FOOD SAFETY

doi: 10.14252/foodsafetyfscj.2014034

Original article

Development of a Tool for Evaluating the Risk of Health Damage by Meat-borne Parasite Infection

Hiroshi Yamasaki[1*], Kyoko Arakawa[1], Takeo Ohashi[2], Kenji Yagita[1], Yasuyuki Morishima[1], Hiromu Sugiyama[1], Kisaburo Nagamune[1], Michiru Kakinuma[2], Yuko Osada[3], Daihi Oushiki[3], Atsushi Hasegawa[4]

[1] Department of Parasitology, National Institute of Infectious Diseases, 1-23-1 Toyama, Shinjuku-ku, Tokyo 162-8640, Japan
[2] Human-Life Research Division, Mitsubishi Research Institute Inc., 2-10-3 Nagatacho, Chiyoda-ku, Tokyo 100-8141, Japan
[3] MRI Research Associates Inc., 1-13-1 Uchikanda, Chiyoda-ku, Tokyo 101-0047, Japan
[4] Platinum Society Center, Mitsubishi Research Institute Inc., 2-10-3 Nagatacho, Chiyoda-ku, Tokyo 100-8141, Japan

In this study, we developed a semi-quantitative risk mapping tool to assess the risk of damage to human health resulting from infection by meat-borne parasites. The developed method is based on the R-Map methodology, which is widely used in industrial settings to assess hazards in Japan. The risk of damage to health due to parasite infection was determined by two main criteria: the annual number of patients and the extent of damage to health. The former criterion was subdivided into four categories and the latter was evaluated based on severity of illness and period required to obtain a cure (hereafter, period to cure). The four categories for extent of damage to health were calculated by multiplying the scores assigned for severity of illness by the period to cure. Each parasite could then be mapped to this 4 × 4 matrix depending on the annual number of patients and the extent of damage to health. Three risk-level zones were then superimposed on the matrix to determine the priority of implementing risk management measures. In this way, the risk to human health associated with each parasite and the priority associated with implementing control measures could be visualized. *Toxoplasma gondii* infection in human immunodeficiency virus-infected patients and newborn babies was mapped to the unacceptable risk zone due to the severity of the disease in these patients. Emerging parasites, such as *Sarcocystis fayeri*, *Kudoa septempunctata* and *Taenia asiatica*, were mapped to the zone in which the risk of parasitic infections should be reduced by implementing urgent control measures, since doing so would prevent any further increase in infections. The risk assessment tool developed in this study can be employed to evaluate previous and potential risks of parasite infection and is useful for assessing the efficacy of risk control measures.

Key words: meat-borne parasites, damage to human health, risk assessment, risk mapping method

Received: 2 October 2014; Accepted: 10 November 2014; Published online: 25 December 2014
*Corresponding author: Hiroshi Yamasaki; Department of Parasitology, National Institute of Infectious Diseases, 1-23-1 Toyama, Shinjuku-ku, Tokyo 162-8640, Japan; Tel: +81 3 4582 2692; Fax: +81 3 5285 1173; E-mail: hyamasak@niid.go.jp
The contents of this article reflect solely the view of the author(s).
The authors declare that no competing interests exist.

1. Introduction

Food-borne diseases can arise from the consumption of food that has been contaminated by pathogenic microbes and parasites, and by chemical substances or natural toxins. In Japan, the "Ordinance for Enforcement of the Food Sanitation Act," which is based on the Food Sanitation Law, stipulates that food-borne parasitic diseases should be treated the same as food poisoning.

The eating habits of Japanese people have become increasingly diversified as their lifestyles have changed, with more processed and ready-to-eat foods being consumed in recent years. In addition to traditional foods, the importation of both exotic food and food cultures from foreign countries has also had a marked impact on their lifestyle. These changes have affected food poisoning patterns by increasing the frequency of incidents and the number of patients and fatalities[1)]. Indeed, food poisoning attributed to emerging parasites[2,3)], i.e., parasites that previously did not occur in Japan, is becoming an increasingly important issue in the area of food sanitation and public health.

