Association between Sanitary Toilet Coverage Rate and Intestinal Infectious Disease in Jiangsu Province, China

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ความสัมพันธ์ระหว่างอัตราความครอบคลุมของส้วมที่ถูกสุขลักษณะกับโรคติดเชื้อในลำไส้ในมลฑลเจียงซู ประเทศจีน

น.ส.ติง ติง เฉิน

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรมหาบัณฑิต
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โรคติดเชื้อในลำไส้ เป็นหนึ่งในกลุ่มโรคที่พบมากที่สุดในโลก และ ยังพบว่าเป็นโรคที่มีการรายงานบ่อยครั้งในมลฑลเจียงซู ประเทศจีน ซึ่งปัญหานี้อาจมาจากการใช้ส้วมที่ไม่ถูกสุขลักษณะ รัฐบาลจีนได้ออกประกาศโครงการปรับปรุงห้องน้ำของจีนมานานกว่าทศวรรษ โดยวัตถุประสงค์ของโครงการนี้คือ การปรับปรุงสุขอนามัยและส่งเสริมสุขภาพของประชาชน อย่างไรก็ตาม การศึกษาเรื่องการประเมินผลของการปรับปรุงห้องน้ำและอุบัติการณ์ของโรคติดเชื้อในลำไส้ยังมีอยู่อย่างจำกัด การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาความสัมพันธ์ระหว่างการเพิ่มขึ้นของห้องน้ำที่ถูกสุขลักษณะกับอุบัติการณ์โรคติดเชื้อในลำไส้ ในมลฑลเจียงซู ประเทศจีน การศึกษานี้ใช้รูปแบบการศึกษาแบบนิเวศวิทยา โดยใช้มลฑลเจียงซู และ อีก 13 เมืองในมลฑล เป็นหน่วยในการวิเคราะห์ข้อมูล อัตราการครอบคลุมของส้วมและอุบัติการณ์โรคติดเชื้อในลำไส้ระหว่างปี ค.ศ. 2011 ถึง 2019 ได้รับจากคณะกรรมการสุขภาพแห่งชาติ และ มลฑลเขียงซู ซึ่งได้รับอนุญาตให้ใช้ข้อมูลทุติยภูมิอย่างถูกต้อง ข้อมูลด้านสิ่งแวดล้อมอื่น ๆ เช่น อุณหภูมิและปริมาณน้ำฝน ได้รับจากสำนักทรัพยากรน้ำและสำนักงานสถิติ ในการศึกษานี้ ใช้การวิเคราะห์เชิงพรรณเพื่ออธิบายการกระจายตัวความครอบคลุมของส้วมและอุบัติการณ์โรคติดเชื้อในลำไส้ และใช้การวิเคราะห์ถดถอยเชิงเส้นพหุคูณเพื่อศึกษาความสัมพันธ์ของอัตราการครอบคลุมของส้วมและโรคติดเชื้อในลำไส้ จากปี ค.ศ. 2011 ถึง 2019 พบว่า อุบัติการณ์ของโรคติดเชื้อที่ต้องควบคุมเข้มงวด ชนิด A (อหิวาตกโรค) และ B (ไวรัสตับอีกเสบ A, E และไวรัสตับอักเสบ ไม่ระบุชนิด โรคบิดจากแบคทีเรีย และอมีบา ไทฟอยด์และพาราไทฟอยด์) มีแนวโน้มลดลง จาก 20.05/100,000 เป็น 8.08/100,000 ราย มีไวรัสตับอักเสบและโรคบิดเป็นโรคหลัก โรคติดเชื้อในลำไส้ชนิด C (โรคท้องร่วงจากการติดเชื้ออื่น และ โรค มือ เท้า ปาก) มีสัดส่วนมากกว่า 90% ของโรคติดเชื้อทั้งหมด และโรคท้องร่วงจากการติดเชื้ออื่น มีแนวโน้มเพิ่มขึ้นทุกปี ในขณะที่โรค มือ เท้า ปาก มีการเพิ่มขึ้นสลับกับลดลง ปีเว้นปี ตลอดระยะการศึกษาพบว่า จำนวนครัวเรือนที่ใช้ส้วมที่ถูกสุขลักษณะสะสมในมลฑลเจียงซู โดยเฉพาะ ห้องส้วมชนิดที่ไม่เป็นอันตราย มีเพิ่มขึ้นทุกปี เมื่อพิจารณาคุณภาพน้ำผิวดินและค่าเฉลี่ยอุณหภูมิรายปีพบว่ามีค่าสูงขึ้นทุกปี ในขณะที่ตัวแปรอื่น เช่น ความชุกของสัตว์พาหะ ปริมาณฝน อุณหภูมิสูงสุดและต่ำสุด มีการเปลี่ยนแปลงค่อนข้างน้อย เมื่อพิจารณาผลของสมการถดถอยเชิงเส้นพบว่าจำนวนครัวเรือนสะสมที่ใช้ส้วมที่ถูกสุขลักษณะ (ส้วมที่ถูกสุขลักษณะ ส้วมที่ไม่เป็นอันตราย ส้วมสาธารณะที่ถูกสุขลักษณะ) คุณภาพน้ำผิวดิน และค่าเฉลี่ยอุณหภูมิรายปี มีความสัมพันธ์กับอุบัติการณ์โรคติดเชื้อในลำไส้ โดยที่ผลรวมอุบัติการณ์ของโรคติดเชื้อในลำไส้ชนิด A และ B ท้องร่วงจากไวรัส ล้วนแต่มีความสัมพันธ์เชิงลบกับปริมาณส้วมที่ถูกสุขลักษณะทั้ง 3 ชนิด คุณภาพน้ำผิวดิน และค่าเฉลี่ยอุณหภูมิรายปี มีความสัมพันธ์เชิงลบกับโรคติดเชื้อในลำไส้ชนิด A และ B ในขณะที่ความสัมพันธ์กับโรคท้องร่วงอื่นของชนิด C นั้นตรงกันข้าม เมื่อพิจารณาในระดับเมือง พบว่า แต่ละปัจจัยล้วนมีผลเกี่ยวข้องกับโรค หากแต่ผลแต่ละเมืองนั้นไม่สอดคล้องกัน เมื่อพิจารณาจากผลของสมการสมการถดถอยเชิงเส้นตรงพหุคูณ พบว่า อุบัติการณ์ของโรคติดเชื้อในลำไส้ชนิด A และ B มีความสัมพันธ์เชิงลบอย่างมนัยสำคัญกับจำนวนการใช้ส้วมสะสมของครัวเรือน (β = -0.036) และคุณภาพน้ำผิวดิน (β = -0.135) ที่ระดับความเชื่อมั่น $p < 0.05$ เมื่อพิจารณาในแต่ละเมือง พบว่าอุณหภูมิเฉลี่ยของแต่ละเมืองเมีความสัมพันธ์เชิงลบกับอุบัติการณ์ของโรคติดเชื้อในลำไส้ชนิด A และ B การศึกษานี้ได้แสดงให้เห็นว่านโยบายการปรับปรุงห้องส้วมและคุณภาพน้ำผิวดินมีผลช่วยควบคุมจำนวนผู้ป่วยใหม่ของโรคติดเชื้อในลำไส้ให้ลดลง ซึ่งส่งผลดีกับประชากรในมลฑล อย่างไรก็ตาม การศึกษานี้เป็นการใช้ข้อมูลทุติยภูมิซึ่งไม่มีข้อมูลรายบุคคลที่เกี่ยวข้องกับพฤติกรรมการใช้ส้วม ในการศึกษาในอนาคต อาจมีการศึกษาที่ระดับครัวเรือน เพื่อผลการศึกษาจะได้ใช้เป็นแนวทางในการแนะนำในระดับบุคคล

สาขาวิชา	สาธารณสุขศาสตร์	ลายมือชื่อนิสิต	
ปีการศึกษา	2562	ลายมือชื่อ อ.ที่ปรึกษาหลัก	

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Tingting Chen : Association between Sanitary Toilet Coverage Rate and Intestinal Infectious Disease in Jiangsu Province, China. Advisor: KRAIWUTH KALLAWICHA, Ph.D.

Intestinal infectious diseases are one of the most common disease group prevalent worldwide. It is also the commonly report acute infectious diseases in Jiangsu Province, China. This problem may result from the use of unhygienic toilet. Chinese government had announced the China's toilet improvement campaign for more than decades. The purpose of this ongoing campaign is to improve the hygiene and promote health. However, there is limited study evaluating the effect of toilet improvement and the incidence of intestinal infectious diseases. This study aims to determine the association of the increasing of sanitary toilets and intestinal infectious diseases in Jiangsu Province, China. The research used ecological study design, taking Jiangsu Province and 13 cities in Jiangsu province as the unit of analysis. The toilet coverage rate and the incidence of intestinal infectious diseases from 2011 to 2019 were obtained through National and Jiangsu Provincial Health Commission with permission of using secondary data. The water quality and other environmental data (i.e. temperature, rainfall) were obtained from Jiangsu Water Resources Bureau and Statistical Bureau, respectively. Descriptive analysis was used to describe the distribution of toilet coverage and the incidence of intestinal infectious diseases. Multiple linear regression analysis was performed to investigate association of toilet coverage rate and intestinal infectious disease. From 2011 to 2019, the total incidence of strictly control type A (cholera) and B (i.e. hepatitis A, E, and untyped viral hepatitis, bacillary and amoebic dysentery, typhoid and paratyphoid) intestinal infectious diseases（IIDs）together in Jiangsu Province showed a downward trend, of which viral hepatitis and dysentery dominated the entire trend. Type C IDD (i.e. other infectious diarrhea and hand-foot-mouth disease) accounted for more than 90% of all IIDs and the incidence of other infectious diarrhea increased year by year, and hand-foot-mouth disease has a high incidence every other year throughout the study period. The accumulative households using various types of sanitary toilets in Jiangsu Province were increased over time. Except for the compliance rate of surface water quality and average temperature showing an upward trend, there are no obvious variation rule in other factors (vector density, environmental factors). Simple linear regression analysis show that the accumulative households using various types of sanitary toilets (i.e. sanitary toilets, harmless sanitary toilets and sanitary public toilets), the compliance rate of surface water quality, and the average temperature are significantly different from intestinal infectious diseases. The total incidence of Type A and B intestinal infectious diseases, incidence of viral inf ections and dysentery are all negatively correlated with the three types of sanitary toilets. The surface water quality and average temperature are mainly negatively correlated to Type A and B intestinal infectious diseases, while the relationship with other infectious diarrhea of Type C is completely opposite. In the study of various cities, there are inconsistent results. Multiple linear regression analysis results suggested that the incidence of type A and B IDDs together was negatively associated with the accumulative use of sanitary toilet ($\beta = -0.036$) and surface water quality ($\beta = -0.135$) with $p < 0.05$. The similar effect on each city was the average temperature, which is negative correlated to the incidence of Type A and B IIDs. This study revealed that the toilet improvement campaign and water quality control can reduce the number of new cases which benefit to the population in the province. However, this study lack of the personal characteristics and behavior of using toilet of each individual. Further study may conduct at the household level and the recommendation for individual can be provided.

Field of Study:	Public Health	Student's Signature ....
Academic Year:	2019	Advisor's Signature ....

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I would like to express my gratitude to the Health Committees of Jiangsu Province and 13 cities. These units provided monitoring data for intestinal infectious diseases and sanitary toilet coverage rate for research. In particular, the Jiangsu Provincial Health Commission not only provided data on the incidence of intestinal infectious diseases in Jiangsu Province, but also spent a lot of extra time to collect and organize detailed data for each city for me, and specifically called to explain the current situation of toilet improvement in Jiangsu Province carefully.

In addition, I would like to sincerely thank my thesis advisor Dr. Kraiwuth Kallawicha for helping me. I am very grateful to him for his guidance and suggestions, especially when I encountered obstacles in obtaining data for my thesis, he pointed out the research direction for me, invested a lot of effort and energy, and put forward a lot of beneficial and improved suggestions.

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Chapter 1
Introduction

1.1 Background & Rationale

Improper disposal of human waste can have serious environmental and public health consequences. Human excreta have been linked to the spread of many infectious diseases, particularly intestinal diseases such as cholera and typhoid. Because of the lack of safe fecal disposal, pathogens can easily enter to the environment where people reside, resulting to the contamination in water and food. Human will have higher chance to expose to these pathogens and develop the disease, especially in developing countries. Children and the low-income families, are most vulnerable (Diaz et al.,2018).

According to the World Toilet Organization report in 2013, 1,000 children died of diarrhea diseases every day due to poor sanitation. In 2015, 1 billion people worldwide (15% of the world's population) still defecate in the open air. More than 2.5 billion people worldwide have inadequate sanitation (Chappuis et al.,2016). Even the cities with relatively good sanitation also have approximately 2 billion people releasing their waste directly into the environment (Zheng et al.,2018). Approximately 880 million urban residents in developing countries have extremely poor living conditions, similar to slums. Eighteen percent of the population lacks of sanitation facilities, while those lacking sanitation in rural areas account for 50% (Shikun et al.,2018).

In 2001, the World Toilet Organization initiated “Focus on Global Toilet Hygiene” program. The World Toilet Summit was held in different places every year. In 2013, the UN General Assembly designated the “World Toilet Day” on November 19th each year. Toilet problems are no longer as inelegant as they were before (Tan,2015).

The World Health Organization defines sanitation as a facility or service that separates human and human waste (urine, feces). Among the UN Millennium Development Goals, one of the health aspects is that by 2015, the proportion of people who do not have continuous access to safe drinking water and sanitation will be halved to ensure environmental sustainability. However, despite the efforts made by various countries to improve their health, the proportion of people with improved sanitation increased by 14% to 68%, and the proportion of open defecation decreased from 24% to 13%. But it is undeniable that the Millennium Development Goals have not been achieved (Xiaoqin et al.,2018).

The toilet revolution is an initiative to transform toilets in developing countries. China's toilet revolution originated from the patriotic health campaign in the 1960s. It runs through the health activities of “killing four pests” and “two managements and five reforms” in 1970s. In the 1980s, the concept of sanitary toilets was basically established, and basic hygiene standards were established. In the 1990s, the National Patriotic Health Commission decided to pilot the construction of rural sanitary toilets throughout the country. In 2015, General Secretary Xi Jinping made important instructions on the toilet revolution and demanded that the toilet revolution be extended to the vast rural areas (People's Tribune,2018).

About 57 million households in China do not have access to their own toilets, but 40 million of them can use public toilets, while 17 million still have serious sanitation problems due to poor toilet conditions. The penetration rate of sanitary toilets in China has continuously increased. By the end of 2016, the penetration rate of sanitary toilets in China was 80.4%, and the penetration rate of harmless sanitary toilets was 60.5%. China's rural public health infrastructure is still not perfect. According to the main data bulletin of the third national agricultural census in 2017, only 48.6% of rural households have access to sanitary toilets, while 2 percent still do not have toilets (Yong-sheng et al.,2019).

Jiangsu Province actively implements the national health work policy, and the health creation ranks first in the country. The rural toilet improvement in Jiangsu Province have been in the forefront of the country. They have introduced the experience of toilet improvement at national conferences. By the end of 2011, the penetration rate of rural sanitary toilets reached 87.36%, the fastest growth rate in the country. Based on the evaluation report of the "11th five-year plan" rural toilet improvement in Jiangsu Province, the total infection rate of intestinal infectious diseases decreased by 36.7%. However, the report focuses on evaluating the effectiveness of reformed sanitary toilets, with parasite detection rates near zero and a significant decline in parasite infection rates. For improving toilets and preventing diseases, only 2005 and 2009 intestinal infectious disease data before and after toilet improvement were selected for a simple descriptive analysis (Xiaoling et al.,2011).

As the eastern coastal province of China, Jiangsu Province ranks first in the index of regional development and people's livelihood. Jiangsu Province belongs to the East Asian monsoon climate zone and is located in a subtropical and warm temperate transition zone. The environment is conducive to the spread of intestinal parasites. Another study in Jiangsu province showed a long-term increase in the incidence of infectious diarrhea, which the spatiotemporal variation was observed (Xinyu et al.,2019).

