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RISK ASSESSMENT OF DIARRHOEAL DISEASE USING A GEOGRAPHIC INFORMATION SYSTEM (GIS) AT THE DISTRICT LEVEL OF SAMUT SONGKHRAM PROVINCE, THAILAND

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ABSTRACT

This study aims to investigate factors related to diarrheal disease occurrence in Samut Songkhram Province and create a spatial model to assess the level of diarrhoea risk at the district level of Samut Songkhram Province, including Muang Samut Songkhram, Amphawa and Bang Khonthi. Ten factors, including land use, population density, number of food establishments, standardized markets, hygienic toilets, volume of waste, water quality, temperature, relative humidity and rainfall were used to study their relationship with cases of diarrhoea. The results of the analysis determined four factors associated with diarrhoea, including land use, standardized markets, volume of waste and water quality ($p \leq 0.05$). Meanwhile, assessment of diarrhoea risk levels employing GIS established that Muang Samut Songkhram had the highest risk followed by Amphawa and Bang Khonthi, respectively. This information is important for planning and controlling diarrhoeal disease in Samut Songkhram Province, Thailand.

Keywords: Risk assessment, Geographic Information System, diarrhoeal disease.

INTRODUCTION

Diarrhoeal disease is a critical public health problem in developing countries, a leading cause of child mortality and morbidity across the world (Boschi-Pinto et al., 2008), especially children under five years of age - there are approximately 1.7 bill-ion cases in and 525,000 deaths of children globally (World Health Organization, 2017). Diarrhoea is defined by the World Health Organization as the passage of three or more loose or liquid stools per day or more frequent passage than is normal for an individual (World Health Organiza-tion, 2017). The mechanisms underlying diarrhoea involve decreased absorption of water or increased water secretion in the intestines, most often caused by pathogenic microorganisms, including viruses, bacteria and parasites from contaminated food and water sources (Roman et al., 2017). In Thailand, diarrheal disease is one of most major public health problems, being a major cause of illness and death among young children. In 2017, there were a total of 1,019,001 diarrheal cases and four deaths from diarrhoea were reported. These data indicate that diarrhoea is a problem in Thailand that should be addressed urgently (Ministry of Public Health, 2017).

Samut Songkhram is a small province located in the lower central region of the country. This province is at the mouth of the Mae Klong River towards the Gulf of Thailand. In addition, Samut Songkhram Province is also an epidemic area of diarrhoea (Ministry of Public Health, 2017). Disease situation information in the epidemiological surveillance network of Samut Songkhram Province in 2017 reported that 5,199 diarrhoea cases were found, representing morbidity at 2,676.97 per one hundred thousand population (Ministry of Public Health, 2017). The district in Samut Songkhram Province with the highest rate of illness per hundred thousand people is Mueang Samut Songkhram, followed by Amphawa and Bang Khonthi, respectively. For the operation, Samut Songkhram Provincial Health Office has always been able to monitor and control, but the issue of diarrhoea has not been eliminated because there are many factors associated with the disease.

Currently, technology is used to help analyse and evaluate the health information of the area, including Geographic Information System (GIS) applications, which have features that can create models and present them in a clear and highly accurate map format (Richards et al., 1999; Rushton, 2003; Naves et al., 2015; Muthukumar et al.,2017). For public health context, GIS have been applied in many works, including analysis of spatial distribution patterns of pathogens, prediction of disease outbreaks, disease risk assessment, disease surveillance planning and information dissemination to populations (Nykiforuk and Flaman, 2011; Christaki, 2015). However, there is much research that use GIS to analyse and make risk assessments of the occurrence of diseases, such as dengue haemorrhagic fever risk assessment in Samut Songkhram Province (Chaiphongpachara et al., 2017), and exploring spatial patterns and hotspots of diarrhoea in Chiang Mai Province (Chaikaew et al., 2009), and the results of these studies suggest it possible to apply this technique to measure the risk of diarrhoea in Samut Songkhram Province.

