Risk Areas of Liver Flukes in Surin Province of Thailand using Geographic Information System

Ratana Rujirakul MEd*, Naporn Ueng-arporn MD*,
Soraya J. Kaewpitoon MD*, Ryan A. Loyd MD*,
Sarochinee Kaewthani MSc**, Natthawut Kaewpitoon PhD*,***

** Parasitic Infectious Disease Unit, Institute of Medicine, Suranaree University of Technology, Nakhon Ratchasima, Thailand*
*** Faculty of Science and Technology, Nakhon Ratchasima Rajabhat University, Nakhon Ratchasima, Thailand*
**** Faculty of Public Health, Vongchavalitkul University, Nakhon Ratchasima, Thailand*

Background: *Opisthorchiasis, caused by Opisthorchis viverrini, is of considerable public health importance in Southeast Asia, particularly in Lao PDR and Thailand.*
Objective: *This study aims to analyze the risk areas for liver flukes in Surin province, Thailand using Geographic Information Systems (GIS).*
Material and Method: *The 5 main factors (131 variables) were: (1) personal data (2) knowledge, attitude and practice, (3) health service unit, (4) environmental data, and (5) climate data. The relationship between these main factors and liver fluke infection was analyzed using multiple regression analysis. Potential surface analysis (PSA) with geographic information systems (GIS) was performed to create maps displaying areas at risk for liver fluke infection in Surin province.*
Results: *The population density (148-169 pop/km^2; X_{73}), human attitude (<50%; X_{111}), and land use (wetland; X_{64}), were statistically significant with liver fluke infection by a percentage of 88.60% (Adjusted R^2 = 0.886). The heavy risk areas covered 221.39 km^2 and including 8 districts; Si Narong, Sangkha, Phnom Dong Rak, Mueang Surin, Non Narai, Samrong Thap, Chumphon Buri and Rattanaburi.*
Conclusion: *Present study identifies the increased risk areas for liver flukes in Surin Province and may be useful for future planning of prevention and control.*

Keywords: *Risk areas, Liver fluke, Surin province, Thailand, Geographic information system*

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Opisthorchiasis, caused by *Opisthorchis viverrini*, is of considerable public health importance in Southeast Asia, particularly in Lao PDR and Thailand[1]. In Thailand, the first nationwide survey of the four regions of Thailand during the years of 1980-1981 revealed an overall prevalence of *O. viverrini* infection of 14%; the Northeast (34.6%), the Central (6.3%), the North (5.6%) and the South (0.01%) regions[2].

It is estimated that 6 million people are infected with *O. viverrini*[3]. Humans are infected by ingesting undercooked fish containing infective metacercariae; this is very common in the northeastern and northern regions, particularly in rural areas[4-7]. The infection is associated with a number of hepatobiliary diseases, including cholangitis, obstructive jaundice, hepatomegaly, cholecystitis and cholelithiasis[8,9]. Experimental and epidemiological evidence strongly implicates liver fluke infection in the etiology of cholangiocarcinoma (CCA) bile duct cancer[10-12]. Therefore, the present study aims to analyze the risk areas of liver fluke in Surin province, Thailand using Geographic Information Systems (GIS).

Correspondence to:
Kaewpitoon N, Faculty of Public Health, Vongchavalitkul University, Nakhon Ratchasima 30000, Thailand.
Phone: +66-44-223998
E-mail: natthawut.k@hotmail.com, natthawut_kae@vu.ac.th

Material and Method

The study protocol was approved by Suranaree University Biotechnological Review Committee (2012).

Study site

Surin province, with a total area about 8,124 km^2 (3,137 sq mi), is in northeast Thailand between the Mun River in the north and the Dongrek Mountain

chain in the south. Originally, it was named Khu Prathai Village by the governor of the city, Luang Surin Phakdi, and was an old city of the ancient Cambodia 200 years ago. It is 450 kilometers from Bangkok by road and 420 kilometers by train. The province is subdivided into 17 districts (amphoe). The districts are further subdivided into 158 subdistricts (tambon) and 2,120 villages (muban), 441,922 houses, and 1,381,761 people (691,425 males and 690,226 females)[13].

