the risk of heart disease and the number of OHCA cases during winter seasons.[2,3] This association concurs with official statistics reported at a Fire and Disaster Management conference on the practical applications of emergency statistics. Empana et al.,[4] report that heat waves can also cause a significant increase in OHCA cases.

Once the event occurs, improved survival from OHCA relies on emergency medical care services and largely depends on primary access to necessary medical care such as early cardiopulmonary resuscitation, rapid defibrillation, and integrated post-cardiac arrest care.[5] It is a challenge for emergency medical care providers to providing care as swiftly as possible. Accordingly, several studies have investigated the extent to which the chances of resuscitation and survival vary over different conditions[6–10] including the types of symptoms, treatment provided,[11–13] patients' attributes[14,15] and situations.[5,16–20] These previous studies have mostly utilized monthly observations of OHCA cases that had already occurred to investigate outcomes in relation to emergency care procedures. Despite such active research, the importance of taking pre-emptive actions for OHCA, such as predicting the occurrence patterns of OHCA over time, has been understated.[21] With predictions we could know a priori when the demand on emergency care facilities might increase, allowing us to improve the present emergency protocol for OHCA cases.

It is essential to obtain OHCA and weather data on a finer spatio-temporal scale and detailed background information of patients to

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2015.08.003.

* Corresponding author at: Department of Biostatistics, Nagoya University Graduate School of Medicine, 65 Tsurumai-cho, Showa-ku, Nagoya 466-8550, Japan.
E-mail address: kunihiko@med.nagoya-u.ac.jp (K. Takahashi).

http://dx.doi.org/10.1016/j.resuscitation.2015.08.003
0300-9572/

be able to identify the daily trends in OHCA and whether there are any particular time periods within which the incidence notably increases. In this study, we examined daily ambulance records of OHCA cases in Japan to identify any temporal patterns in OHCA presentation, taking into account environmental factors such as low and high temperature.

Methods

Data

Daily ambulance records of OHCA cases were obtained from the All-Japan Utstein registry data of cardiopulmonary arrest patients provided by FDMA. This was a nationwide and population-based registry system of OHCA cases available since 2005, in accordance with the Utstein guidelines.[22,23] Since all the records were made anonymous by FDMA, according to the informed consent guidelines in Japan[24] we were exempt from obtaining informed consent from each patient to use this dataset. We set the study period from 1st January 2005 to 10th March 2011 (2,260 days), before the Great East Japan Earthquake occurred, to avoid any heterogeneity induced by the natural disaster. The 701,651 cases were separately analyzed based on sex and the etiology of cardiac arrest (Table 1, Fig. 1).

The meteorology data were obtained from the Japan Meteorological Agency website.[25] Since the fluctuation of temperature records showed similar patterns for the maximum, minimum, and average temperature among weather stations, apart from a consistent difference in absolute values, we used the daily average temperature observed at a Tokyo weather station in the present analysis. The minimum, 25th percentile, 50th percentile, 75th percentile, and maximum temperature values were 1.3 °C, 9.0 °C, 16.3 °C, 22.9 °C, and 32.7 °C, respectively, throughout the study period.

Detecting temporal clustering of out-of-hospital cardiac arrest cases

To detect a time period within which the incidence of OHCA became higher than expected, we adopted a cluster detection test widely used in spatial epidemiology contexts that calculates scan statistics under a Poisson model as proposed by Kulldorff and Nagarwalla.[26] This allows us to detect temporal clusters of OHCA cases under a statistical hypothesis test setting without undertaking multiple testing. The expected number of OHCA cases, μ_i, on day i, was estimated by a Poisson regression model for observed OHCA cases D_i, accommodated 2 by 2 stratification by sex (male/female) and the etiology of arrest (cardiac/non-cardiac). This model represents the null hypothesis that there was no clustering of OHCA cases during the study period. We considered five factors in the model: year ($y = 2005, \ldots, 2011$), month ($m = 1, 2, \ldots, 12$), weekday ($w = 1$ for Sunday, . . ., 7 for Saturday), holidays ($h = 1$ for national holidays and the Japanese new year holiday period, 28th December through 3rd January, excluding Saturdays and Sundays or $h = 0$ otherwise), and temperature (t_i). To account for the effects of temperature, we employed a twofold linear-threshold model[27]: $t_{C,i} = \max\{(\tau_C - t_i), 0\}$ and $t_{H,i} = \max\{(t_i - \tau_H), 0\}$ for temperature either below the low threshold τ_C (cold effects) or above the high threshold τ_H (heat effects). These were modeled as lag effects up to L days. The model is given as

(Model 1)

$$\log(\mu_i) = \beta_0 + \beta_y + \beta_m + \beta_w + \beta_h + \sum_{l=0}^{L} \beta_{TC,l} t_{C,i-l} + \sum_{l=0}^{L} \beta_{TH,l} t_{H,i-l},$$

where β_0, β_y, β_m, β_w, β_h, $\beta_{TC,l}$, $\beta_{TH,l}$ are the coefficients to be estimated, but those estimates β_y, β_m, β_w and β_h, are set to be 0 for the cases $y = 2005$, $m = 1$ (January), $w = 1$ (Sunday) and $h = 1$ (weekday) as constraints. The time lag L was initially set to be 6 days. The thresholds (τ_C, τ_H) were respectively estimated for each stratum as 21.6 °C and 26.9 °C for the male cardiac (MC) cases, 25.3 °C and 25.4 °C for the male non-cardiac (MNC) cases, 22.1 °C and 28.3 °C for the female cardiac (FC) cases, and 21.7 °C and 29.7 °C for the female non-cardiac (FNC) cases, by maximizing the likelihood of Model 1 for each stratum.

To examine whether the incidence of OHCA cases showed any particular temporal clustering, we calculated flexible scan statistics implemented with the restricted likelihood ratio.[28] This was an improved version of Kulldorff's analysis. We set two default arguments of the program: the maximum temporal length of a cluster was set to 20 days and the pre-specified significance level for a restriction was set as $\alpha_1 = 0.2$. The significance level of the test was set as $\alpha = 0.05$ and its p-value was calculated from 999 replications of the Monte Carlo hypothesis testing.

The regression analysis was carried out using R, version 3.1.2,[29] and the cluster detection test was performed using FleXScan, version 3.1.2.[30]

Adjusted risk ratio for clustered periods of out-of-hospital cardiac arrest

To quantify the increased incidence of OHCA around New Year's Day in particular, we introduced a new variable "significantly clustered period around New Year's Day" (SCP-NY) for those days around New Year's Day. The periods of clustering were identified by the temporal cluster detection test with $p < 0.05$. We further

Table 1
Characteristics of patients with out-of-hospital cardiac arrest in Japan, 2005–2011.

Total number of cases	Male 410,480		Female 291,171	
Etiology of OHCA:	Cardiac	Non-cardiac	Cardiac	Non-cardiac
Total	224,661	185,819	162,680	128,491
2005	33,280	28,095	23,132	18,231
2006	33,606	29,302	23,576	19,458
2007	34,288	29,798	24,713	20,662
2008	36,724	29,714	26,572	20,817
2009	37,518	29,534	27,441	20,757
2010	39,003	31,865	29,290	22,937
2011 (before March 11th)	10,242	7,511	7,959	5,629
Maximum of daily counts	216	244	168	136
Minimum of daily counts	44	43	20	19

OHCA, out-of-hospital cardiac arrest.