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REGULAR ARTICLE

The linkage among ambulance transports, death and climate parameters in Asahikawa City, Japan

Hiroaki Kataoka · Kazumi Dokai Mochimasu · Akihiko Katayama · Kanae Oda Kanda · Noriko Sakano · Keiko Tanaka · Nobuyuki Miyatake

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Abstract
Objective The aim of this study was to investigate the linkage among climate parameters, total ambulance transports and the number of deaths in Asahikawa City in northern Japan.
Methods Monthly data on total ambulance transports and the number of deaths from January 2004 to December 2011 were obtained from Asahikawa City Fire Department and the Asahikawa City official website. Climate parameters for the required period were also obtained from the Japan Meteorological Agency, Japan. To adjust for the population, we also used monthly population data on Asahikawa City. The linkage among climate parameters, total ambulance transports and the number of deaths was evaluated by ecological analysis.
Results The mean air temperature in the Asahikawa area was 7.3 ± 10.1 °C. Total ambulance transports (/a hundred thousand people/day) and the number of deaths (/a hundred thousand people/day) were 10.0 ± 0.6 and 2.6 ± 0.3, respectively. Using quadratic curves, total ambulance transports and the number of deaths were weakly correlated with some climate parameters. The number of deaths was weakly and positively correlated with total ambulance transports.
Conclusion A weak linkage among climate parameters, total ambulance transports and the number of deaths was noted in Asahikawa City, Japan. However, these associations were not as high as expected.

Keywords Ambulance transports · Death · Climate parameters · Air temperature · Asahikawa

H. Kataoka · K. D. Mochimasu (✉) · A. Katayama · K. O. Kanda · K. Tanaka · N. Miyatake
Department of Hygiene Faculty of Medicine, Kagawa University, 1750-1, Miki, Takamatsu, Kagawa 761-0793, Japan
e-mail: dokai@med.kagawa-u.ac.jp

K. D. Mochimasu
Department of Food Science, Mimasaka University, Okayama 708-8511, Japan

N. Sakano
Department of Gerontology Research,, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Okayama 700-8558, Japan

Introduction

It is well known that winter weather with low air temperature and snowfall is closely associated with cardiovascular diseases and many other health problems [1–8]. We have also previously reported that lower air temperature was associated with higher ambulance transports in the Sakata area, Yamagata Prefecture, Tohoku, Japan [9]. In addition, lower air temperature was closely linked to a higher the number of deaths in the Takamatsu area, which is located on Shikoku Island, Japan [10]. However, we could not fully evaluate especially the effect of very low air temperature and snowfall on ambulance transports and the number of deaths for Japan as a whole. Although there are many reports on the relationship between climate parameters and ambulance transports and/or deaths in foreign countries, [1–8], it is important to clarify the variation of the relationship between low air temperature and the number of deaths for reducing future ambulance transports and deaths in Japan.

The Asahikawa area, which is located in the northernmost part of Japan, features a humid continental climate with warm summers and very cold, snowy winters. Asahikawa winters are very long and very cold with average

monthly air temperatures from December to March failing to reach 0 °C. Summers are generally warm and humid with high average air temperatures in the warmest month around 26 °C. Spring and fall are short and transitional [11].

Therefore, in this ecological and pilot study, we evaluated the linkage among total ambulance transports, the number of deaths and climate parameters including air temperature, humidity, daylight hours and especially snowfall in Asahikawa City, Japan.

Methods

Study area

Asahikawa City is in the Kamikawa District, Hokkaido, Japan. Asahikawa is the subprefectural capital and the second largest city in Hokkaido after Sapporo. The city has an estimated population of 350,000 people and a total area of about 750 km^2.

Ambulance transports

Monthly incidence data on total ambulance transports in Asahikawa City was obtained from the Asahikawa City Fire Department, Japan, from January 2004 to December 2011 for 8 years [12], and the number of total ambulance transports was used for analysis. We used the total number of ambulance transports for this analysis. Detailed information of the definition has been shown in previous reports [13].