The existing studies only descriptively described the connection between toilet improvement and intestinal infectious diseases, and lacks control over confounding factors. In a study of Tai'an, China, bacillary dysentery decreased with increasing toilet coverage, but the incidence of infectious diarrhea showed an upward trend. The research did not specifically analyze why such a result was observed. Their finding was similar to most studies (Wei et al.,2018).

In general, there are currently fewer studies on sanitary toilets and intestinal infectious diseases in China, not to mention Jiangsu Province, especially after 2011. Two methods are mainly used in these studies. One is to analyze the trend of intestinal infectious diseases with the increase in the popularity of toilet improvement, but there is a lack of further analysis of the situation that is different from the envisaged trend. Such as the lack of analysis of the slight fluctuations in the trend of incidence of intestinal infectious diseases; The other is the use of chi-square test to analyze the incidence of intestinal infectious diseases in areas with higher and lower toilet penetration rates. Most of the research is to evaluate the performance of toilet improvement, including health benefits, environmental benefits and economic benefits. The incidence of intestinal infectious diseases is included in the evaluation of health benefits, and only a simple descriptive analysis is carried out. Very few studies have analyzed the effects of confounding factors. Therefore, comprehensive study should be conducted in order to investigate the actual association of the Toilet

Improvement Campaign and the incidence of intestinal infectious disease in Jiangsu Province.

1.2 Research question

Is there any association between sanitary toilet coverage rate and the incidence of intestinal infectious diseases in Jiangsu Province?

1.3 Objectives

1.3.1 General objective

To investigate the association of sanitary toilet coverage rate and intestinal infectious diseases.

1.3.2 Specific objectives

- To describe the coverage rate of sanitary toilet in Jiangsu from 2011 to 2019.
- To investigate the incidence and the trend of intestinal infectious diseases in Jiangsu Province during 2011 to 2019.
- To describe the spatial distribution of incidence of Type A and B intestinal infectious disease in Jiangsu Province from 2011 to 2019
- To investigate the association of domestic water quality and the density of four pests and other environmental factors and the overall incidence of intestinal infectious diseases in Jiangsu Province.

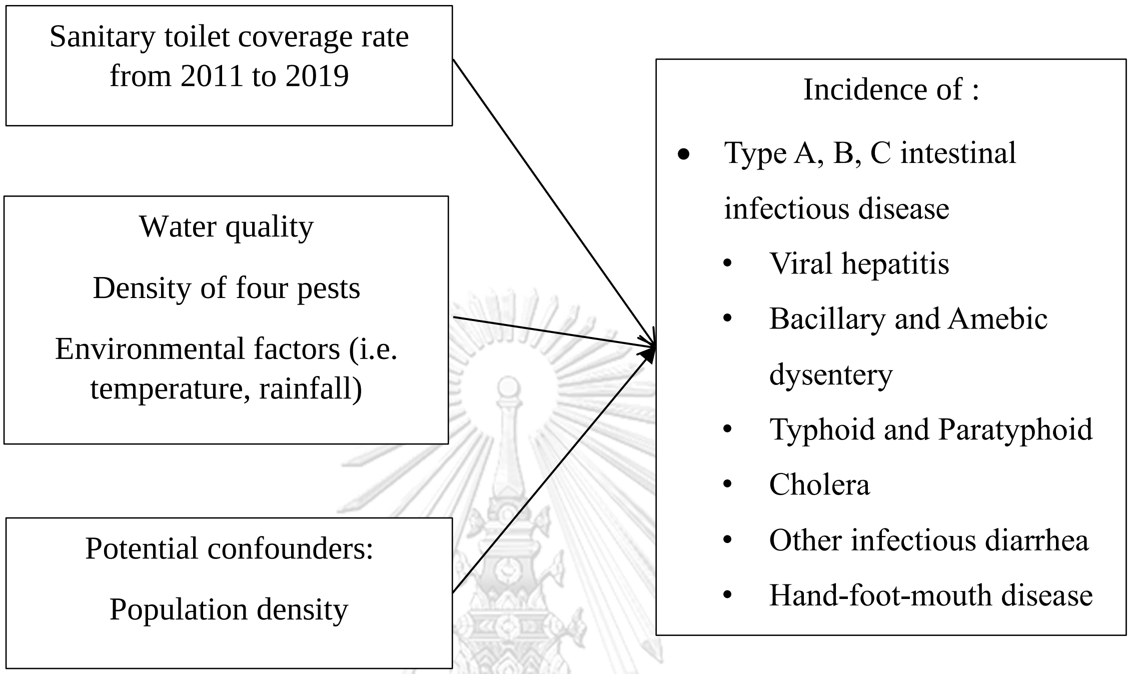
1.4 Hypothesis

Ho: There is no association between sanitary toilet coverage rate and the incidence of intestinal infectious diseases.

Ha: There is an association between sanitary toilet coverage rate and the incidence of intestinal infectious diseases.

1.5 Conceptual Framework

Independent Variable Dependent Variables



1.6 Operational Definitions

Sanitary toilets: Sanitary household toilets in rural areas of cities in Jiangsu Province. It includes 3 types of toilets in the improvement of rural household toilets: sanitary toilets, harmless sanitary toilets and sanitary public toilets.

Sanitary (public) toilets: Fences and roofs are required, and the septic tank is impermeable and airtight. The toilet is clean, free of fly maggots, and basically odorless, remove feces as required.

Harmless sanitary toilet: Toilets that meet the basic requirements of sanitary toilets. It should have facilities for the decontamination of feces, and are managed according to specification.

Sanitary toilet coverage rate: The ratio of the number of households using sanitary toilets and the harmless sanitary toilets to the total number of households.

Intestinal infectious diseases: Intestinal infectious diseases listed in China's statutory infectious diseases report. There are 3 types of intestinal infectious diseases including cholera [ICD-10-A00.] in Type A infectious diseases, typhoid[ICD-10-A01.0], paratyphoid[ICD-10-A01.1-A01.4), dysentery (i.e. bacillary dysentery[ICD-10-A03.0] and amoebic dysentery[ICD-10-A06.0]), viral hepatitis (i.e. hepatitis A[ICD-10-B15.], hepatitis E[ICD-10-B17.2], and untyped hepatitis[ICD-10-B19.] in Type B and Other infectious diarrhea (i.e. infectious diarrhea other than cholera, bacterial and amoebic dysentery, typhoid fever and paratyphoid fever [ICD-10-A09]), hand-foot-mouth disease [ICD-10-B08.4] in Type C. In the report, typhoid and paratyphoid, various dysentery, and various viral hepatitis are usually combined for statistics so six intestinal infectious diseases written in the study.

Incidence of intestinal infectious diseases: the total incidence of 6 types of intestinal infectious diseases in Jiangsu Province = the total reported cases of 6 types of intestinal infectious diseases / the total population of Jiangsu Province * 100,000; The single incidence of 6 intestinal infectious diseases in Jiangsu Province = the number of reported cases of each intestinal infectious disease / the total population of Jiangsu Province * 100,000. The total incidence of 6 types of intestinal infectious diseases in 13 cities of Jiangsu Province = the total reported cases of 6 types of intestinal infectious diseases in each city / population of each city in Jiangsu Province.

Water quality: The surface water compliance rate is adopted in the cross-section included in the national surface water environmental quality assessment, and the average annual water quality meets the type III cross-section ratio of "Surface Water Environmental Quality Standard" (GB 3838-2002). Drinking water in Jiangsu province is mainly centralized water supply, so the water quality data adopted in the study are the monitoring data of water intake from all centralized drinking water sources in Jiangsu province. After the water samples are collected, the natural settlement is 30mm, and the upper non-settlement part is taken. Evaluate according to "Surface Water Environmental Quality Standards" and "Groundwater Quality Standards", and calculate the proportion of the water volume that meets the standard. (qualified copies / sampled copies).

Density of four pests: four pests refer to mosquitoes, flies, mice and cockroaches. The elimination of the four pests was classified as a patriotic health movement and incorporated into China's socialist construction. According to the "national vector biological monitoring program" and "Jiangsu province vector biological monitoring program", each city selected monitoring points in different geographical locations. The mosquito density monitoring selects residential areas in the city in the urban area, urban-rural fringe area and rural villages in the countryside, livestock sheds that are not adjacent. It adopts the light trap method (number of mosquitoes captured / (time of catching mosquitoes * the number of mosquito trap lights); Fly density monitoring randomly select farmer's market, environments outside the restaurant, green belt and residential area. It adopts cage trapping method (number of flies / number of trapping cages); Mice density monitoring select urban residential area, special industry (catering, food production and sales) and rural natural village. It adopts trap-at-night method (total number of mice caught / total number of effective rat traps); Cockroach density monitoring randomly select farmer's market, restaurants, hotel, hospital and residential area. It adopts sticky cockroach paper method (total number of cockroaches captured / recovery Number of sticky cockroach paper).

Population density: the number of people living on a unit of land. The calculation method is the total population (person) of each city in Jiangsu Province / the total area of each city (square kilometers).

Environmental factors: rainfall and temperature. Rainfall: The total annual rainfall of each city, the total monthly rainfall, in millimeters. Temperature: The annual average temperature of each city, the monthly average temperature, the highest temperature, the lowest temperature, in degrees Celsius.

Patriotic health campaign: the aim is to prevent and reduce diseases and protect people's health. Health work is integrated with the masses, oriented to the grassroots, and reaching the community. Improving water and toilets is one of the specific requirements of the patriotic health campaign.

Chapter 2
Literature Review

2.1 Toilet Improvement

Since the end of the Qing Dynasty and the beginning of the People’ Republic of China, Chinese people's toilet behavior and toilet conditions have been criticized by foreigners. Therefore, China has carried out a series of toilet improvement practices at different times, hoping to get rid of this embarrassing situation. In the early years of the People's Republic of China, especially in the countryside, the health condition was very backward. Therefore, in order to prevent and control infectious diseases, the Chinese government implemented a series of measures to improve health. In the late 1970s, China implemented reform and opening up, with economic construction as the center of work. The use of chemical fertilizers led to a reduction in the rate of excrement disposal, and its impact on the environment was more prominent. Therefore, this period promoted the development of sanitary toilets. In the 1990s, some plans and decisions were made for toilet improvement in rural areas, and toilet improvement was officially started in rural areas (Yanfen,2019).

China's unique cultural and social conditions have led to the toilet problem has not been ordinary people's attention. Toilet problems are in the least important, most difficult and least conscious position. As a large agricultural country, China's agricultural population accounts for half of the total industrial population. Human and livestock waste has always been an important fertilizer in agriculture, so it can be said that waste has always been an important resource, people do not find waste unacceptable. In China's civil wedding, the traditional toilet as an important dowry, meaning many children and grandchildren. Thus, people don't think toilets are dirty (Xing and Chao,2018).

Toilet improvement is closely related to the country's politics, economy and culture." Toilets are the measure of human civilization," said Mr. Jack, the founder of the world toilet organization. Toilets not only improve the tourism environment, but also improve the working and living environment of the general public. Since General Secretary Xi Jinping emphasized the reform of toilets in rural areas in 2015, toilet improvement has become a social revolution throughout the urban and rural areas, promoting the reform of China's living environment. improving the toilet breaks China's traditional concept of toilets and promotes the construction of an ecological civilization in rural areas (Xiaowen,2018). Improving the toilet is an investment in health, and changes in the toilet environment and toilet behavior have greatly reduced the prevalence of people (Lei et al.,2019). That is why the process of improving toilets is called a "revolution".

The core of rural toilet improvement is centered on the people. The promotion of toilet improvement requires the cooperation of all rural residents. The power of the people determines the implementation of toilet improvement and the revitalization of the countryside. As the ultimate beneficiary, people should have a sense that they are the masters of the country and participate in the toilet improvement work. The government should shoulder the responsibility of guiding and educating rural residents (Junfeng and Guo,2018).

Open defecation is very common in India. Even though the government has developed a sanitation plan and subsidized it, many families still do not use household toilets. Because of the lack of private wells and water supply in the family, in addition, Indian women are arranged to go to toilets in groups at fixed times to protect safety and privacy. At the same time, they enjoy this time without having to do housework, they can chat with others and have a relax. Even if the government provides subsidies, each family still has to pay a part of the fee, which is still a burden for them, and the incomplete structure of the toilets, and the quality does not meet the specifications. It is difficult to popularize toilets in India (Routray et al.,2015).

Government intervention is also indispensable in the implementation of toilet improvement. In assessing the impact of various interventions including toilet maintenance, privacy, and cleanliness on toilet coverage and utilization, most interventions can moderately increase toilet coverage and utilization. The toilet coverage rate of the intervention group was about 14% higher than that of the control group (Garn et al.,2017).

2016 is the first year of China 's thirteenth Five-Year Plan. Among them, under the general direction of promoting the patriotic sanitation movement, it has put forward requirements for toilets, accelerating the construction of harmless sanitary toilets. In the final year of the thirteenth Five-Year Plan, the coverage rate of sanitary toilets in rural areas should reach 85% (Central People's Government of the People's Republic of China,2016). In the same year, the Chinese government formulated the "Healthy China 2030 Planning Outline", which also involves the issue of toilets, aiming to ensure that almost all rural residents in China would have access to harmless toilets by 2030 (Central People's Government of the People's Republic of China,2016).

2.2 The benefits of building sanitary toilets

Improving sanitary conditions can reduce the spread of parasitic diseases; reduce the cost of medical care; maintain the dignity of vulnerable groups such as women and children, especially those who are still defecation in the open air, provide a safe toilet environment; extract water, renewable resources and nutrients (WHO,2019); Change backward ideas, strengthen people's awareness of health and environmental protection, change health habits; Harmlessly treated excrement can be used as organic fertilizer, which is conducive to the sustainable use of land resources and reduces production costs (Zhibang,2018). Toilet improvement can bring obvious economic and social benefits. Based on the calculation formula, the direct economic benefits of the fecal-mouth-transmitted disease nationwide in China in 2011 were calculated, which saved a total of medical costs and Lost work cost was 32.95 million yuan (approximately 4.73 million US dollars) (Qiong and Yan-qing,2014).

The improvement of toilets can improve residents' health awareness and improve the quality of family life in terms of social benefits. To a certain extent, they have encouraged entrepreneurs returning to their hometowns and migrant workers to reunite (Yue yang et al.,2019).

2.3 Problems in the process of popularizing sanitary toilets

Local measures are not good enough. For example, in the northern cold regions, the average temperature is very low, and sanitary toilet pipes are easy to freeze and damage. In some areas, water resources are scarce, and flushing toilets is not very suitable. Some residential houses are old and do not have construction conditions (Wen bo and Jia xin,2019).

During the construction of sanitary toilets, there are unreasonable toilet relocation and schemes, some of the toilets that do not meet the standards, the materials do not meet the requirements, and the lack of follow-up management and maintenance after the toilets are built. Sanitary toilets have their own standards for construction and professional maintenance. In some areas, the old toilets have not been dismantled after owning sanitary toilets. Many residents still insist on using old toilets to save costs (Li xin and Jie feng,2019).

2.4 Intestinal infectious diseases

Intestinal infectious diseases are one of the most common diseases in the world, with high morbidity but low mortality (Doorduyn et al.,2012), even in developed countries. Intestinal infectious diseases will bring a large burden of disease. Intestinal infectious diseases affect approximately 25% of the UK's population each year, causing about 1.5 billion pounds in damage to the economy, individuals and the NHS each year (Adams et al.,2017).

In 2013, 77,000 children and adolescents died worldwide. The most common cause for children aged 5 to 9 years is diarrhea, with 38,325 deaths. Lower respiratory tract infections, road injuries, and intestinal infectious diseases have also been fatal. Of these, 36,110 have died of intestinal infectious diseases. At the same time, intestinal infectious diseases are the leading cause of death in South Asian countries (Kyu et al.,2016).

