prolonged period. Many commuters were stranded because of interrupted transportation services, and there was a high risk of radioactive contamination associated with the nuclear accident. The increased prevalence of insomnia among minors in Tokyo, who are generally less susceptible to stress induced by indirect sources such as media coverage, may be attributable to the effects of the aftershocks. In contrast, the seismic intensity of the main shock in Osaka was 3.0; therefore, direct feelings of fear were likely to be less common, and there was an absence of palpable aftershocks. The prevalence of insomnia among minors in Osaka following the earthquake was not increased, which can be explained by the residents' exposure to fewer direct and local effects. However, an increased number of adults in Osaka reported insomnia. This may have stemmed from exposure to information reported by the media. Other possible causes of insomnia among these adults include anxiety about their future and memories of the disaster caused by the Great Hanshin Earthquake of 1995.

Questionnaire Survey and Its Advantages

A Web-based questionnaire survey was used in the current study because more data are acquired with Internet-based epidemiological surveys than with conventional, paper-based surveys [20,21]. This method was effective in targeting general residents and enabling the acquisition of information from people with medical complaints deemed very mild to warrant a visit to a medical facility. In addition, this survey method was successful because the participants were required to respond only to simple questions regarding the presence or absence of symptoms, thus, the input burden was low. Although a meta-analysis of 68 studies [22] indicated that the normal response rate to Internet-based surveys is low (39.6%), the daily response rate for this study during the period when reminder emails were sent was 64.17% (5.78%) for Tokyo and 68.31% (5.18%) for Osaka. The survey questions were not specifically designed to detect post-disaster psychological conditions, and insomnia was only 1 of several conditions investigated. Participants' responses were limited to the presence or absence of insomnia, and there was no attempt to determine the severity of the condition. Because insomnia was investigated as only 1 of several conditions, participants were unaware that their responses would be used in a study on post-disaster stress, even after the earthquake struck. It is possible, therefore, that the participants were less inclined to answer "yes" to the question about any experience of insomnia symptoms. This possibility is supported by the fact that the average daily prevalence of insomnia among adults before the earthquake was 1.1% in Tokyo and 1.3% in Osaka; these rates are lower than the values reported by an earlier survey on the prevalence of insomnia among Japanese adults [23].

Limitations

Immediately after the earthquake struck, an ethical decision was made to refrain from sending reminder emails. Therefore, the response rate was low during this period. However, no significant difference in the daily prevalence of insomnia correlated with the use of these reminder emails in either Tokyo or Osaka. The chi-square test results were similar between analysis including and excluding this time period. Although the reminder emails were included in the logistic regression analysis as an independent variable, the presence or absence of the reminder emails inevitably remains a limitation of this study and a potential source of bias. However, we believe that this factor had a negligible effect on the results.

Conclusions

This study examined the prevalence of insomnia among residents in areas distant from the epicenter of the Great East Japan Earthquake. In Tokyo, where the seismic intensity was higher, both adults and minors experienced increased rates of insomnia as a direct result of the earthquake and its aftershocks. Further, mental stress induced by information broadcast by the media may have influenced the prevalence of insomnia. In Osaka, where the seismic intensity was lower, only adults exhibited an increased prevalence of insomnia. Health care practitioners should be aware that individuals might experience mental stress, including insomnia, even in areas distant from those that are directly affected by a natural disaster.

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Conflicts of Interest

None declared.

References

1. Maruyama S, Kwon YS, Morimoto K. Seismic intensity and mental stress after the Great Hanshin-Awaji Earthquake. Environ Health Prev Med 2001 Oct;6(3):165-169 [FREE Full text] [doi: 10.1007/BF02897965] [Medline: 21432256]
2. Sekizuka N, Sakai A, Aoyama K, Kohama T, Nakahama Y, Fujita S, et al. Association between the incidence of premature rupture of membranes in pregnant women and seismic intensity of the Noto Peninsula earthquake. Environ Health Prev Med 2010 Sep;15(5):292-298 [FREE Full text] [doi: 10.1007/s12199-010-0142-5] [Medline: 21432558]
3. Shibahara S. The 2011 Tohoku earthquake and devastating tsunami. Tohoku J Exp Med 2011;223(4):305-307 [FREE Full text] [Medline: 21478655]

4. Hirose K. 2011 Fukushima Dai-ichi nuclear power plant accident: summary of regional radioactive deposition monitoring results. J Environ Radioact 2012 Sep;111:13-17. [doi: 10.1016/j.jenvrad.2011.09.003] [Medline: 22119330]
5. Ohnishi T. The disaster at Japan's Fukushima-Daiichi nuclear power plant after the March 11, 2011 earthquake and tsunami, and the resulting spread of radioisotope contamination. Radiat Res 2012 Jan;177(1):1-14. [Medline: 22059981]
6. Goodwin R, Takahashi M, Sun S, Gaines SO. Modelling psychological responses to the Great East Japan earthquake and nuclear incident. PLoS One 2012;7(5):e37690 [FREE Full text] [doi: 10.1371/journal.pone.0037690] [Medline: 22666380]
7. Bryant RA. Acute stress disorder as a predictor of posttraumatic stress disorder: a systematic review. J Clin Psychiatry 2011 Feb;72(2):233-239. [doi: 10.4088/JCP.09r05072blu] [Medline: 21208593]
8. Mills MA, Edmondson D, Park CL. Trauma and stress response among Hurricane Katrina evacuees. Am J Public Health 2007 Apr;97 Suppl 1:S116-S123. [doi: 10.2105/AJPH.2006.086678] [Medline: 17413068]
9. Japan Meteorological Agency. accessed-12-12. 2012. Tables explaining the JMA Seismic Intensity Scale URL: http://www.jma.go.jp/jma/en/Activities/inttable.pdf [accessed 2012-12-12] [WebCite Cache ID 6CrJ8Z3mU]
10. Sugiura H, Ohkusa Y, Akahane M, Sano T, Okabe N, Imamura T. Development of a web-based survey for monitoring daily health and its application in an epidemiological survey. J Med Internet Res 2011;13(3):e66 [FREE Full text] [doi: 10.2196/jmir.1872] [Medline: 21946004]
11. Kaneko Y, Motohashi Y, Nakamura H, Endo T, Eboshida A. Increasing prevalence of Japanese cedar pollinosis: a meta-regression analysis. Int Arch Allergy Immunol 2005 Apr;136(4):365-371. [doi: 10.1159/000084256] [Medline: 15746556]
12. Chen CH, Tan HK, Liao LR, Chen HH, Chan CC, Cheng JJ, et al. Long-term psychological outcome of 1999 Taiwan earthquake survivors: a survey of a high-risk sample with property damage. Compr Psychiatry 2007 Jun;48(3):269-275. [doi: 10.1016/j.comppsych.2006.12.003] [Medline: 17445522]
13. Roy N. The Asian Tsunami: PAHO disaster guidelines in action in India. Prehosp Disaster Med 2006 Oct;21(5):310-315. [Medline: 17297900]
14. Hyodo K, Nakamura K, Oyama M, Yamazaki O, Nakagawa I, Ishigami K, et al. Long-term suicide mortality rates decrease in men and increase in women after the Niigata-Chuetsu earthquake in Japan. Tohoku J Exp Med 2010 Feb;220(2):149-155 [FREE Full text] [Medline: 20139666]
15. Shinfuku N. Disaster mental health: lessons learned from the Hanshin Awaji earthquake. World Psychiatry 2002 Oct;1(3):158-159 [FREE Full text] [Medline: 16946841]
16. Cairo JB, Dutta S, Nawaz H, Hashmi S, Kasl S, Bellido E. The prevalence of posttraumatic stress disorder among adult earthquake survivors in Peru. Disaster Med Public Health Prep 2010 Mar;4(1):39-46. [Medline: 20389194]
17. Neria Y, Nandi A, Galea S. Post-traumatic stress disorder following disasters: a systematic review. Psychol Med 2008 Apr;38(4):467-480. [doi: 10.1017/S0033291707001353] [Medline: 17803838]
18. Pyari TT, Kutty RV, Sarma PS. Risk factors of post-traumatic stress disorder in tsunami survivors of Kanyakumari District, Tamil Nadu, India. Indian J Psychiatry 2012 Jan;54(1):48-53 [FREE Full text] [doi: 10.4103/0019-5545.94645] [Medline: 22556437]
19. Varela E, Koustouki V, Davos CH, Eleni K. Psychological consequences among adults following the 1999 earthquake in Athens, Greece. Disasters 2008 Jun;32(2):280-291. [doi: 10.1111/j.1467-7717.2008.01039.x] [Medline: 18380855]
20. Ekman A, Dickman PW, Klint A, Weiderpass E, Litton JE. Feasibility of using web-based questionnaires in large population-based epidemiological studies. Eur J Epidemiol 2006;21(2):103-111. [doi: 10.1007/s10654-005-6030-4] [Medline: 16518678]
21. Schleyer TK, Forrest JL. Methods for the design and administration of web-based surveys. J Am Med Inform Assoc 2000 Aug;7(4):416-425 [FREE Full text] [Medline: 10887169]
22. Cook C, Heath F, Thompson RL. A meta-analysis of response rates in web- or internet-based surveys. Educ Psychol Meas 2000 Dec;60:821-836. [doi: 10.1177/00131640021970934]
23. Kim K, Uchiyama M, Okawa M, Liu X, Ogihara R. An epidemiological study of insomnia among the Japanese general population. Sleep 2000 Feb 1;23(1):41-47. [Medline: 10678464]

