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Influence of Media on Seasonal Influenza Epidemic Curves

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ABSTRACT

Back ground: Theoretical investigations predicting the epidemic curves of seasonal influenza have been demonstrated so far; however, there is little empirical research using ever accumulated epidemic curves. The effects of vaccine coverage and information distribution on influenza epidemics were evaluated.
Materials and Methods: Four indices for epidemics (i.e., onset-peak duration, onset-end duration, ratio of the onset-peak duration to onset-end duration and steepness of epidemic curves) were defined, and the correlations between these indices and anti-flu drug prescription dose, vaccine coverage, the volume of media and search trend on influenza through internet were analyzed. Epidemiological data on seasonal influenza epidemics from 2002/2003 to 2013/2014 excluding 2009/2010 season were collected from National Institute of Infectious Diseases of Japan.
Results: The onset-peak duration and its ratio to onset-end duration correlated inversely with the volume of anti-flu drug prescription. Onset-peak duration correlated positively with media information volume on influenza. The steepness of the epidemic curve, and anti-flu drug prescription dose inversely correlated with the volume of media information. Pre-epidemic search trend and media volume on influenza correlated with the vaccine coverage in the season. Vaccine coverage had no strong effect on epidemic curve.
Conclusion: Education through media has an effect on the epidemic curve of seasonal influenza.

1. Introduction

Health education through media is one of the important measures for the infection control in infectious diseases. In this study, the effects of vaccine coverage, media information distribution and internet-based search trends for influenza on the flu epidemic curve was evaluated using data base on recent 13 seasonal influenza epidemics. The effect of the education on flu epidemic curve was shown in this study.

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2. Materials and Methods

2.1. Data collection

2.1.1. Data on seasonal influenza epidemics

Epidemiological data on seasonal influenza epidemics were collected using data from the sentinel surveillance system in 47 prefectures in Japan; where the local governments in each of the 47 prefectures in Japan compile cases of influenza reported from the local sentinel sites. The total number of the sentinels is approximately 4,500. All results since 2000/2001 season are available to the public on the website of National Institute of Infectious Diseases, Japan. Data from 2002/2003 were utilized concerning the timing of oseltamivir and rapid diagnostic tests for influenza have launched and spread in Japan. Four indices were defined: the duration (weeks) of the onset to peak (DOP), the

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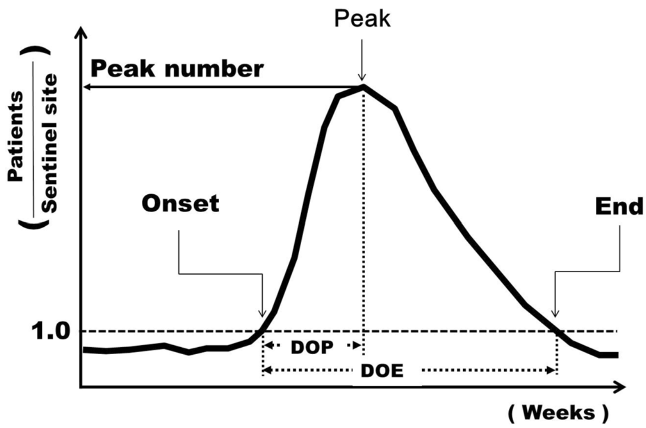

Figure 1. A schematic diagram showing the indices
The duration of the onset to peak (DOP), the duration from the onset to end (DOE), DOP / DOE ratio and the steepness of epidemic curve(SI; Peak number / DOE) were utilized as the indicators of epidemic curves in this study.

duration from the onset to end (DOE), DOP / DOE ratio and the steepness of epidemic curve. The onset of an influenza epidemic was defined as the week when the number of cases per sentinel site exceeded 1.0, and the end of the epidemic was defined as the week when that number dropped below 1.0. The steepness of the epidemic curve was expressed as steepness index (SI) which was calculated by dividing the largest number of cases in the season by the epidemic duration (Figure 1).

Table 1
Calculation of MIVI in pre-epidemic (A; Jun.-Sep.) and epidemic season (B; Oct.-Mar.)

