Heat Stroke Information in Japan.

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Abstract

Heat stroke patients, caused by hot environment, has been increasing in these 10 years and 'heat stroke' becomes the one of big issues in Japanese summer. In order to inform heat stroke risks to the public for preventing heat strokes, the Ministry of the Environment manages heat stroke information web site from May to October. At the site, 1 hourly actual WBGT value and WBGT forecast for 840 cities (2days forecast in 3 hourly interval) are provided and 1.14 million hits were recorded in 2013 summer. Additionally Fire and Disaster Management Agency and National Institute for Environmental Studies report daily number of heat stroke patients (whole Japan and big cities) once a week, and Ministry of Health, Labour and Welfare provides the number of heat stroke patients in previous day based on a prompt report from emergency care centers.

1. Introduction

An average temperature in Japan rose 1.14 degree in Celsius in last 100 years, and around big cities urbanization helps temperature rise and an average temperature at Tokyo rose 3.2 degree in Celsius in last 100years (JMA, 2013)[(1)]. With temperature rise, summer environment becomes severer year by year and health damage caused by heat becomes one of the big issues in Japanese summer especially after the hottest summer 2010. As well known, heat stroke patients increase with high temperature, high humidity, less wind and strong radiation. There are several indexes related to heat disorders, however, WBGT (Wet Bulb Globe Temperature, Yaglou, 1957) [(2)], adopted as ISO 7243, is commonly used in Japan. WBGT is calculated from T_w (wet bulb temperature), T_g (globe temperature) and T_a (dry bulb temperature) as follows.

$$WBGT = 0.7 \times T_w + 0.2 \times T_g + 0.1 \times T_a \quad (1)$$

WBGT is widely used to control/monitor worker's health in industries, and the Health and Safety Department of Labour and Welfare Ministry issued Health Advisory # 0619001 at 19th of June 2009 and in this advisory they informs 'Heat stroke prevention measures' based on WBGT. In sports health field, Japan Amateur Sports Association settled 'A guideline for preventing heat disorders during sports activities' [(3)] in 1994 and

this guideline has been used in schools and sport clubs. The guideline was promoted through lessons for coaches and teachers sponsored by private companies (ex. beverage manufacturers), and through such activities casualties in younger ages during sports activities decreased clearly. In order to reduce heat disorder risks in daily life, Japanese Society of Biometeorology issued 'A guideline for preventing heat stroke in daily life' [4] in 2008 and this guideline is widely used in heat stroke prevention activities. In this guideline, WBGT is also used as the threshold for controlling activities.

The Ministry of Environment (MOE) issued 'A guide book for preventing heat disorders' [5] from 2005 annually and MOE started WBGT observation at 5 cities (Tokyo, Niigata, Nagoya, Osaka and Hiroshima) under cooperation of JMA (Japan Metrological agency) and WBGT information web sites in 2006 (Hiroshima from 2007 and Sapporo, Sendai, Kagoshima from 2014). Additionally, MOE held seminars for nurses, care managers and local government staffs to inform knowledge for heat strokes and its prevention methods and to show/share good samples at local governments' activities from 2012 at 14 big cities.

2. Public information regarding heat disorders

The Health, Labour and Welfare Ministry (MHLW) issues 'Population Survey Report' annually (usually issued in next September). Heat stroke casualties is categorized as [X30: Exposure to excessive natural heat] or [T67: Effects of heat and light] based on ICD 10 (International Statistical Classification of Diseases and Related Health Problems version 10) categories.

The trend of 2 months average (July to August) of daily maximum WBGT at 6 cities (Tokyo, Niigata, Nagoya, Osaka, Hiroshima and Fukuoka) and the number of casualties categorized in [T67] and the scatter diagram of these 2 factors are shown in Fig.1. The number of heat stroke casualties has a positive relationship with WBGT (r=0.83, N=6) and it reveals that hotter summer brought greater casualties by heat disorders.