Globally, diarrhea has consistently been listed as one of the top 10 causes of death and disability-adjusted life years for all ages, with a particularly severe impact on children under five years of age and a high burden of diarrhea in people over 70 years of age. In 2016, diarrhea deaths in people over the age of five were mainly due to shigella, and vibrio cholerae was the third leading cause of diarrhea deaths in all age groups (Troeger et al.,2017).

Intestinal infectious diseases are the main types of infectious diseases in

China, and they are also the most prevalent and widespread epidemic of acute infectious diseases in China (Xiaohui,2013). Compared with respiratory infectious diseases, blood borne and sexually transmitted infectious diseases, vector-borne, and natural epidemic infectious diseases, the number of intestinal infectious diseases was higher, while the mortality rate was the lowest, especially in 2009-2010 (Fenghua et al.,2013).

The latest statistical results of China ’s statutory reported infectious diseases show that in 2019, the cases of intestinal infectious diseases of Type A and B was 150,752 and 27 deaths. The reported morbidity is 10.79 / 100,000 and the mortality is 0.00 / 100,000. Compared with the epidemic in 2018, the morbidity has dropped by 7.6% and the mortality has increased by 18.8%. The incidence of other infectious diarrhea and hand-foot-mouth disease reached 95 / 100,000 and 137 / 100,000 respectively. Ranked No. 2 and No. 3 in the number of reported cases of Type C infectious diseases (The bureau of disease control and prevention,2020). In 2019, a total of 7,047 cases of intestinal infectious diseases were reported in Type A and B statutory reported infectious diseases in Jiangsu Province, the reported incidence rate was 8.75 per 100,000. The incidence of other infectious diarrhea disease reached 33 / 100,000 and hand-foot-mouth disease reached 130 / 100,000, which is the most common type C infectious disease (Jiangsu Commission of Health,2020).

2.5 Improper disposal of human waste

In the Global Burden of Disease Study, water, sanitation (fecal matter) and health care are the second largest disability-adjusted life-year percentages after malnutrition. Diseases such as diarrhea, schistosomiasis, and intestinal worms are largely related to excreta (Carr and Strauss,2001).

Improper handling of feces is an important source of intestinal infectious diseases. Many cases of intestinal infectious diseases are caused by fecal contamination. As early as 166 years ago, the cholera outbreak in London, England, John Snow confirmed that cholera was transmitted by water contaminated with feces. At its source, the diaper water of a baby girl with cholera was poured directly into the septic tank. Inadequate infrastructure has caused pathogens to penetrate the soil, which in turn has polluted the well water (Snow,2017).

In 1988, a large outbreak of hepatitis broke out in Shanghai, China. Hepatitis patients reached 19,000 in one day. In 3 months, the number of infected people reached nearly 300,000, and 31 people died in this major public health event. The cause of this outbreak of hepatitis was raw foods from clam, and the water source of this clam was seriously polluted by human feces (Shun-zhang,2017).

Due to inadequate toilet sanitation, human feces were directly exposed to the air, providing a living environment for the breeding of mosquitoes and flies. In addition, improper cleaning of the feces, a large number of parasites and bacteria present in the feces are spread through soil and water sources. It is the main cause of many diseases, especially intestinal infections. The excreta without precipitation and other processes are directly discharged into the soil, the septic tank does not play the role of compost, and the quality is poor, causing the excreta to overflow or the soil caused by the excreta caused by flooding. Soil contact with a large amount of feces can cause soil salts to dissolve and increase soil salinity. At the same time, the decomposition process of feces is prone to produce harmful gases such as methane and ammonia, and will also consume the oxygen content of the soil.

Due to changes in dietary structure, people have paid too much attention to the intake of various nutrients. Increased intake of protein, which has led to an increase in nitrogenous compounds in human excretion. Feces pass through the soil and eventually cause serious pollution to groundwater. Decomposition has toxic effects on the human body and aquatic life (Lin and Shanfen,1993).

While paying attention to the treatment of human feces, the disposal of child feces should not be ignored. Children as a special group are susceptible to intestinal infectious diseases, but the disposal of children's feces is not satisfactory. A Bangladesh-based study found that children in households with unsafe disposal of feces had significantly higher environmental bowel disease activity scores (George et al.,2016).

The human gastrointestinal tract is a huge microbial ecosystem with trillions of microbial cells. There are many ways in which microorganisms can spread from person to person, including feces, airborne, direct contact, or through vectors. Intestinal pathogens can be transmitted directly through the mouth or indirectly through contaminated liquids. They can transmit directly from person to person through the fecal-oral route. Most pathogens that pass through the fecal mouth are very stable and can survive under various conditions (De Graaf et al.,2017).

2.6 Transmission of intestinal infectious diseases

The main mode of transmission of intestinal infectious diseases is fecal-oral-fecal, that is, bacteria, viruses and parasites entering the human digestive tract by polluting water sources, food, tableware, etc. and cause a series of infectious disease (Jingyu et al.,2016).

There are four routes of transmission: water-borne, food-borne, contact-borne, and insect-borne. Studies have shown that one gram of stool contains 1×10^7 virus, 1×10^6 bacteria, 1×10^3 parasite cysts, and 100 parasite eggs. Proper handling of excreta and maintaining a minimum level of personal and home hygiene are the main obstacles to preventing excreted pathogens from entering the environment (ENVIS Centre India,2011).

2.7 Links of common intestinal infectious diseases to stool and sanitary toilets

Infectious diarrhea is a typical disease caused by intestinal infection. Diarrhea is considered to be one of the leading causes of morbidity and mortality in developing countries (Hongxing et al.,2016).

It has been reported that one of the important ways to combat diarrhea diseases in developing countries is to eliminate open defecation and reduce pathogen exposure. The pathogens of open defecation, that is, bacteria, viruses, worms, etc., will reach the food through feces, water, soil, flies, fingers, spread to the mouth to find new hosts, and circulate continuously, causing intestinal pathogens to spread between humans. Children are more susceptible to infection, and diarrhea is the second leading cause of death among children under five in the world, more children die from diarrhea than the total number of children died from acquired immunodeficiency syndrome (AIDS), malaria and measles. The number of children under 5 years of age who die from diarrhea in rural China is 13 times that of cities (Tambe et al.,2015, Dandabathula et al.,2019).

Studies have shown that there is a significant correlation between levels of human fecal exposure pollution in households and childhood diarrhea (Odagiri et al.,2016). Children in households without toilets are more likely to have diarrhea than households with toilets (Aziz et al.,2018). A study in India showed that improving health conditions can reduce the risk of diarrhea by 2.2% (Nandi et al.,2017).

The world bank estimates that inadequate sanitation and unsafe discharge of toilet water cause intestinal infections in about 1.5 million children each year (Zheng et al.,2018).

Typhoid fever and paratyphoid fever are also transmitted through the fecal-oral route. In poor countries such as Asia and Africa, these diseases are particularly serious due to the lack of corresponding sanitation facilities. The incidence of typhoid fever in people with poor health habits is significantly higher. In rural areas, poor sanitation (outdoor toilets, etc.) and lack of hygiene awareness make farmers more susceptible to typhoid fever (Hua et al.,2018).

Fiji has a high incidence of typhoid fever. A case-control study found that poor sanitation may be the main source of Salmonella typhi. Compared with the control group, typhoid patients use more unrepaired or damaged pit toilets, many of them do not have toilet (Prasad et al.,2018). From 2010 to 2018, more than 810,000 people were infected with cholera in Haiti, more than half of which were serious cases. The source was that the longest river in Haiti was affected by untreated sewage, and deficiencies in Haiti 's environmental health and medical care have increased cholera infection. In the two areas most affected by cholera, less than 3% household have better toilets (Guillaume et al.,2018). In a case-control study of a cholera outbreak in Kenya in 2015, people who lacked toilets at home were twice as likely to contract cholera (Oyugi et al.,2017).

2.8 Toilet improvement technology and principle

The traditional aqua latrines commonly used in rural China, which store fat but do not ferment or sterilize, can easily cause the spread of intestinal infectious diseases. Improving the toilet can effectively control the occurrence and epidemic of the disease (George et al.,2016).

On the one hand, toilet improvement in rural areas can degrade eggs and control the infection source to reduce the pollution of air, water and soil. On the other hand, the process of toilet improvement is also a health education for farmers and enhances their awareness of disease prevention. Thereby reducing the chance of contracting intestinal infectious diseases (Gemei,2007).

The rural old-fashioned toilet that does not accord with sanitation standard, stink volatilization is serious. Especially in rainy days, the infusion of rainwater will cause the feces to overflow, and a large number of pathogens and eggs will be released into the environment along with the pollutants. According to statistics, toilet sewage discharge will eventually lead to 64.9% of pollutants seeping into the ground, and 35.1% of pollution will cause direct pollution to water bodies such as rivers and lakes (Shengbiao,2018).

Rural toilet improvement is mainly to add harmless treatment in the process of sewage disposal in the toilet, and then use it as fertilizer on farmland, reducing the pollution of soil and water (Xingui and Dong,2013).

China has a vast territory and a complicated terrain. According to the characteristics of different regions, the corresponding implementation plan of the "Toilet Revolution" has been issued. At present, there are mainly six commonly used toilet improvement technologies, including three-format septic tanks, double-wrench funnel and sewer flushing septic tanks that are generally applicable nationwide. It has the advantages of high killing rate of E. coli and high sinking rate of parasites (Yanfang,2019).

2.9 Control of intestinal infectious diseases in Chinese toilet improvement

A test based on intestinal parasite eggs in a county in Hunan, the detection rate of unimproved toilet households was 6 times that of improved toilets. For the feeding tank test of the three-compartment septic tank, parasite eggs detection rate of the upper sample and the lower sample of the feeding tank is 15% and 5% indicating that the three-compartment septic tank has significant effect on the harmless treatment of feces (Jianru et al.,2007).

Statistics from the Guangxi Zhuang Autonomous Region in China show that the incidence of intestinal infectious diseases in the entire region has decreased year by year after the implementation of the toilet improvement. Intestinal infectious diseases such as typhoid fever, paratyphoid fever, and bacterial dysentery have all declined sharply, bringing a huge society. Benefits and economic benefits (Gemei,2018).

A study on the effect of intestinal infectious diseases control in the toilet improvement in Jiangxi Province, comparing the incidence of intestinal infectious diseases in the areas where the toilet was improved and not improved. With the increase in the coverage of toilet improves, the incidence of intestinal infectious diseases has decreased significantly. The decline has confirmed that the implementation of the toilet improvement project can effectively reduce the incidence of intestinal infectious diseases (Yan-hua et al.,2014).

In 2012, an analysis was conducted on the economic and social benefits of toilet improvement in 28 provinces and 459 counties in China. Based on the calculation formula, the direct economic benefits of the fecal-mouth-transmitted disease nationwide in 2011 were calculated, which saved a total of medical costs and Lost work cost was 32.95 million yuan (approximately 4.73 million US dollars). During the survey, the vast majority of respondents stated that the number of mosquitoes and flies has decreased and environmental sanitation has improved. More than half of the respondents believe that the number of illnesses has decreased significantly (Qiong and Yan-qing,2014).

Based on the analysis of relevant data in Yuhuan County from 2000 to 2010, it is shown that the work of sanitary toilets has realized the use of gravity sedimentation, liquefaction decomposition, and anaerobic fermentation techniques to treat feces in a closed environment, eliminating pathogens and parasites in feces, and significantly reducing the occurrence or spread of common intestinal infectious diseases. Compared with areas where sanitary toilets have not been implemented, the density of adult flies in sanitary toilets is significantly smaller; the density of slugs entering septic tanks is almost zero; it is basically odorless; ammonia concentration is low; The detection rate of parasite eggs in the septic tank is extremely low. The TOPSIS method is used to divide the implementation of toilet improvement work into five periods. The high incidence of common intestinal infectious diseases in this area is in the early stage of implementation of sanitary toilet improvement. From the middle of implementation, the incidence of intestinal infectious diseases has begun to show a significant downward trend (Haiyang,2017)

2.10 Other factors affecting intestinal infectious diseases

Water quality

According to the "Environmental Quality Standards for Surface Water" revised in 2002, standards were established for total nitrogen, PH value, dissolved oxygen, ammonia nitrogen, total phosphorus, and potassium permanganate etc. The standard is divided into five categories according to the environmental functions and protection objectives of surface waters. The water quality compliance rate used in the study must meets or exceeds the Category III standard (It is applicable to the secondary protection zone of centralized surface water source of drinking water, the wintering ground and the migration channel of fish and shrimp, the aquaculture area and other fishery waters and swimming areas). Surface water is also divided into five categories, including turbidity, visible substances, sulfates, chlorides, heavy metals such as iron, manganese, etc. The three types of standards involved in the study are based on human health benchmark values and are mainly applicable to centralized drinking water sources and industrial and agricultural water use.

Canadian scholars have studied the relationship between water supply and endemic intestinal infectious diseases. The subjects of the study are residents of a mixed rural and urban community. Almost all local residents use tap water for cooking, and most people drink tap water. Chlorination is one of the main methods of local water treatment. After research, chlorinated water is associated with a reduction in the rate of doctor visits and hospitalization of intestinal infectious diseases (Teschke et al.,2010).

In Mexico, high incidence of intestinal infectious diseases and lack of sanitation facilities are common. According to census data, 3.2 million households have no access to water supply, and households that already have water supply services may have unsatisfactory service quality. Studies have shown that improving water services for residents can reduce the incidence of common diseases. In areas where residents have access to pipeline water supply, the incidence of intestinal infectious diseases is lower, and in areas with higher levels of water supply services, the incidence of intestinal infectious diseases is relatively lower (Sisto et al.,2017).

A study in Ethiopia reached similar conclusions, but the study population was children from 6 to 59 months. Most home water sources are protected wells, however, about 70% of home drinking water contains bacteria and is not suitable for drinking. Drinking water sources and water supply services are associated with intestinal parasite infections in children. Children who drink water from unprotected water sources are about 8 times more likely to be infected with intestinal parasites than children who drink protected water (Gizaw et al.,2018).

Pests

During the Korean War in 1952, bacterial weapons were used in Northeast China and North China, and a large number of pests such as mice, flies, and mosquitoes with germs were spread, which led to the obstruction of agricultural development and threatened the health of the people. At that time, the president of China proposed the concept of eliminating the four pests. The four pests were mosquitoes, flies, mice and sparrows. This movement almost caused the sparrow to disappear in China. Because sparrows have the characteristics of eating food and many pests at the same time, the reduction in the number of sparrows has led to a large increase in the number of insects. Finally, the Chinese government removed sparrows from the list of four pests and replaced it with bedbugs. As society changed, cockroaches gradually became the main household pest, eventually replacing the bedbugs. So, the final four pests are mice, cockroaches, flies and mosquitoes

A review article analyzed the effects of various pests as vectors of human parasites and bacterial diseases.

Cockroaches like dirty places, they may spread different diseases, and cockroaches carry many microorganisms, which are resistant to antibiotics. People ingest food contaminated with feces or insects, and bacteria enter the body through the digestive system. Cockroaches in the East and Germany mainly transmit infectious diseases such as dysentery and typhoid fever. Rodents host various parasites and microorganisms that cause human diseases. Among them, rats and mice transmit diseases account for the largest proportion of rodents. It can be said that mice share lives with humans, and there is also the possibility of infection by pathogens. Many types of diptera insects are vectors that can spread pathogens such as bacteria and parasites. Flies have complex feeding habits and are omnivorous. A large number of bacteria can be found in the feces of the flies. The flies may spread the bacteria to the food, causing people to be infected with bacteria or viruses. House flies can transmit diseases such as typhoid fever, dysentery, and poliomyelitis. Mosquitoes are also a species of Diptera, and they are found all over the world. Many people are affected by mosquito-borne diseases. Mosquitoes can transmit microorganisms in subtropical and tropical regions to cause diseases such as malaria and viral encephalitis. However, it has been confirmed that mosquito species in Poland do not pose a threat to human health (Cholewiński et al.,2017).