Deaths

Monthly incidence data on deaths in Asahikawa City were obtained from the Asahikawa City official web site for the same period [14] and used for this analysis.

Population

To adjust for population, the monthly population data of Asahikawa City for the required period were also used for analysis [15].

Climate parameters

The monthly climate parameters in Asahikawa City for the required periods were obtained from the Japan Meteorological Agency [16]. Mean air temperature (°C), mean of the highest air temperature (°C), mean of the lowest air temperature (°C), the highest air temperature (°C), the lowest air temperature (°C), mean humidity (%), the lowest humidity (%), daylight hours (hours/month), the number of snow days (/month), total snowfall (cm/month), the highest snowfall (cm/day) and maximum depth of snow cover (cm/month) were used for analysis.

Statistical analysis

Data are calculated and expressed as mean ± standard deviation (SD) values in Tables 1, 2, 3 and 4. Comparisons among more than three groups were performed by ANOVA and Scheffe's F test. $p < 0.05$ was considered to indicate statistical significance. In addition, simple correlation

Table 1 Profiles of climate parameters, ambulance transports and the number of deaths from 2004 to 2011 in the Asahikawa area, Japan

	Mean ± SD	Minimum	Maximum
Number of months	96		
Mean air temperature (°C)	7.3 ± 10.1	−8.5	23.4
Mean of the highest air temperature (°C)	12.2 ± 10.9	−4.8	28.8
Mean of the lowest air temperature (°C)	2.5 ± 10.1	−13.7	19.4
The highest air temperature (°C)	19.4 ± 10.7	−0.2	34.2
The lowest air temperature (°C)	−4.5 ± 11.3	−25.7	15.3
Mean humidity (%)	75.6 ± 5.4	60.0	84.0
The lowest humidity (%)	31.7 ± 11.4	11.0	56.0
Daylight hours (h/month)	130.4 ± 50.5	45.1	237.8
The number of snow days (/month)	11.6 ± 12.5	0.0	31.0
Total snowfall (cm/month)	53.2 ± 68.7	0.0	228.0
The highest snowfall (cm/day)	8.8 ± 10.5	0.0	36.0
Maximum depth of snow cover (cm/month)	26.3 ± 32.3	0.0	117.0
Total ambulance transports	1,076.8 ± 71.2	936.0	1,277.0
Total ambulance transports (/a hundred thousand people/day)	10.0 ± 0.6	8.7	11.5
Deaths	277.8 ± 32.5	206.0	363.0
Deaths (/a hundred thousand people/day)	2.6 ± 0.3	1.8	3.3

Table 2 Comparison of ambulance transports and the number of deaths as classified by month in the Asahikawa area, Japan

Month	Ambulance transports Mean ± SD	Death Mean ± SD
January	10.1 ± 0.6	2.8 ± 0.3
February	9.9 ± 0.6	2.5 ± 0.2
March	9.9 ± 0.9	2.7 ± 0.2
April	9.4 ± 0.4	2.5 ± 0.3
May	9.7 ± 0.5	2.6 ± 0.3
June	9.7 ± 0.5	2.5 ± 0.2
July	10.1 ± 0.5	2.4 ± 0.2
August	9.9 ± 0.5	2.5 ± 0.4
September	10.0 ± 0.6	2.4 ± 0.3
October	9.6 ± 0.4	2.5 ± 0.3
November	10.2 ± 0.6	2.7 ± 0.3
December	10.5 ± 0.5	2.6 ± 0.3

$N = 8$

/a hundred thousand people/day

analysis and quadratic curves were applied to the link between ambulance transports, the number of deaths and climate parameters.

Ethics

The protocol of the study was approved by the Ethics Committee of the Mimasaka University, Okayama, Japan(Approval number: 26–5).

Results

Data on total ambulance transports, the number of deaths and climate parameters from 2004 to 2011 in Asahikawa City are summarized in Table 1. Total ambulance transports (/a hundred thousand people/day) and the number of deaths (/a hundred thousand people/day) were 10.0 ± 0.6 and 2.6 ± 0.3, respectively. The mean air temperature was 7.3 ± 10.1 (−8.5 to 23.4) (°C).