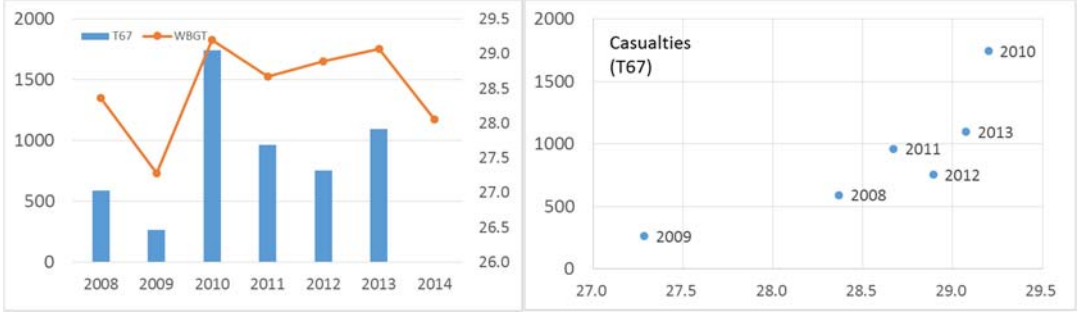

Fig. 1. The trend chart (left) and scatter diagram (right) of heat disorder casualties and WBGT (July to August at 6 cities).

The Fire and Disaster Management Agency (FDMA) issues heat disorder patients weekly report (patients taken to hospitals by ambulance cars) [6] on every Tuesday (based on reports from Fire Department Agency at each prefecture). The report informs daily number of patients categorized in age bracket and symptom as shown in Table 1. Here, age bracket is consist from 'neonate' (younger than 28 days from his/her birth), 'baby and toddler' (28 days old to 6 years old), 'young boys and girls' (7 to 17 years old), 'adults' (18 to 64 years old) and 'elderly' (older than 65 years old), and symptom bracket is consist from 'mild' (inpatient treat not required), 'moderate' (not mild not severe), 'severe' (more than 3 weeks inpatient treat required) and 'unknown'. This prompt report informs last week situation of heat disorder patients and lots of newspapers and TV programs report it with experts' comments. In 2014, the report stared from 26th of May and will be continuing till early October.

Table 1. A sample of FDMA report

heat disorder patiens taken to hospitals by amburance cars (21th to 27th of Jul. 2014)
(prompt report)

date		patients	age bracket						symptom at first medical check					
			neonate	toddler	boys girls	adults	elderly	total	dead	severe	moderate	mild	N/A	total
7月21日	MON	485	0	6	106	140	233	485	0	11	157	314	3	485
7月22日	TUE	644	0	7	105	211	321	644	0	18	219	400	7	644
7月23日	WED	960	0	7	132	441	380	960	0	22	315	609	14	960
7月24日	THU	1,128	0	9	165	478	476	1,128	3	19	372	715	19	1,128
7月25日	FRI	1,794	0	9	225	750	810	1,794	4	42	572	1,138	38	1,794
7月26日	SAT	2,489	0	19	470	945	1,055	2,489	6	57	685	1,677	64	2,489
7月27日	SUN	1,080	0	13	164	365	538	1,080	2	24	336	695	23	1,080
total		8,580	0	70	1,367	3,330	3,813	8,580	15	193	2,656	5,548	168	8,580
ratio			0.0%	0.8%	15.9%	38.8%	44.4%	100.0%	0.2%	2.2%	31.0%	64.7%	2.0%	100.0%

(http:// http://www.fdma.go.jp/neuter/topics/fieldList9_2.html)

The FDMA weekly report of heat disorder patients started from 2008 (in 2008 and 2009, the number of heat disorder patients reported from July to August) and period becomes longer and information category becomes richer gradually. The FDMA report patients also has strong positive relationship with 2 months average (July to August) of daily maximum WBGT at 6 cities ($r=0.95$, $N=7$) and it also reveals that hot summer increases heat disorder patients.

Table 2. The FDMA number of heat disorder patients and WBGT at 6 cities.