Population density

A study in China selected Beijing, Tianjin and Hebei, one of the regions with the most severe bacillary dysentery infection. After analysis, the population density was positively correlated with the high incidence of local bacterial dysentery. In addition, any combination of population density and age, per capita GDP and rural population ratio will increase the spread of bacterial dysentery. The decisive effect of the correlation between population density and per capita GDP and rural population proportion is 0.5 (Xu et al.,2017).

Hepatitis E virus (HEV) is a type of viral hepatitis. After research, population density is the main parameter that affects HEV outbreaks. Using the spatial adaptability model of virus outbreaks, population density is the most important variable with a contribution rate of 80.9% (Carratalà and Joost,2019).

A study in northeastern Brazil analyzed the distribution of co-infection of schistosomiasis and viral hepatitis. The cases in this area are mainly concentrated in the central urban area, and there are fewer cases in the suburbs. The result of the distribution of cases may be due to the high population density in the central urban area (Santos et al.,2017).

Environmental factors

In Chiang Mai, Thailand, a study on the impact of high temperatures on the number of outpatients and inpatients was conducted. The study included five types of diseases, including intestinal infectious diseases (A00-A99). The results show that the daily incidence of the disease is positively correlated with temperature. When the temperature is higher than 29℃, the number of outpatient visits and hospitalizations due to intestinal infectious diseases has increased significantly. For every 1℃ increase in temperature, the outpatient consultation rate increased by 2.6% and the hospitalization rate increased by 5.8% (Pudpong and Hajat,2011).

Ho Chi Minh City is the most populous city in Vietnam. Studies in the city have proven that heavy rain events (HRE) increase the incidence of intestinal infectious diseases. After the HRE, IID levels and trends change with HRE and lag days. During the lag period of 0-21 days, the incidence of IID gradually increased in the first 7 days of the heavy rain events, peaked on the 7th day, and slowly decreased from the 7th to the 21st day. In general, there is a positive correlation between heavy rain events and the incidence of intestinal infectious diseases (Phung et al.,2017).

From 2003 to 2006, in Lusaka, Zambia, the relationship between the increase in cholera cases and climate factors was analyzed. All local epidemics have been shown to be related to the rainy season, with increases in temperature and rainfall observed in the weeks before the epidemic. The outbreak of cholera was associated with a temperature increase of 1°C 6 weeks ago and a rainfall increase of 50 mm 3 weeks ago. Increased temperature affects water temperature and salinity and provides a favorable environment for the survival of Vibrio cholerae, resulting in a 5.2% increase in cholera cases per week, while an increase in rainfall results in a 2.5% increase in cholera cases per week (Luque Fernández et al.,2009).

Chapter 3
Methodology

3.1 Study Design

Research design of this study is an ecological retrospective study design. The study will analyze the situation of toilet improvement and intestinal infectious diseases in Jiangsu Province from 2011 to 2019. Jiangsu Province and thirteen cities (i.e. Nanjing, Wuxi, Xuzhou, Changzhou, Suzhou, Nantong, Lianyungang, Huaian, Yancheng, Yangzhou, Zhenjiang, Taizhou, and Suqian) of Jiangsu Province was being used as the unit of analysis.

3.2 Study Area

The study area is within the administrative area of Jiangsu Province. Jiangsu has a total area of 107,200 square kilometers. As of January 2020, Jiangsu has 13 prefecture-level cities (unit of analysis of this study), 55 municipal districts, 22 county-level cities, 19 counties, and a total of 96 county-level districts. According to the statistical data published by the Jiangsu Statistical Yearbook, the residents of Jiangsu Province, as of the end of 2018 were 80.51 million people, among these 24.46 million people were in the rural area.

Jiangsu Province is located in the eastern coastal region of the mainland， China and the Yangtze River Economic Belt. It is one of the provinces with the highest comprehensive development level and the largest population density province in China. Jiangsu is the lowest-lying province in China, the terrain is dominated by plains, which account for 86.89% of the area. Jiangsu Province is rich in water resources, numerous rivers and lakes, and complex water systems. The Yangtze River and the Beijing-Hangzhou Grand Canal across east-west and north-south. Taihu Lake and Hongze Lake among the five largest freshwater lakes in China are located in Jiangsu. Jiangsu Province belongs to the East Asian monsoon climate zone. The climate has the characteristics of both southern and northern China, with 4 distinctive seasons and moderate rainfall.

For a long time, people used to divide Jiangsu into southern and northern

Jiangsu with the Yangtze River as the boundary. People's subjective impression is that southern Jiangsu is rich and northern Jiangsu is backward. In fact, there are indeed differences in economy and culture between southern Jiangsu and northern Jiangsu. Officially, Jiangsu is divided into southern Jiangsu, central Jiangsu and northern Jiangsu according to geographical location. Southern Jiangsu includes five prefecture-level cities of Nanjing, Zhenjiang, Suzhou, Changzhou and Wuxi. Central Jiangsu includes three prefecture-level cities of Nantong, Yangzhou and Taizhou. The northern Jiangsu includes five prefecture-level cities of Xuzhou, Lianyungang, Suqian, Huai'an and Yancheng. Southern Jiangsu, Central Jiangsu, and Northern Jiangsu are three economic regions with obvious gradient differences, and the spatial distribution of GDP per capita coincides with these three administrative regions. The southern Jiangsu region is closer to Shanghai. The cities of southern Jiangsu and central Jiangsu are designated as the city cluster of the Yangtze River Delta centered on Shanghai, while only Yancheng is included in the northern Jiangsu region. The Yangtze River Delta is an important intersection of the "Belt and Road" and the Yangtze River Economic Belt. Its development plan is to face the world, radiate to the Asia-pacific region and leads the whole country, and is an important engine for China's economic and social development.

In summary, the overall development level of Jiangsu is very high, and the development levels of 13 prefecture-level cities are high nationwide, but there are obvious differences between the cities.

Map of China

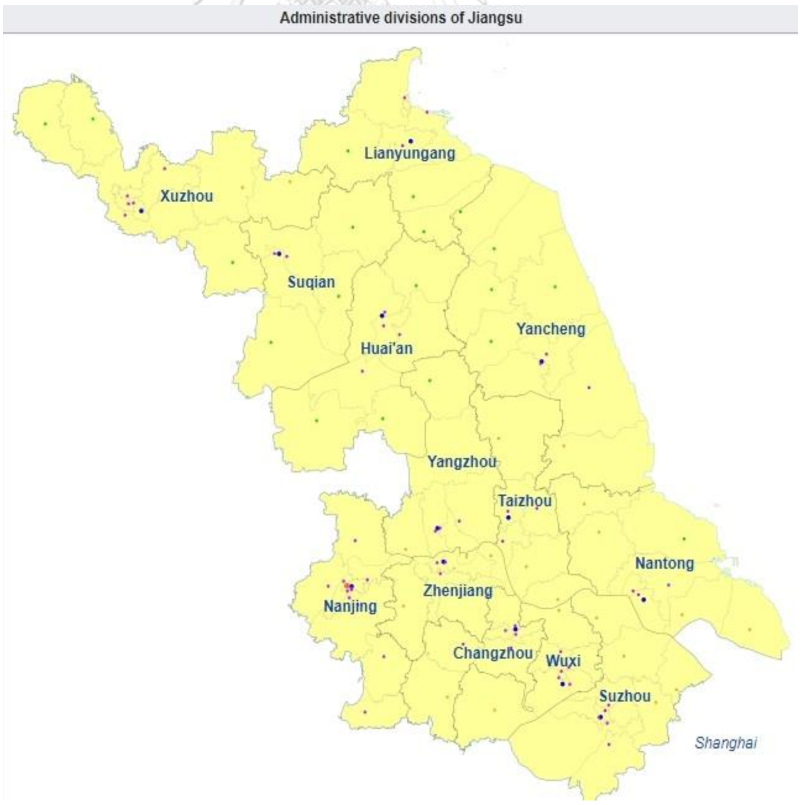


Figure 1: The administration division of Jiangsu Province

3.3 Data Collection

All data used in the research are secondary data for the period from 2011 to 2019. Because the Patriotic Health Committee of Jiangsu Province, which is responsible for the toilet improvement project, evaluated the benefits of toilet improvement from 2006 to 2010 in 2011. There are many indicators for evaluation. But since then, the Chinese government has put forward many new requirements for toilet improvement, and there has been a lack of corresponding research during this period.

The outcome data includes the incidence of 3 types of intestinal infectious diseases in Jiangsu Province and total incidence of type A and B intestinal infectious diseases in various regions of Jiangsu Province, Type A includes cholera [ICD-10-A00.]. Type B includes typhoid[ICD-10-A01.0], paratyphoid[ICD-10-A01.1-A01.4), dysentery (i.e. bacillary dysentery[ICD-10-A03.0] and amoebic dysentery[ICD-10-A06.0]), viral hepatitis (i.e. hepatitis A[ICD-10-B15.], hepatitis E[ICD-10-B17.2], and untyped hepatitis[ICD-10-B19.]. Type C includes 0ther infectious diarrhea (i.e. infectious diarrhea other than cholera, bacterial and amoebic dysentery, typhoid fever and paratyphoid fever [ICD-10-A09]), hand-foot-mouth disease [ICD-10-B08.4]. In addition, it also includes data on the coverage rate of various types of sanitary toilets, the density of four pests, water quality, and population density. This study will also consider environmental factors that may be related to the incidence of intestinal infectious diseases.

There are five main sources of data, Jiangsu Provincial Health Commission, Water Resources Bureau and Department of Ecology and Environment of Jiangsu Province, China Environmental Statistical Yearbook and Jiangsu Statistical Yearbook.

Table 1: List and characteristics of the variables collected in this study

Variables	Unit	Variable types	City/province level	Source
Sanitary toilet coverage rate	%	continuous	Province level	China Environmental Statistical Yearbook Jiangsu Provincial Health Commission
Total incidence of all IID	1 / 100,000	continuous	Province level	Jiangsu Provincial Health Commission
	1 / 100,000	continuous	City level	Jiangsu Provincial Health Commission
Incidence of each IID	1 / 100,000	continuous	Province level	Jiangsu Statistical Yearbook Jiangsu Provincial Health Commission
Density of 4 pests:				
- Mice	number of mice/trap	continuous	Both	Jiangsu Provincial Health Commission
- Cockroach	number of cockroaches/piece			
- Flies	number of flies/cage			
- Mosquito	number of mosquito/hour * light			
Water quality	%	continuous	Both	Department of Ecology and Environment of Jiangsu Province Water Resources Bureau
Population density	per km^2	continuous	Both	Jiangsu Statistical Yearbook
Rainfall	mm	continuous	Both	Jiangsu Statistical Yearbook
Temperature	℃	continuous	Both	Jiangsu Statistical Yearbook

The incidence data of type A and B enteric infectious diseases in Jiangsu Province and various cities used in the study in 2019 are calculated based on the number of patients as of the end of November 2019.

Regarding the coverage rate of sanitary toilets in Jiangsu Province, the calculation formula of Jiangsu Health and Health Commission is using the number of households using various types of sanitary toilets divided by the number of rural households who should change toilets, but the denominator of the coverage rate calculation formula published in the China Environmental Statistical Yearbook based on data from the National Health Commission of the People's Republic of China is the total number of rural households, Therefore, this study uniformly used data from the National Health Commission. In 2018, Jiangsu Provincial Health Commission organized and carried out self-inspection and verification work on the construction of sanitary toilets, combined with the actual situation in the countryside, and adjusted and eliminated the data of dynamic changes such as toilets in disrepair and damage, so the accumulative households using sanitary toilet in 2018 has decreased significantly, so according to the data of the new sanitary toilets in 2018 published by the Health Commission, In this study, the number of newly built toilets in 2018 was added on the basis of 2017 to obtain the total number of households in 2018. And used the denominator of the 2017 calculation formula to estimate the sanitary coverage rate in 2018.

Since the relevant departments of Jiangsu province have not sorted out and released some data in 2019, there is a lack of data in the study. The missing data was calculated at about 7 percent.

3.4 Data Analysis

In this study, SPSS software version 22 was used for the statistical analysis.

3.4.1 Province Level

Descriptive statistics includes:

- Trend in the coverage rate of sanitary toilets (sanitary toilets, harmless sanitary toilets and sanitary public toilets) in Jiangsu Province from 2011 to 2019
- Distribution of the incidence of 3 types and 6 intestinal infectious diseases
- Trend in incidence of total and each 6 intestinal infectious diseases
- Variation trend of temperature, rainfall, water quality and 4 pests' density in Jiangsu Province.

Regression analysis:

The association between incidence of 6 intestinal infectious diseases and sanitary toilet coverage rate will be analyzed using the simple linear regression analysis. The unit of analysis is Jiangsu Province. The dependent variable (Y) is the incidence of 6 intestinal infectious disease in each year from 2011 to 2019, while the independent variables (X) are accumulative households using sanitary toilet, harmless sanitary toilet and sanitary public toilet, the four pests' density, water quality, temperature and rainfall. $P<0.2$ was used as the test standard to determine the variables included in the multiple regression model. The variables in the regression model with the $p<0.05$ is considered statistically significant.

3.4.2 City Level

Descriptive statistics includes:

- Distribution and Trend in the total incidence of Type A and B intestinal infectious diseases in 13 cities for each year
- Variation trend of temperature, rainfall, water quality and 4 pests' density in 13 cities

Regression analysis:

The association between total incidence of Type A and B intestinal infectious diseases and other factors will be analyzed using the regression analysis. The smallest unit of analysis is 13 cities in Jiangsu Province. The dependent variable (Y) is the total incidence of the intestinal infectious disease in each year for each city from 2011 to 2019, while the independent variables (X) are the four pests' density, water quality, temperature, rainfall and population density. $P<0.2$ was used as the test standard to determine the variables included in the multiple regression model. The variables in the regression model with the $p<0.05$ is considered statistically significant.

3.5 Spatial distribution of intestinal infectious disease

ArcMap software version 10.6 was used to draw GIS map. Use the dot density map to describe the annual incidence of type A and B intestinal infectious diseases in 13 cities in Jiangsu Province for each year from 2011 to 2019, and the average incidence of each city from 2011 to 2019, so as to determine which cities are areas with high incidence. One dot represents 1/100,000 cases

3.6 Ethical Consideration

None of individual data are exposed and used in the analysis. Only secondary data are utilized. In addition to getting data from statistical yearbooks. All secondary data are legally applied through the government information publicity channels of the Jiangsu Provincial Health Commission and the Jiangsu Municipal Health Commission. According to article 15 of "People 's Republic of China Government Information Disclosure Bill", government information that involves business secrets, personal privacy, etc., that would damage the legitimate rights and interests of third parties, will not be disclosed by administrative agencies. The stated reasons and data usage are all true. All communications with relevant responsible personnel of the Health and Health Committee are made by email, honest and transparent. All data are for research use only. The study was approved by the Ethical Reviewing Board Committee of Chulalongkorn University (Ethic No. 102/2020).

Chapter 4
Results

4.1 Incidence of intestinal infectious disease

4.1.1 Descriptive analysis at Province level

From 2011 to 2019, among the three types of intestinal infectious diseases that are legally reported as infectious diseases in Jiangsu Province, the incidence of Type C intestinal infectious diseases including other infectious diarrhea and hand-foot-mouth disease is the highest, accounting for 93.26% of the total intestinal infectious diseases, and the average incidence in 9 years is 181.32/100,000.The incidence of Type B intestinal infections accounts for about 7%, while the average incidence of Type A infectious diseases is 0.00/100,000, the proportion is very small.