Meat products that are distributed and consumed in Japan are derived from livestock (cattle, pig, horse, sheep, and goat) and game animals (wild boar, deer, bear etc.). In the case of meat products from livestock, inspections of animals that have been sent to slaughter are routinely performed in abattoirs and meat inspection centers, as this is prescribed by the Slaughterhouse Act. By conducting these inspections, data on contamination by parasites can be estimated. However, since the act does not extend to game meat, very little information is currently available on the contamination of game meat products by parasites.

It is therefore necessary to implement effective risk assessment methods to carefully manage the risk associated with meat-borne parasitic infections. In Japan, a risk assessment methodology for zoonotic diseases including parasites has already been reported[4)]. In that study, the risk associated with approximately 100 zoonotic diseases was quantified using a hierarchical analytical process that ranked each disease and assigned a risk factor. The results revealed that the majority of the 30 parasitic diseases examined had low risk scores, which made it difficult to prioritize the risks associated with a particular parasitic disease. However, the reason for the low scores was because the assessment items were biased toward human-to-human transmission. Consequently, parasitic diseases were assigned a relatively low-risk status if there was no human-to-human transmission and/or if transmissibility was low, unlike bacterial and viral infections which would score highly, since they are typically spread by human-to-human transmission.

Outside of Japan, risk-assessment studies on parasite infections have been performed for *Cryptosporidium parvum*[5–7)], *Giardia intestinalis* (syn. *G. lamblia*)[7)], *Toxoplasma gondii*[8,9)], *Anisakis* spp.[10)], *Trichinella spiralis*[11,12)], *Taenia solium* cysticercus[13)], and *Taenia saginata*[14)]. In these studies, most of the risk assessments employed quantitative approaches, such as probabilistic analysis using Monte Carlo modeling[5,14)], hazard impact analysis[6,7,9)], scoring risks[8)], risk profiling[10,11,13)], and exposure assessment[12)].

The present study aimed to develop a risk assessment tool for assessing the potential damage to human health resulting from infection by meat-borne parasites based on currently available epidemiological and enzootic information in Japan, and to prioritize the identification of parasitic diseases for which control measures should be implemented.

2. Materials and Methods

2-1. Profiling of Meat-borne Parasites Targeted for Risk Assessment

A total of 14 parasites, including two protozoa, myxozoa, and 11 helminths associated with meat and fish, were selected for this assessment (**Table 1**). **Table 1** also shows the sources of infection for each parasite. Two fish-borne parasites, *Kudoa septempunctata* and *Anisakis* spp., were included for comparing the risk associated with infection to the risk associated with meat-borne parasites. The data on livestock meat contaminated with any of these parasites were obtained from meat inspection statistics provided by the Ministry of Health, Labour and Welfare (MHLW), Japan[15)]. The annual number of patients infected with these 14 parasites was estimated based on 1) Food Poisoning Statistics from the MHLW[1)], 2) a literature search of material held by the Japan Medical Abstracts Society, 3) PubMed, 4) annual reports of the National Institute of Infectious Diseases (2007 to 2013)[16)], and 5) medical insurance data from the Japan Medical Data Center[17)]. To select the most suitable assessment items for estimating the risk of damage to human health due to infection by the target parasites, each parasite was profiled by considering the following items: annual number of food poisoning cases, annual number of patients, clinical symptoms, severity of illness, presence or absence of treatment and

Table 1. Parasites and sources of infection considered for the risk mapping method.

Parasite	Food product as source of infection
Protozoa	
Sarcocystis fayeri	Horse meat
Toxoplasma gondii	Pork, beef, mutton, goat meat
Myxozoa	
Kudoa septempunctata	Flounder
Helminths	
Toxocara canis and *Toxocara cati*	Beef liver, free-range chicken liver
Trichinella spp.	Bear meat
Anisakis spp.	Mackerel, squid, Pacific saury (=samma in Japanese)
Paragonimus westermani	Wild boar meat, Japanese mitten crab, Japanese freshwater crab
Paragonimus miyazakii	Japanese freshwater crab
Fasciola spp.	Beef liver
Taenia asiatica	Pork liver
Taenia saginata	Beef
Taenia solium (adult)	Pork
Taenia solium (larval cysticercus)	Food and drinking water contaminated with *T. solium* eggs
Spirometra erinaceieuropaei	Snakes, frogs, free-range chicken

preventive methods, high-risk groups, presence or absence of secondary infection, seasonality, regionality, and current estimates of the proportion of meat products contaminated by parasites in Japan.