A comparison of total ambulance transports and the number of deaths as classified by month groups is shown in Table 2. There were no significant differences in total ambulance transports and the number of deaths among months. Total ambulance transports in December and the number of deaths in January were the highest of all months, but were not at a significant level (Table 2).

Next, we estimated the relation between total ambulance transports (/a hundred thousand people/day) and climate parameters using quadratic curves (Table 3). Total ambulance transports were weakly associated with climate parameters except for maximum depth of snow cover (cm/month). The correlation coefficients between total ambulance transports and the lowest humidity were the highest among the variables.

The relation between the number of deaths (/a hundred thousand people/day) and climate parameters by quadratic curves was also evaluated (Table 4). The number of deaths was weakly correlated with mean air temperature, mean of the highest air temperature, mean of the lowest air temperature, the highest air temperature, daylight hours, total snowfall and the highest snowfall. The correlation coefficients between the number of deaths and the mean of the highest air temperature were also the highest among the variables ($r = 0.269$, $p = 0.0301$).

Finally, simple correlation analysis showed that the number of deaths was significantly correlated with total ambulance transports in Asahikawa City, Japan ($r = 0.386$, $p = 0.0001$).

Table 3 Approximation by quadratic curve between ambulance transports (/a hundred thousand people/day) and climate parameters in the Asahikawa area, Japan

	r	*p*	Quadratic curve (*Y* ambulance transports, *X* climate parameters)
Mean air temperature (°C)	0.303	**0.0115**	$Y = 0.002X^2 - 0.038X + 9.869$
Mean of the highest air temperature (°C)	0.324	**0.0058**	$Y = 0.002X^2 - 0.056X + 10.069$
Mean of the lowest air temperature (°C)	0.271	**0.0289**	$Y = 0.002X^2 - 0.016X + 9.763$
The highest air temperature (°C)	0.255	**0.0439**	$Y = 0.001X^2 - 0.053X + 10.355$
The lowest air temperature (°C)	0.256	**0.0426**	$Y = 0.001X^2 - 0.006X + 9.762$
Mean humidity (%)	0.370	**0.0011**	$Y = 0.001X^2$-0.057X + 10.413
The lowest humidity (%)	0.419	**0.0001**	$Y = 0.0002X^2 + 0.011X + 9.38$
Daylight hours (hours per month)	0.338	**0.0035**	$Y = -0.0004X^2 - 0.013X + 10.95$
The number of snow days (/month)	0.316	**0.0074**	$Y = 0.0002X^2 - 0.033X + 9.85$
Total snowfall (cm/month)	0.339	**0.0035**	$Y = 0.00002X^2 - 0.00004X + 9.797$
The highest snowfall (cm/day)	0.302	**0.0119**	$Y = 0.001X^2 - 0.002X + 9.806$
Maximum depth of snow cover (cm/month)	0.171	0.2497	

Bold values indicate $p < 0.05$

Table 4 Approximation by quadratic curve between deaths (/a hundred thousand people/day) and climate parameters

	r	*p*	Quadratic curve (*Y* death, *X* climate parameters)
Mean air temperature (°C)	0.264	**0.0355**	$Y = 0.0002X^2 - 0.01X + 2.607$
Mean of the highest air temperature (°C)	0.269	**0.0301**	$Y = 0.0002X^2 - 0.011X + 2.654$
Mean of the lowest air temperature (°C)	0.254	**0.0449**	$Y = 0.0001X^2 - 0.008X + 2.565$
The highest air temperature (°C)	0.265	**0.0342**	$Y = -0.0002X^2 - 0.007X + 2.701$
The lowest air temperature (°C)	0.239	0.0646	
Mean humidity (%)	0.095	0.6576	
The lowest humidity (%)	0.176	0.2312	
Daylight hours (hours per month)	0.274	**0.0263**	$Y = 0.00001X^2 - 0.005X + 2.978$
The number of snow days (/month)	0.245	0.0562	
Total snowfall (cm/month)	0.267	**0.0318**	$Y = -0.000004X^2 + 0.002X + 2.493$
The highest snowfall (cm/day)	0.266	**0.0333**	$Y = -0.001X^2 + 0.019X + 2.486$
Maximum depth of snow cover (cm/month)	0.241	0.0619	

Bold values indicate $p < 0.05$

Discussion

We evaluated the linkage among total ambulance transports, the number of deaths and climate parameters, including air temperature and snowfall, in Asahikawa City, which is located in northern Japan. Weak associations among the variables were noted, although these associations were not as high as expected.

