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Miscellaneous

The Synthetic Evaluation Model for Analysis of Flooding Hazards

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Background: Although many previous epidemiological studies have reported the incidence of diseases, mortality rate and economic losses after natural disasters, none of these studies has been comprehensive enough. Our aim was to establish a synthetic evaluation model (SEM) that can be used to analyze flood hazards.
Methods: Initial evaluation indicators were selected using systematic and literature data analysis. These indicators were tested with single or multiple variable analyses. Final evaluation indicators and their weights were determined using the Delphi procedure. We established a SEM of flood hazards using the hierarchy method and tested the model using jack-knife analysis.
Results: The SEM on flood hazards consists of 6 first-rank indicators and 24 second-rank indicators. First-rank indicators were: direct casualties ($w = 0.2123$), the increased incidence and prevalence rate of the disease ($w = 0.1715$), excess mortality rate ($w = 0.1745$), mental injury ($w = 0.1038$), epidemic focus expansion ($w = 0.1572$) and economic loss ($w = 0.1807$). The agreement of the model reached 98.2% tested with the jack-knife analysis.
Conclusion: A SEM of flood hazards was established with an agreement of 98.2%, which can be used to evaluate the hazards, and assist public health-care workers provide appropriate flood disaster management.

Keywords: Delphi method, flood hazards, jack-knife analysis, synthetic evaluation

Natural disasters are increasing in frequency because of the worldwide deterioration in the natural environment. The incidence of floods, storms, earthquakes and droughts and the number of people affected by them are escalating greatly.[1] Weather-related disasters throughout the world continue to rise, from an annual average of 200 in 1993–1997 to 331 per year in 1998–2002.[2] Floods are the most common of natural disasters, affecting more people across the globe (140 million per year on average) than are affected by all other natural or technological disasters.[2,3] In 1998 a flood killed 3004 people in China.[4] A flood in East Java destroyed 20 000 houses and thousands of hectares of rice fields in 130 villages.[5]

The investigation of distribution, hazards and risk factors of natural disasters is very important for preventing their occurrence and reducing hazards associated with such events. It is also very important to evaluate the disaster comprehensively and in time in order to initiate appropriate management and to reduce the effects of the event.

Although many previous epidemiological studies have reported the incidence of infectious diseases such as water-borne dysenteries, and non-infectious diseases such as stroke or myocardial infarction, the mortality rate and the economic losses that follow natural disasters,[6–11] have not been reported comprehensively enough in these studies.

We therefore carried out a large retrospective study on flood hazards and established a synthetic evaluation model (SEM) that can be applied to these. This model can be easily used to manage the flood during the acute phase, as well as to implement disease prevention measures.

Methods

Setting and sample

An epidemiological study was carried out in 1999 in Hunan province, a severely flood-prone area, located in the South of China. A sample was selected randomly using a multiple-stage sampling method. In the first stage of sampling, 8 counties were selected among 38 flooded counties. In the second stage half of the flood affected towns in the eight counties were selected. In the third stage, half of the flood affected villages in the selected towns were selected. Non-flooded villages located near the selected flooded villages with similar social, environmental and economic conditions were used as controls. In the fourth stage of sampling, we selected half of the flood-affected families in the selected flooded villages and half of the families in the selected control villages. The family was the smallest sampling unit; we investigated all members of the selected families.

Contents and methods of investigating

We investigated the rate at which flood affected the populations, the number of casualties that directly resulted from the flood, which included drowning and accidental injury etc., the total, age-specific, sex-specific, cause-specific mortality and morbidity using the method of face-to-face investigation. The incidence rate of post-traumatic stress disorder (PTSD) was rated by an experienced psychiatrist using the diagnostic criteria of DSM-IV.[12] The spread of the focus of the epidemic of Schistosomiasis was rated by investigating the areas of embankment with snails and by looking at the incidence and mortality rate

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of Schistosomiasis during the flood years. The positive rate of Leptospirosa antibody and haemorrhagic fever with renal syndrome (HFRS) antibody in the local populations, the economic investment, as well as economic loss due to flood were all included in the study. All diseases and causes of death were then classified by ICD-10 criteria. The snails were picked up directly using a scoop, transferred to plastic containers, brought to the field laboratory and checked for cercarial shedding by placing them in small plastic containers and exposing them to light for 4 h. The infection of schistosoma was diagnosed by the faecal testing of each individual using the katokatz method, two slides being prepared for each faecal sample. The Leptospirosa antibody was detected using the microscopic agglutination test. The HFRS antigen was detected in the rodent lung using direct immunofluorescence; the population serum HFRS IgG antibody was detected using indirect immunofluorescence.

