Analysis of Risk and Burden of Dysentery Associated with Floods from 2004 to 2010 in Nanning, China

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Abstract. This study aimed to examine the association between floods and the morbidity of dysentery and to quantify the burden of dysentery due to floods in Nanning, China. A generalized additive mixed model was conducted to assess the relationship between monthly morbidity of dysentery and floods from 2004 to 2010. The years lived with disability (YLDs) of dysentery attributable to floods were then estimated based on the WHO framework of the burden of disease study for calculating the potential impact fraction. The relative risk (RR) of floods on the morbidity of dysentery was 1.44 (95% confidence interval [CI] = 1.18–1.75). The models suggest that a potential 1-day rise in flood duration may lead to 8% (RR = 1.08, 95% CI = 1.04–1.12) increase in the morbidity of dysentery. The average attributable YLD per 1,000 of dysentery caused by floods were 0.013 in males, 0.005 in females, and 0.009 in persons. Our study confirms that floods have significantly increased the risk and the burden of dysentery in the study area. Public health action should be taken to prevent and control the potential risk of dysentery after floods. Vulnerable groups such as males and children should be paid more attention.

INTRODUCTION

Floods are the most common natural disaster in both developed and developing countries. On average, floods and other hydrological events have accounted for over 50% of the disasters between 2001 and 2010 globally.¹ Under future climate change, altered patterns of precipitation and sea level rise are expected to increase the frequency and intensity of floods in many regions of the world.² Guangxi province, located in a tropical and subtropical monsoon climate area, suffered from flood disasters frequently.³ Persistent and heavy rainfall caused several floods from 2004 to 2010 in Nanning City of Guangxi.⁴ The floods destroyed houses and forced an evacuation of thousands of people from homelands. Frequent occurrence of floods in recent years have caused inestimable economic losses.⁵

The health effects of floods are complex and far reaching, which may include increased mortality and morbidity of diarrheal diseases.⁶ Dysentery is an important cause of disease burden in the world, particularly for resource-limited countries and for children under age of 5 years. Dysentery, including bacillary dysentery and amebic dysentery, remains a major public health problem in some developing countries including China.⁷ The incidence of dysentery each year ranged from 15.5 to 32.9 per 100,000 in Guangxi during 2004–2010, which was the second most common disease among the 39 of notified infectious diseases in China.⁸

Diarrheas including dysentery are common infectious diseases related to floods.⁹ Morbidity of dysentery may increase because of the transmission and infection of the pathogens during/after floods. For example, a study from northern China revealed that floods may be significantly associated with dysentery (relative risk [RR] = 1.66, 95% confidence interval

[CI] = 1.52–1.82).¹⁰ However, the association between floods and dysentery is far from clear. Some studies found there was no clear evidence that floods can increase the morbidity of dysentery after controlling seasonality and other confounding factors.^{11,12} More research is needed to elucidate the potential risk of floods on the transmission of dysentery. With few studies conducted to quantify the risk and burden of dysentery due to floods, the effects of the floods on dysentery in Nanning remain unknown. Therefore, this study was aimed to explore the association between dysentery and floods based on a longitudinal analysis from 2004 to 2010 in Nanning City. Results will contribute to have a better understanding of the health impacts of floods and assist in developing local strategies to reduce the future risk of dysentery associated with floods.

MATERIALS AND METHODS

Study area. Nanning, the capital of Guangxi Province, is located between latitudes 22°13' and 23°32' N and longitudes 107°45' and 108°51' E, with two rivers named You River and Yong River (Figure 1). The city has a subtropical monsoon climate with an annual average temperature of 21.6°C and an annual average rainfall between 1,241 and 1,753 mm.¹³ Nanning has an area of 33,112 km² and a population of 6.82 million in 2010.