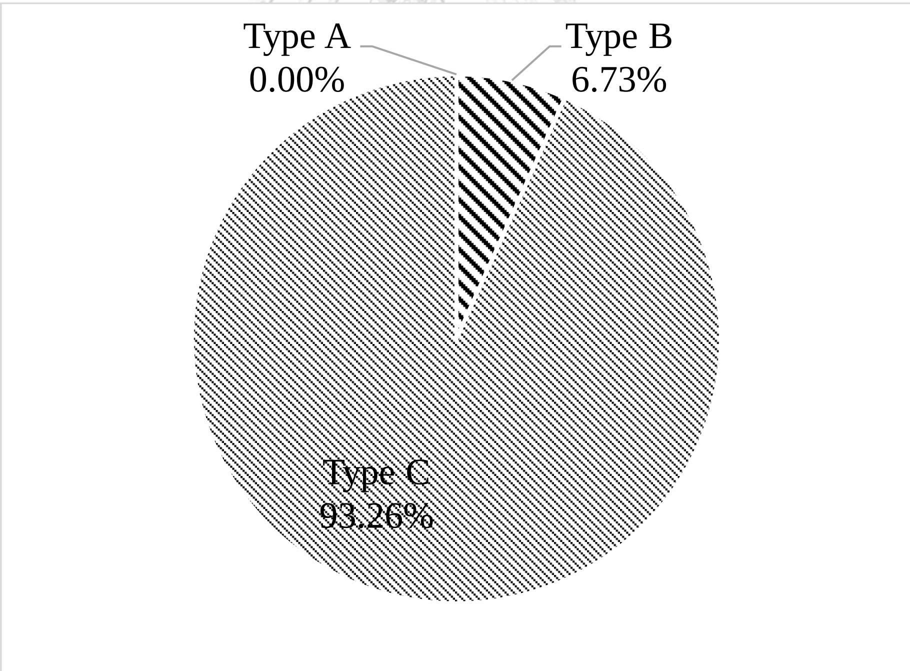


Figure 2: Distribution of the average incidence of 3 types of intestinal infectious diseases

Table 2: Incidence of each type of intestinal infectious diseases in Jiangsu Province for each year during 2011 − 2019

Year	Total (type A+B+C)	Total (type A+B)	Type A	Type B	Type C
2011	184.32	20.05	0.00	20.04	164.28
2012	182.53	16.87	0.01	16.87	165.66
2013	157.27	15.50	0.01	15.49	141.77
2014	243.18	14.01	0.00	14.00	229.17
2015	151.31	12.73	0.00	12.72	138.58
2016	228.04	11.14	0.01	11.13	216.90
2017	156.07	9.99	0.00	9.99	146.08
2018	274.58	9.27	0.00	9.27	265.30
2019	172.88	8.28	0.00	8.28	164.13

Type A and B intestinal infectious diseases showed a clear downward trend, from 20.04/100,000 in 2011 to 8.28/100,000 in 2019. For Type C intestinal infectious diseases, its incidence also fluctuated, but after 2017, the fluctuation range was relatively large. The incidence in 2019 is almost the same as that in 2011. The variation trend of the total incidence of Type A, B and C intestinal infectious diseases generally consistent with that of Type C intestinal infectious diseases.

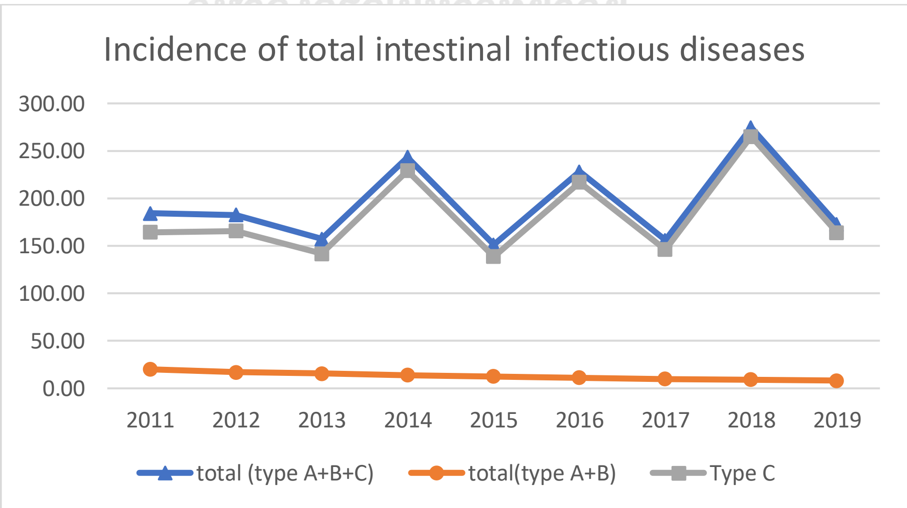


Figure 3: Variation trends of three types of intestinal infectious diseases in Jiangsu Province

Since the incidence of some diseases is combined, the data finally shows 6 intestinal infectious diseases. The incidence of hand-foot-mouth disease is the highest, accounting for 81% of total intestinal infectious diseases, and the average incidence in 9 years is 158.23/100,000, followed by other infectious diarrhea in Type C intestinal infectious disease, the incidence account for 12%. The incidence of viral hepatitis and dysentery accounted for 4% and 3%, respectively. The incidence of typhoid in Type B intestinal infectious diseases and Cholera which is the only Type A intestinal infectious disease is very low.

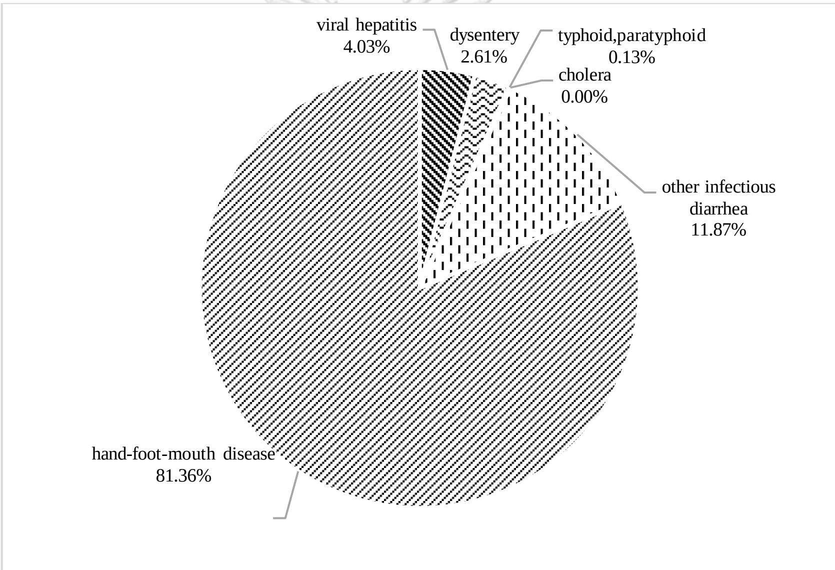


Figure 4: Distribution of the average incidence of 6 intestinal infectious diseases

Table 3: Incidence of each intestinal infectious diseases in Jiangsu Province for each year during 2011 − 2019

Year	Incidence of Intestinal Infectious Disease (1/100,000)					
	Cholera	Viral hepatitis	Dysentery	Typhoid, Paratyphoid	Other infectious diarrhea	Hand-foot-mouth disease
2011	0.00	10.29	9.41	0.34	18.30	145.98
2012	0.01	9.29	7.32	0.26	19.20	146.45
2013	0.01	9.48	5.74	0.27	20.06	121.71
2014	0.00	8.78	5.02	0.20	18.65	210.52
2015	0.00	7.63	4.90	0.20	19.16	119.43
2016	0.01	6.68	4.05	0.40	19.32	197.58
2017	0.00	6.43	3.37	0.19	31.86	114.22
2018	0.00	6.01	3.08	0.18	27.81	237.50
2019	0.00	5.90	2.79	0.22	33.47	130.66

The incidence of two typical diseases of Type B intestinal infection, viral hepatitis and dysentery, showed a general downward trend from 2011 to 2019. The incidence of viral hepatitis has dropped from 10.29/100,000 to 5.90/100,000 in 2019, and the incidence has fallen by nearly half. That of dysentery dropped from 9.41/100,000 to 2.79/100,000, the largest decline. The incidence of cholera, typhoid and paratyphoid is low, and the range of change is also very small. Even though the average incidence of cholera as shown in Table 4 is 0, but Jiangsu Province has a large population, and because it retains only two decimal places, the cholera incidence is actually greater than zero.

From the overall change trend of 9 years, the incidence of typhoid and paratyphoid is declining, except for the sudden increase in the incidence in 2016, which even reached the peak in 9 years. The incidence of other infectious diarrhea did not change much from 2011 to 2016, fluctuating around 19/100,000, but since 2017, the incidence has gradually shown an upward trend, although there was a slight decline in 2018, but in 2019 it rose again, reached 33.47/100,000, an increase of 15.17/100,000 compared to 2011. The change trend of the incidence of hand-foot-mouth disease was fluctuating, showed a high incidence every other year, and the change range is very large. The incidence in 2014 and 2018 both exceeded 200/100,000, especially the incidence rate of hand-foot-mouth disease in 2018 was

237.50,100,000 which was the highest in 9 years, while the incidence in 2017 was the lowest in 9 years, only 114.22/100,000. The incidence in 2018 has more than doubled compared to 2017. Due to the high incidence, even though the incidence of 130.66/100,000 in 2019 has decreased by 15.32 compared with 2011, the change in hand-foot-mouth disease is not very large.

Table 4: Descriptive statistics of incidence of 6 intestinal infectious diseases in Jiangsu Province during 2011 − 2019

Type	Incidence of IID	N	Mean	Std. Deviation	Minimum	Maximum
A	Cholera	9	0.00	0.00	0.00	0.01
B	Viral hepatitis	9	7.83	1.66	5.90	10.29
	Dysentery	9	5.08	2.17	2.79	9.41
	Typhoid and Paratyphoid	9	0.25	0.08	0.18	0.40
C	Other infectious diarrhea	9	23.09	6.16	18.30	33.47
	Hand-foot-mouth disease	9	158.23	45.27	114.22	237.50

Note: incidence is 1 per 100,000
The permanent population of Jiangsu Province in 2019 was 80.7 million

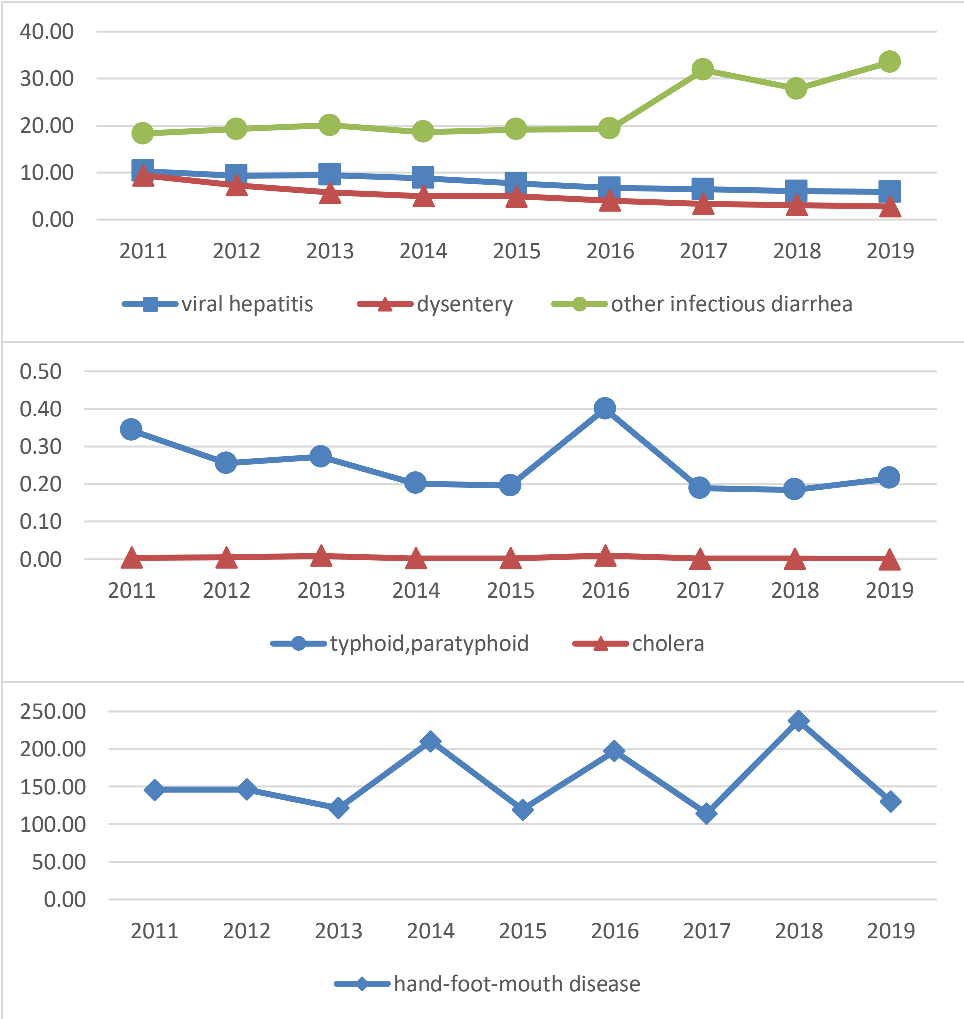


Figure 5: The incidence trend of 6 intestinal infectious diseases

4.1.2 Description analysis at City level

Figures 6 –17 are the average incidence of Type A and B intestinal infectious disease of each city in Jiangsu Province from 2011–2019. Figure 6 shows the distribution map of the average incidence of type A and B intestinal infectious diseases in Jiangsu Province from 2011 to 2019. Jiangsu Province is the eastern coastal region of mainland China. As can be seen from the figure 6, the incidence in Xuzhou City, Jiangsu Province is the highest, the incidence in coastal cities is higher, while that in cities close to the interior like Nanjing city and Huaian city have a lower incidence.

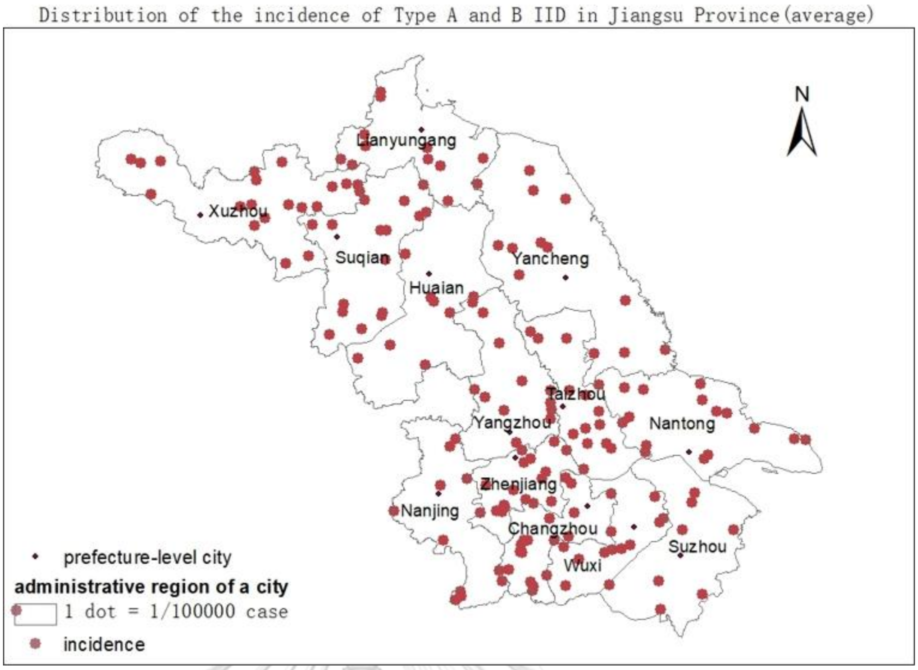


Figure 6: Distribution of the average incidence of Type A and B intestinal infectious diseases in Jiangsu Province from 2011 to 2019

The average incidence of Type A and B intestinal infectious diseases in 13 cities of Jiangsu Province during 9 years is shown in the figure 7. The incidence in Huai'an City is 8.31/100,000, which is the city with the lowest incidence in Jiangsu Province, and Xuzhou is the city with the highest incidence of 19.70/100,000, which is more than twice the incidence in Huaian City.