Study design and data collection

Descriptive and analytical studies were performed in this study. Data were collected from 2012 and 2013 including:

1) Personal data, knowledge, attitudes, and behaviors were collected by constructed questionnaire.

2) Liver fluke cases were determined from 680 samples (40 samples per district) using Kato's thick smear technique.

3) Health service unit information was collected from the Surin provincial public health office, Ministry of Public Health, Thailand.

4) Geographic data were collected from the administrative organization of Surin Province, Thailand.

5) Satellite data were collected from Geo-Informatics and Space Technology Development Agency (Public Organization), Thailand.

Potential surface analysis

Of the five main factors (131 variables) were: (1) personal data; sex, age, and occupation, (2) knowledge, attitudes, and behavior about liver fluke infection (3) health service unit, (4) environmental data; population density, land used (agriculture areas, number of houses, water reservoirs, forest areas), (5) climate data; average annual rainfall, average annual temperature, and average annual relative humidity, were used to analyze and calculate the areas with ArcGIS 9.2. The factors were analyzed by rating value from the relevant research which divided into five levels from 1 (very low risk) to 5 (heavy risk). Stepwise multiple regression analysis was used for weighting analyzed the relationship between infection with five main factors. Following

$$Y = a+b_{73}X_{73}+b_{111}X_{111}+b_{81}X_{81}$$

$$Y = -0.155+0.004X_{73}+0.049X_{111}+0.010X_{81} \quad (1)$$

When,

Y = trend of *O. viverrini* infection

a = constant

b_{73} = coefficient of regression of X_{73}

X_{73} = population density 148-169 person/Km^2

b_{111} = coefficient of regression of X_{111}

X_{111} = attitude point <50%

b_{81} = coefficient of regression of X_{83}

X_{81} = rainfall level 248.80-517.84 ml

Results

Forty-six of the 680 samples were determined to be infected with *O. viverrini* (6.76%). The relationship between liver fluke to the five main factors was analyzed; three categories, population density (148-169 pop/km^2; X_{73}), human attitude (<50%; X_{111}), and land used (wetland; X_{64}), were statistically significance and influence to liver fluke infection (Adjusted R^2 = 0.886). This model could be predicted the *O. viverrini* infection by percentage of 88.60% (*p*-value <0.05) (Table 1). Surin province has a risk area covered 8,124 km^2 including 17 districts. The heavy risk areas covered 196.29 km^2 (2.22%) including 4 districts: Si Narong (0.92%), Sangkha (0.65%), Phnom Dong Rak (0.60%) and Samrong Thap (0.05%) (Fig. 1, Table 2, 3).

Discussion

O. viverrini is still a major public health problem in Thailand[1]. The infection is associated with cholangiocarcinoma[10-12]. Prevention and control are needed in order to decrease the morbidity and mortality of this disease. GIS was applied to potential surface analysis of risk areas for liver fluke infection in this

Table 1. The relationship between liver fluke infection with 65 variables in the 5 main factors in Surin province, Thailand

Variables	B	Std. error	β	t	*p*-value
Constant	-0.155	0.433		-0.359	0.726
X73: population density	0.004	0.002	0.296	2.689*	0.019
X111: human attitude	0.049	0.008	0.683	6.436*	0.001
X81: land use (wet land)	0.010	0.002	0.414	4.281*	0.001