Data collection and management. *Disease surveillance data.* Monthly disease surveillance data of dysentery from January 2004 to December 2010 were obtained from the National Notifiable Disease Surveillance System (NDSS). The definition of dysentery, according to the NDSS, is a group of the human diseases that are caused by *Shigella* and protozoan parasite *Entamoeba histolytica*, accompanied by fever, abdominal pain, tenesmus, and bloody or mucus stool as the typical clinical presentation. In our study, all dysentery cases were defined based on the diagnostic criteria and principles of management for dysentery (GB 16002-1995) issued by the Ministry of Health of the People's Republic of China.¹⁴ Only

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FIGURE 1. Location of the study area in the Guangxi Zhuang Autonomous Region, China.

the cases confirmed by both clinical laboratory tests, including microscopic examination and biochemical identification, were included in our study. Microbiologic assays for bacillary dysentery was stool cultivation of *Shigella* and for amebic dysentery was stool cultivation of trophozoite of *E. histolytica*. In China, dysentery is a statutory notifiable category B infectious disease. According to the National Communicable Disease Control Act, physicians in hospitals must report every case of dysentery to the local health authority within 24 hours.¹⁵ The Direct Network Report system for infectious diseases in China has been established and applied well since January 1, 2004.¹⁶ Therefore, it is believed that the degree of compliance with disease notification was consistent over the study period.

Data on floods. The yearbooks of meteorological disasters in China recorded the occurrence of floods and their consequences, including number of deaths, damaged areas, and economic loss from 2004 to 2010.⁴ According to the yearbooks of meteorological disasters in China, there were eight floods recorded in Nanning from 2004 to 2010. Most of them occurred in June and July. In total, eight floods affected 3,912 thousand people and killed 13 people with more than 14,056 houses toppled with estimated economic damage of approximately 740 million Yuan (US\$121 million).

Demographic and meteorological data. Demographic data were obtained from the Center for Public Health Science Data in China (<http://www.phsciencedata.cn/>). Monthly meteorological data were obtained from the China Meteorological Data Sharing Service System (<http://cdc.nmic.cn/>). The meteorological variables included monthly cumulative precipitation (MCP), monthly average temperature (MAT), monthly average relative humidity (MARH), monthly average wind velocity (MAWV), and monthly cumulative sunshine duration (MCS D).

Study design and statistical analysis. *Quantifying the association between floods and morbidity due to dysentery.* First, a descriptive analysis was performed to describe the distribution of morbidity of dysentery for the flooded and non-flooded months. Then spearman correlation was adopted to examine the association between floods, climate variables, and the morbidity of dysentery with various lagged values. The lagged value with the maximum correlation coefficient for each variable was included in the subsequent regression analysis. According to the living habits of the pathogen and

the incubation period of dysentery, a time lag of 0–2 months was considered in our study.¹⁷

Second, a Poisson regression with a generalized additive mixed model (GAMM) was developed to examine whether floods was related to the morbidity of dysentery. The generalized additive model (GAM) method is an effective technique for conducting nonlinear and linear regression analysis in time-series studies with a Poisson regression.¹⁸ GAM allows Poisson regression to be fit as a sum of nonparametric smooth functions of predictor variables. The GAMM allows the parametric and nonparametric functions to be analyzed together in the model. In time-series studies of the association between weather variables and health outcomes, GAM has been widely applied, because it allows for nonparametric adjustment of confounding effects of seasonality and long-term trends.¹⁹ Several studies showed that meteorological factors, such as mean temperature, cumulative precipitation, average wind velocity, average relative humidity, and cumulative sunshine duration, were associated with diarrheal diseases.^{20–22} Consequently, the GAMM model was performed to evaluate the association between the morbidity of dysentery and flood variables with adjustment for the multiple-lag effects of MAT, MCP, MARH, MAWV, and MCS D. Because of the high correlation between floods and flood duration, we designed two models for floods and flood duration to avoid collinearity. The GAMM regression models can be written as:

Model 1:

$$\begin{aligned} \text{Ln}Y_t = & \text{Ln}(\text{population}) + \beta_0 + \beta_1(\text{floods}) + \beta_2(\text{season}) \\ & + s_1(t) + s_2(\text{temperature}) + s_3(\text{precipitation}) \\ & + s_4(\text{humidity}) + s_5(\text{sunshine duration}) \\ & + s_6(\text{wind velocity}) \end{aligned}$$