A	α	β	β/α x 1,000
	Total hit counts for 0,1,2,3,4,5,6,7,8 and 9 from Jun. to Sep.	Hit counts for "Influenza" (in Japanese letter) from Jun. to Sep.	MIVI (Jun.-Sep.)
2002/2003	5,334,000	29,200	5.5
2003/2004	7,391,000	51,300	6.9
2004/2005	14,698,000	98,500	6.7
2005/2006	15,423,000	151,000	9.8
2006/2007	12,050,000	219,000	18.2
2007/2008	12,270,000	210,000	17.1
2008/2009	14,090,000	212,000	15.1
2009/2010			
2010/2011	19,700,000	217,000	11.0
2011/2012	21,190,000	219,000	10.3
2012/2013	26,360,000	225,000	8.5
2013/2014	27,740,000	296,000	10.7
B	α	β	β/α x 1,000
	Total hit counts for 0,1,2,3,4,5,6,7,8 and 9 from Oct. to Mar.	Hit counts for "Influenza" (in Japanese letter) from Oct. to Mar.	MIVI (Oct.-Mar.)
2002/2003	5,617,000	11,000	2.0
2003/2004	4,928,000	12,400	2.5
2004/2005	6,541,000	34,900	5.3
2005/2006	7,605,000	64,900	8.5
2006/2007	5,037,000	93,900	18.6
2007/2008	6,483,000	142,000	21.9
2008/2009	8,614,000	199,000	23.1
2009/2010			
2010/2011	11,510,000	209,000	18.2
2011/2012	11,760,000	211,000	17.9
2012/2013	11,940,000	214,000	17.9
2013/2014	14,240,000	225,000	15.8

2.1.2. Vaccine coverage

The data on vaccine coverage from 2002 to 2014 were extracted from the data base of the Ministry of Health Labour and Welfare, Japan. Data of the 2009-2010 season, in which the A(H1N1)pdm09 strain prevailed and the vaccine against A(H1N1)pdm09 was not supplied in time, was excluded in the evaluation of the effect of vaccine coverage on the epidemic curves.

2.1.3. Estimation of the media information volume about influenza

The volume of information about influenza was estimated using "Google", an internet search engine. The search area was restricted to Japan. Firstly, the number of websites hit by a search word, "influenza" (in Japanese) was obtained (α) after designating the period. Epidemic period of seasonal influenza begins as early as late October and ends as late as May in Japan; however, we excluded April and May from epidemic period in this study. Because A(H1N1)pdm09 pandemic occurred in April 2009 had a disturbing effect on the media information and search volume in 2008/2009 season. Period from the $1^{st.}$ of June to the $31^{st.}$ of September was defined as pre-epidemic period. Secondary, the numbers of websites hit by non-specific search word was checked in the same designated period. In this study, ten numbers from "0" to "9" were used as non-specific search word. The total counts for the ten search number was calculated (β). Then, α was divided by β for neutralizing the time-dependent decrease of websites. α/β multiplied by 1,000 was defined as media information volume index (MIVI) (Table 1). Considering the possibility that the hit count may be influenced by increasing number of websites during the study period and the different number of months included in pre-epidemic and epidemic period, we utilized MIVI as an indicator of media volume in this study.

2.1.4. Estimation of the public concerns regarding influenza

The strength of the public concerns regarding influenza was estimated using "Google trends" which displays how often specific key words have been searched for on Google over a period of time. Data from Google trends was available from 2004. The search area was restricted to Japan. After "influenza" (in Japanese) was entered as a key word, the total of scale numbers displayed on the search-trend curve in designated period was calculated and defined as search volume index (SVI) (Table 2).

2.1.5. The scale of influenza epidemics

The scale of influenza epidemics was estimated by the dose of anti-flu drug prescriptions in each season from 2002/2003 to 2012/2013. The anti-flu drug prescription dose was estimated from the documents published by the Ministry of Health, Labour and Welfare, Japan.[1,2]

Table 2
Search volume index in pre-epidemic (A; Jun.-Sep.) and epidemic season (B; Oct.-Mar.)

	SVI	
	A	B
2004/2005	5	73
2005/2006	8	83
2006/2007	7	62
2007/2008	7	69
2008/2009	22	115
2009/2010		
2010/2011	9	88
2011/2012	6	103
2012/2013	5	108
2013/2014	6	119

Table 3
Data used in the analysis

Season	DOP (weeks)	DOE (weeks)	DOP/DOE	SI	Estimated dose of anti-flu drug prescription (counts)	Vaccine coverage (%)
2002/2003	5.70	16.50	0.35	2.26	7,159,000	35.4
2003/2004	4.65	12.50	0.37	2.31	5,721,000	43.4
2004/2005	5.65	15.60	0.36	3.13	8,956,000	47.6
2005/2006	6.04	16.90	0.36	2.02	6,472,000	48.8
2006/2007	7.98	17.20	0.46	1.83	5,461,000	48.3
2007/2008	7.87	17.50	0.45	0.93	3,039,000	52.8
2008/2009	6.83	23.00	0.30	1.50	5,484,000	55.9
2009/2010						
2010/2011	5.52	22.20	0.25	1.39	8,279,000	53.0
2011/2012	5.52	20.76	0.27	1.94	8,457,000	51.7
2012/2013	6.52	22.40	0.29	1.52	7,757,000	49.6
2013/2014	5.67	20.90	0.27	1.64	NA	49.7