2-2. Selection of Risk Assessment Method

The profiling procedure revealed that it was difficult to employ quantitative risk assessment methods. The reasons for this were that the incidence of human cases infected by the target parasites was generally low, and epidemiological and enzootic information on meat-borne parasites was difficult to obtain. The R-Map risk assessment tool, which was originally developed to quantitatively assess the hazards associated with industrial products, is widely used in Japan[18]. Briefly, the R-Map method involves mapping the “frequency of occurrence” and “extent of damage” on a two-dimensional matrix (6 × 5) to visualize the associated risk and to evaluate the appropriate level of risk management.

In the present study, we developed a semi-quantitative method for evaluating risks associated with parasitic infections based on the R-Map methodology; this method was referred to as a risk mapping method.

2-3. Development of the Risk Mapping Method

Prior to developing the risk mapping method, two assessment items—annual number of patients and extent of damage to health—were selected to evaluate the risk of damage to health from the items used for initial profiling. The first item, annual number of patients, was subdivided into four categories (<10, 10 to 99, 100 to 999 and ≥1,000 cases) according to the number of reported cases per year. The second item, extent of damage to health, was evaluated based on the severity of illness and the period required to obtain a cure (hereafter referred to as period to cure). The severity of illness was also subdivided into four categories according to the Disability Weights (DW) defined by WHO[19] (**Table 2**), with each subcategory assigned a score of 1 to 4 in order of increasing severity (**Table 3**). The period to cure was subdivided into three categories: short (<1 month), medium (1 to <3 months) and long (≥3 months), with each category assigned a score of 1 to 3, respectively (**Table 3**). In this way, a total score representing the extent of damage to health could be

Table 2. Main symptoms associated with parasitic diseases and their severities.

	Severity[19]			
	Slight*	Mild**	Moderate***	Severe****
Symptoms	Diarrhea	Liver abscess	Bloody sputum	Meningitis
	Bloody stool	Jaundice	Pneumothorax	Blindness
	Abdominal pain	Hepatomegaly	Pleural effusion	
	Cough	Liver hypertrophy	Epileptic attacks	
	Anemia	Gastrointestinal disorder	Pernicious anemia	
	Wandering mass	Ileus	Ascites	
	Myalgia	Dizziness/vertigo		
	Creeping disease	Lymphangitis		
	Pyrexia	Central nervous system manifestations		
	Rash			
	Lymphadenitis			

* Disability Weights (DW)<0.03, ** 0.03≤DW <0.1,*** 0.1≤DW <0.3, **** DW ≥0.3

Table 3. Assessment items for evaluating the extent of damage to health.

Items	Assessment	Score	Definition
Severity of illness	Slight	1	See **Table 2**.
	Mild	2	
	Moderate	3	
	Severe	4	
Period to cure	Short	1	<1 month. Patient recovers to original condition relatively soon after treatment.
	Medium	2	1 month to <3 months. Recovery (including complications) takes long but does occur.
	Long	3	≥3 months. Disease often becomes chronic and results in permanent impairment.

expressed by multiplying the scores assigned for severity of illness by the period to cure (**Table 4**). Any potentially lethal parasites were assigned a score of 12, because death was considered to be the most severe form of health damage. Similarly, emerging parasites, such as *Sarcocystis fayeri, K. septempunctata* and *Taenia asiatica,* which have become increasingly prevalent in recent years, were also assigned a score of 12, despite only having a severity of illness score of 1. The reason emerging parasites were assigned such high scores was because urgent control measures and management initiatives need to be implemented to prevent further infection by these parasites (**Table 5**). Total scores of 1 to 3, 4 and 6, 8 and 9, and 12 were assigned as very low, low, moderate, and high, respectively. Consequently, a risk map, which consisted of a 4 × 4 matrix based on the annual number of patients on the vertical axis and the extent of damage to health on the horizontal axis, was compiled. The risk associated with target parasites was assessed based upon profiled data from 2000 to 2013 and the risk was then compared with that for the period from 1960s to 1980s.