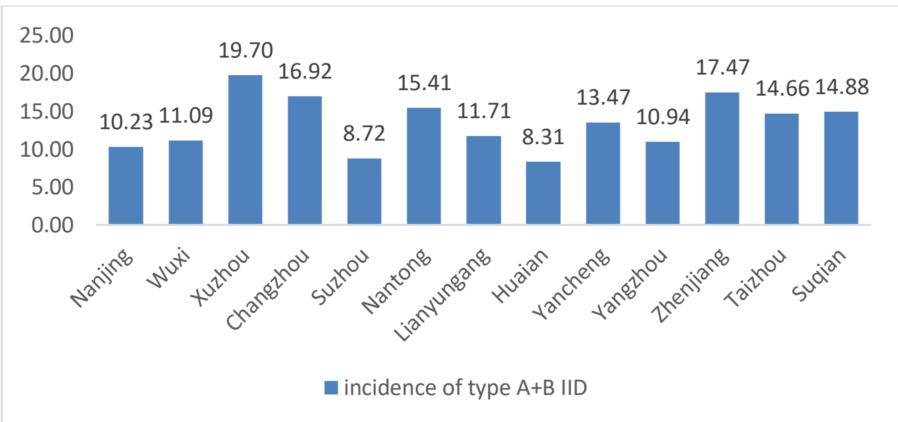


Figure 7: Average incidence of Type A and B intestinal infectious diseases in 13 cities of Jiangsu Province

The incidence of Type A and B intestinal infectious diseases in 13 cities of Jiangsu province showed a fluctuating downward trend from 2011 to 2019, except that Xuzhou began to show a large increase inconsistent with other cities since 2016.

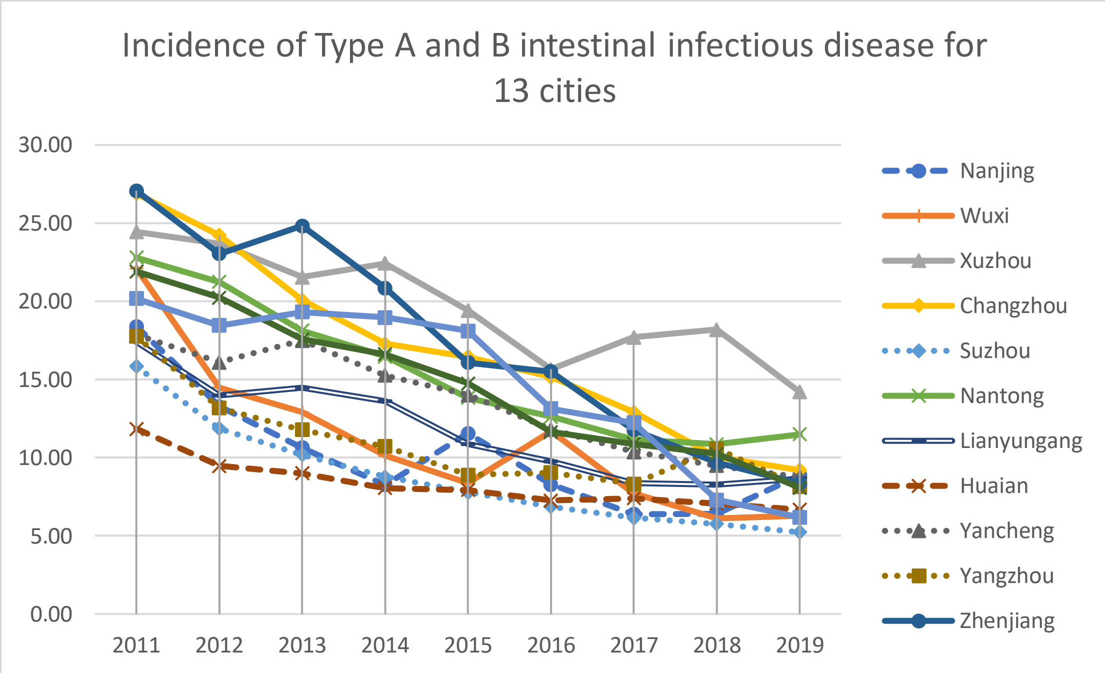


Figure 8: Trends in the average incidence of Type A and B intestinal infectious diseases in 13 cities of Jiangsu Province

Figure 9-17 shows the changes in the distribution of the incidence of Type A and B intestinal infectious diseases in Jiangsu province from 2011 to 2019.In general, cities closer to the inland have a lower incidence rate. The most typical city is Huai 'an, which has been the city with the lowest incidence rate in the whole province for 9 years, while coastal cities have a slightly higher incidence rate, which is in the middle level of Jiangsu Province. Suzhou, in the southeast of the province, also has a low incidence of intestinal infectious diseases, while Xuzhou, in the northwest of the province, has been the city with the highest incidence. Zhenjiang gradually changed from a severe epidemic area to a lighter epidemic area between 2011-2019.

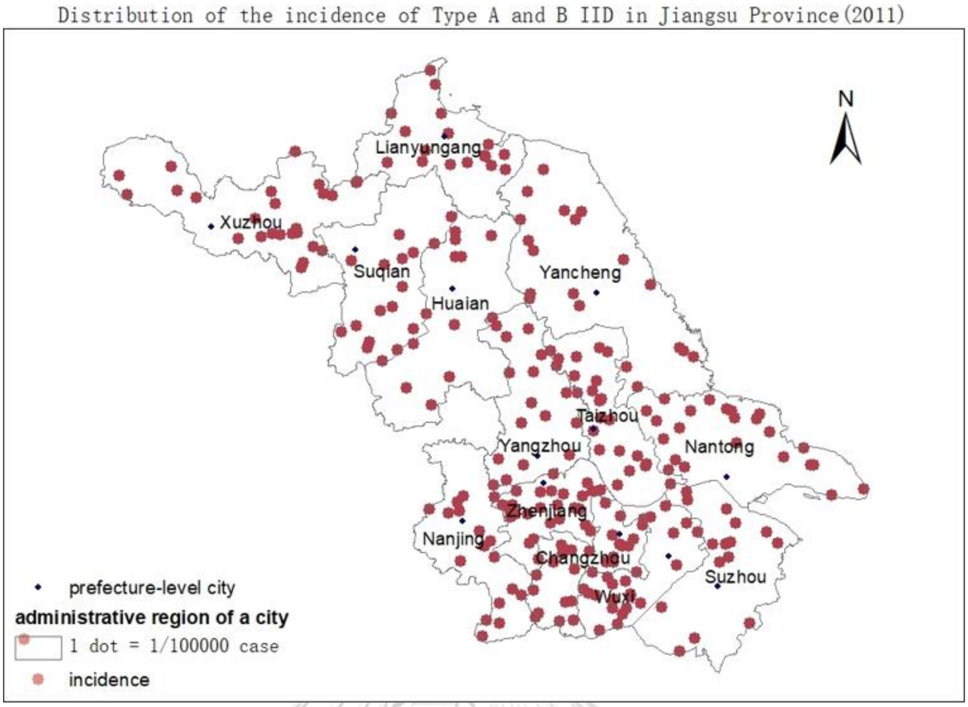


Figure 9: Distribution of the incidence of Type A and B intestinal infectious diseases in Jiangsu Province (2011)

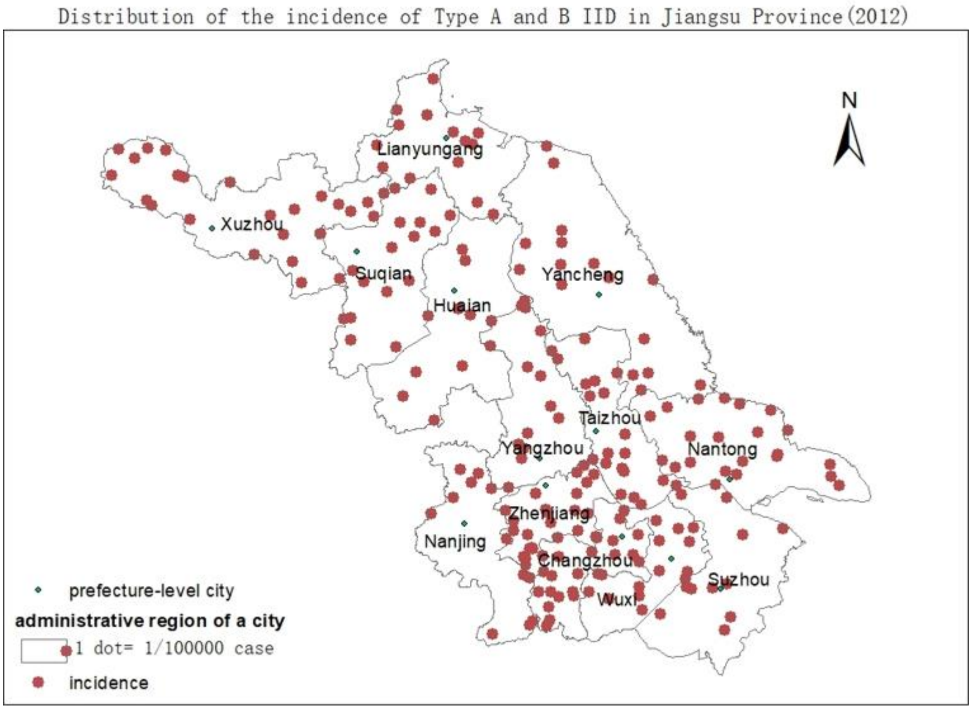


Figure 10: Distribution of the incidence of Type A and B intestinal infectious diseases in Jiangsu Province (2012)

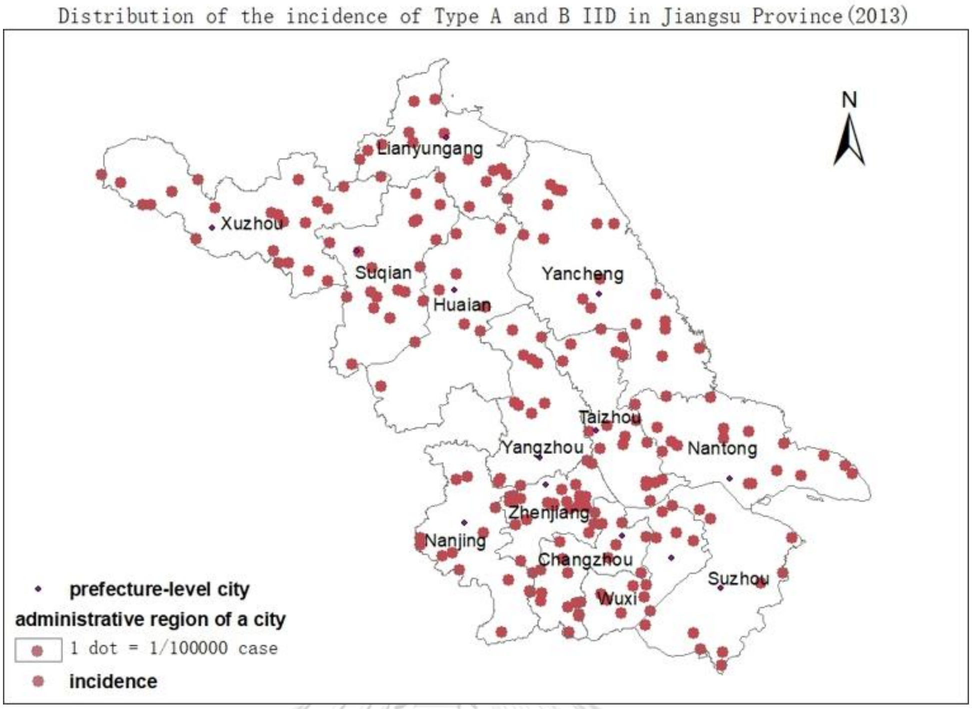


Figure 11: Distribution of the incidence of Type A and B intestinal infectious diseases in Jiangsu Province (2013)

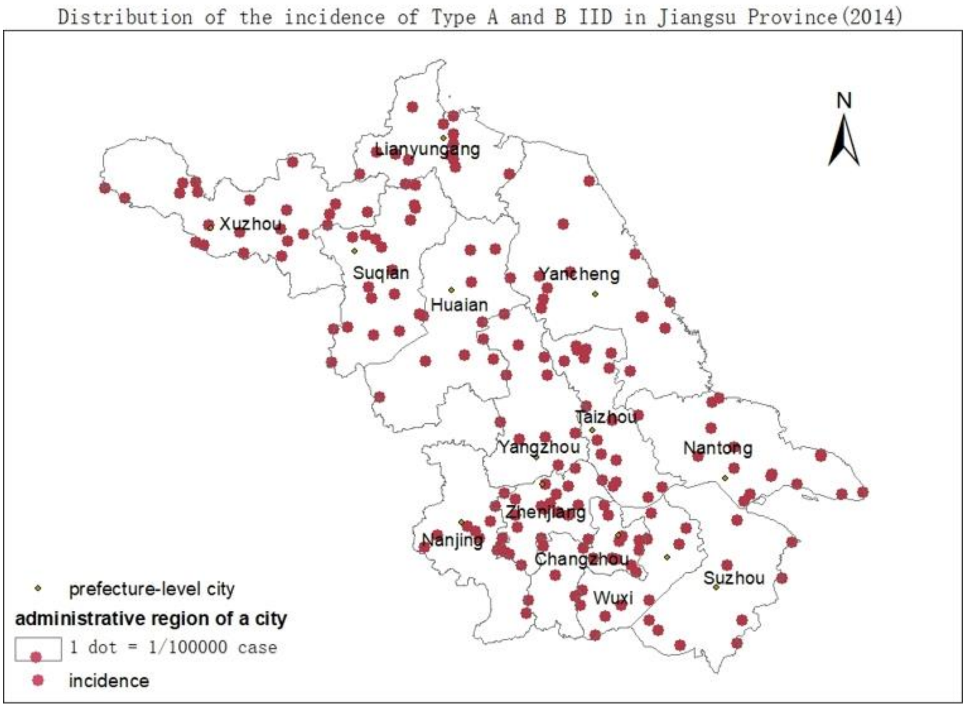


Figure 12: Distribution of the incidence of Type A and B intestinal infectious diseases in Jiangsu Province (2014)

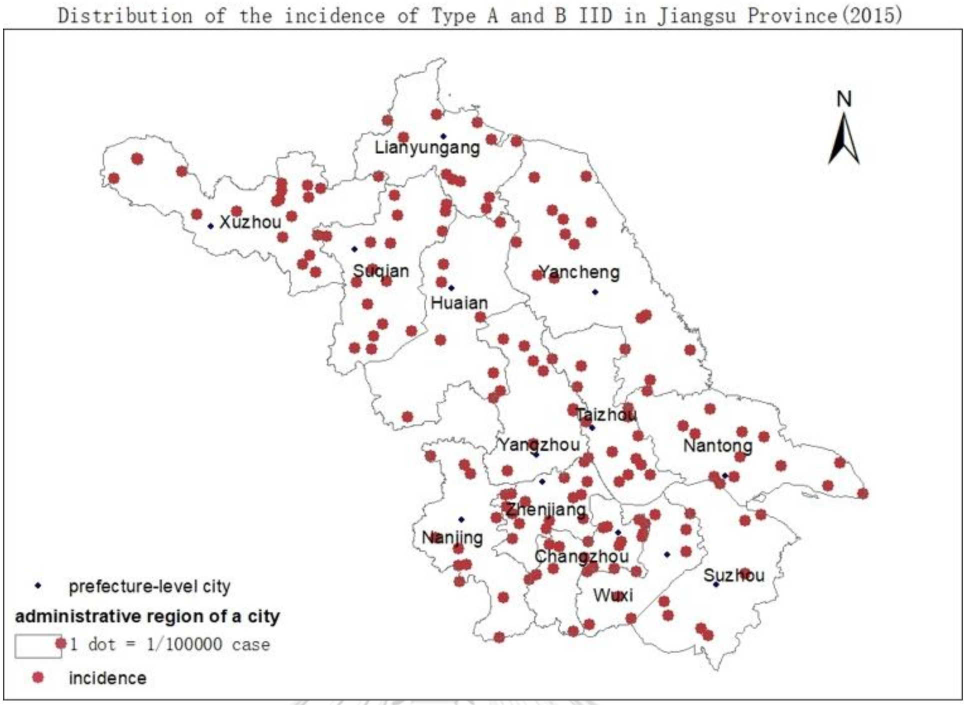


Figure 13: Distribution of the incidence of Type A and B intestinal infectious diseases in Jiangsu Province (2015)