Abbreviations

ASD: acute stress disorder
CO-OP: Consumers' Co-operative Union
JMA: Japan Meteorological Agency
PTSD: post-traumatic stress disorder

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Internet survey of the influence of environmental factors on human health: environmental epidemiologic investigation using the web-based daily questionnaire for health

Tomomi Sano[a]*, Manabu Akahane[a], Hiroaki Sugiura[a], Yasushi Ohkusa[b], Nobuhiko Okabe[b†] and Tomoaki Imamura[a]

[a]*Department of Public Health, Health Management and Policy, Nara Medical University School of Medicine, 840 Shijo-cho, Kashihara, Nara 634-8521, Japan;* [b]*National Institute of Infectious Disease, Infectious Disease Surveillance Center, 1-23-1 Toyama, Shinjuku-ku, Tokyo 162-8640, Japan*

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With increasing Internet coverage, the use of a web-based survey for epidemiological study is a possibility. We performed an investigation in Japan in winter 2008 using the web-based daily questionnaire for health (WDQH). The WDQH is a web-based questionnaire survey formulated to obtain information about the daily physical condition of the general public on a real-time basis, in order to study correlations between changes in physical health and changes in environmental factors. Respondents were asked whether they felt ill and had specific symptoms including fever. We analysed the environmental factors along with the health conditions obtained from the WDQH. Four factors were found to influence health: minimum temperature, hours of sunlight, median humidity and weekday or holiday. The WDQH allowed a daily health survey in the general population in real time via the Internet.

Keywords: web-based survey; environmental factor; minimum temperature; general population

Background

With the rapid progression of Internet technology, a web-based epidemiological survey was developed and implemented for use with the general public (Ekman and Litton 2007). This allowed epidemiological studies to be conducted at lower cost, with greater speed and with higher data precision compared with paper-based or face-to-face surveys on a similar scale (Bennett et al. 2007; Ekman and Litton 2007). Although early web-based surveys were found to be problematic because of population bias, this has been mitigated with the marked increase in the proportion of the population using the Internet (Ekman et al. 2006).

Web-based epidemiological studies came to be implemented for cross-sectional studies as well as for follow-up investigations (Bennett et al. 2007). To date, web-based follow-up surveys have been conducted with patients with specific diseases, but

*Corresponding author. Email: sanotomo@naramed-u.ac.jp
†Present address: Kawasaki City Institute for Public Health, 5-13-10 Oshima, Kawasaki-ku, Kawasaki city, Kanagawa, 210-0834, Japan.

not with the general public. Specifically, no studies have been conducted to investigate the correlations between daily environmental changes and the daily physical condition of members of the general public. There is currently concern over human health with regard to air pollution (Huang et al. 2009) and global warming (McMichael et al. 2006). Accordingly, it would be useful to be able to determine the influence of environmental factors on the health of the general population on a daily basis. Therefore, we developed a follow-up survey system using the Internet to question citizens directly on a daily basis. We named this survey the web-based daily questionnaire for health (WDQH).

We then studied the correlations between changes in the daily physical condition of the subjects and changes in environmental factors that are considered to have an influence on health (minimum temperature, hours of sunlight, median humidity, weekday or holiday) using the WDQH.

Methods

Survey method

The WDQH is a prospective survey system designed to conduct a direct health-related questionnaire survey of individuals every day for a certain period to collect and analyse information on a real-time basis. The WDQH has already been put into operation in part, and its usefulness has been established (Sugiura et al. 2010).

Participants

Participants were persons already registered with an existing internet survey company, who noticed the request to participate in the questionnaire survey on the company website, and voluntarily decided to participate. They understood the purpose of the survey, and that it also included information on their families. In this survey, the residential area of the participants was limited to Izumo, a regional city in Japan. We only included those who understood the details of our request and agreed to cooperate in the survey. The population of Izumo is approximately 150,000, with approximately 50,000 households. The study included 702 subjects (333 males, 369 females; mean age 37.4 years; range 16–72 years) from 181 households. We collected information describing the survey participants including their residential district, age, gender, occupation, marital status, number of children and annual income. The survey was performed for 78 days from January 10, 2008 to March 28, 2008.

Questionnaire

The survey required participants to answer questions regarding subjective symptoms every day. The internet survey company sent a reminder email to each subject daily requesting completion of the questionnaire survey. The subject opened the email, accessed his/her personal password and then answered the questionnaire about himself/herself and his/her family. Respondents were asked whether they felt ill. If not, they closed the survey on that day. Those who answered in the affirmative were then asked detailed questions about whether they had any of the following symptoms: fever, coughing, diarrhoea, vomiting, rash, convulsion and others. Remuneration (approximately 60 yen/answer: US$ 0.75; US$1.00 = 80 yen at the time of writing) was given to the registered monitors. The survey was repeated every

day over the study period. We analysed and studied the correlations between changes in the daily physical condition of the participants and changes in environmental factors.

Environmental factors

Data describing the following 12 environmental factors are monitored and published by The Japan Meteorological Agency: mean temperature, maximum temperature, minimum temperature, hours of sunlight, cloud cover (the percentage or fraction of the sky obscured by clouds represented by an 11-point scale), median humidity, atmospheric pressure, vapour pressure, precipitation, wind direction, wind speed and weekday or holiday. Data describing these environmental factors in the survey area were collected. Mondays to Fridays were considered weekdays, while Saturdays, Sundays and public holidays were considered to be holidays.

In addition, three individual factors (sex, age and annual income) were included.

The 15 variables were first subjected to principal component analysis. As a result, five principal components were identified. The first component was temperature; the second component was hours of sunlight; the third components were sex and age; the fourth component was wind direction; and the fifth component was median humidity.