	FDMA patients		casualties *1	WBGT	
	Jul. to Aug.	Jun. to Sep.	Jan. to Dec.	Jul. to Aug.	Jun. to Sep.
2008	21,604	N/A	591	28.4	N/A
2009	11,789	N/A	264	27.3	N/A
2010	46,198	56,119	1,745	29.2	27.2
2011	34,643	45,583	961	28.7	26.9
2012	39,655	45,701	756	28.9	27
2013	48,242	81	1,095	29.1	27.1
2014	32,456	N/A	N/A	28.1	N/A

*1 casualties categorized in [T67: effects of heat and light]

The MHLW provided a prompt report of heat disorder patients on their web site experimentally from 2012, with cooperation of the Research team 'Effective data collection system and structure for preventing Heat Strokes' (representative researcher: Prof. Yasushi Miyake). The site provided the number of patients at the previous day from July to September every day. The data sheet is sent from emergency medical care centers and hospitals under cooperation of Japanese Association for Acute Medicine by fax (patient judged as level II or level III based on Table 3) and once a day a software makes a digital data from sheets and reports the number of patients automatically around noon. In 2013, subscribed care centers and hospitals were 159 and reported cases were 1105. According to the final report of this study 2013, the number of MHLW prompt report increases/decrease with FDMA patients report and WBGT (Fig.2), and when the number of MHLW reports is greater than 15 cases, it has a clear positive relationship with FDMA patients and it may become an index of actual heat disorder patients (Fig.3).

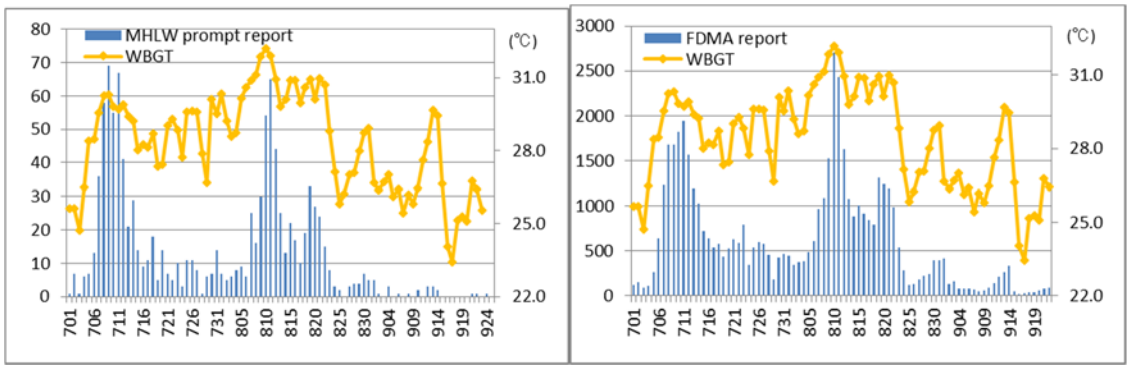

Fig. 2 Daily trend of FDMA report patients and WBGT (left), and Daily trend of MHLW prompt report patients and WBGT (right) in 2013 summer.

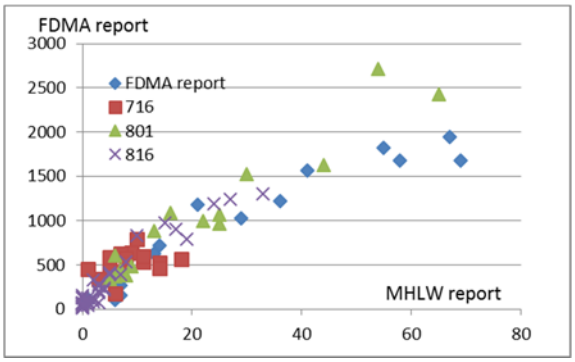

Table 3 Symptom Category

Level Ⅰ	heat cramps
	heat syncope
Level Ⅱ	heat exhaustion
	nausea, vomitting, a sense of malaise,
Level Ⅲ	heat stroke
	disturbance of consciousness
	organ failure

Fig. 3 Scatter diagram of FDMA report and MHLW report.

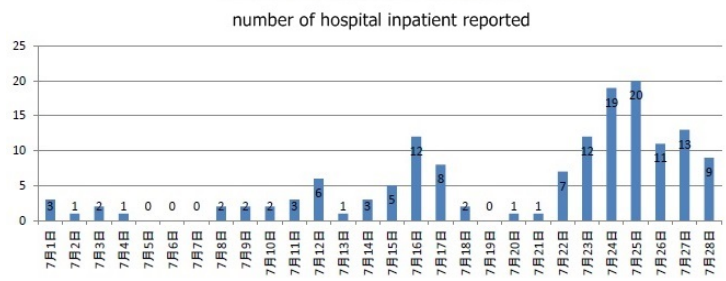

Fig. 4 A sample of MHLW report

http://www.mhlw.go.jp/stf/seisakunitsuite/bunya/nettyuu/h26.html

3. Heat Stroke Information Web Site

MOE manages 'Heat Stroke Information web site' from 2005 and in 2014 season MOE provides the information May to October. Indexes at the site are as follows.