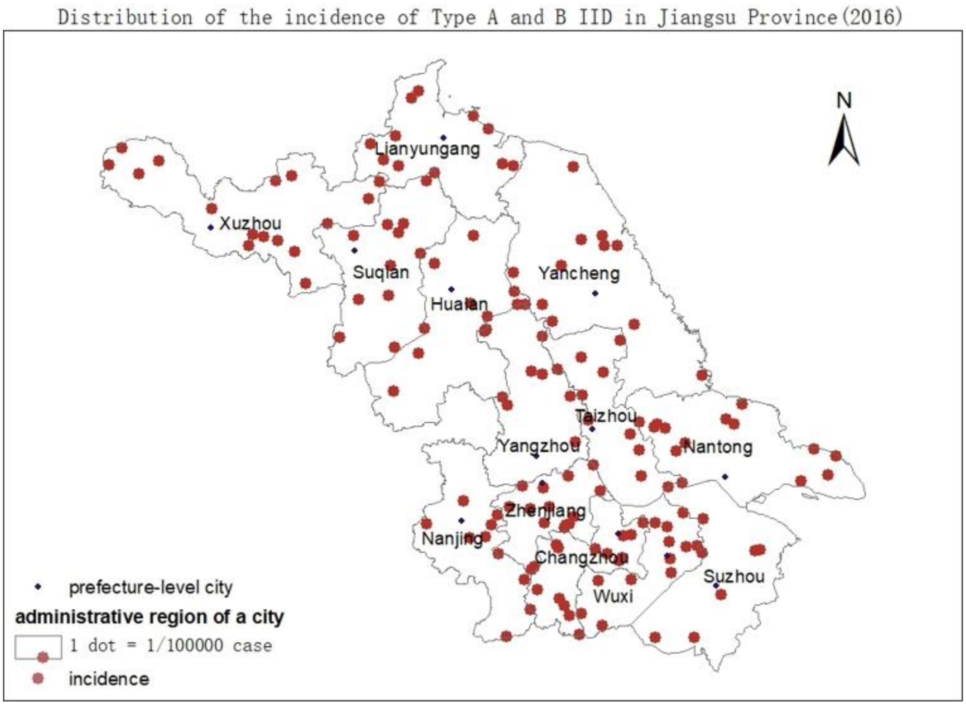


Figure 14: Distribution of the incidence of Type A and B intestinal infectious diseases in Jiangsu Province (2016)

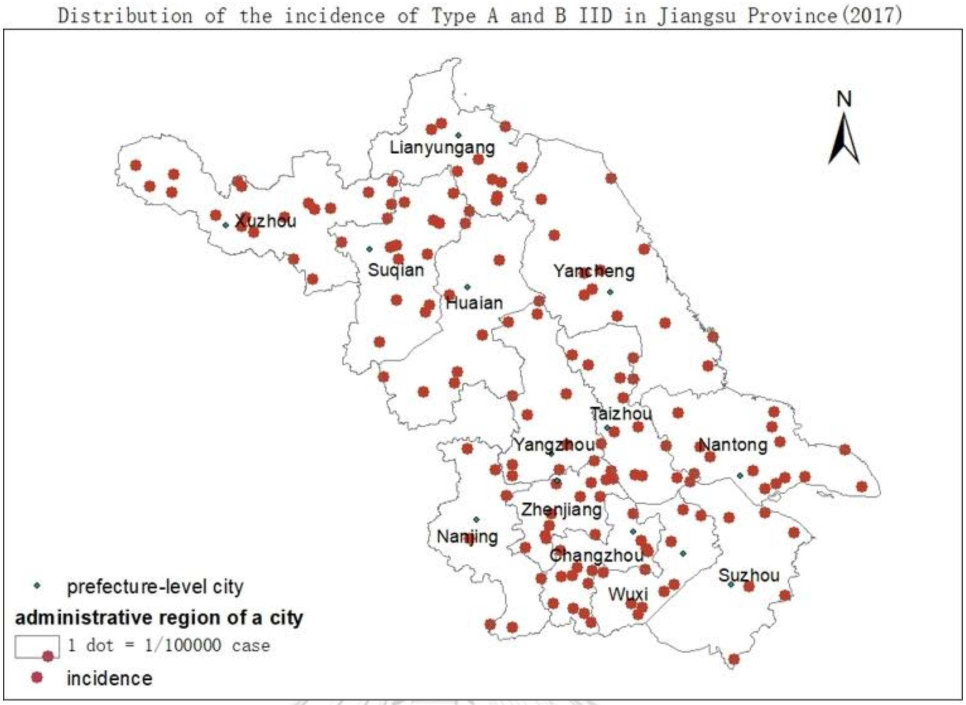


Figure 15: Distribution of the incidence of Type A and B intestinal infectious diseases in Jiangsu Province (2017)

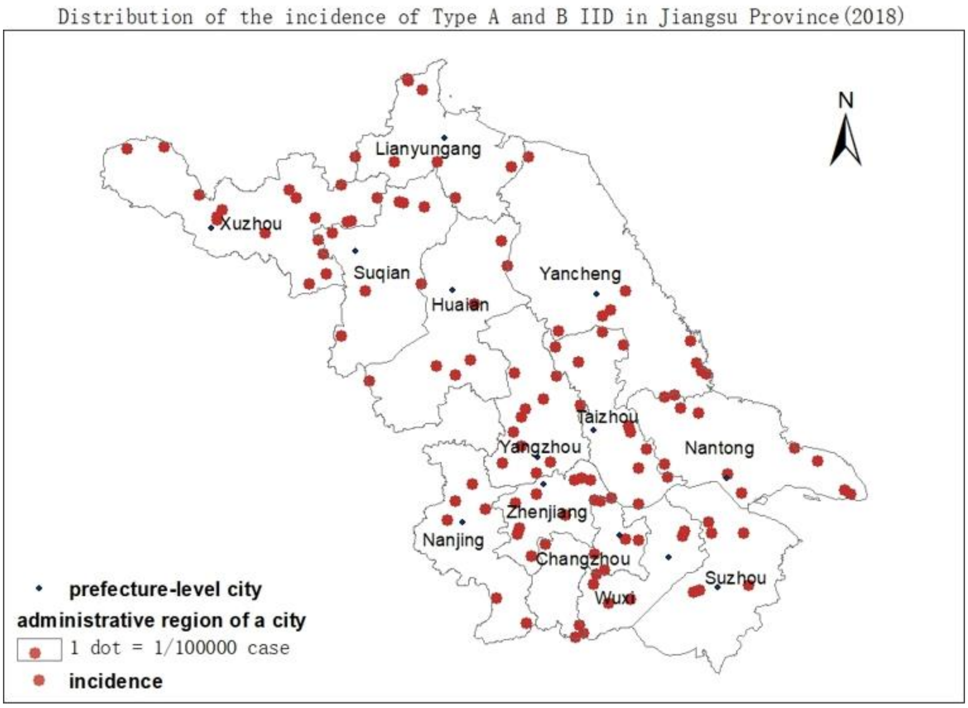


Figure 16: Distribution of the incidence of Type A and B intestinal infectious diseases in Jiangsu Province (2018)

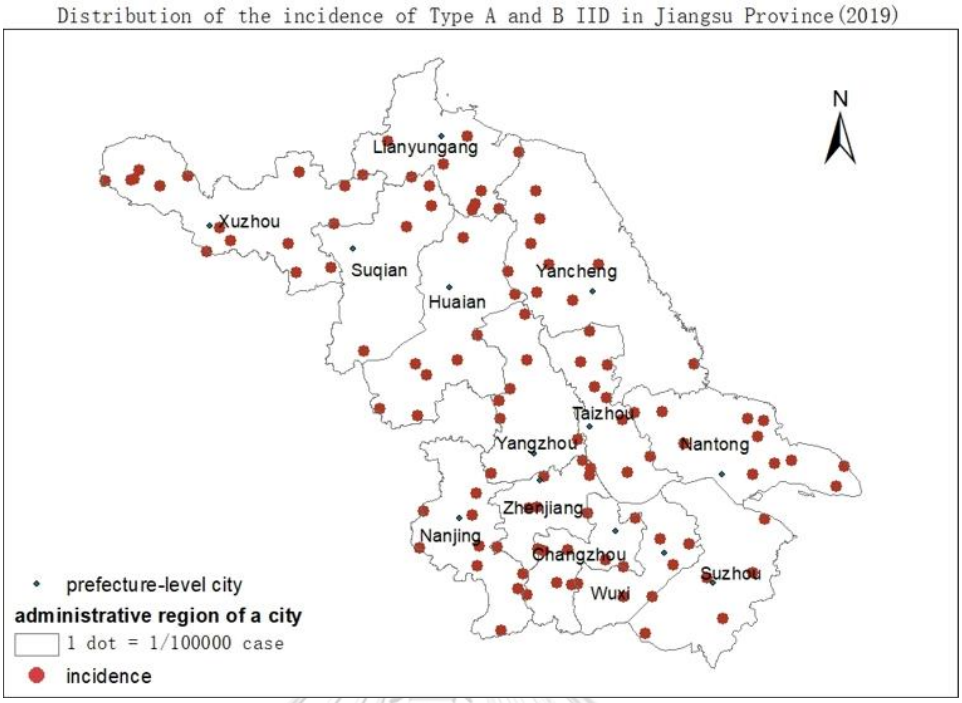


Figure 17: Distribution of the incidence of Type A and B intestinal infectious diseases in Jiangsu Province (2019)

4.2 Sanitary toilet coverage

There are three types of sanitary toilets in Jiangsu Province, namely sanitary toilet, harmless sanitary toilet and sanitary public toilet. The accumulative use of these three types of sanitary toilets is increasing. The earliest construction one was sanitary toilets, so in 2011, the coverage rate of sanitary toilet has reached 87.36%, in 2018 the data has reached 99.61%, nearly 100%, the number of households using sanitary toilet has reached 15.4083 million. The coverage rate of harmless sanitary toilet has changed greatly. In 2011, the coverage rate was only 67.42%, and the accumulative households using it just exceeded 10 million households, and in 2019 it has risen to 95%. The accumulative households using sanitary public toilet increased from 587,000 in 2011 to 825,000 in 2019.

Table 5: Basic characteristics of 3 types of sanitary toilet

Year	Sanitary toilet coverage rate (%)	Accumulative households using sanitary toilet (10,000 households)	Harmless sanitary toilet coverage rate (%)	Accumulative households using harmless sanitary toilet (10,000 households)	Sanitary public toilet (10,000 households)
2011	87.36%	1372.70	67.42%	1059.39	58.70
2012	90.89%	1428.17	73.90%	1161.22	65.40
2013	93.08%	1462.56	79.19%	1244.34	72.40
2014	96.08%	1509.75	85.48%	1343.17	72.80
2015	96.90%	1522.40	87.70%	1377.85	71.50
2016	97.40%	1507.10	91.10%	1409.86	77.60
2017	97.90%	1514.40	92.50%	1430.88	82.50
2018	99.61%	1540.83	94.21%	1457.31	ND
2019	ND	ND	95.00%	ND	ND

ND is no data available

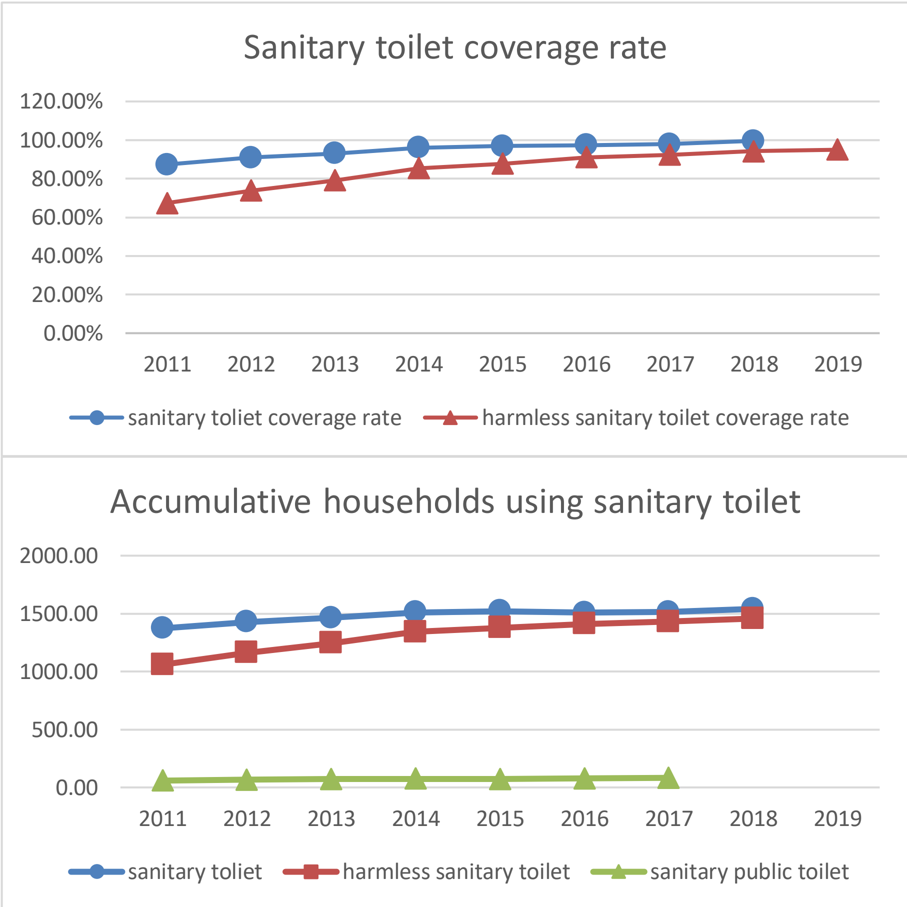


Figure 18: Trends in the coverage rate of 3 types of sanitary toilet

4.3 Density of four pests

The distribution of four pests is showed in the Figure 19. There is no consistent change pattern in the overall density of the four pests in Jiangsu Province. The distribution of fly and mosquito were fluctuated, while cockroach and mice were more stable. Among them, the density of flies is the highest, the average density in 9 years is 3.91/trap, followed by the density of mosquitoes, cockroaches, and mice. No special pattern was found in the changes of the density of the four pests in 13 cities in Jiangsu Province.