Model 2:

$$\begin{aligned} \text{Ln}Y_t = & \text{Ln}(\text{population}) + \beta_0 + \beta_1(\text{duration}) + \beta_2(\text{season}) \\ & + s_1(t) + s_2(\text{temperature}) + s_3(\text{precipitation}) \\ & + s_4(\text{humidity}) + s_5(\text{sunshine duration}) \\ & + s_6(\text{wind velocity}) \end{aligned}$$

where Y_t denoted the monthly number of dysentery cases at time t , which represented the specific month. $\text{Ln}(\text{population})$ was designed as an offset to make the model appropriate for rate

data. “Floods” were coded as a categorical variable, including non-flooded or flooded months, and represented by 0 and 1, respectively. “Duration” represented the days with flooding in a month. s_2 (precipitation), s_3 (temperature), s_4 (humidity), s_5 (sunshine duration), and s_6 (wind velocity) were smooth functions of MCP, MAT, MARH, MCSD, and MAWV, respectively, which were designed to control the effect of confounding meteorological factors. The smooth spline of specific month was projected as $s_1(t)$ to avoid the influence of any secular trend. “Season” was conceived as a dummy variable, including spring, summer, autumn, and winter (as a reference season), to control the seasonal component in time series data. SPSS 16.0 (SPSS Inc., Chicago, IL) and R 3.1.3 (R Foundation for Statistical Computing, Vienna, Austria) were used in all statistical analyses with a significant level of 0.05.

Estimating the YLDs of dysentery attributable to floods. The years lived with disability (YLDs) were calculated to estimate the burden of dysentery during flooded months. We used the World Health Organization (WHO)–recommended methodological framework to estimate YLDs.²³ Calculations of YLDs were made using Microsoft Office Excel 2010 (Microsoft Corp., Redmond, WA).

The potential impact fraction (PIF) was estimated based on the environmental framework of comparative risk assessment (CRA), developed by the WHO for the percentage of burden of dysentery due to floods.²⁴ The formula for PIF was described as follows:

$$\text{PIF} = \frac{\left(\sum p_i \text{RR}_i - 1 \right)}{\sum p_i \text{RR}_i}$$

where p_i = proportion of the population in exposure category i and RR_i = relative risk at exposure category i compared with the reference level.

Finally, to calculate the attributable burden of dysentery due to floods, we used the equation as follows:

$$\text{Attributable YLDs} = \text{PIF} \times \text{YLDs}$$

RESULTS

Descriptive and correlation analysis. A total of 16,183 cases of dysentery were notified in the study area over non-flooded and flooded months from 2004 to 2010. The morbidity of dysentery had a mild secular trend and a distinct seasonal trend with most cases occurred during summer (Figure 2).

Spearman correlation analyses suggested that the monthly incidence of dysentery was positively correlated with floods ($r = 0.48$, lag = 0, $P < 0.05$), monthly flood duration ($r = 0.55$, lag = 0, $P < 0.05$), MCP ($r = 0.50$, lag = 0, $P < 0.05$), MAT ($r = 0.62$, lag = 0, $P < 0.05$), MARH ($r = 0.39$, lag = 0, $P < 0.05$), and MCSD ($r = 0.45$, lag = 1, $P < 0.05$) with relevant lag times from 0 to 1 month. However, the MAWV ($r = -0.47$, lag = 2, $P < 0.05$) was negatively correlated with the morbidity of dysentery with a lag time of 2 months.

Regression analysis. The parameters of the GAMM and RRs of floods for the risk of dysentery are presented in Table 1. Results showed that the morbidity of dysentery was significantly associated with both floods (coefficients = 0.364, $P < 0.001$) and flood duration (coefficients = 0.075, $P < 0.001$). After adjusting meteorological factors, the RR value for dysentery during flooded months was 1.44 (95% CI = 1.18–1.75). The GAMM suggested that a 1-day increase in flood duration was related to an extra 8% (RR = 1.08, 95% CI = 1.04–1.12) incidence of dysentery.

Analysis for attributable YLDs of dysentery. Figure 3A shows the burden of dysentery during flooded months among

FIGURE 2. Dynamics of dysentery with the analysis of generalized additive mixed model (GAMM) from 2004 to 2010. (A) Dynamics of dysentery for model 1 and (B) dynamics of dysentery for model 2.

TABLE 1

Parameters coefficients from the GAMM for the dysentery

Model	Variables	Coefficients	SE	P value	RR (95% CI)
Model 1*	Intercept	-10.64	0.12	< 0.001	—
	Floods	0.364	0.10	< 0.001	1.44 (1.18–1.75)
	Spring	0.05	0.15	0.7	—
	Summer	-0.06	0.22	0.79	—
	Autumn	0.14	0.16	0.39	—
	Winter†	—	—	—	—
Model 2*	Intercept	-10.63	0.12	< 0.001	—
	Duration	0.075	0.02	0.001	1.08 (1.04–1.12)
	Spring	0.05	0.16	0.72	—
	Summer	-0.09	0.23	0.68	—
	Autumn	0.13	0.17	0.45	—
	Winter†	—	—	—	—

CI = confidence interval; GAMM = generalized additive mixed model; RR = relative risk; SE = standard error.