Then, the correlation coefficients of all 15 variables were examined. Eight variables (sex, age, annual income, median humidity, precipitation, wind direction, wind speed and weekday or holiday) were included because of no correlations between them. Cloud cover, vapour pressure and atmospheric pressure, which were not extracted as main components and showed strong correlations (correlation coefficient >0.5), were excluded from the variables. Mean temperature was strongly correlated with maximum temperature ($r = 0.924$) and minimum temperature ($r = 0.722$). Hence, a single variable could be selected from mean temperature, maximum temperature and minimum temperature. Minimum temperature, which was not correlated with hours of sunlight ($r = -0.097$), was selected as a variable to negate interaction with hours of sunlight, which was selected as the second component for principal component analysis. Thus, 10 variables were selected: sex, age, annual income, minimum temperature, hours of sunlight, median humidity, precipitation, wind direction, wind speed and weekday or holiday.

Additionally, the 10 selected variables were analysed using generalized estimating equations (GEE). Three variables (precipitation, wind direction and wind speed) showed no significant correlation with any independent variable (ill or healthy and details of symptoms) and were excluded from covariates by a stepwise method. The variables remaining in the final analysis included four environmental factors (minimum temperature, hours of sunlight, median humidity and weekday or holiday).

Statistical analysis

Statistical analysis was conducted using IBM SPSS 20. A p-value <0.05 was considered to indicate significance. Adjusted odds ratios and standard deviations were determined with 95% confidence intervals.

The data used in this study were answers repeatedly collected from the same subject to the same question. We selected the GEE useful for the analysis of repeated

measurements of health results. The repeated measurements included individuals and households as subject variables and days as an intra-subject variable.

Generalized estimating equations was conducted using "ill or healthy" as a dependent variable and three individual factors (sex, age and annual income) and four environmental factors (minimum temperature, hours of sunlight, median humidity and weekday and holiday) as independent variables. The GEE was also performed using presence/absence of specific symptoms (fever, coughing, diarrhoea, vomiting, rash and others) as a dependent variable, and the seven aforementioned independent variables.

Ethics and consent

This research was conducted with the approval of the Ethics Committee of Nara Medical University (Authorization code: 220).

Results

The largest age group of the enrolled subjects was between 35 and 39 years old (37 years old on average) for both males and females. The ratio of males to females of the participants was approximately 1:1. The male and female participants were similar in age distribution. Approximately, 500 completed questionnaires were received each day during the survey period, giving a daily response rate of 35% to 51% (47% on average) (Figure 1). The mean response rate was 48.7% on weekdays and 44.4% on holidays. The everyday responder rate throughout the survey period was 3.2%. Although 34.5% of persons registered to show his/her willingness to answer the survey, they did not respond. As shown in Figure 2, the proportion of respondents who reported that they felt ill during the survey period ranged from 3% to 10% on a daily basis during the survey period.

Table 1 illustrates the outcome of the questionnaire according to gender. There were more female respondents than male respondents who suffered changes in their

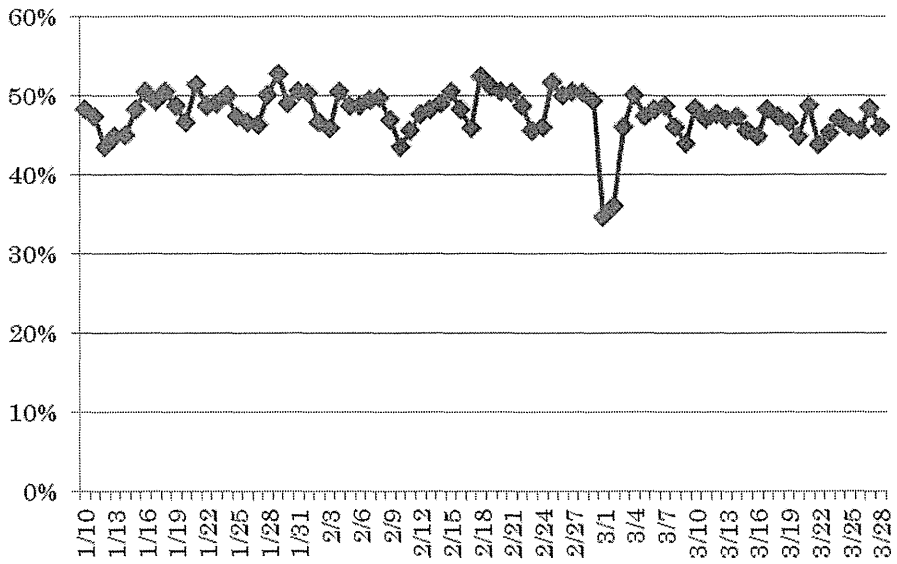

Figure 1. Daily response rate to the questionnaire.

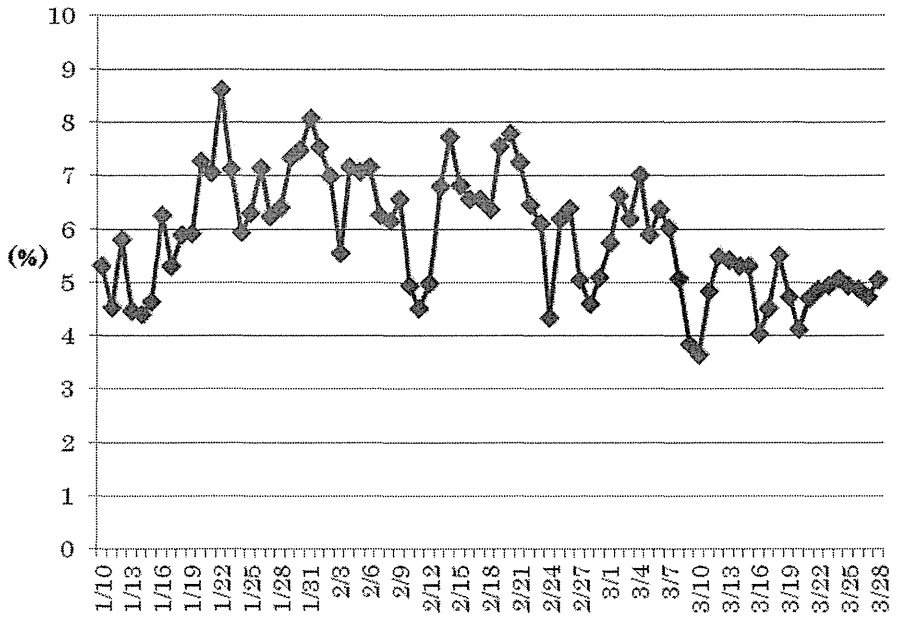

Figure 2. Proportion of respondents who answered that they were ill on specific days.

Table 1. Questionnaire outcomes.

	Male		Female		Total	
	Presence of symptoms (%)	Absence of symptoms (%)	Presence of symptoms (%)	Absence of symptoms (%)	Presence of symptoms (%)	Absence of symptoms (%)
Ill	1746 (5.7)	28,830 (94.3)	2246 (6.9)	30,274 (93.1)	3992 (6.3)	59,104 (93.7)
Fever	247 (0.8)	30,329 (99.2)	249 (0.8)	32,271 (99.2)	496 (0.8)	62,600 (99.2)
Coughing	944 (3.1)	29,632 (96.9)	958 (2.9)	31,562 (97.1)	1902 (3)	61,194 (97)
Diarrhoea	117 (0.4)	30,459 (99.6)	181 (0.6)	32,339 (99.4)	298 (0.5)	62,798 (99.5)
Vomiting	94 (0.3)	30,482 (99.7)	116 (0.4)	32,404 (99.6)	210 (0.3)	62,886 (99.7)
Rash	28 (0.1)	30,548 (99.9)	34 (0.1)	32,486 (99.9)	62 (0.1)	63,034 (99.9)
Convulsion	19 (0.1)	30,557 (99.9)	2 (0)	32,518 (100)	21 (0)	63,075 (100)
Others	768 (2.5)	29,808 (97.5)	1602 (4.9)	30,918 (95.1)	2370 (3.8)	60,726 (96.2)
Sum total	30,576		32,520		63,096	

physical condition. Coughing accounted for the highest proportion (3%) of an individual symptom suffered by respondents during the survey period.