- Observed hourly WBGT at 9 cities (Tokyo, Niigata, Nagoya, Osaka, Hiroshima, Fukoka and Sapporo, Sendai, Kagoshima: last 3 cities are added from 2014)
- Estimated hourly WBGT at 831 cities (estimated from observation data by JMA)
- 3 hourly WBGT forecast for 840 cities beyond the day after tomorrow
- WBGT SMS (mail) service
- WBGT CSV (ftp or http) provision service
- WBGT at various situation (parking area, bus stop, residential area, green house and gymnasium)
- WBGT risk calendar and historical data (last 5 years)
- Related Information (What is WBGT, how to prevent heat strokes, how to use WBGT information)

WBGT observation and forecast data is displayed with 5 colored categories separated by WBGT threshold (Japan Amateur Sports Association, 1994)[6] shown in Table 4. 'Pink' (WBGT is greater than 28 degree) warns the heat condition is in alert level (patients

taken to hospitals will be increasing). And 'Red' (WBGT is greater than 31 degree) warns the heat condition is in danger (patients taken to hospitals might exceed to 1,000 in a day or several fatalities might be recorded). In the web site or in the MOE guidebook (6), directions how to reduce heat risks or how to protect health condition are mentioned.

Table 4 WBGT warning categories and remark
(Japan Amateur Sports Association, 1994)

WBGT threshold (degrees C)		
31	danger	Stop exercises in principle
28	alert	Stop severe exercises
25	advisory	Take rests frequently
21	caution	Frequent hydration
	almost safe	Risk is relatively lower

At 9 observatories, MOE observes global temperature (Tg) and dry bulb temperature is observed by JMA, and wet bulb temperature (Tw) is calculated from dry bulb temperature (Ta), relative humidity and vapor pressure by JMA (Iribarne, 1981) [8].

At 60 observatories, Tg is not observed. At these sites we estimate Tg from dry bulb temperature, Sun radiation and wind speed using statistical equation (2) (settled by 2008 observation data at 6 cities). And at 80 observatories, we cannot obtain Sun Radiation data neither. In such case we calculate sun radiation (S0) in clear sky condition by NEDO method (estimate Sun Radiation from latitude, longitude, elevation, date and time) [9], and with using sun duration during 10 minutes (SD) estimate first sun radiation value (SR) with equation (3).

$$T_g = T_a - 0.17 + 0.029 \times SR - 0.48 \times WS^{1/2} - 1.27 \times 10^{-5} \times SR^2 \quad (2)$$

$$SR = S0 / c \quad (\text{when } SD = 0)$$
$$S0 / \{1 + a \times \exp(-c \times sun)\} \quad (\text{when } SD = 1 \text{ to } 10 \text{ (min.)}) \quad (3)$$

here, coefficient a, b and c are calculated from 2011 observation data at the nearest observatory where sun radiation is observed. For example a= 1.3, b=0.19 and c=4.0 at 2011 Tokyo.

At 690 AWS observatories relative humidity is not observed. At these observatories, we estimate relative humidity from re-analysis humidity data (re-analyze MSM [Meso Scale Model output] humidity with observed humidity at 150 SYNOP stations). The special resolution of 840 observation is almost 23km.

At JMA observatories, relative humidity is observed under forced draft condition (5m/s) by fan, however, ISO instructed relative humidity for WBGT should be observed under natural ventilation. The average bias of WBGT under natural ventilation to WBGT under forced draft condition, estimated for Nagoya in 2008 by heat budget equations, is +0.54 (0.22 to 2.55) degree in Celsius and standard deviation of bias is 0.18 degree in Celsius. The bias becomes bigger under weak wind and lower temperature condition.(10)

Additionally we developed statistical equation to estimate WBGT directly from dry bulb temperature, relative humidity, sun duration and wind speed as shown equation (4), and we use it to calculate WBGT forecast. This equation was obtained from observed data at 6 cities (Tokyo, Niigata, Nagoya, Osaka, Hiroshima and Fukuoka) during 2007, 2008, 2009 season.

$$WBGT=0.735\times T_a+0.0374\times RH+0.00292\times T_a\times RH+7.619\times SR-4.557\times SR^2-0.0572\times WS-4.064 \quad (4)$$

here, Ta is temperature (deg. in Celsius), RH is relative humidity (%), SR is sun radiation (kW/m２), WS is wind speed (m/s).