*Adjusted R^2 was 0.912 for the model 1 and 0.905 for the model 2.

†The reference season.

males and females. The average annual YLD per 1,000 of dysentery during flooded months was 0.009 in persons, with a higher burden in males. The year with the highest YLD per 1,000 of dysentery during flooded months was 2006 in males (0.028) and 2005 in females (0.009). Figure 4A displays the average annual burden of dysentery during flooded months in males and females and among different age groups. The average YLD per 1,000 of dysentery was highest in children under the age of 4 years (0.117), followed by the group of 5–14 years of age (0.006). Since we considered the morbidity of dysentery during flooded months only, the proportion of population in the flooded category can be 100% ($p_i = 1$). On the basis of the estimates of RRs and the formula of PIF provided above, PIF of the study population exposed to floods alone was 0.306. Figure 3B shows attributable YLD per 1,000 of dysentery caused by floods in males and females. The average attributable YLD per 1,000 of dysentery caused by floods was 0.004 in males, 0.001 in females, and 0.003 in persons. Figure 4B shows the average annual attributable YLD per 1,000 of dysentery caused by floods in males and females and among different age groups. Result showed that children under 4 (0.036) and 5–14 years (0.002) of age carried more

attributable burden of dysentery due to floods than the other age groups.

DISCUSSION

Our study, for the first time, has quantified the risk and burden of dysentery due to floods in Nanning. The results indicate that floods play an important role in the epidemic of dysentery during the flooded months after controlling related meteorological factors and seasonal trend. Children aged 0–4 and 5–14 years were the most vulnerable groups of dysentery. Since our study was only based in Nanning City, the real impact of floods on dysentery will be much larger than the estimates from this study, given the larger population at risk in China.

An increased risk of diarrheal disease after floods has been reported in other countries. After severe flooding occurred in the midwestern United States in 2001, an increase in the incidence of gastrointestinal symptoms during the flood was observed (incidence rate ratio = 1.29, 95% CI = 1.06, 1.58).²⁵ A German study also showed that the major risk factor for diarrhea was contacting with floodwater (odds ratio = 5.8, 95% CI = 1.3–25.1).²⁶ Similar findings have been reported in our study. The results of the multivariate models shows that after the adjustment of meteorological factors and seasonal trend, floods could be an independent risk factor for dysentery, and the risk of dysentery could be higher from a prolonged flooding than that from a shorter one. Suitable temperature and rainfall during flood period are conducive to the breeding of germs and propagation. Several studies showed that pollution of drinking water has been associated with water-borne disease outbreaks, such as dysentery, cholera, hepatitis A, typhoid fever, and other gastrointestinal diseases after floods.^{27,28} Dysentery as a water-borne disease is caused by ingestion of water contaminated by human or animal feces that contain *Shigella* or the protozoan parasite *E. histolytica*.²⁹ A study from Pakistan showed that 20% of the drinking water samples collected during flood periods were contaminated with *Shigella*, *Vibrio cholerae*, *Salmonella*, *Staphylococcus aureus*, and others, which means the risk of outbreaks may increase

FIGURE 3. The year lived with disability (YLD) per 1,000 (A) and attributable YLD per 1,000 (B) of dysentery during flooded months among different genders and flood periods.

FIGURE 4. The year average year lived with disability (YLD) per 1,000 (A) and attributable YLD per 1,000 (B) of dysentery during flooded months among different genders and age groups.

because drinking water can be easily contaminated by pathogens during flood periods.³⁰