From principal component analysis, the first principal components were mean temperature, maximum temperature and minimum temperature. The second principal component was hours of sunlight. The third principal components were sex and age. The fourth principal component was wind direction. The fifth principal component was median humidity.

Pearson's correlation coefficients were calculated. Variables strongly correlated were as follows: mean temperature and maximum temperature ($r = 0.924$; $p < 0.001$), mean temperature and minimum temperature ($r = 0.722$; $p < 0.001$), mean temperature and atmospheric pressure ($r = -0.547$; $p < 0.001$), mean temperature and vapour pressure ($r = 0.880$; $p < 0.001$), maximum temperature

and hours of sunlight ($r = 0.566$; $p < 0.001$), maximum temperature and cloud cover ($r = -0.579$; $p < 0.001$), maximum temperature and vapour pressure ($r = 0.779$; $p < 0.001$), minimum temperature and atmospheric pressure ($r = -0.520$; $p < 0.001$), minimum temperature and vapour pressure ($r = 0.760$; $p < 0.001$), atmospheric pressure and vapour pressure ($r = -0.521$; $p < 0.001$).

Table 2 shows the results of the GEE of ill participants. The number of ill subjects was inversely proportional to individual factors (age and annual income) and environmental factors (minimum temperature and hours of sunlight). In addition, fewer people were found to be ill on holidays.

Table 3 shows the results of GEE of individual symptoms. The results revealed that the number with fever, cough, diarrhoea, vomiting and rash decreased with age. Others (unidentified complaints) decreased as annual income increased. Fever and rash decreased as the minimum temperature increased. Additionally, fever and vomiting decreased as hours of sunlight increased. On holidays, cough and others decreased and rash increased.

Discussion

In the present study, the relationship between environmental factors and health conditions, which changed on a daily basis, were analysed from health results in the daily web questionnaire survey. Case control designs, generalized linear models (GLIM), and GEE are useful for such repeated epidemiological analyses. The GEE was established by modifying GLIM, and has been found to be useful for repeated measurements and longitudinal data analysis. The GEE allows unbiased estimation and bias correction for individual confounding factors that may be generated from Internet survey results. They are commonly used in large epidemiological studies, especially multi-site cohort studies as they can handle many types of unmeasured dependence between outcomes (Nitta et al. 2010). Thus, we employed GEE for analysis of the repeated measurements of health results in our web survey to analyse the changes in environmental and health conditions.

Correlations between environmental changes and changes in daily symptoms have been reported for particular diseases (Vocks et al. 2001; Srinivasan et al. 2007; Pantavou et al. 2008). A decrease in temperature is associated with an increase in ischemic cardiac events such as angina pectoris and a rise in blood pressure, while an

Table 2. Generalized estimating equations of ill subjects.

	Ill		Healthy		GEE			
	Mean	SD	Mean	SD	*B*	SE	*p*-value	Exp(B)
Sex					0.099	0.2440	0.686	1.104
Age	36.15	6.460	37.90	9.000	−0.023	0.0111	0.035**	0.977
Annual income	3.07	1.499	3.53	1.609	−0.197	0.0893	0.027**	0.821
Minimum temperature	5.078	2.8328	5.359	2.9440	−0.029	0.0128	0.024**	0.972
Hours of sunlight	2.873	3.1088	3.163	3.2276	−0.030	0.0111	0.007**	0.971
Median humidity	76.47	7.411	76.08	7.353	0.002	0.0035	0.563	1.002
Weekday or holiday					0.122	0.0474	0.010**	1.130

Notes: $^{**}p < 0.05$; $^{*}p < 0.1$. The table shows the mean and standard deviation (SD) based on the presence/absence of symptoms for comparison. GEE: generalized estimating equations; SE: standard error.

Table 3. Generalized estimating equations for each symptom.

	Symptom present		No symptom		GEE			
Fever	Mean	SD	Mean	SD	*B*	SE	*p*-value	Exp(B)
Sex					0.046	0.2661	0.862	1.048
Age	34.78	6.924	37.82	8.895	−0.044	0.0110	0.000**	0.957
Annual income	3.70	1.591	3.50	1.607	0.073	0.0637	0.250	1.076
Minimum temperature	4.655	2.5315	5.348	2.9407	−0.058	0.0270	0.031**	0.944
Hours of sunlight	2.578	2.8574	3.151	3.2239	−0.076	0.0254	0.003**	0.926
Median humidity	76.31	7.231	76.10	7.358	−0.009	0.0088	0.32	0.991
Weekday or holiday					0.080	0.1347	0.554	1.083
Coughing								
Sex					0.384	0.2593	0.138	1.469
Age	36.06	5.545	37.85	8.954	−0.029	0.0080	0.000**	0.971
Annual income	3.51	1.359	3.50	1.613	−0.010	0.0650	0.882	0.990
Minimum temperature	5.015	2.8145	5.352	2.9413	−0.042	0.0223	0.062	0.959
Hours of sunlight	2.772	3.0623	3.157	3.2254	−0.034	0.0181	0.058	0.966
Median humidity	76.85	7.592	76.08	7.349	0.008	0.0057	0.145	1.008
Weekday or holiday					0.222	0.0697	0.001**	1.248
Diarrhoea								
Sex					−0.113	0.3287	0.732	0.894
Age	35.49	6.418	37.81	8.893	−0.030	0.0146	0.038**	0.970
Annual income	3.55	1.664	3.50	1.607	0.026	0.0905	0.773	1.027
Minimum temperature	5.112	2.9279	5.344	2.9386	0.019	0.0369	0.611	1.019
Hours of sunlight	2.794	3.2217	3.148	3.2217	−0.032	0.0376	0.396	0.969
Median humidity	76.55	7.174	76.10	7.357	0.002	0.0120	0.889	1.002
Weekday or holiday					−0.156	0.1906	0.414	0.856
Vomiting								
Sex					−0.109	0.3291	0.741	0.897
Age	34.26	7.620	37.81	8.887	−0.046	0.0214	0.032**	0.955
Annual income	2.97	1.632	3.50	1.607	−0.217	0.1449	0.134	0.805
Minimum temperature	4.371	2.5365	5.346	2.9391	−0.051	0.0462	0.271	0.950
Hours of sunlight	2.050	2.5977	3.150	3.2228	−0.135	0.0469	0.004**	0.874
Median humidity	77.35	6.879	76.10	7.358	0.001	0.0171	0.933	1.001
Weekday or holiday					−0.034	0.2165	0.874	0.966
Rash								
Sex					1.185	1.0015	0.237	3.270
Age	28.43	3.664	37.81	8.885	−0.199	0.0326	0.000**	0.617
Annual income	3.69	1.814	3.50	1.607	0.053	0.2451	0.827	1.055
Minimum temperature	4.786	2.9974	5.344	2.9385	−0.144	0.0643	0.025**	0.866
Hours of sunlight	3.017	3.0967	3.147	3.2220	−0.019	0.0625	0.762	0.981
Median humidity	76.12	7.510	76.10	7.357	0.004	0.0172	0.838	1.004
Weekday or holiday					−0.483	0.2155	0.025**	0.617
Others								
Sex					−0.440	0.3542	0.214	0.644
Age	36.55	6.917	37.84	8.938	−0.002	0.0147	0.913	0.998
Annual income	2.43	1.222	3.53	1.606	−0.654	0.1765	0.000**	0.520
Minimum temperature	5.214	2.8481	5.347	2.9413	−0.020	0.0150	0.189	0.981
Hours of sunlight	3.041	3.1820	3.151	3.2230	−0.017	0.0130	0.198	0.983
Median humidity	76.08	7.301	76.10	7.359	−0.003	0.0042	0.426	0.997
Weekday or holiday					0.147	0.0609	0.016**	1.159