R square = 0.907, Adjust R square = 0.886, Std. error of the estimate = 1.46528

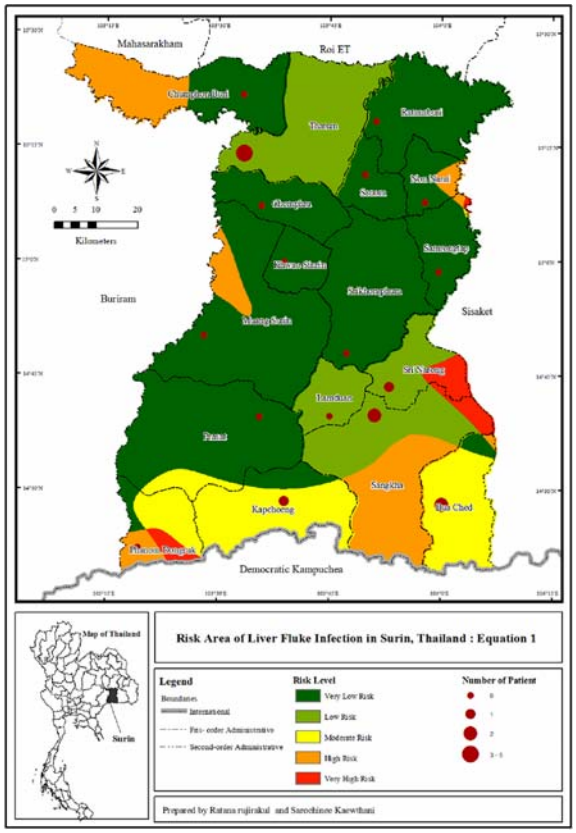

Fig. 1 Map of risk areas of liver fluke in Surin province, Thailand.

present study. Three factors were identified as being statistically related to liver fluke infection. The present study is the first to report that population density is statistically related to liver fluke infection. These data are surprising; however, it may be suggested that people who live in the same community, culture, socio-economic stratum, etc. have an increased chance to consume the raw fish containing liver flukes. Human attitudes were related to liver fluke infection in this study; this is similar to other published research that showed a high risk of infection in people who had risky behavior and attitudes, mainly frequently eating raw cyprenoid fish in endemic areas[6,7,15-17]. Previous studies have indicated that wetlands are endemic areas for liver flukes in the northeastern and northern regions of Thailand. Wetlands are an appropriately ecosystem for the life cycle of liver flukes, especially since they have a high population of Bithynia snails (the 1st intermediate

Table 2. Risk areas of liver fluke in Surin province, Thailand

Level of risk areas	Areas (km^2)	%
Very low risk	4,833.66	54.64
Low risk	1,607.83	18.17
Moderate risk	1,169.73	13.22
High risk	1,039.37	11.75
Heavy risk	196.29	2.22

Table 3. Distribution of risk areas of liver fluke in Surin province, Thailand, by district

District	Very low risk (%)	Low risk (%)	Moderate risk (%)	High risk (%)	Heavy risk (%)	Total
1) Si Narong	0.00	2.60	0.00	0.00	0.92	3.52
2) Sangkha	0.00	4.86	0.00	5.69	0.65	11.20
3) Phanom Dong Rak	0.42	0.00	1.80	0.84	0.60	3.66
4) Samrong Thap	3.01	0.00	0.02	0.06	0.05	3.15
5) Mueang Surin	11.25	0.00	0.00	1.14	0.00	12.39
6) Prasat	10.07	0.00	1.01	0.00	0.00	11.08
7) Sikhoraphum	8.25	0.00	0.00	0.00	0.00	8.26
8) Tha Tum	0.01	8.24	0.00	0.00	0.00	8.24
9) Chumphon Buri	3.91	0.00	0.00	3.49	0.00	7.41
10) Kap Choeng	0.99	0.00	5.47	0.01	0.00	6.47
11) Rattanaburi	6.46	0.00	0.00	0.00	0.00	6.47
12) Buachet	0.35	0.00	4.92	0.08	0.00	5.34
13) Chom Phra	3.73	0.00	0.00	0.00	0.00	3.73
14) Lamduan	0.00	2.46	0.00	0.00	0.00	2.47
15) Sanom	2.42	0.00	0.00	0.00	0.00	2.42
16) Non Narai	1.68	0.00	0.00	0.43	0.00	2.11
17) Khwao Sinarin	2.09	0.00	0.00	0.00	0.00	2.09
Total	54.64	18.17	13.22	11.75	2.22	100.00

host) and cyprenoid fish (the 2nd intermediate host of liver flukes)[1,6,7,18-20]. The present study is the first to determine the risk areas in Surin province, Thailand. The area of Surin Province that was risk stratified covered 17 districts and the heavy risk area covered eight districts including Srinarong, Sangkha, Phnom Dongruk, Mueang Surin, Non Narai, Samrongthab, Chumphon Buri, and Ratanaburi. These areas require campaigns to address health behaviors and attitudes. Moreover, people in these areas should be screened for cholangiocarcinoma.