Table 4. Scores representing extent of damage to health.

		Severity of illness			
		Slight (1)	Mild (2)	Moderate (3)	Severe (4)
Period to cure	Short (1)	1	2	3	4
	Medium (2)	2	4	6	8
	Long (3)	3	6	9	12

Scores 1-3 (very low), 4 and 6 (low), 8 and 9 (moderate) and 12 (high). Numbers in the parenthesis indicate scores assigned for each subcategory of severity of illness and period to cure.

3. Results and Discussion

3-1. Risk Assessment of 14 parasites Based on Data for the Period 2000 to 2013.

Fig. 1 shows 14 parasites mapped to a matrix to visualize the risk of health damage associated with parasite infection. Due to differences in susceptibility to infection, *T. gondii* was mapped to different positions in human immunodeficiency virus (HIV)-infected patients and newborn babies, and healthy adults. *Toxocara canis* and *Toxocara cati*, and *Spirometra erinaceieuropaei* were also mapped to different positions in the matrix due to differences in severity associated with the site infected by the parasite.

The R-Map method, in which a 6 × 5 matrix is divided into 3 risk level zones for purposes of risk management[18], is the risk mapping method developed in this study; it employed three risk zones to determine the need for risk management measures: i) unacceptable risk, ii) risk that should be reduced, and iii) socially acceptable risk. Thus, *T. gondii* infections in HIV-patients and congenital neonates were mapped to the unacceptable risk zone due to the high severity of the illness and absence of an effective therapy, indicating the highest priority for risk management and urgent need to implement control measures. Emerging parasites, such as *S. fayeri*, *K. septempunctata* and *T. asiatica*, were mapped to the zone in which a risk should be reduced. The reason urgent control measures need to be implemented against emerging diseases is to promote the establishment of diagnostic methods and methods for preventing the expansion of infection. *Toxoplasma gondii* infection in adults, *Anisakis* spp., and *T. canis* and *T. cati* infections were mapped to the zone in which the risk should be reduced due to the moderate severity of illness associated with infection by these parasites. Other parasites were mapped to the socially acceptable risk zone because of the very low severity or mild nature of the symptoms and the presence of effective therapy. This risk mapping method facilitates risk assessments by visually representing the annual number of patients and the extent of damage to health in two dimensions.

3-2. Application of the Risk Mapping Method

The risk mapping method developed in this study was used to compare the risk of parasite infection for the period from 1960s to 1980s (**Fig. 2**). During this period, parasites such as *T. solium* (larval cysticercus), *T. canis* and *T. cati,* and *S. erinaceieuropaei* were mapped to the zone in which the risk should be reduced (**Fig. 2**). However, these parasites would now be reassigned to the socially acceptable zone (**Fig. 1**). Although it is possible to estimate which factors were likely to be effective in reducing the risk of parasite infections[20], doing so with absolute certainty is difficult. It is generally considered that the adoption of national control measures combined with improved sanitation conditions[21]. In particular the abolishment of latrine facilities adjoined to pigsties was very effective for reducing *T. solium* infection[22]. Further, advances in diagnostic and therapeutic methods have also contributed to a reduction in the severity of illness caused by parasite infections[23,24]. On the other hand, a preference among Japanese people for eating raw and undercooked meat has contributed to an increase the risk of the emerging parasites such as *S. fayeri*[2], *K. septempunctata*[2] and *T. asiatica*[3].

Thus, the risk mapping method described here is considered to be a useful tool, not only for assessing extant parasite infection risks, but also for assessing previous or potential risks, both of which have been affected by changes in the international food trade, diversification of food cultures, and advances in medical technologies and control measures.