Notes: $^{**}p < 0.05$; $^{*}p < 0.1$.

increase in minimum temperature, especially during the warm season, is associated with a decrease in the onset of cardiovascular or respiratory events (Pantavou et al. 2008). It has also been reported that a decrease in humidity at a temperature of less than 15°C resulted in an increase in the rate of torsion of the testes (Srinivasan et al. 2007). A sharp decrease in temperature has been reported to exacerbate symptoms such as itching sensations in patients with atopic dermatitis (Vocks et al. 2001). Moreover, an increase in maximum temperature of 1°C was found to increase overall mortality by 0.9%, and a mean temperature of 32°C or above has been reported to increase overall mortality by 7.3% (Hu et al. 2008). An article about the relationship between climate and hospitalization in children with asthma demonstrated that children aged 0–4 years were the most vulnerable to climatic changes. More children were hospitalized on cold and dry days with low absolute humidity (Nastos et al. 2008). An article on the relationship between climate and respiratory infection demonstrated that temperature and humidity were strongly associated with the development and aggravation of respiratory infection. Of note, there was an increase in death rate about two weeks after cold days with low humidity (Nastos et al. 2006). An article on the relationship between climatic changes and death rates demonstrated that rapid climatic changes were a critical risk factor for death. Of note, the physical conditions are influenced at three days in winter and at one day in summer after rapid climatic changes (Nastos et al. 2011).

However, few studies have been conducted to investigate the correlation between changes in the daily physical condition of a general population not suffering from any particular disease, and changes in environmental factors.

When ambient temperature decreases during winter, symptoms such as runny nose, sneeze, cough or fever commonly appear. Moreover, bacterial infections, common cold and influenza are frequently reported to increase during winter in clinical practice (Heikkinen and Järvinen 2003; Tanaka 1998). These correspond to the result that when the minimum ambient temperature decreases, it is likely that many people will experience symptoms of poor health, especially fever. Conversely, when the minimum ambient temperature increases, the overall health conditions of the general population tend to improve. The web-based questionnaire collects data regarding changes in the respondents' daily physical condition on a real-time basis, which allowed investigation of the correlation between environmental factors and the physical condition of the general population.

The results also revealed that the physical condition of the respondents improved as the hours of sunlight increased. Additionally, more people were ill on weekdays than on holidays. It is possible that the latter finding was related to stress. Indeed, an increase in the prevalence of disease caused by psychosocial stress in recent times has been reported (Schmidt et al. 2008), and attending school or work on a weekday may result in psychosocial stress, which could have an effect on the physical condition. In contrast, a more relaxing time on holiday is likely to relieve stress (Butler et al. 2009) and improve the physical condition.

The "presence/absence of specific symptoms" was found to be significantly correlated with hours of sunlight. Hours of sunlight has been reported to be correlated with the secretion of serotonin in the brain; therefore, mental disorders such as depression and anxiety, which are associated with decreased serotonin secretion, may be improved by sunlight exposure (Lambert et al. 2002). In addition, ultraviolet exposure increases the synthesis of vitamin D, and appropriate quantities of vitamin D may be a preventative factor against immune-related disorders, such as

multiple sclerosis and type 1 diabetes mellitus, infections and cancer (Norval et al. 2007). It has also been reported that the risk of human papillomavirus (HPV) infection decreases as the amount of sunlight exposure increases. Despite the reported effects of increased sunlight, the increase in ultraviolet radiation resulting from depletion of the ozone layer could have adverse effects on the body such as acute damage to the eyes and skin. Additionally, sunlight exposure is associated with an increased risk of skin squamous cell carcinoma, epidermodysplasia verruciformis-HPV infection and decreased skin or systemic immunoreactivity (Termorshuizen et al. 2004).

The results of this study revealed that the appearance of symptoms decreased with increased hours of sunlight. These findings were in accordance with the positive effects of sunlight exposure on the human body observed in previous reports.

Although it has been reported that intra-individual variability, amount of sunlight exposure and individual background significantly influenced the effects of sunlight exposure on intracellular DNA, and that ultraviolet-induced DNA damage accumulated over three to six days (Moller et al. 2002), this was not relevant at the time of year our survey was conducted.

An article about the relationship between health conditions and individual factors indicated that health conditions varied with sex, age and income. Men were more vulnerable than women. Younger persons were more vulnerable. Those with higher incomes had better health conditions (Belloc et al. 1970). The present survey also demonstrated that individual factors influenced health conditions.

It should be noted that there are some limitations to this study. In the questionnaire, the severity and specificity of symptoms in the questions could not be determined by the researcher. This survey was also limited in terms of the assessment of the reliability of respondents' answers due a self-reporting system being used.

The cost of the three-month survey in Izumo was 8.28 million yen (US$ 103,500). It would be ideal to conduct surveys about changes in the environment and health conditions of the general population in major cities in Japan all year long. Although a web-based survey is cheaper than paper-based or face-to-face surveys, if the survey was expanded to main cities in Japan or carried out over a full year, the expense would be massive. Thus, because of the excessive cost of such surveys, the target area and period in this survey were limited. January to March was selected because we assumed that changes in health conditions caused by environmental changes would be most common during the period from winter to spring (specifically January to March). The results of this study demonstrated that changes in body conditions were associated with environmental changes. However, as described above, health conditions and climatic changes have time trends. Thus, a survey should be conducted throughout the year in different seasons and months. In the future, we hope to expand the survey area and study period. In addition, given that sunlight exposure may have an impact on the human body not only on the day of exposure, but three to six days later (Moller et al. 2002), it may be necessary to perform a more detailed analysis using lag times to investigate the correlation of sunlight with physical condition.

Conclusions

The WDQH enabled monitoring of changes in physical condition on a real-time basis by daily collection of data. Changes in the daily physical condition of the

general population were found to be correlated with changes in certain environmental factors. In particular, it was revealed that the following factors in winter/spring were associated with physical condition: fever, cough, diarrhoea, vomiting and rash decreased with age. Others decreased as household income increased. An increase in minimum temperature was associated with a reduction in fever and rash; an increase in hours of sunlight was associated with a reduction in fever, and vomiting; holidays were associated with better physical condition and less coughing and others, while rash increased.

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References

Belloc NB, Breslow L, Hochstim JR. 1970. Measurement of physical health in a general population survey. Am J Epidemiol. 93(5):328–336.

Bennett RM, Jones J, Turk DC, Russell IJ, Matallana. 2007. An internet survey of 2,596 people with fibromyalgia. BMC Musculoskelet Disord. 8:27.

Butler JM, Whalen CK, Jamner LD. 2009. Bummed out now, feeling sick later: weekday versus weekend negative affect and physical symptom reports in high school freshmen. J Adolesc Health. 44(5):452–457.