NA: Data was not available

2.1.6. Data analysis

Correlations between the formerly mentioned four indices of influenza epidemic curves and vaccine coverage, the four indices and anti-flu drug prescription dose, the four indices and MIVI, the four indices and SVI, MIVI and vaccine coverage, MIVI and anti-flu drug prescription dose, SVI and vaccine coverage and SVI and anti-flu drug prescription dose were investigated. Data of 2009/2010 season were excluded because of A(H1N1)09pdm pandemic. Data used in the analysis was summarized in Table 3.

2.1.7. Statistical analysis

The statistical analysis was carried out using the Analysis ToolPak for Excel (Microsoft, USA). Pearson coefficient was calculated, and the significance of correlation was diagnosed by p-value less than 0.05. The correlation was regarded as weak, moderate, strong and very strong for absolute correlation coefficient values (ρ) of 0.2-0.39, 0.40-0.59, 0.6-0.79 and 0.8-1, respectively.

2.1.8. Ethics statement

The ethics committee of Hirosaki University Graduate School of Medicine recognized this study as an analysis of de-identified and publicly available data, which did not require to be reviewed.

3. Results

The estimated total dose of anti-flu drug prescriptions, which indicates the scale of influenza epidemic of the season, had a strong inverse correlation with DOP (ρ = -0.65, p = 0.03) and DOP/DOE (ρ = -0.70, p = 0.02) (Table 4). While, vaccine coverage had no significant correlations with the four indices; however, it has a tendency to reduce SI (ρ = -0.56, p = 0.06) (Table 5). SVI in pre-epidemic period has a strong positive correlation with the vaccine coverage of the season (ρ = 0.76, p = 0.01) (Figure 2, Table 6). The annual change of vaccine coverage and SVI suggested the linkage of these indices; however, both SVI and vaccine coverage have decreased after the novel flu pandemic in 2009/2010 season. SVI in epidemic period had a very strong positive correlation with DOE (ρ = 0.81, p = 0.004) and an inverse correlation with DOP/DOE (ρ = -0.81, p = 0.004) (Table 6). MIVI in pre-epidemic period had positive correlations with DOP (ρ = 0.85, p = 0.0005) and vaccine coverage (ρ = -0.81, p = 0.004), and inverse correlations with SI (ρ = -0.66, p = 0.02) and the estimated dose of anti-flu drug prescriptions of the season (ρ = -0.66, p = 0.03). MIVI in epidemic period had positive correlations with DOP (ρ = 0.64, p = 0.02), DOE (ρ = 0.76, p = 0.004) and vaccine coverage (ρ = 0.85, p = 0.0005) (Table 7). Taken together, these findings indicate that the public concern and the volume of media information on influenza have an influence on the vaccine coverage. Moreover, media information volume on influenza in pre-epidemic season was suggested to have effects on flu epidemic curve of the season such as prolonging the period from onset to peak and reducing the size of epidemics.

Table 4
Correlations between estimated dose of anti-flu drug prescriptions and epidemic curve indices

Correlation coefficient and p-value	ρ	p
DOP	**-0.65**	**0.03**
DOE	0.22	0.51
DOP / DOE	**-0.70**	**0.02**
SI	0.55	0.08

Table 5
Correlations between vaccine coverage and epidemic curve indices

Correlation coefficient and p-value	ρ	p
DOP	0.38	0.22
DOE	0.51	0.09
DOP / DOE	-0.22	0.22
SI	-0.56	0.06