Synthetic evaluation method

The initial evaluation indicators were selected using systematic analysis and literature data analysis. All of the initial evaluation indicators were tested using the single or multiple variable analysis method. Indicators with no statistical significance were excluded from the study. A frame of evaluation indicators was drafted using variable cluster analysis[13] and analytical hierarchy methods.[14] The evaluation indicators and their weights were determined using the Delphi procedure.[15] The SEM of the flood hazards was established using the hierarchy method; the model was tested by jack-knife analysis[16] and correlation analysis. The Delphi method is a consensus method used to determine the extent of agreement on an issue or object, which was originally developed by the Rand Corporation in order to evaluate the appropriateness of medical and surgical techniques. It synthesizes the opinions of experts with the available evidence in order to provide detailed assessment.[17]

Experts who participated in the Delphi procedure were polled individually and anonymously, with a self-administered questionnaire. The survey was conducted over three or four rounds, depending on the agreement coefficient. The result obtained in the first round of the survey was presented to experts in the second round, and so on. Experts were assembled for the Delphi survey questionnaire based on the following criteria: (i) they had had at least 10 years of experience in disaster management, (ii) they were familiar with flooding or other natural disaster information and (iii) they were willing to participate in the Delphi procedure.

Using the Delphi procedure, each expert was asked to assess the sensitivity, specificity and feasibility of the evaluation indicators for the evaluation of flood hazards and to rank the indicators against 0–10 scores. The mean score of the four values for each indicator–representative, sensitivity, specificity and feasibility, was regarded as the score of primary importance. The higher the value given by the expert, the more important the indicator became. The experts were also asked to self-rate themselves on authority (authority coefficient) in the indicator of evaluation. The product of the primary importance score and the authority coefficient of the indicator were defined as the initial weight of the indicator. The indicators whose initial weight <5.0 and had a coefficient of variance of >0.5 or mean score of feasibility <5.0 were excluded.

Some related variables in the Delphi procedure and model establishment are as follows.

The agreement coefficient (AC, ω) represents the harmony degree of all evaluating variables among all experts; it is defined as follows:

$$\omega = \frac{12}{m^2(n^3 - n) - m\sum_{i=1}^{m} T_i} \sum_{j=1}^{n} d_j^2 \qquad (1)$$

where ω is the signal of AC; n is the number of indicators in questionnaires; m is the number of experts in the rounds; T_i is the number of indicators with the same rank; d_j is the value of the rank sum of indicators minus the mean of rank sum of all indicators.[17]

The authority coefficient (C'_{rj}) is the authority degree of experts on the evaluating indicators, which is determined by two factors: one is the judgment criterion for the indicator and the other is the experts' familiarity with the indicators.[17]

Weight (W) is a very important parameter in the evaluating model, reflecting the importance of indicators. The initial weight (W_j) equal to the weighted mean of expert scores, the unitary weight (W_{uj}) equal to the initial weight divided by the sum of initial weights of all indicators in the same rank and the final combined weight (W_{cj}) is defined as follows:

$$W_{cj} = W_{1uj} W_{2uj}, \qquad (2)$$

where W_{1uj} represents the first-rank unitary weight and W_{2uj} represents the unitary weight of the second-rank indicator.[17]

The SEM of flood hazards based on the analytic hierarchy method is defined as follows:

$$\mathrm{SEM}_{\mathrm{AH}} = \sum_{j=1}^{n} W_{cj} Y'_j, \qquad (3)$$

where n is the number of indicators in the SEM, W_{cj} is the combined weight of indicator J and Y'_j is the value of indicator J in the flood area.[14]