Ekman A, Dickman PW, Klint A, Weiderpass E, Litton JE. 2006. Feasibility of using web-based questionnaires in large population-based epidemiological studies. Eur J Epidemiol. 21(2):103–111.

Ekman A, Litton JE. 2007. New times, new needs; e-epidemiology. Eur J Epidemiol. 22(5):285–292.

Heikkinen T, Jarvinen A. 2003. The common cold. Lancet. 361(9351):51–59.

Hu W, Mengersen K, McMichael A, Tong S. 2008. Temperature, air pollution and total mortality during summers in Sydney, 1994–2004. Int J Biometeorol. 52(7):689–696.

Huang W, Tan J, Kan H, Zhao N, Song W, Song G, Chen G, Jiang L, Jiang C, Chen R, et al. 2009. Visibility, air quality and daily mortality in Shanghai, China. Sci Total Environ. 407(10):3295–3300.

Lambert GW, Reid C, Kaye DM, Jennings GL, Esler MD. 2002. Effect of sunlight and season on serotonin turnover in the brain. Lancet. 360(9348):1840–1842.

McMichael AJ, Woodruff RE, Hales S. 2006. Climate change and human health: present and future risks. Lancet. 367(9513):859–869.

Moller P, Wallin H, Holst E, Knudsen LE. 2002. Sunlight-induced DNA damage in human mononuclear cells. FASEB J. 16(1):45–53.

Nastos PT, Matzarakis A. 2006. Weather impacts on respiratory infections in Athens, Greece. Int J Biometerol. 50: 358–369.

Nastos PT, Matzarakis A. 2011. The effect of air temperature and human thermal indices on mortality in Athens, Greece. Theor Appl Climatol. 108(3–4):591–599.

Nastos PT, Paliatsos AG, Papadopoulos M, Bakoula C, Priftis KN. 2008. The effect of weather variability on pediatric asthma admissions in Athens, Greece. J Asthma. 45: 59–56.

Nitta H, Yamazaki S, Omoro T, Sato T. 2010. An introduction to epidemiologic and statistical methods useful in environmental epidemiology. J Epidemiol. 20(3):177–184.

Norval M, Cullen AP, de Gruijl FR, Longstreth J, Takizawa Y, Lucas RM, Noonan FP, van der Leun JC. 2007. The effects on human health from stratospheric ozone depletion and its interactions with climate change. Photochem Photobiol Sci. 6(3):232–251.

Pantavou K, Theoharatos G, Nikolopoulos G, Katavoutas G, Asimakopolos D. 2008. Evaluation of thermal discomfort in Athens territory and its effect on the daily number of recorded patients at hospitals' emergency rooms. Int J Biometeorol. 52(8):773–778.

Schmidt MV, Sterlemann V, Muller MB. 2008. Chronic stress and individual vulnerability. Ann N Y Acad Sci. 1148:174–183.

Srinivasan AK, Freyle J, Gitlin JS, Palmer LS. 2007. Climatic conditions and the risk of testicular torsion in adolescent males. J Urol. 178(6):2585–2588; discussion 2588.

Sugiura H, Ohkusa Y, Akahane M, Sugahara T, Okabe N, Imamura T. 2010. Construction of syndromic surveillance using a web-based daily questionnaire for health and its application at the G8 Hokkaido Toyako Summit meeting. Epidemiol Infect. 138(10): 1493–1502.

Tanaka M. 1998. Tendency of seasonal disease in Japan. Global Environ Res. 2:169–176.

Termorshuizen F, Feltkamp MC, Struijk L, de Gruijl FR, Bavinck JN, van Loveren H. 2004. Sunlight exposure and (sero)prevalence of epidermodysplasia verruciformis-associated human papillomavirus. J Invest Dermatol. 122(6):1456–1462.

Vocks E, Busch R, Frohlich C, Borelli S, Mayer H, Ring J. 2001. Influence of weather and climate on subjective symptom intensity in atopic eczema. Int J Biometeorol. 45(1):27–33.

第12回集会から

■セッションI

食品防御から見たバイオリスク認知・バイオリスク評価・バイオリスクマネジメントの考え方と食品バイオテロに対する食品防御による対応

今村 知明
奈良県立医科大学健康政策医学講座

はじめに

人類の食、それは常に危険と隣り合わせの歴史の上に現在の安全が成り立っている。現在我々が口に入れているもの全てがハザードと言っても過言ではない。しかし、ハザードによる悪影響とそのハザードとなり得る可能性、つまりリスクの大きさは、毒性の強さと摂取する量により変わる。

それらは、人類の長年の経験で自然に身についてきた知識となり食の安全が保たれるようになった。しかし、近年、ライフスタイルの多様化と共に、日常生活で占めるウェイトの高い食生活も多様化を極め、食に関する問題は多岐に渡るようになった。

中でも、9.11世界同時多発テロ事件とほぼ時を同じくして起こった炭疽菌事件を機にバイオテロが注目され、そのターゲットになりやすい食品へのテロ対策の重要性が高まってきた。日本でも、毒入り餃子事件などで意図的な食品汚染に関する具体的対策が急務となった。

そこで、食品防御から見たバイオリスク認知・バイオリスク評価・バイオリスクマネジメントの考え方と食品バイオテロに対する食品防御による対応について述べる。

食品安全とは

食品の安全とはどのように考えるべきだろうか。

夏場日中に常温で放置した刺身は、もはや「食べ物」ではなく、むしろ、食中毒により命を落とす危険が生じた「毒物」である。この変化は容易く起こるものであり、この変化こそが食べ物の本質である。容易く「毒物」に変化してしまうものを普段食べているという認識が大切なのだ。食品添加物などを恐れるのは、次のステップである。

冒頭でも述べたように、そもそも食品とは危険でリスクのあるものである。ジャガイモの青芽は毒性のアルカロイドを含み、メークインを数日間日光に当てて緑色になった部分や青芽だけを集めたら、成人中毒量（200mg）を超えることもある。また、コーヒーに含まれる一般的なカフェインの量を食品添加物として使用すると、食品添加物の基準から見て、流通が認められることはないと考えられる。では、なぜそんな危険なものを口にしているのか。それは、多数の人間が長期にわたり実際に食べて大丈夫であったことが、その食品を食べることの安全性を示していると言える。そうして、現在はジャガイモもコーヒーも危険という認識を持たずに安心して口にすることができている。

では、新たに発見された食品の毒性について食の安全は保たれているだろうか。これには、リスクに対する過剰反応が伴い、安全という認識がしばしば置き去りにされている。2000年代初頭に発生したBSE問題を例に取ると、我が国におけるBSE問題によるvCJDの患者数は英国の滞在歴のある者1名であるにもかかわらず、この問題による関係者の自殺者数は酪農家など5名にものぼる。これはリスコミュニケーションがうまくいっていない事が大きな原因だと思われ、いかに正しい情報を過剰反応せずに理解するか、が食品の安全につながると言える。また、残留農薬などの食の安全性に関する諸問題も発生したが、いずれも、消費者等における不明確なリスクや不可視なリスクに対する実際のリスク以上の反応、という問題が伴い、本来の食品の安全に対しての正しい評価が難しくなるのである。

しかし、2008年の冷凍ギョーザ事件では、残留農薬等の食の安全性にかかわる一般的な問題ではなく、食品を犯罪やテロからいかに防ぐかという食品防御に係る問題が新たに俎上に上り、リスク回避と危機管理体制の構築の必要性に迫られた[1]。