In addition, while the present study focused on risk assessment within the context of damage to personal health due to infection by meat-borne parasites, the developed method could also be used to assess the risk of epidemics, as well

Table 5. Results of risk assessment for 14 parasitic diseases.

No.	Parasites	Annual number of patients	Extent of health damage								
			(A)			(B)		(C)	(D)	Score (A x B)	Risk assessment
			Main symptoms	Severity of illness	Score (A)	Period to cure	Score (B)	Any deaths in past 10 years	Any occurrence in the last 2–3 years		
1	*Sarcocystis fayeri**	10–99	Diarrhea	Slight	1	Short	1	None	Yes	12	High
2-H	*Toxoplasma gondii*	100–999	Encephalitis	Severe	4	Long	3	Unknown	Yes	12	High
2	*T. gondii*	≥1,000	Lymphadenitis	Slight	1	Short	1	None	Yes	1	Very low
3	*Kudoa septempunctata**	100–999	Diarrhea	Slight	1	Short	1	None	Yes	12	High
4-H	*Toxocara canis* and *T. cati*	<10	Blindness	Severe	4	Long	3	None	Yes	12	High
4	*T. canis* and *T. cati*	10–99	Hepatomegaly	Mild	2	Short	1	None	Yes	2	Very low
5	*Trichinella* spp.	<10	Fever, muscle pain	Mild	2	Medium	2	None	No	4	Low
6	*Anisakis* spp.	≥1,000	Gastric pain	Slight	1	Short	1	None	Yes	1	Very low
7	*Paragonimus westermani*	10–99	Bloody sputum	Moderate	3	Medium	2	None	Yes	6	Low
8	*Paragonimus miyazakii*	<10	Pleural effusion	Moderate	3	Medium	2	None	Yes	6	Low
9	*Fasciola* spp.	<10	Liver abscess	Mild	2	Short	1	None	Yes	2	Very low
10	*Taenia asiatica**	<10	Abdominal discomfort	Slight	1	Short	1	None	Yes	12	High
11	*Taenia saginata*	<10	Abdominal discomfort	Slight	1	Short	1	None	Yes	1	Very low
12	*Taenia solium* (adult)	<10	Abdominal discomfort	Slight	1	Short	1	None	Yes	1	Very low
13	*T. solium* (larval cysticercus)	<10	Central nervous system manifestations	Moderate	3	Long	3	None	Yes	9	Medium
14	*Spirometra erinaceieuropaei*	<10	Central nervous system manifestations	Moderate	3	Medium	2	None	Yes	6	Low
14	*S. erinaceieuropaei*	<10	Creeping disease	Slight	1	Short	1	None	Yes	1	Very low