Our study has identified that attributable burden of dysentery due to floods could be more severe in males than in females. In addition, we found that children aged 0–4 and 5–14 years were vulnerable groups of dysentery, especially 0–4 years old boys. It is not clear whether the difference between genders was caused by different behaviors to floods response. A possible explanation is that males participated in more relief work and engaged more frequently than females, leading to a higher exposure for males in the flood period. The reason for a high burden of dysentery in children cannot be identified from our study. This may be because that young children have more contact with infected floodwater because of exposure during play and lack of attention to hygienic practices during floods. Skin contact with floodwater is a risk factor for diarrhea, this effect was pronounced in children.²⁵ These may bring more burden of dysentery to young children than others, which suggest that children, as vulnerable groups, must be paid more attention during floods. The reason why the burden is higher in boys than girls is not clear. The attributable burden of dysentery due to floods has been lower in recent years, which may be due to the rapid development of social economy and improvement of the public health facilities in China. However, compared with developed countries, the burden of dysentery due to floods in China is still a serious public health problem, which warned us that much more work should be done to prevent dysentery.

Some limitations of our study should be acknowledged. First, few factors that can affect transmission of dysentery such as the variability of pathogen, the mobility of population, changes of behavior and lifestyle, and different immune levels could not be included in our analysis. Second, underreporting bias is inevitable for diarrheal disease. Most notified cases were those with severe symptoms, who chose to visit doctors in a hospital.³¹ Some people with mild clinical symptoms and self-treated cases might not seek medical help. This could lead to an underestimation of the burden of dysentery due to floods. Finally, we could only obtain monthly data from the NDSS. It would be better if daily data or weekly data were used to evaluate the association between floods and dysentery.

In conclusion, our study indicates that floods can significantly increase the risk of dysentery in the study area. Prolonged floods may bring a higher risk of dysentery than

floods with a shorter period. Vulnerable groups, such as children and males should be paid more attention in public health responses to floods. Our findings have also significant implications for developing local strategies to prevent and reduce health impact of floods, given more extreme floods may occur in the future.

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REFERENCES

1. Guha-Sapir D, Vos F, Below R, Ponslerre S, 2011. *Annual Disaster Statistical Review 2010: The Numbers and Trends*. Brussels, Belgium: CRED. Available at: http://www.cred.be/sites/default/files/ADSR_2010.pdf. Accessed December 4, 2014.
2. Parry ML, 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom: Cambridge University Press.
3. Chen RD, Li L, 2004. Review and expectation of flood control and drought relief in Guangxi [in Chinese]. *Guangxi Water Resour Hydropower Engin S2*: 59–61.
4. China Meteorological Administration, 2004–2010. *The Yearbook of Meteorological Disasters in China* [in Chinese]. Beijing, China: China Meteorological Press.