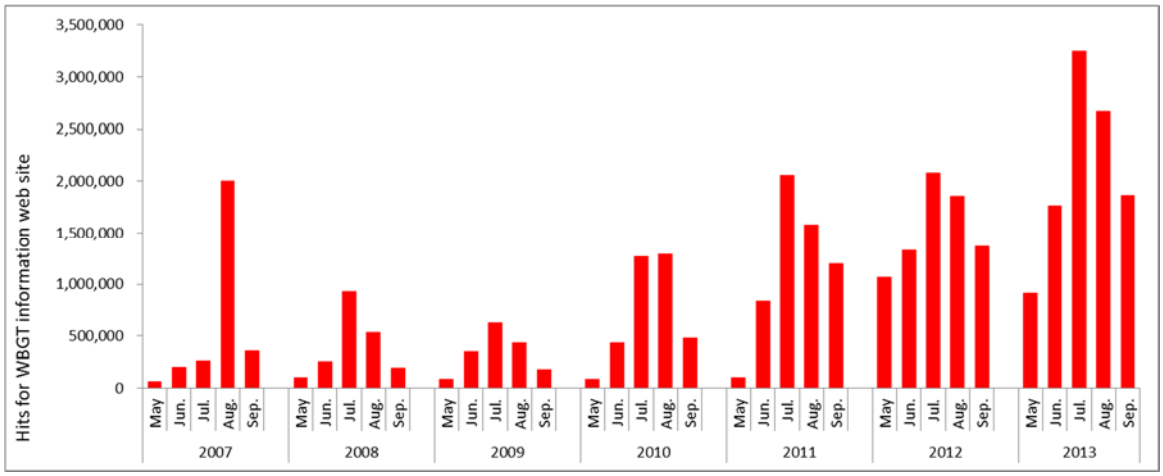

Fig. 5 Access to 'Heat stroke information site'

Table 5 Access to 'Heat stroke information site'

	2007	2008	2009	2010	2011	2012	2013
May	63,279	101,347	86,550	86,048	99,914	1,069,013	912,095
June	198,817	258,923	345,963	432,972	834,506	1,330,514	1,763,005
July	267,175	931,572	629,219	1,265,431	2,060,140	2,077,986	3,247,828
August	2,001,659	531,251	434,937	1,289,938	1,577,592	1,857,996	2,667,945
September	356,186	196,672	179,671	483,685	1,198,865	1,368,055	1,864,235
	2,887,116	2,019,765	1,676,340	3,558,074	5,771,017	7,703,564	10,455,108

The number of hits to the 'Heat Stroke Information Site' was exceeded to around 10 million in 2013 as shown in Fig. 5 and Table 5 (11,442,472 hits at 18th of October in 2013). The system provided actual WBGT and WBGT forecast to 1,366 local governments, related organizations, companies and so on by ftp/http protocol. After local governments received WBGT information, they distributed the information to staff who responsible for schools, hospitals, care managements, sports fields and so on. Additionally the system delivered SMS information to subscribed users (15,382 addresses was subscribed at 18th of October in 2013).

4. Effect of educational activities and information

MOE has been implementing several projects from 2005, and other ministries/agencies (ex. The Health, Labour and Welfare Ministry, the FDMA and etc) also have promoted various educational activities. We evaluated the effects of such educational activities and information with comparison of patients in FDMA reports. We compared the 2013 first heal spell, from 8th to 14th of July, and the 2010 first heat spell continued from 20th to 26th of July. During the first spell in 2010, average of maximum WBGT at 6 cities (Tokyo, Niigata, Nagoya, Osaka, Hiroshima and Fukuoka) was 30.0 degree in Celsius and average of maximum WBGT in 2013 was almost same as 29.8 degree in Celsius. And the statistical values of patients during the first heat spell in 2010 and 2013 are shown in Table 6.