*emerging parasites

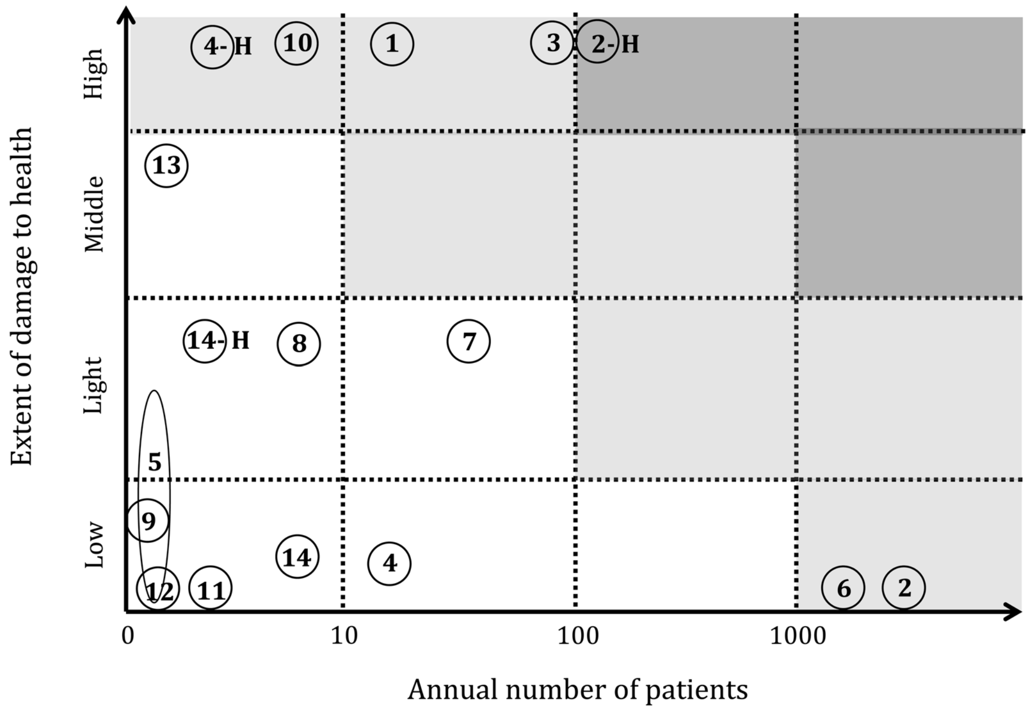

Fig. 1. Risk map for 14 parasites based on data from 2000 to 2013.
1, *Sarcocystis fayeri*: 2-H, *Toxoplasma gondii* (HIV/neonate): 2, *T. gondii* (adult): 3, *Kudoa septempunctata*: 4-H, *Toxocara canis* and *Toxocara cati* (blindness): 4, *T. canis* and *T. cati* (visceral larva migrans): 5, *Trichinella* spp.: 6, *Anisakis* spp.: 7, *Paragonimus westermani*: 8, *Paragonimus miyazakii*: 9, *Fasciola* spp.: 10, *Taenia asiatica*: 11, *Taenia saginata*: 12, *Taenia solium*: 13, *T. solium* (neurocysticercosis due to larval cysticercus): 14-H, *Spirometra erinaceieuropaei* (meningitis): 14, *S. erinaceieuropaei* (cutaneous larva migrans). Dark grey, light gray and white cells indicate unacceptable risk zone, zone in which the risk should be reduced, and socially-acceptable risk zone, respectively.