Results

Our study in Hunan province, China, included 55 towns, 438 villages, 20 230 families and 75 033 people. The non-flooded control group consisted of 15 towns, 129 villages, 7008 families and 25 136 people. The flooded group consisted of 40 towns, 309 villages, 13 222 families and 49 897 people. Subjects were selected randomly and 96.2% of the subjects responded. The direct injury rate was 191 per 100 000 and the direct mortality rate was 77 per 100 000 in the area of the collapsed embankment. The incidence rate of infectious diseases (44.3‰) and the prevalence rate of non-infectious diseases (68.8‰) were significantly higher in the flooded group compared with the non-flooded group (23.9 and 52.1‰, respectively; $P < 0.01$). The incidence and prevalence rates of all types of disease increased with the severity of the flood. The total mortality rate was significantly higher in the flooded group (939 per 100 000) than in the non-flooded control group (726 per 100 000; $P < 0.01$). In the flooded group the rate of PTSD was 32.6% in the population in the age group of above 6 years. The rate of PTSD was higher in the more severely flooded area than in the mildly flooded area. The rate of Schistosoma infection (8.76%) and acute Schistosomiasis (6.92 per 10 000), was significantly higher in the flood years than in the non-flood years (5.47%, 3.54 per 10 000). The density of rats (6.95%) and rate of rats infected with Leptospirosa (4.63%) and HFRS virus (15.07%) was significantly higher in the flooded area than in non-flooded area (5.98, 1.35, and 9.25%). The total economic loss was 13.2 billion Chinese Yuan (£1 billion) in 40 flooded towns. The investment in flood prevention strategies before and during the flood years was negatively related to the economic loss caused by the flood. The cost–benefit ratio of investment in anti-flood strategies was calculated to be 1:250.

Using systematic analysis and literature data analysis methods, 128 initial evaluation indicators were selected, of which 54 indicators having no statistical significance in the single variable analysis or in the multiple regression analysis were excluded. The remaining 74 indicators were divided into six categories--direct casualties, mental injury, incidence and prevalence rates of diseases, mortality rate, economic loss and infectious vector

Table 1 The expert's authority coefficient (C'_{rj}) in Delphi procedure

	Indicators	
	First rank	**Second rank**
Direct casualties	0.80	0.70–0.83
Increases of diseases incidence or prevalence rate	0.75	0.65–0.85
Excess mortality rate	0.72	0.65–0.87
Mental injury	0.65	0.50–0.65
Expansion of epidemic focus	0.76	0.60–0.80
Economic loss	0.73	0.70–0.87

Table 2 The expert's agreement coefficient (AC, ω) after three round Delphi procedures

	ω	X^2	P
First rank indicators	0.82	11.07	<0.05
Second rank indicators			
Direct casualties	0.52	6.51	<0.050
Increases of diseases incidence or prevalence rate	0.72	7.34	<0.050
Excess mortality rate	0.65	12.37	<0.001
Mental injury	0.75	12.34	<0.010
Expansion of epidemic focus	0.64	13.50	<0.050
Economic loss	0.82	11.62	<0.050

spreading--by variable cluster analysis and analytic hierarchy methods. These were called first-rank indicators.

We selected 28 experts in the Delphi procedure. Ten of them held university research posts, 10 were specialists working in a Centre Of Disease Control & Prevention (CDC) and 8 were government health administrators. The respondent rate was more than 88.9% for experts working in a university, 77.8% for those working in a CDC, 83.3% for those working in the government, and the total respondent rate was 87.8%. The expert authority coefficient ranged from 0.50 to 0.87 (table 1).

After three rounds of the Delphi procedure, the AC reached 0.5 or more for the second-rank indicators and 0.82 for first-rank indicators (table 2).

All of the first and second rank indicators and their weights remained in the final SEM listed in table 3.

Based on the 24 indicators in table 3, we established a SEM using the analytical hierarchy method. This model is presented as follows:

$$\mathrm{SEM}_{\mathrm{AH}} = \sum_{j=1}^{n} W_{cj} YX'_j$$

$$\begin{aligned}
&= 0.0711\mathrm{YX}_{1.01} + 0.0619\mathrm{YX}_{1.02} + 0.0793\mathrm{YX}_{1.03} + 0.0514\mathrm{YX}_{2.01} \\
&\quad + 0.0524\mathrm{YX}_{2.09} + 0.0677\mathrm{YX}_{2.11} + 0.0460\mathrm{YX}_{3.01} + 0.0423\mathrm{YX}_{3.06} \\
&\quad + 0.0485\mathrm{YX}_{3.11} + 0.0377\mathrm{YX}_{3.13} + 0.0269\mathrm{YX}_{4.01} + 0.0238\mathrm{YX}_{4.03} \\
&\quad + 0.0271\mathrm{YX}_{4.04} + 0.0261\mathrm{YX}_{4.09} + 0.0283\mathrm{YX}_{5.07} + 0.0264\mathrm{YX}_{5.08} \\
&\quad + 0.0249\mathrm{YX}_{5.10} + 0.0222\mathrm{YX}_{5.15} + 0.0238\mathrm{YX}_{5.18} + 0.0315\mathrm{YX}_{5.22} \\
&\quad + 0.0500\mathrm{YX}_{6.02} + 0.0412\mathrm{YX}_{6.03} + 0.0417\mathrm{YX}_{6.04} + 0.0476\mathrm{YX}_{6.08}
\end{aligned}$$