5. Xiao HX, Qi S, Li SY, Wang ZY, Wang JX, Zhang GF, 2011. Evaluation of economic losses of flood disaster in Guangxi Zhuang Autonomous [in Chinese]. *Region Bull Soil Water Conserv* 31: 233–236.
6. Alderman K, Turner LR, Tong S, 2012. Floods and human health: a systematic review. *Environ Int* 47: 37–47.
7. Kosek M, Bern C, Guerrant RL, 2003. The global burden of diarrheal disease, as estimated from studies published between 1992 and 2000. *Bull World Health Organ* 81: 197–204.
8. Data center for Public Health, 2010. *National Notifiable Infectious Disease Database* [in Chinese]. Available at: http://www.phscience.data.cn/Share/ky_sjml.jsp. Accessed December 4, 2014.
9. Sultana F, 2010. Living in hazardous waterscapes: gendered vulnerabilities and experiences of floods and disasters. *Environ Hazards* 1: 43–53.
10. Ni W, Ding G, Li Y, Li H, Liu Q, Jiang B, 2014. Effects of the floods on dysentery in north central region of Henan Province, China from 2004 to 2009. *J Infect* 69: 430–439.
11. Kondo H, Seo N, Yasuda T, Hashizume M, Koido Y, Ninomiya N, Yamamoto Y, 2002. Post-flood-infectious diseases in Mozambique. *Prehosp Disaster Med* 17: 126–133.
12. Milojevic A, Armstrong B, Hashizume M, McAllister K, Faruque A, Yunus M, Kim SP, Moji K, Wilkinson P, 2012. Health effects of flooding in rural Bangladesh. *Epidemiology* 23: 107–115.
13. Liu D, Gao A, Tang G, Yang W, 2003. Study of the relationship between the onset of peptic ulcers and meteorological factors. *Chin Med J (Engl)* 116: 1940–1942.
14. State Bureau of Technical Supervision of China, 1995. *GB 16002-1995: Diagnostic Criteria and Principles of Management of Bacillary and Amebic Dysentery* [in Chinese]. Ministry of Health of the People's Republic of China. Beijing, China: Standards Press.
15. Ministry of Health of the People's Republic of China, 2006. *Emergency Events and Regulation of the Notifiable Disease Surveillance System* [in Chinese]. Available at: <http://www.moh.gov.cn/mohzcfgs/pgz/200901/38689.shtml>. Accessed December 4, 2014.
16. Wu XL, Fu ZZ, Deng GH, Zhou JY, 2013. Analysis on the operational status of Direct Network Report system for infectious diseases. *Applied Prev Med* 1: 26–28.
17. Kudaka J, Horikawa K, Uryu K, Matsuyuki S, Ogata K, Kawano K, Yamaguchi Y, Yamasaki S, Watanabe H, Iwanaga M, 2005. Symptoms of food-borne diseases and gastroenteritis in Kyushu, Japan. *Kansenshogaku Zasshi* 79: 864–870.
18. Wood SN, 2004. Stable and efficient multiple smoothing parameter estimation for generalized additive models. *J Am Stat Assoc* 99: 467.
19. Zhang Y, Peng L, Kan H, Xu J, Chen R, Liu Y, Wang W, 2014. Effects of meteorological factors on daily hospital admissions for asthma in adults: a time-series analysis. *PLoS One* 9: e102475.
20. Gao L, Zhang Y, Ding G, Liu Q, Zhou M, Li X, Jiang B, 2014. Meteorological variables and bacillary dysentery cases in Changsha City, China. *Am J Trop Med Hyg* 90: 697–704.
21. Chou WC, Wu JL, Wang YC, Huang H, Sung FC, Chuang CY, 2010. Modeling the impact of climate variability on diarrhea-associated diseases in Taiwan (1996–2007). *Sci Total Environ* 409: 43–51.
22. An QY, Wu J, Wang XL, Fan XS, Yao W, 2012. Association of climate change and time distribution of intestinal infectious diseases in Dalian, China [in Chinese]. *Chin Prev Med* 13: 288–291.
23. Mathers CD, Vos T, Lopez AD, Salomon J, Ezzati M (eds.), 2001. *National Burden of Disease Studies: A Practical Guide. Edition 2.0. Global Program on Evidence for Health Policy*. Geneva, Switzerland: World Health Organization. Available at: <http://www.who.int/entity/healthinfo/nationalburdenofdiseasemanual.pdf>. Accessed December 4, 2014.
24. Prüss-Ustün A, Mathers C, Corvalán C, Woodward A, 2003. *Introduction and Methods: Assessing the Environmental Burden of Disease at National and Local Levels*. WHO Environmental Burden of Disease Series, No. 1. Geneva, Switzerland: World Health Organization. Available at: http://www.who.int/quantifying_ehimpacts/publications/en/9241546204.pdf. Accessed December 4, 2014.
25. Wade TJ, Sandhu SK, Levy D, Lee S, LeChevallier MW, Katz L, Colford JJ, 2004. Did a severe flood in the Midwest cause an increase in the incidence of gastrointestinal symptoms? *Am J Epidemiol* 159: 398–405.
26. Schnitzler J, Benzler J, Altmann D, Mucke I, Krause G, 2007. Survey on the population's needs and the public health response during floods in Germany 2002. *J Public Health Manag Pract* 13: 461–464.
27. McMichael AJ, Woodruff RE, Hales S, 2006. Climate change and human health: present and future risks. *Lancet* 367: 859–869.
28. Patz JA, Vavrus SJ, Uejio CK, McLellan SL, 2008. Climate change and waterborne disease risk in the Great Lakes region of the U.S. *Am J Prev Med* 35: 451–458.
29. Cabral JP, 2010. Water microbiology. Bacterial pathogens and water. *Int J Environ Res Public Health* 7: 3657–3703.
30. Farhat AK, Javed A, Riaz U, Sultan A, 2013. Bacteriological quality assessment of drinking water available at the flood affected areas of Peshawar. *Toxicol Environ Chem* 95: 1448–1454.
31. Yan W, Xu Y, Yang X, Zhou Y, 2010. A hybrid model for short-term bacillary dysentery prediction in Yichang City, China. *Jpn J Infect Dis* 63: 264–270.