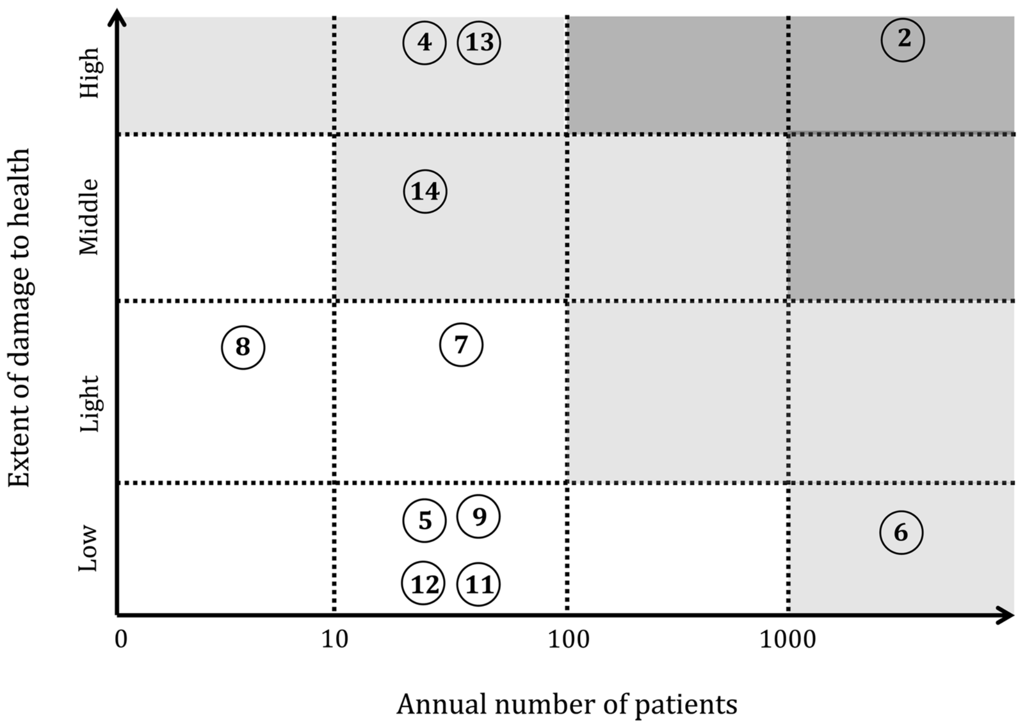

Fig. 2. Risk map for 11 parasites based on data from 1960s to 1980s.
Symbols and risk zones are the same as those in **Fig. 1**. Note different positions of several parasites, such as *T. canis* and *T. cati*, *T. solium, S. erinaceieuropaei, Trichinella* spp., *Fasciola* spp. and *T. saginata*.

as social and economic losses arising from parasite infections. Given these potential threats, it is considered important to develop alternative risk assessment items to extend the potential application of the methods described here. More detailed description of the developed method can be found elsewhere[25]. A part of the contents reported here has been published in Food Sanitation Research[26].

Acknowledgements

The authors thank Drs. T. Nozaki, H. Ohmae, S. Izumiyama, K. Tsukui and Y. Nakano at the Department of Parasitology, National Institute of Infectious Diseases, for their critical comments and suggestions regarding this study.

This study was supported by a grant from the Food Safety Commission, Cabinet Office, Government of Japan (Research Program for Risk Assessment Study on Food Safety, No. 1202).

References

1. Ministry of Health, Labour and Welfare of Japan. Food Poisoning Statistics. Available at: http://www.mhlw.go.jp/english/topics/foodsafety/poisoning/index.html.
2. Yamasaki H, Morishima Y, Sugiyama H, Muto M. [Cases of *Taenia asiatica*, possible emerging parasitic infestation reported from Kanto area of Japan since June 2010.] Infectious Agents Surveillance Report (IASR). 2011; **32**: 106–107. Japanese.
3. Infectious Disease Surveillance Center, National Institute of Infectious Diseases. [*Kudoa* and *Sarcocystis* food poisoning in Japan.] Infectious Agents Surveillance Report (IASR). 2012; **33**: 147–148. Japanese.
4. Yoshikawa Y. [Study on the risk management of zoonotic infectious diseases based on the risk analysis method.] Annual report of the Grant-in-Aid for Scientific Research from the Ministry of Health, Labour and Welfare, 2011. Available at: http://mhlw-grants.niph.go.jp/niph/search/NIDD00.do?resrchNum=201123004B. Japanese.
5. Masago Y, Katayama H, Hashimoto A, Hirata T, Ohgaki S. Assessment of risk of infection due to *Cryptosporidium parvum* in drinking water. Water Sci Technol. 2002; **46**(11-12): 319–324. [Medline]
6. Pouillot R, Beaudeau P, Denis JB, Derouin F, AFSSA Cryptosporidium Study Group. A quantitative risk assessment of waterborne cryptosporidiosis in France using second-order Monte Carlo simulation. Risk Anal. 2004; **24**(1): 1–17. [Medline] [CrossRef]
7. Robertson LJ, Greig JD, Gjerde B, Fazil A. The potential for acquiring cryptosporidiosis or giardiosis from consumption of mung bean sprouts in Norway: a preliminary step-wise risk assessment. Int J Food Microbiol. 2005; **98**(3): 291–300. [Medline] [CrossRef]
8. Mie T, Pointon AM, Hamilton DR, Kiermeier A. A qualitative assessment of *Toxoplasma gondii* risk in ready-to-eat smallgoods processing. J Food Prot. 2008; **71**(7): 1442–1452. [Medline]
9. Bayarri S, Gracia MJ, Pérez-Arquillué C, Lázaro R, Herrera A. *Toxoplasma gondii* in commercially available pork meat and cured ham: a contribution to risk assessment for consumers. J Food Prot. 2012; **75**(3): 597–600. [Medline] [CrossRef]
10. European Food Safety Authority. Scientific opinion on risk assessment of parasites in fishery products. EFSA J. 2010; **8**: 1543.
11. European Food Safety Authority. Opinion of the scientific panel on biological hazards (BIOHAZ) on the risk assessment of a revised inspection of slaughter animals in areas with low prevalence of *Trichinella*. EFSA J. 2005; 200: 1–41. Available at: http://www.efsa.europa.eu/en/efsajournal/pub/200.htm.
12. Teunis PF, Koningstein M, Takumi K, van der Giessen JW. Human beings are highly susceptible to low doses of *Trichinella* spp. Epidemiol Infect. 2012; **140**(2): 210–218. [Medline] [CrossRef]
13. European Food Safety Authority. Opinion of the scientific panel on biological hazards (BIOHAZ) on the risk assessment of a revised inspection of slaughter animals in areas with low prevalence of cysticercosis. EFSA J. 2004; **176**: 1–24.
14. Skjerve E. Possible increase of human *Taenia saginata* infections through import of beef to Norway from a high prevalence area. J Food Prot. 1999; **62**(11): 1314–1319. [Medline]
15. Ministry of Health, Labour and Welfare of Japan. [Surveillance on animal foods.] Available at: http://www.mhlw.go.jp/toukei/list/113-1.html. Japanese.
16. Sugiyama H, Morishima Y, Ohmae H, Yamasaki H, Kimura S. [*Anisakis* food poisoning: the annual number of cases noticed by ordinance for enforcement of the food sanitation act and estimated through healthcare claim data analysis.] Clin Parasitol. 2013; **24**: 44–46. Japanese.
17. National Institute of Infectious Diseases, Japan. Annual Reports (2007–2013).
18. Product Safety Technology Center, National Institute of Technology and Evaluation (NITE), Japan. [The risk assessment of the product accident using R-Map analysis method.] 2011. Available at: http://www.cao.go.jp/consumer/history/01/kabusoshiki/anzen/doc/006_110201_shiryou2.pdf. Japanese.
19. WHO. Global burden of disease 2004 update: Disability weights for diseases and conditions. Available at: http://www.who.int/healthinfo/global_burden_disease/GBD2004_DisabilityWeights.pdf.