where YX is the value of evaluation indicators X listed in table 3. We calculated the synthetic evaluation value of every flooded town using this model and classified the towns based on slight flooding (<P50), moderate flooding (P50–P74), severe flooding (P75–P94) and the severest flooding (≥P95) by the percentile method.

We tested this model by comparing the classification results of the SEM classification with traditional classification and jack-knife analysis for the 55 investigated towns and by one-way ANOVA and correlation analysis. The traditional flood classification method is based on the flooded acreage: slight flood (<50%), moderately severe flood (50–75%) and severe flood (>75%). The flood classification result by SEM is significantly different from the result by the traditional classification method. The total agreement rate was 34.55%. Eighty percent of the non-flooded control towns were classified as flooded (table 4). The agreement rate of flood classification of the SEM and the jack-knife analysis reached 98.2% (table 4). This showed that the model is reliable and repeatable. We compared the mean values of SEM among different classified flood by one-way ANOVA and LSD test; the results showed that the mean value of SEM was 0.87 for non-flooded areas [95 confidence interval (95% CI) of mean −0.65 to 2.39], 13 228.49 for slightly flooded areas (95% CI of mean 9969.75–16 487.23), 45033.04 for moderately flooded areas (95% CI of mean 42 346.68–47 719.40), 119 884.42 for severely flooded areas (95% CI of mean 116 844.93–122 923.91) and 236 149.48 for the most severely flooded areas (95% CI of mean 226 258.40–246 040.56); there were significant differences among the mean values of SEM in different classified flood ($F = 107.3$, $P < 0.001$); the model had satisfied differentiability. The correlation analysis results showed that only 38 (13.8%) correlation coefficients had statistical significance among 276 correlation coefficients ($(24 \times 23)/2 = 276$); most of the evaluation indicators were independent.

Discussion

We investigated 55 towns, 438 villages, 20 230 families and 75 033 people in Hunan province, China, focusing on the number of direct casualties resulting from the flood, infectious and non-infectious disease mortality and morbidity, the incidence rate of PTSD, spread of the epidemic focus of schistosomiasis, leptospirosa, and HFRS, as well as economic investment and economic loss during and after the floods. Based on these data, we established a SEM using the analytical hierarchy method, which included six first-rank indicators and 24 second-rank indicators, and which can be used to evaluate flood hazards. The results of model testing showed that the agreement rate of the model reached 98.2% in the flood classification, compared with the result of the jack-knife analysis. This model is the most practical flood evaluation model among all models reported so far in the literature.

The analytic hierarchy method is a method commonly used to establish a SEM. Ramanthan *et al.*[18] used this method to establish an evaluation indicator system regarding the effect of the environment on human health, and Hummel *et al.*[19] used this method to evaluate the medical instruments in hospitals. We used this method to establish a SEM on flood hazards, which included 6 first-rank indicators and 24 second-rank indicators, reflected the influence of flood on human health, environment, as well as the economic loss. To our knowledge, this is the most comprehensive and practical SEM of flood hazard evaluation including six main fields of flood hazards compared with other studies.[20,21] It is the first time that mental injury has been included, and the evaluation indicator frame is most comprehensive and reasonable.