食品防御でのリスクの認知とバイオリスクの認知

それ以前から、2001年9.11テロ後の炭疽菌事件など世界各国でのバイオテロの危険性が指摘されていた。そして、そのターゲットとして食品のリスクは非常に高いものと考えられた。特に、米国では食品産業の危険性を認識し積極的な対策措置が講じられるようになった。しかし、テロ対策にはグローバルな各国の協調が不可欠である。それに加え、前述の冷凍ギョーザ事件が発生するなど、我が国でも食品防御の対策の検討が必要となった。

従来の食品安全に対する信頼を脅かす事例が発生し、意図的な食品汚染に対して脆弱な製造現場が明らかになってきた。

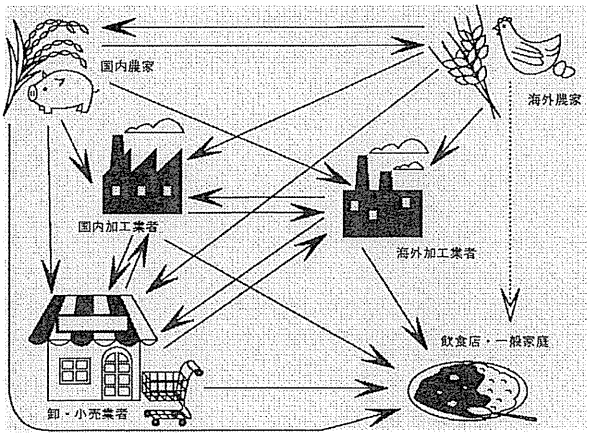
食品工場への聞き取りによると、

○意図的な食品汚染への備え（“管理部門や責任者の設置”、“計画・手続きの策定”、“評価の実施”）を行っている工場はほとんどない

○工場内に監視カメラはあるものの、従業員の作業状況をチェックする目的のものではない（⇒そもそも、従業員の心理面を考慮すると、従業員の作業状況をチェックするためのカメラ設置は現実的ではない）

等、特に、食品テロのように「悪意」をもって食品に毒物が混入されるような場合には、極めて弱いのである。

食品の流通経路は一般に「フードチェーン」と呼ばれている。この複雑なチェーンのどの部分が汚染された場合でも、多方面に大きな被害が生じる。そして、今、食品の流通はグローバル化が進み、流通経路も複雑になり汚染物質の持ち込みはますます防ぎにくくなっているのである[2]。



食品防御でのリスク評価とバイオリスク評価

では、食品防御におけるリスク評価、バイオリスク評価はいかに行うべきか。

それには、食品防御の脆弱性をチェックする方法が挙げられる。つまり、「何を用いてテロを行うか」と、「効率よく効果的に攻撃できるのはどこか」を考えることが重要となる。

アメリカの食品医薬品局（FDA）と農務省（USDA）では、米軍で開発された「CARVER+Shock法」という攻撃に対する弱点を洗い出す手法を、テロ攻撃対象箇所の優先順位付けのツールとして採用している[3-5]。このツールで、食品テロに対するシステムやインフラの脆弱性を評価し、それによって対策を講ずるべき箇所を把握できるので効率的な対策が可能となる。これはフードチェーン全体から個々の施設やプロセスまで、様々な範囲の評価に適用できる。

C	Criticality (消費者への)危険性:	テロによる公衆衛生および経済的影響の度合い ⇒死者数、および経済的損失額によって定量評価
A	Accessibility アクセス容易性:	テロ対象への物理的なアクセスの容易性
R	Recuperability 回復容易性:	テロ後のシステムの回復容易性
V	Vulnerability 脆弱性:	テロの遂行容易性
E	Effect (自社への)影響:	テロによる直接的損失規模(生産量の損失等)
R	Recognizability 認識容易性:	テロ実行における攻撃対象の認識の容易さ
+Shock 衝撃度:		テロにより波及する健康・経済・心理的影響

得点の定量的評価基準の例 Criticality
9-10 :死者1万人以上、または損失10兆円以上
7-8 :死者1,000人～1万人、または損失1兆～10兆円
5-6 :死者100人～1,000人、または損失1,000億～1兆円
3-4 :死者100人未満、または損失1,000億未満
1-2 :死者発生なし、または損失100億円未満

評価を実施するためには、各分野の専門家から構成されたチームを組織化して臨まなければならない。評価対象のフードサプライチェーンを最小の要素（工程）にまで細分化し構造を図示する。各工程に対して7つの評価項目に関する得点付けを行い(1～10点)、総合得点の高い工程は脆弱性が高いと判断する。各工程の総合得点を比較することで、脆弱な工程を明確化することが可能である。この評価をもとに、テロ対象としての魅力度を下げる対策の実施計画を策定することができる[6]。

食品への混入が想定される生物剤・化学剤の要件を下記にまとめる。

生物剤

要件	概要	生物剤の特性上留意すべき点等
致死性	①消費者がターゲット ②企業の信用失墜 ③広く社会的混乱を狙う のそれぞれにより致死性の高さの要件は異なる。	△一般的な食中毒の原因菌:影響小。 △腸管系病原菌(赤痢・コレラ・チフス):治療法が確立しているため影響小、広まりにくい。
潜伏期間	・対象に依存 ・フードチェーンの段階に依存	? 生産側への投入／消費者への暴露など、対象に依存 ? 生産・流通・加工・販売などの段階に依存
入手容易性	・入手が容易	○入手・生成しやすいものもしくは一般的な条件下で増殖しやすいもの
可搬性	・取扱い・持ち運びが容易	○取扱いに高度な装置・技術を必要としないもの
安定性	・諸条件下で安定	○毒素:熱に強く効果が高い。 △萌芽:熱に強いが、増殖には一定条件が必要 ×嫌気性病原菌等:酸素の存在下で減少・死滅
実行犯の安全性	・実行犯に被害が及びにくい	−
特定困難性	・容易に特定されない	○検知に時間を要するand/or検知困難なもの

化学剤

要件	概要	化学物質の特性上留意すべき点等
致死性	・致死性が高い (毒性が強い)	○食品によっては生産・加工段階で希釈されるものがあるため、少量で高い毒性を持つもの (LD50値が低いもの)
潜伏期間	—	—
入手容易性	・入手が容易	○入手・製造が容易であるもの
可搬性	・取扱い・持ち運びが容易	○取扱いに高度な装置・技術を必要としないもの
安定性	・諸条件下で安定、食品に混入された状態が保てる	○揮発性物質ではないもの(水に溶解するもの)
実行犯の安全性	・実行犯に被害が及びにくい	○特に、揮発性でないもの
特定困難性	・容易に特定されない	○特に、無色・無臭であるもの ○検知に時間を要するand/or検知困難なもの

ここでCARVER+Shock法を参考として、我が国において脆弱性評価を試行し、その有効性を検証した例を紹介しよう。

食品	対象とした理由
牛乳	先進的な衛生管理の下で製造されてはいるが実際に食中毒の発生事例がある
お弁当	製造工程において多くの人の手に触れる可能性がある
納豆	日本特有の食品であり、またその大部分が小規模の工場で製造されている
給食	子どもに被害が発生する可能性が高い
清涼飲料	
プロセスチーズ	
冷凍食品	実際に被害が発生した
ドレッシング	米国でドレッシング汚染事例あり
冷凍・冷蔵食品取り扱い倉庫	製造工程以外の結節点における検討の必要性
ドライ品取り扱い倉庫	