Anderson et al. [1] reported that they examined the short-term effect of low air temperature on the incidence of ischemic heart disease over a 15-year period, and found an increased frequency of death from ischemic heart disease in winter, particularly among the elderly. Baker-Blocker [2] also reported that snow was somewhat more important in triggering deaths from heart disease than air temperature. de'Donato et al. [3] showed that cold-related mortality is still and important issue and should not be underestimated in public health policy. Prostate cancer may be also partially correlated with meteorological factors such as colder air temperature [4]. In addition, there were fewer fatal crashes on snow days than dry days, but more non-fatal injury crashes and property-damage-only crashes [5], while the first snow day of the year was more dangerous, particularly for elderly drivers [5]. These findings suggest that winter weather, i.e., low air temperature and snowfall, are associated with higher ambulance transports and numbers of deaths.

In this study, we compared the total ambulance transports and the number of deaths, as classified by month groups, and found no significant differences in those parameters among months. In addition, by quadratic curves, we estimated the relationship between total ambulance transports and climate parameters, and between the number of deaths and climate parameters. The correlation coefficients, especially between the number of deaths and climate parameters, were not as high compared with our previous reports in the Takamatsu area, which is located in Shikoku Island, Japan [10]. Southern et al. [6] showed that despite the potential for significant adverse effects of snow days on the incidence of myocardial infarction, snow days had only minor effects, if any. However, it is well known that summer is shorter and winter longer in the Asahikawa area than in the Takamatsu area. In addition, the difference in snowfall, city location and coping with winter weather such as wearing suitable clothes, between Asahikawa City and Takamatsu City may have influenced the findings in this study. Nevertheless, it is reasonable to suggest that dealing with winter weather effects, i.e., innovation in terms of thermal energy metabolism, in cities, for individuals and groups to help them cope with [17] winter weather may be required in the Asahikawa area as well as other areas in Japan (Fig. 1).

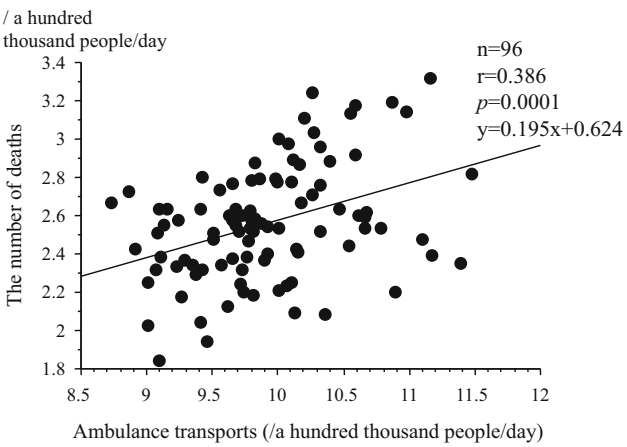

Fig. 1 Simple correlation analysis between total ambulance transports and the number of deaths in Asahikawa City, Japan

Potential limitations remain in this study. First, this was an ecological study, and we evaluated the effect of climate parameters on total ambulance transports and deaths in only the Asahikawa area. Therefore, the result obtained from this study is hypothetical and needs to be evaluated all over Japan and in foreign countries. Second, detailed daily and individual (i.e., age and sex) data of total ambulance transports and deaths could not be obtained and analyzed in this study. Therefore, we could not evaluate the linkage among total ambulance transports, the number of deaths and climate parameters as accurately as we wished. Further ongoing studies using individual data are urgently required to prove such a link.

Conflict of interest The authors declare no conflict of interests.

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