Therefore, with the goal of more effectively monitoring and controlling diarrhoea in Samut Songkhram Province, this research adopted GIS to assess

the risk of diarrhoea using factors associated with diarrhoea in a database and creating a district-level risk model for determining surveillance and disease control, intended to lead to a reduction in the number of diarrhoea patients in Samut Songkhram Province further.

MATERIALS AND METHODS

This research assessed factors related to diarrhoea in Samut Songkhram Province. Afterwards, these data were utilised to create a spatial model to assess diarrhoea risk at the district level of Samut Songkhram Province, including the Muang Samut Songkhram, Amphawa and Bang Khonthi districts.

Data collection: In this research, secondary data in 2017 was employed for analysis to evaluate risk using GIS. Information related to the existence of diarrhoea was collected from government agencies and other relevant sources. Spatial data on Provinces, District and Village positions, as well as on rivers and roads of Samut Songkhram Province was collected from the Department of Provincial Administration. Datasets contained the number of diarrhoea cases, density of food establishments, sanitation, including standardized markets, hygienic toilets, volume of waste and water quality was collected from Samut Songkhram Provincial Health Office. Population density data was gathered from the Office of the Registrar of Samut Songkhram Province. Environmental data (land use data) was obtained from Samut Songkhram Provincial Natural Resources and Environment Office. Finally, climate data, including rainfall, temperature and relative humidity, was collected from the Samut Songkhram Provincial Meteorological Department.

Research ethics: This study has been exempted from human ethics approval because it is not related to humans according to Suan Sunandha Rajabhat University, Thailand. The certificate number of the exemption in the consideration of research ethics was COE. 1-088/2018.

Analysis of factors related to diarrhoea: This study selected 10 factors, including land use, population density, number of food establishments, standardized markets, hygienic toilets, volume of waste, water quality, temperature, relative humidity and rainfall, to investigate their relationship with cases of diarrhoea. After that, Pearson's correlations coefficient at ≤ 0.05 level of significance was applied to analyse factors related to diarrhoea. Ten factors were assessed in relation to the number of patients with SPSS program version 20.

Building a spatial model for assessing diarrhoea risk: After analysing the factors associated with diarrhoea, the QGIS program was used to build a spatial model for assessing diarrhoea risk, which is freely available at https://www.qgis.org/en/site/forusers/download.html. A spatial model of diarrhoea risk assessment in each district of Samut Songkhram was created based on overlay analysis. Data on each related factor was scored by five specialists on a scale ranging from 1-5. The total score calculation to analyse the data and assess the level of risk of diarrhoea was according to the following.

$S = W_1R_1 + W_2R_2 + \ldots W_nR_n$.

S is the total score of factors that were related to diarrhoea in Samut Songkhram Province.

$W_1 \ldots n$ is the weighted score of factors 1to n.

R_1 ... n is the score of factors 1to n.

The division of the diarrhoea risk level of this area is considered from the total score in each district of Samut Songkhram Province. In this study, risk of diarrhoeal disease is divided into four levels according to quartile methods. High risk levels have a range of 120 - 159 scores, which are shown in red. Moderate risk levels have a range of 80 – 119 scores, which are shown in orange. Low risk levels have a range of 40 – 79 scores, which are shown in yellow. Very low risk levels have a range of 1 – 39 scores, which are shown in green.

RESULTS

Factors associated with diarrhoea: Ten factors, including land use, population density, number of food establishments, standardized markets, hygienic toilets, volume of waste, water quality, temperature, relative humidity and rainfall, were used to analyse statistical relationships between them and diarrhoea. The results of the analysis found four factors specifically associated, with diarrhoea including land use, standardized markets, volume of waste and water quality ($p \leq 0.05$, Table 1).

Table 1: Correlation coefficients between number of diarrhoea cases and selected factors.