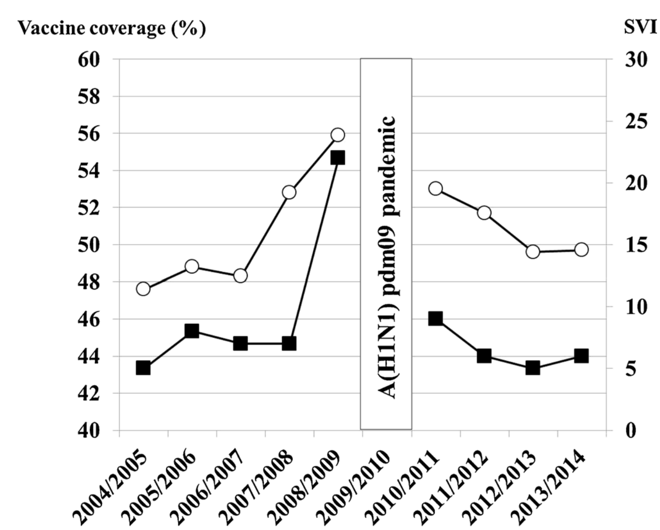

Figure 2. Change of vaccine coverage and pre-seasonal (Jun.-Sep.) search volume index calculated using *Google trends*.
The vaccine coverage of the season is influenced by the search volume index, the total search scale numbers by Google trends for the keyword "influenza" (in Japanese), in each pre-epidemic season (June to September).
(○: Vaccine coverage, ■: Search volume index).

Table 6
Correlations between search volume index and the epidemic curve indices, vaccine coverage and anti-flu drug prescription dose in pre-epidemic (A; Jun.-Sep.) and epidemic season (B; Oct.-Mar.)

	SVI			
Period	A		B	
Correlation coefficient and p-value	ρ	p	ρ	p
DOP	0.17	0.17	-0.47	0.17
DOE	0.45	0.45	**0.81**	**0.004**
DOP/DOE	-0.14	-0.14	**-0.81**	**0.004**
SI	-0.26	-0.26	-0.21	0.57
Vaccine coverage	**0.76**	**0.01**	0.39	0.26
Estimated dose of anti-flu drug prescription	0.31	0.31	-0.31	0.31

Table 7
Correlations between media information volume index and the indices, vaccine coverage and anti-flu drug prescription dose in pre-epidemic (A; Jun.-Sep.) and epidemic season (B; Oct.-Mar.)

	MIVI			
Period	A		B	
Correlation coefficient and p-value	ρ	p	ρ	p
DOP	**0.85**	**0.0005**	**0.64**	**0.02**
DOE	0.29	0.36	**0.76**	**0.004**
DOP/DOE	0.17	0.42	-0.12	0.71
SI	**-0.66**	**0.02**	**-0.80**	**0.002**
Vaccine coverage	**0.63**	**0.03**	**0.85**	**0.0005**
Estimated dose of anti-flu drug prescription	**-0.66**	**0.03**	-0.31	0.36

4. Discussion

It was reported that meteorological and demographic factors such as humidity,[3] temperature,[4] population-density[5] and urbanization[6] influence on the onset and spread of seasonal influenza. With regard to epidemic curves of seasonal influenza, vaccination,[7] low activity of society[8] and education of people through media[9] are estimated to depress the peak and widen the base of the curve. Our results supported these theoretical simulations. Furthermore, SVI and MIVI in pre-epidemic season were suggested to have some effect on vaccine coverage in the current study. The diagnosis and treatment of seasonal influenza has changed at the beginning of the 21st century. Oseltamivir was launched in 1999 and widely used from 2001 in Japan. Point of care testing which could identify and discriminate influenza A from B was available from 2001/2002 season, and was widely distributed from 2002/2003 season.[10] Supply of rapid diagnostic tests and oseltamivir was kept stable from this period. While, the volume of information about influenza began to increase in the middle of the first decade of 21st century including the topics about encephalopathy (2005-2007), emergence of oseltamivir-resistant strain of seasonal influenza (2008), detection of H5N1 from the birds in Akita prefecture and Hokkaido (2008) and fear of novel influenza pandemics. The vaccine coverage increased in accordance with SVI until 2009/2010 season when A(H1N1)pdm09 prevailed the world. People became more aware of the protection against influenza and other infectious diseases during this period. But the vaccine coverage and SVI decreased after 2009/2010 season. It was concerned that people became less interested in influenza after they went through the pandemic of A(H1N1)pdm09 which was not as harmful as people had expected. Correct understanding and appropriate performance of protective measures by people could lower and delay the peak of endemic curve.[11] Flu vaccination is expected to lessen the prevalence of pneumonia[12] and excess death.[13] As were suggested in this study, media information volume and public concern for influenza in pre-epidemic period have protective effect against flu-epidemics. Education of people through media is important for achieving high vaccination coverage and strict protective measures including hand washing, cough etiquette and reduction of person to person contact.

This study has some limitations. This study is a retrospective observational study limited to media information volume, search trends through internet and vaccine coverage. Other factors which may influence the epidemic curves such as the immunological status for each prevalent strains of influenza and the quality of the media information were not taken into account.

In conclusion, education through media has an effect on the onset to peak duration, steepness of the seasonal influenza epidemic curve, size of epidemic and the vaccine coverage of the season.

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Conflicts of interest: All authors have declared that there are no conflicts of interest.

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