20. Anonymous. Foodborne helminthiases emerging diseases in Japan. Infectious Agents Surveillance Report (IASR). 2004; 25:114–115. Available at: http://idsc.nih.go.jp/iasr/25/291/tpc291.html.

21. Kobayashi A, Hara T, Kajima J. Historical aspects for the control of soil-transmitted helminthiases. Parasitol Int. 2006; **55** (Suppl): S289–S291. [Medline] [CrossRef]

22. Okabe K. *Taenia* and taeniasis. In:Progress of Medical Parasitology in Japan. Vol. 4, pp.514–525, 1972. Meguro Parasitological Museum, Tokyo. Available at: http://www.kiseichu.org/Documents/E4-11-532.pdf.

23. Graeff-Teixeira C, da Silva AC, Yoshimura K. Update on eosinophilic meningoencephalitis and its clinical relevance. Clin Microbiol Rev. 2009; **22**(2): 322–348. [Medline] [CrossRef]

24. Lv S, Zhang Y, Steinmann P, Zhou XN, Utzinger J. Helminth infections of the central nervous system occurring in Southeast Asia and the Far East. Adv Parasitol. 2010; **72**: 351–408. [Medline] [CrossRef]

25. Yamasaki H. Survey of contamination by parasites in livestock and game meat and development of risk assessment method for meat-borne parasitic diseases based on the epizootic and epidemiological characteristics. Report on Research Program for Risk Assessment Study on Food Safety (No. 1202), Food Safety Commission, Cabinet Office, Government of Japan. March 2014. Available at: http://www.fsc.go.jp/fsciis/technicalResearch/show/cho99920131202. Japanese.

26. Arakawa K, Ohashi T, Yagita K, et al. Development of a semi-quantitative risk assessment method for health damage affected by infection of meat-borne parasites in Japan. Food Sanit Res. 2014; 64(12): 43–53. Japanese.