上に挙げた牛乳について牛乳工場を総括評価した例を示す。ただし、この例により脆弱ポイントが明らかになる危険性があるのでその部分は＊等によって伏せておく。

ポイント		混入の可能性	相対評価
○○○○		・＊＊＊＊＊であり、誰でも容易に近づくことができる状態にあった。また、＊＊は施錠がされていない状態であった。 ・＊＊＊＊＊であれば人的被害を及ぼすのに十分な物質を投入可能と考えられる。 ・＊＊＊＊＊ており、非専門家でも攻撃対象の認識が容易である。 ・以上の理由から、＊＊＊＊＊から攻撃を受ける可能性が相対的に高いポイントであると言うことができる。	脆弱性が高い
殺菌	清浄化 均質化 殺菌 冷却・貯乳(昼上)	・＊＊＊＊＊のため、外部からのアクセスは困難であると考えられる。 ・また、＊＊＊＊＊のシステムとなっており、一度に大量の物質の投入は困難であると考えられる。 ・但し、＊＊＊＊＊で作業を行ない、＊＊＊＊＊により製造中の牛乳に(一応は)触れることができる。加えて、＊＊＊＊＊も無く、日常的に＊＊＊＊＊を行なっているなど、ラインに手を触れる光景がそれほど特異なものと映らない。 ・以上より、攻撃は困難であるが、内部犯行の可能性には留意する必要があると考えられる。	脆弱性は低いが、施設・機器を熟知した内部犯行の可能性には留意する必要がある
検査 充填 冷蔵保管		・短期間での大量投入が困難であり、攻撃の危険性は比較的低いと考えられる。	脆弱性は低い
出荷		・常時＊＊＊＊＊多くの人が係っており、その中にまぎれて犯行を遂行することも考えられる。 ・また、＊＊＊＊を装えば外部からアクセスすることも容易であり、攻撃対象の認識性も高い。 ・一方で、出荷時には既に小分けされた状態になっており、一度に大量の物質を投入することは困難である。 ・また、商品(攻撃対象年代)、配送先などまで認識することが可能であるという特徴がある点には留意が必要である。 ・以上より、攻撃は比較的容易であるが、甚大な被害を及ぼすような攻撃の危険性は比較的低いと考えられる。但し、グリコ・森永事件のように、少しの攻撃が、企業の経営に多大な経済被害を及ぼす可能性については留意するべきである。	脆弱性は中程度であるが、甚大な被害発生の可能性は低い
全般		・外部メーカー(顔見知りではない場合も多い)の立寄りが多いにもかかわらず、場合によっては＊＊＊＊＊をさせることもあるということであった。攻撃対象へのアクセシビリティの観点から大きな問題であり、何らかの改善が求められる。 ・また、従業員の＊＊＊＊＊、＊＊＊＊＊の詳細な把握が行なわれていないため、内部犯行の可能性にも留意すべきである。	

他の食品についても総括評価を行った試行結果により、下記のセキュリティ強化の必要性が明らかになった。

○人為的な異物混入等に対する食品工場のセキュリティ対策の実施状況は、かなり低いレベルにある。

○特に、上記セキュリティ対策の基本である、現場におけるテロもしくは犯罪行為に対する危険性の認識は、極めて低いものであった。

○これらは、食品製造業における、従業員間・労使間の信頼関係をベースにした運営に起因していると推察される。今後テロや犯罪への対策を講じる際には、この運営を「悪意の既存」的なものにシフトしていく必要がある。

このような運営により、テロや犯罪に対するセキュリティ水準のみならず、食品衛生の管理水準も向上することが期待できる。

しかし実際にこの方法を取り入れるには、食品企業でも多くの労力が必要である。各企業の人的要因や経済的な負担を考慮すると、中小零細規模の食品工場が取り組む課題としては困難であると考えられる。そのため、日本の実情に応じた脆弱性評価手法の開発が必要となった。

食品防御でのリスクマネジメントとバイオリスクマネジメント

そこで、食品関連施設の現場において、脆弱性を比較的簡単に評価できる手法で日本の実情に合ったものが有用であると考え、まず、「食品工場における人為的な食品汚染防止に関するチェックリスト」を作成した(※1)。

※1 平成18～20年度厚生労働科学研究費補助金（食品の安心・安全確保推進研究事業）「食品によるバイオテロの危険性に関する研究」（研究代表者：今村知明）研究班による(7)。

その構成は、1.組織マネジメントについて、2.従業員の管理について、3.部外者の管理について、4.施設の管理について、5.運営の管理について、の5分野計94項目である。

さらに、食品防御は製造過程だけでなく商品が手元に届くまでの物流の過程でも必要であることから、食品工場版のチェックリストにTAPA-FSR(※2)を参考にした物流施設における視点を補足して、「物流施設版チェックリスト」を上記同様5分野で計98項目を作成した。

※2 TAPA（Transported Asset Protection

Association）1997年設立、米国の非営利団体による、資産セキュリティに関する要求事項（Freight Security Requirements）

チェックリストは下記よりダウンロードが可能である。

「食品工場における人為的な食品汚染防止に関するチェックリスト」について
http://www.naramed-u.ac.jp/~hpm/pdf/ff_checklist/ff_checklist_h22ver.pdf

「食品に係る物流施設における人為的な食品汚染防止に関するチェックリスト」について
http://www.naramed-u.ac.jp/~hpm/pdf/df_checklist/df_checklist_h22ver.pdf

そしてこれらチェックリストをベースに食品防御ガイドライン（案）の策定を行った(※3)。

※3 平成21～23年度厚生労働科学研究費補助金（食品の安全確保推進研究事業）「食品防御の具体的な対策の確立と実行可能性の検証に関する研究」（研究代表者：今村知明）研究班による(8)。

ガイドラインは、本来であれば米国のように、人為的な食品汚染の危険性が関係者全般に広く認知された状況下で、各工場における防御対策実施の要件として公表されることが望ましい。しかし、わが国は未だ米国のような状況にない。そこで、より多くの食品関係事業者が人為的な食品汚染の危険性に関心を持ち、現実的に可能な対策を検討することができるように、2つの推奨レベルに分けて作成した。その構成「1. 優先的に実施すべき対策」と、「2. 可能な範囲での実施が望まれる対策」について解説する(9)。

1 優先的に実施すべき対策

■ 組織マネジメント

①食品工場の責任者は、日ごろから全ての従業員等(*)が働きやすい職場環境の醸成に努める。これにより、従業員等が自社及び自社製品への愛着を高め、自社製品の安全確保について高い責任感を感じながら働くことができるような職場づくりを行う。

(*) 派遣社員、連続した期間工場内で業務を行う委託業者などについても、同様の扱いが望まれる。

②食品工場の責任者は、自社製品に意図的な汚染が疑われる事態が発生した場合、消費者や一般社会から、その原因としてまず内部の従業員等に対して疑いの目が向けられる可能性が高いことを、従業員等に意識付けておく。

③自社製品に意図的な汚染が疑われる事態が発生した場合において、その原因、経過等について迅速に把握、情報公開ができるよう、普段から従業員の勤務状況、業務内容について正確に把握しておく。

④製品の異常を早い段階で探知するため苦情や健康危害情報等を日常的に確認するとともに、万一、意図的な食品汚染が発生した際に迅速に対処できるよう、意図的な食品汚染が疑われる場合の社内外への報告、製品の回収、保管、廃棄等の手続きを定めておく。

■ 人的要素（従業員等(**)）

(**) 派遣社員、連続した期間工場内で業務を行う委託業者などについても、同様の扱いが望まれる。可能であれば、“食品防御に対する留意”に関する内容を、契約条件に盛り込む。

①従業員等の採用面接時において、可能な範囲で身元確認を行う。例えば、身分証、各種証明書