Conclusion

The area of Surin Province that was risk-stratified covered 17 districts and the heavy risk area covered eight districts including Srinarong, Sangkha, Phnom Dongruk, Mueang Surin, Non Narai, Samrongthab, Chumphon Buri, and Ratanaburi. These areas require campaigns to address health behavior and attitudes. Moreover, people in these areas should be screened for cholangiocarcinoma. The present study identifies the increased risk areas for liver flukes in Surin Province and may be useful for future planning of prevention and control measures.

What is already known on this topic?

Previous studies have indicated that wetlands are endemic areas for liver flukes in the northeastern and northern regions of Thailand.

What this study adds?

The present study identifies the increased risk areas for liver flukes in Surin province and may useful for future planning of prevention and control measures.

Acknowledgement

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Potential conflicts of interest

None.

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พื้นที่เสี่ยงพยาธิใบไม้ตับโดยการประยุกต์ใช้ระบบสารสนเทศภูมิศาสตร์

รัตนา รุจิรกุล, นพร อึ้งอาภรณ์, สรญา แก้วพิทูลย์, สโรชินี แก้วธานี, ณัฏฐวุฒิ แก้วพิทูลย์

ภูมิหลัง: *พยาธิใบไม้ตับออร์พิสทอร์คิส วิเวอร์รินิ เป็นปัญหาทางสาธารณสุขที่สำคัญมากในเขตทวีปเอเชียตะวันออกเฉียงใต้ โดยเฉพาะประชาชนในประเทศสาธารณประชาธิปไตยประชาชนลาวและประเทศไทย*

วัตถุประสงค์: *เพื่อวิเคราะห์พื้นที่เสี่ยงต่อการติดเชื้อพยาธิใบไม้ตับในจังหวัดสุรินทร์ ประเทศไทย โดยการใช้ระบบสารสนเทศภูมิศาสตร์*

วัสดุและวิธีการ: *การศึกษานี้ได้นำ 5 ปัจจัยหลัก (131 ตัวแปร) ประกอบไปด้วย (1) ข้อมูลส่วนบุคคล (2) ความรู้ ทัศนคติ และการปฏิบัติตัว (3) สถานให้บริการด้านสุขภาพ (4) ข้อมูลด้านสิ่งแวดล้อมและ (5) ข้อมูลภูมิอากาศ การหาความสัมพันธ์ระหว่าง 5 ปัจจัยหลัก กับการติดเชื้อพยาธิใบไม้ตับโดยการวิเคราะห์ด้วยการวิเคราะห์ถดถอยพหุคูณแบบขั้นตอน การวิเคราะห์พื้นที่เสี่ยงด้วยการประยุกต์ใช้ระบบสารสนเทศภูมิศาสตร์เพื่อสร้างแผนที่เสี่ยงของพยาธิใบไม้ตับในจังหวัดสุรินทร์*

ผลการศึกษา: *ปัจจัยด้านความหนาแน่นของประชากร (148-169 pop/km^2; X_{73}), ทัศนคติ (<50%; X_{111}), และการใช้ประโยชน์ที่ดิน (พื้นที่ลุ่ม; X_{64}) มีความสัมพันธ์อย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05 โดยพบว่าสมการดังกล่าวสามารถทำนายผลการติดเชื้อพยาธิใบไม้ตับได้ร้อยละ 88.60 (Adjusted R^2 = 0.886) พื้นที่เสี่ยงสูงคลุมพื้นที่ 221.39 ตารางกิโลเมตร ประกอบด้วย 8 อำเภอ ดังนี้ ศรีณรงค์ สังขะ พนมดงรัก เมืองสุรินทร์ โนนนารายณ์ สำโรงทาบ ชุมพลบุรี และรัตนบุรี*

สรุป: *การศึกษานี้สามารถจำแนกพื้นที่เสี่ยงของพยาธิใบไม้ตับในจังหวัดสุรินทร์ อาจจะเกิดประโยชน์ในการนำข้อมูลไปใช้ในการวางแผนควบคุมและป้องกันโรคได้*