The Delphi procedure is a common method used to determine the synthetic evaluation indicators and their weight and a key process used in order to obtain a reliable result. In our study, all the experts who participated in the Delphi

Table 3 All indicators and their weights included in the final synthetic evaluation model after three round Delphi procedures

	Initial weight (W_j)	Unitary weight (W_{uj})	Combined weight (W_{cj})
Direct casualties[a]	7.75	0.2123	
Affected rate in total population by flood ($X_{1.01}$)[b]	6.23	0.3348	0.0711
Injury incidence attribute to flood ($X_{1.02}$)	5.43	0.2917	0.0619
Mortality rate attribute to floods ($X_{1.03}$)	6.95	0.3735	0.0793
Increases of diseases incidence	6.26	0.1715	
Total prevalence rate ($X_{2.01}$)	4.99	0.2999	0.0514
Digestive system diseases prevalence rate ($X_{2.09}$)	5.08	0.3053	0.0524
Infectious and parasitic diseases incidence rate ($X_{2.11}$)	6.57	0.3948	0.0677
Excess mortality	6.37	0.1745	
Total death rate ($X_{3.01}$)	5.72	0.2634	0.0460
Death rate in 20- to 64-years-old ($X_{3.06}$)	5.27	0.2426	0.0423
Infectious and parasitic diseases mortality ($X_{3.11}$)	6.04	0.2781	0.0485
Death rate of injury ($X_{3.13}$)	4.69	0.2159	0.0377
Mental injury	3.79	0.1038	
Total rate of PTSD in adult ($X_{4.01}$)	2.62	0.2589	0.0269
Rate of persistent re-experiencing symptoms in adult ($X_{4.03}$)	2.32	0.2292	0.0238
Rate of increased arousal symptoms in adult ($X_{4.04}$)	2.64	0.2609	0.0271
Rate of PTSD in older than 60 population ($X_{4.09}$)	2.54	0.2510	0.0261
Expansion of epidemic focus	5.74	0.1572	
Number of acute schistosomiasis patient ($X_{5.07}$)	5.54	0.1803	0.0283
Prevalence rate of schistosomiasis ($X_{5.08}$)	5.17	0.1682	0.0264
Rat density ($X_{5.10}$)	4.86	0.1582	0.0249
Positive rate of HFRS antibody in 15- to 49-years-old ($X_{5.15}$)	4.35	0.1416	0.0222
Positive rate of leptospirosis antibody in population ($X_{5.18}$)	4.66	0.1516	0.0238
New appeared snail areas inside embankment ($X_{5.22}$)	6.15	0.2001	0.0315
Economic loss	6.59	0.1807	
Type of floods ($X_{6.02}$)	6.18	0.2769	0.0500
Total losses per family attributed to floods ($X_{6.03}$)	5.09	0.2280	0.0412
Average social losses per person attribute to floods ($X_{6.04}$)	5.16	0.2312	0.0417
Rate of destroyed house ($X_{6.08}$)	5.89	0.2639	0.0476

a: First rank indicators
b: Second rank indicators

procedure were specialists or experienced flood managers, and the mean of their working years was 24.5. The authority coefficient was >0.6 in first-rank indicators and >0.5 in the second-rank indicators. The experts' respondent rate ranged from 77.8 to 100% from the first to the third round; all of the expert agreement coefficients reached 0.50 or more for the second-rank indicators and 0.82 for first-rank indicators. These results showed that the experts were qualified for the Delphi procedure.[17] The experts' consulting result is reliable and better than Rivara and Lavicoli's results.[22,23]

Our SEM is more sensitive and specific than the traditional method of flood hazard evaluation. Traditional methods evaluate flood hazards only according to the flooded acreage; however flooded acreage is not the only determinant of flood hazard, flood hazard being related also to flood type, period of time, affected population and economic loss. Our model includes 24 evaluation indicators and is more sensitive in evaluating the flood hazard than previous methods. Our SEM classified 12 of the 15 non-flooded towns as flooded towns. This was reasonable and consistent with the facts, as the selected non-flooded towns (control) were near the flooded towns, most of the population in the non-flooded towns participated the anti-flood work, experienced the flood disaster and subsequently suffered a decrease in their income, as well as increase in infectious diseases during the flood year.

Every flooded area can have an index value of synthetic evaluation applied to it by our SEM and can subsequently be classified into a particular flood grade. This would help public health-care decision-makers and workers develop appropriate

Table 4 The comparison of flood classification by synthetic evaluation model, traditional classification method, and jackknife analysis

Classified by SEM_{AH}	Classified by traditional method				Classified by jackknife analysis				
	Non-flood	Slight flood	Middle flood	Severe flood	Non- flood	Slight flood	Middle flood	Severe flood	Severest flood
Non-flood	3[a]	0	0	0	3*	0	0	0	0
Slight flood	8	8	6	6	1	27	0	0	0
Middle flood	3	4	3	3	0	0	13	0	0
Severe flood	1	2	1	5	0	0	0	9	0
Severest flood	0	0	2	0	0	0	0	0	2

a: Number of towns

rescuing measures and help the flood victims in the most efficient way possible.