Table 6 Statistical values during the first heat spell in 2013 and 2014 compare to 2010.

	2013 8th to 14th of July	2014 23rd to 27th of July	2010 20th to 26th of July
WBGT(degree in Celsius)	29.8	30.3	30.0
Total patients	10,913 (1,559/day)	8,095 (1,619/day)	10,303 (1,472/day)
Fatalities	16 * (2.3/day)	15 * (3.0/day)	76 (10.9/day)
Severe symptom patients	409 * (3.7%)	197 * (2.3%)	624 (5.9%)
Severe/Moderate symptom patients	4,263 * (38.6%)	2,696 * (33.6%)	4,631 (44.8%)

＊ P<0.01(compare to 2010 heat spell)

The number of heat disorder patients has a proportionate relationship with exponential of maximum WBGT, and we revised 2013 patients with using regression equation calculated from 2010 data. The 2013 patients at WBGT 30.0 degree in Celsius increased 13 or 20 percent (estimated by

2010 and 2013 equation) compare to 2010. However, the fatalities decreased in 21% and the number of severe symptom decreased in 38%. We suppose that public awareness for heat disorders and various educational activities effect “Patients increase and reduction of severe patients”. In table 6 we add 2014 1st heat spell data too.

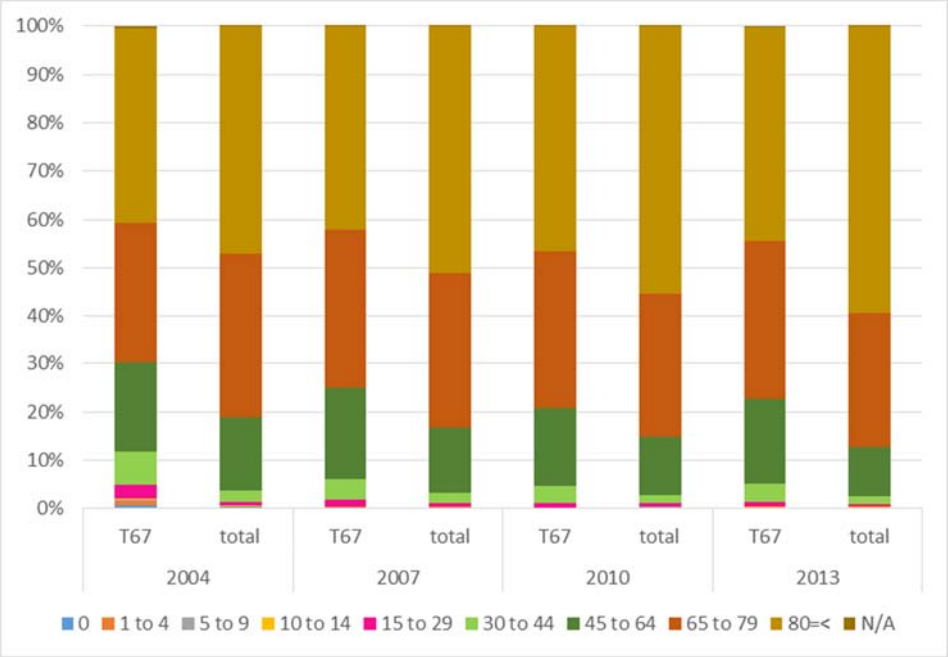

Fig. 6 Age blacket casualties ratio (T67)

The ratio of age bracket casualties categorized in T67 (Effects of heat and light) and the ratio of age bracket casualties heat of total are described in Fig. 7. Before starting heat stroke promotion in 2004, heat related casualties younger than 45 years old is 11.8% and total casualties in this age bracket is 3.7%. However in 2013, heat related casualties (younger than 45 years old) becomes 5.0% and total casualties in this age bracket is 2.4%. We suppose heat related casualties in younger age (<45 years old) has been improved. Contrary casualties in 45 to 65 years old decreased from 18.5% to 17.7% slowly and casualties in 65 to 79 years bracket increased from 29% to 32.7% (total casualties decreased from 34.1% to 28.0%).

In next few years, we continue our activities especially focusing on following 2 targets.

- Reduce severe/moderate symptom patients
- Reduce middle and aged patients especially in daily life

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