Factors	R	*p*-value	correlation
Land use	.997*	.046	positive
Standardized markets	-.999*	.032	negative
Volume of waste	.997*	.050	positive
Water quality	-.997*	.048	negative
Population density	.768	.443	-
Number of food establishments	.952	.197	-
Hygienic toilets	-.983	.117	-
Temperature	-.682	.522	-
Relative humidity	.415	.728	-
Rainfall	.094	.940	-

**p-value ≤ 0.05.

A spatial model for assessing diarrhoea risk: Scores of the four factors associated with diarrhoea were calculated by five specialists to create a spatial model for assessing diarrhoea risk using overlay analysis of GIS. Scores of the four factors are listed in Table 2. Afterwards, a spatial model for assessing diarrhoea risk was found in Figure 1. The diarrhoea risk level from the GIS analysis in each district found that Muang Samut Songkhram had the highest risk, namely a high-risk level, followed Amphawa as moderate risk and Bang Khonthi as low risk (Figure 1). Meanwhile, risk of diarrhoea at the village level is portrayed in Figure 2. In Samut Songkhram Province, there were 87 villages in high-risk areas, 96 villages in moderate-risk areas and 101 villages in low-risk areas (Table 3).

Table 2: Determining scores of related factors for risk assessment of diarrhoea in Samut Songkhram Province, Thailand.

Related factors	Class interval	Weighted score	Score	Total score
Land use	91 – 140 houses/km^2	3	1	3
	141 – 190 houses/km^2	3	2	6
	191 – 240 houses/km^2	3	3	9
Standardized markets	7 – 10 %	4	1	4
	11 – 14 %	4	2	8
	15 – 18 %	4	3	12
Water quality	1 – 6 %	4	3	12
	7 – 12 %	4	2	8
	13 – 18 %	4	1	4
Volume of waste	7,615 – 15,606 ton/year	5	1	5
	15,607 – 23,598 ton/year	5	2	10
	23,599 – 31,590 ton/year	5	3	15

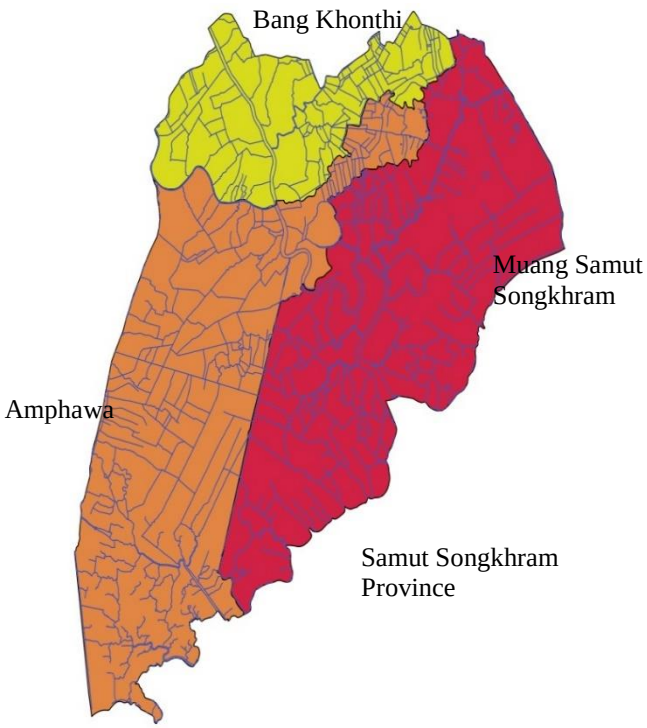

Figure 1: A district-level risk model for assessing the risk of diarrhoea in Samut Songkhram Province, Thailand (red = high risk level, orange = moderate risk level and yellow = low risk level).