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Key points

- We investigated the flood hazards in 6 fields on 75 033 people in flooded areas of China. Based on these results, a synthetic evaluation model on flood hazards consisting of 6 first-rank indicators and 24 second-rank indicators was established with an agreement of 98.2%, which is the first synthetic evaluation model for flood hazards assessment and can be used to evaluate flood hazards, as well as to assist public health-care workers provide appropriate flood disaster management.

References

1 Matsuoka T, Yoshioka T, Oda J, et al. the impacts of a catastrophic earthquake on morbidity rates for various illnesses. *Public Health* 2000;114:249–53.

2 World Disasters Reports 2003. Available at: http://www.ifrc.org/publication/wdr2003/chapter 8 (20 October 2003, date accessed).

3 National Climatic Data Centre. Available at: http://www.ncdc.noaa.gov (20 April 2003, date accessed).

4 Wen Jiabao. The report on fighting flooding in present in China. *People's daily*, 27 August 1998.

5 United Nations General Assembly. Available at: http://www.un.org/documents/ga (20 April 2003, date accessed).

6 Kunii O, Nakamura S, Abdur R, et al. The impact on health and risk factors of the diarrhoea epidemics in the 1998 Bangladesh floods. *Public Health* 2002;116:68–74.

7 Ogawa K, Tsuji I, Shiono K, et al. Increased acute myocardial infarction mortality following the 1995 Great Hanshin-Awaji earthquake in Japan. *Int J Epidemiol* 2000;29:449–55.

8 Kario K, Ohashi T. After a major earthquake, stoke death occurs more frequently than coronary heart disease death in very old subjects. *J Am Geriatr Soc* 1998;46:537–8.

9 Jonkman SN, van Gelder PH, Vrijling JK. An overview of quantitative risk measures for loss of life and economic damage. *J Hazard Mater* 2003;99:1–30.

10 Chan CC, Lin YP, Chen HH, et al. A population-based study on the immediate and prolonged effects of the 1999 Taiwan earthquake on mortality. *Ann Epidemiol* 2003;13:502–8.

11 Centers for Disease Control and Prevention. Storm-related mortality—central Texas, October 17–31, 1998. *JAMA* 2000;283:1560–1.

12 American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders.* 4th edition. Washington, DC: American Psychiatric Association, 1994.

13 Johnson RA, Wichern DW. *Applied Multivariate Statistical Analysis.* 5th edition. London: Prentice Hall, 2002.

14 Dolan JG, Isselhardt BJ Jr, Cappuccio JD. The analytic hierarchy process in medical decision making: a tutorial. *Med Decis Making* 1989;9:40–50.

15 Fink A, Kosecoff J, Chassin M, Brook RH. Consensus methods: characteristics and guidelines for use. *Am J Public Health* 1984;74:979–83.

16 Oppenheimer L, Capizzi TP, Miwa GT. Application of jackknife procedures to inter-experiment comparisons of parameter estimates for the Michaelis-Menten equation. *Biochem J* 1981;197:721–9.

17 Brown B. Delphi Process: A methodology using for the elicitation of opinions of experts. *The Rand Corporation* 1987;9:3925.

18 Ramanathan R. A note on the use of the analytic hierarchy process for environmental impact assessment. *J Environ Manage* 2001;63:27–35.

19 Hummel JM, Rossum W, Verkerke GJ, Rakhorst G. Medical technology assessment: the use of the analytic hierarchy process as a tool for multi- disciplinary evaluation of medical devices. *Int J Artif Organs* 2000;23:782–7.

20 Jonkman SN, van Gelder PH, Vrijling JK. An overview of quantitative risk measures for loss of life and economic damage. *J Hazard Mater* 2003;99:1–30.

21 Kunii O, Nakamura S, Abdur R, et al. The impact on health and risk factors of the diarrhea epidemics in the 1998 Bangladesh floods. *Public Health* 2002;116:68–74.

22 Rivara FP, Johansen JM, Thompson DC. Research on injury prevention: topics for systematic review. *Inj Prev* 2002;8:161–4.

23 Lavicoli S, Marinaccio A, Vonesch N, et al. Research priorities in occupational health in Italy. *Occup Environ Med* 2001;5:325–9.

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