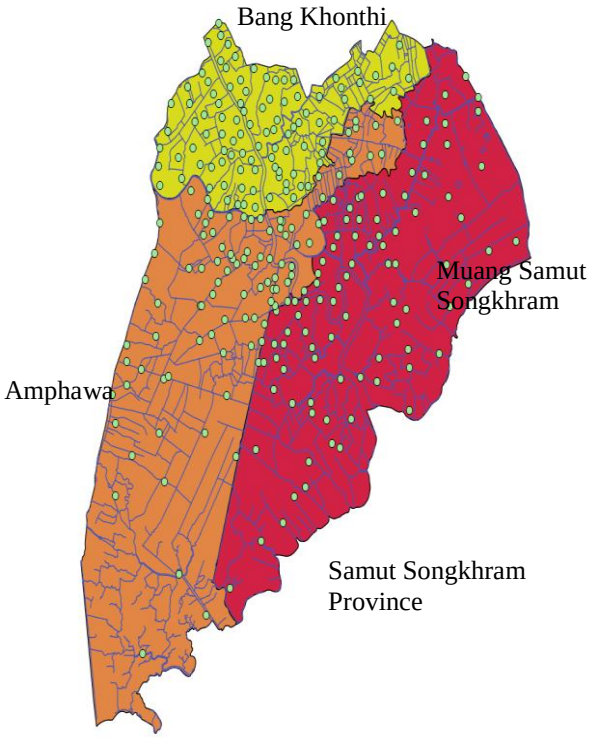

Figure 2: Distribution of villages in Samut Songkhram Province, Thailand.

Table 3: Risk of diarrhoea at the village level.

Degree of risk	District name	Numbers of villages	Percentage of villages
High risk	Muang Samut Songkhram	87	30.63
Moderate risk	Amphawa	96	33.80
Low risk	Bang Khonthi	101	35.56

DISCUSSION

This study sought to investigate factors related to diarrheal disease occurrence in Samut Songkhram Province, Thailand and create a spatial model to assess the level of diarrhoea risk at the district level in Samut Songkhram Province, including the Muang Samut Songkhram, Amphawa and Bang Khonthi regions. Four factors in this study were found to be associated with diarrhoea, including land use, standardized markets, volume of waste and water quality.

Land use is an important environmental factor which in areas with different environmental conditions can influence the diarrhoea's occurrence. An important example is the density of flies as vectors of diarrheal disease in each area that differs according to the environment. Previous research has studied environmental factors associated with high densities and diarrhoea in Vellore, India, finding that risks of diarrhoea and duration of diarrhoea are associated with fly density (Collinet-Adler et al., 2015). Meanwhile, standardized markets, volume of waste and water quality are factors that are indicators of sanitation in each area, whereby a negative direction of these factors can affect the occurrence of diarrhoea at the individual level. Usually, diarrhoea is a foodborne disease and therefore is related to sanitation (Cairncross et al., 2010). These results were consistent with previous research that study hygiene and sanitation risk factors of diarrhoeal disease among under-five-years-of-age children in Ibadan, Nigeria (Oloruntoba et al., 2014).

Assessment of diarrhoea risk levels using GIS found that Muang Samut Songkhram Province has the highest risk followed by Amphawa and Bang Khonthi, respectively. The results of a spatial model for assessing diarrhoea risk were consistent with the number cases of diarrhoeal disease in 2017, of which Muang Samut Songkhram had the highest number of cases followed by the Amphawa and Bang Khonthi regions, respectively. This research also revealed that GIS is an effective tool for assessing the risk of diarrhoeal disease at the district level of Samut Songkhram Province, Thailand. Along with the findings of previous research, this tool was used for assessing diarrhoea risk in other areas and was successful for evaluating diarrhoeal disease, such as a spatial-temporal comprehensive analysis in India (Nilima et al., 2018), risk analysis in Nigeria (Njemanze et al., 1999) and analysis of spatial distribution in the Tshikuwi Community in Venda, South Africa (Bessong et al., 2009).

Conclusion

GIS is an effective tool for assessing the risk of diarrhoea. The results of this study found that the Muang Samut Songkhram district has the highest risk followed by Amphawa and Bang Khonthi, respectively. This information is important for planing and controlling diarrhoeal disease in Samut Songkhram Province, Thailand.

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