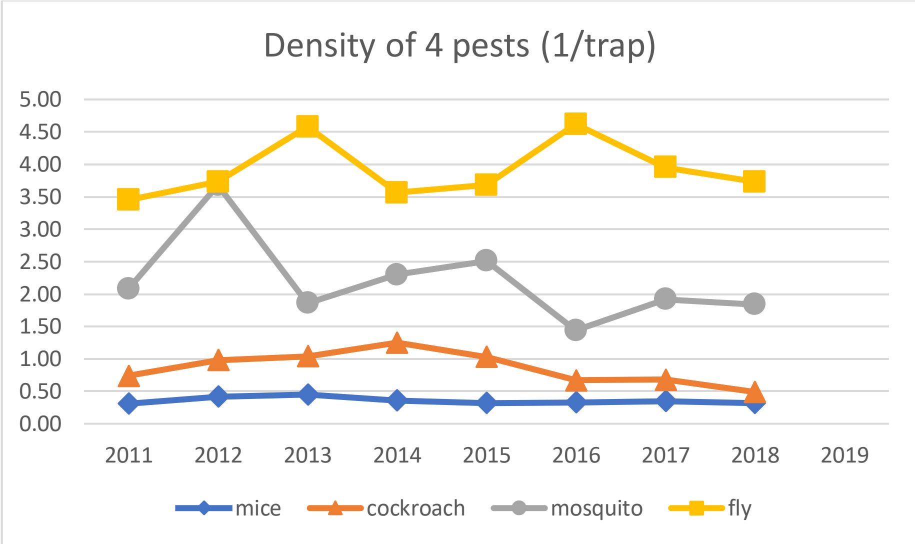


Figure 19: The distribution of the density of four pests during 2011-2018 (Note: Data of 2019 was not available.)

4.4 Water Quality

The rate of reaching the water quality standard of drinking water sources in Jiangsu Province is very high, nearly 100%. From 2011 to 2019, the compliance rate varied between 98% and 100%. Only in 2016, the compliance rate was 100%. The proportion of surface water quality meeting the Class III and above standards showed an overall upward trend, from 35.5% in 2011 to 77.9% in 2019 except for a slight decline in 2018.

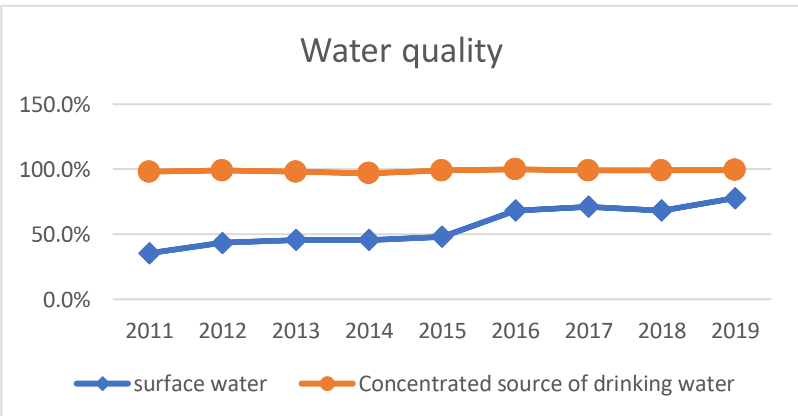


Figure 20: Distribution trend of water quality compliance rate

4.5 Environmental parameters

The average annual temperature in Jiangsu Province was increased during the past 9 years as shown in Figure 21. Average temperature was rising from 15.4°C in 2011 to 16.5°C in 2019, and the temperature from 2013 to 2015 decreased slightly. However, the variation in the highest temperature is relatively large, showing a fluctuating change, which exceeded 30°C in 2013 and 2017, and slightly lower in 2014 and 2015, at 27.1°C.

The average rainfall in Jiangsu Province is shown in Figure 21. Basically, the average rainfall varied across the study period and above 800 mm every year. In 2016, the rainfall was reach with a maximum value of 1612.3mm.°C

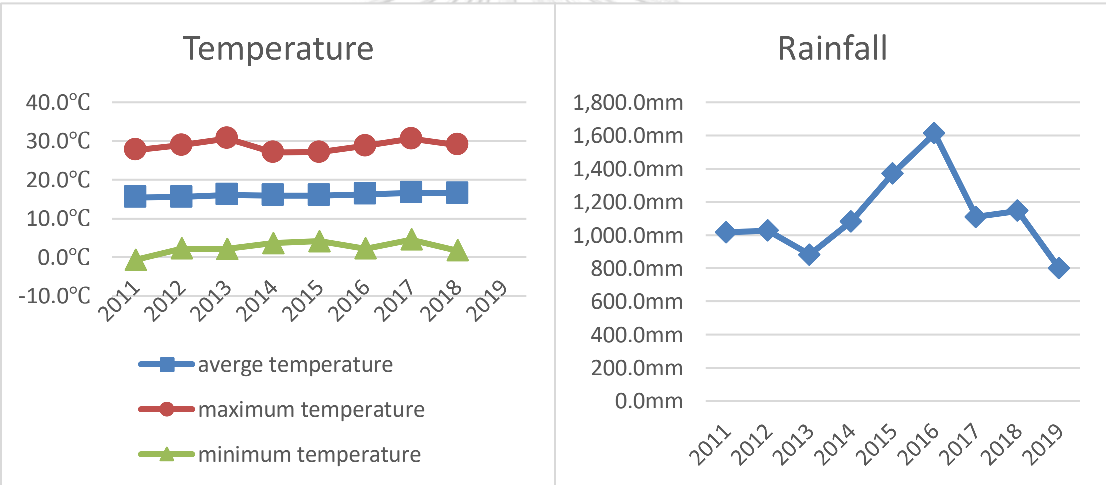


Figure 21: The distribution of temperature and rainfall

The annual average temperature does not change much for 13 cities, but on the whole, it shows a slight upward trend. However, there is a large gap between the rainfall in 13 cities. Changzhou has the most abundant precipitation, with an average of 1354mm per year. Xuzhou, Lianyungang, Huai'an, and Suqian have fewer annual precipitations. The average annual precipitation is less than 1000mm. At the same time, the precipitation in all nine cities except these four cities has increased significantly since 2014, and most of them reached the maximum precipitation in nearly nine years in 2017. The drinking water sources in 13 cities have high water quality compliance rates. Among them, Nanjing, Wuxi, Xuzhou, and Changzhou reached 100% in nine years. However, water quality tests in Yangzhou, Taizhou, Xuzhou, Suqian and Nantong all declined to varying degrees in 2016.

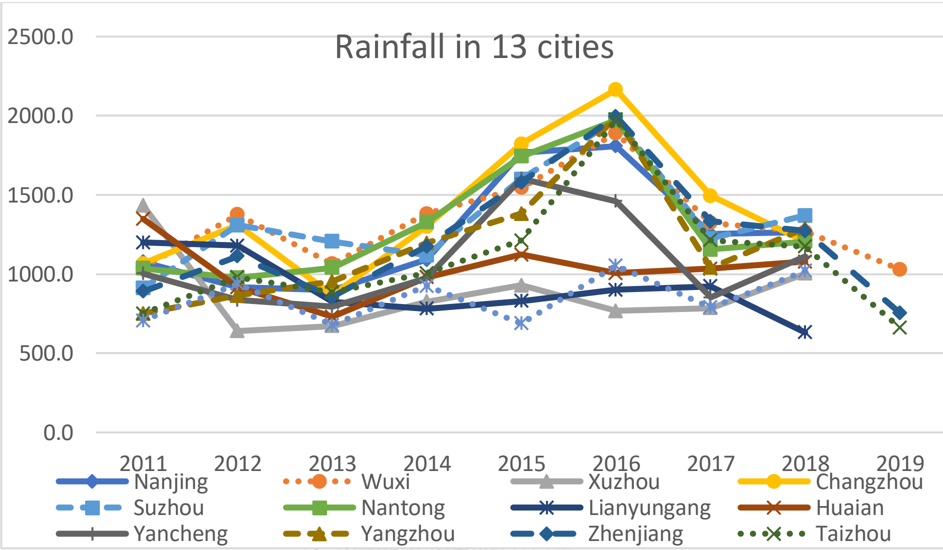


Figure 22: Variation trend of rainfall in 13 cities of Jiangsu Province

The population density varies greatly among cities. The average population density in Wuxi city is the largest, close to 1400per km2, and that in Yancheng city is the smallest, only 433per km2. In general, the areas with relatively good economic development in southern Jiangsu have higher population density.

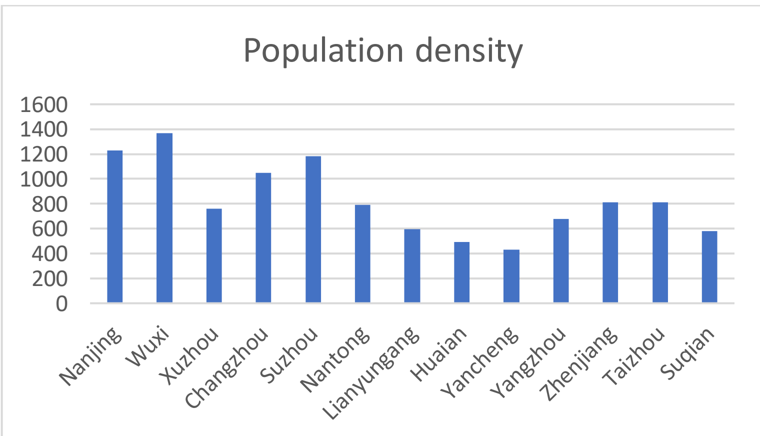


Figure 23: Average population density in 13 cities of Jiangsu Province from 2011-2019

4.6 Regression analysis

4.6.1 Province level

The results of the simple linear regression analysis show that the total incidence of intestinal infectious diseases, viral hepatitis and dysentery are significantly different from the accumulative households using various types of sanitary toilets (sanitary toilet, harmless sanitary toilet, sanitary public toilet) ($P<0.2$), with the increase in the number of toilet users, the incidence of intestinal infectious diseases decreases. The incidence of typhoid and paratyphoid is also negatively correlated with the accumulative number of households using sanitary toilets.

Surface water quality compliance rate and annual average temperature are also the influencing factors of the total incidence of intestinal infectious diseases, viral hepatitis, dysentery. In addition, the incidence of cholera is positively correlated with the density of fly and the incidence of viral hepatitis is positively correlated with the density of cockroaches ($P<0.2$).

Table 6: The association between the incidence of Type A and B intestinal infectious diseases and various factors in Jiangsu Province

Simple linear regression

Variables	Type A and B			Cholera			Viral hepatitis			Dysentery			Typhoid and Paratyphoid		
	β	SE	*P* value	β	SE	*P* value	β	SE	*P* value	β	SE	*P* value	β	SE	*P* value
Accumulative households using sanitary toilets	**-0.060**	**0.009**	**0.001***	-0.001	0.000	0.549	**-0.024**	**0.006**	**0.008***	**-0.036**	**0.004**	**<0.001***	**-0.001**	**0.000**	**0.188**
Accumulative households using harmless sanitary toilets	**-0.025**	**0.002**	**<0.001***	0.000	0.000	0.607	**-0.010**	**0.002**	**0.001***	**-0.015**	**0.001**	**<0.001***	0.000	0.000	0.305
Accumulative households using sanitary public toilets	**-0.429**	**0.056**	**0.001***	0.000	0.000	0.948	**-0.167**	**0.041**	**0.010***	**-0.260**	**0.027**	**<0.001***	-0.003	0.004	0.550
Density of mice	19.437	28.123	0.515	0.029	0.024	0.270	13.291	11.521	0.293	6.190	16.715	0.724	-0.074	0.636	0.911
Density of cockroach	6.006	5.402	0.309	0.001	0.005	0.823	**3.704**	**2.097**	**0.128**	2.362	3.294	0.500	-0.063	0.127	0.643
Density of mosquito	2.381	1.990	0.277	-0.001	0.002	0.610	1.013	0.872	0.290	1.401	1.146	0.267	-0.033	0.046	0.506
Density of fly	-2.369	3.205	0.488	0.006	0.002	0.013	-0.798	1.422	0.595	-1.660	1.814	0.396	0.083	0.065	0.247
Surface water（Meets Class III standards and above）	**-0.239**	**0.033**	**<0.001***	0.000	0.000	0.455	**-0.104**	**0.012**	**<0.001***	**-0.126**	**0.024**	**0.001***	-0.001	0.002	0.588
Concentrated source of drinking water	**-2.199**	**1.371**	**0.153**	0.000	0.001	0.788	**-1.169**	**0.527**	**0.062**	-0.980	0.814	0.268	0.019	0.031	0.369
Average temperature	**-7.778**	**1.351**	**0.001***	-0.001	0.003	0.825	**-3.201**	**0.745**	**0.005***	**-4.523**	**0.759**	**0.001***	-0.054	0.072	0.483
Maximum temperature	-0.731	1.039	0.508	0.001	0.001	0.513	-0.267	0.458	0.581	-0.464	0.596	0.466	-0.001	0.024	0.983
Minimum temperature	**-1.386**	**0.714**	**0.100**	-0.001	0.001	0.515	-0.483	0.345	0.211	**-0.873**	**0.388**	**0.065**	**-0.030**	**0.016**	**0.109**
Rainfall	-0.003	0.006	0.676	0.000	0.000	0.302	-0.002	0.002	0.505	-0.001	0.003	0.692	0.000	0.000	0.317

The incidence of other infectious diarrhea was positively correlated with the number of households using sanitary toilets and sanitary toilets. Surface water quality compliance rate and annual average temperature and maximum temperature are also positively correlated with other infectious diarrhea($P<0.2$). There are no other significant differences in hand-foot-mouth disease.

Table 7: The association between the incidence of Type C intestinal infectious diseases and various factors in Jiangsu Province

Simple linear regression

Variables	Type C IID			Other infectious diarrhea			Hand-foot-mouth		
	β	SE	*P* value	β	SE	*P* value	β	SE	*P* value
Accumulative households using sanitary toilets	0.341	0.310	0.313	0.043	0.032	0.228	0.298	0.315	0.380
Accumulative households using harmless sanitary toilets	0.138	0.124	0.307	**0.021**	**0.012**	**0.131**	0.117	0.127	0.389
Accumulative households using sanitary public lavatories	0.480	2.104	0.829	**0.417**	**0.208**	**0.101**	0.063	2.226	0.979
Density of mice	-322.600	353.398	0.397	-15.989	40.059	0.704	-306.594	353.152	0.419
Density of cockroach	-60.430	72.477	0.436	**-12.165**	**6.575**	**0.114**	-48.265	73.464	0.536
Density of mosquito	-19.830	27.413	0.497	-2.203	2.942	0.482	-17.629	27.470	0.545
Density of fly	-10.020	43.012	0.823	0.129	4.650	0.979	-10.152	42.724	0.820
Surface water （Meets Class III standards and above）	0.727	1.076	0.521	**0.337**	**0.084**	**0.005***	0.391	1.112	0.736
Concentrated source of drinking water	-4.006	18.448	0.834	2.595	2.347	0.305	-6.601	18.525	0.732
Average temperature	33.640	42.369	0.457	9.123	**3.017**	**0.023***	24.516	43.101	0.590
Maximum, temperature	-8.020	13.564	0.576	2.197	**1.204**	**0.118**	-10.217	13.220	0.469
Minimum temperature	-4.657	11.603	0.702	-0.001	0.001	0.515	1.108	1.182	0.384
Rainfall	0.053	0.066	0.448	-0.009	0.009	0.337	0.062	0.065	0.375

These factors are not related to the change in the total incidence of intestinal infectious diseases of Type A, B and C.

Table 8: The association between the total incidence of Type A B and C intestinal infectious diseases and various factors in Jiangsu Province

Variables	Type A B and C IID		
	β	SE	*P* value
Accumulative households using sanitary toilets	0.281	0.309	0.399
Accumulative households using harmless sanitary toilets	0.113	0.124	0.397
Accumulative households using sanitary public toilets	0.051	2.1	0.982
Density of mice	-303.12	344.45	0.413
Density of cockroach	-54.419	70.901	0.472
Density of mosquito	-17.449	26.809	0.539
Density of fly	-12.391	41.624	0.776
Surface water （Meets Class III standards and above）	0.494	1.069	0.658
Concentrated source of drinking water	-6.152	17.938	0.892
Average temperature	25.861	41.915	0.56
Maximum temperature	-8.75	13.062	0.528
Minimum temperature	-6.043	11.141	0.607
Rainfall	0.05	0.064	0.464

Use $p<0.2$ as the test standard to determine the variables included in the multiple regression model. The final multiple linear regression results showed that the accumulative households using sanitary toilets (β=-0.036), the proportion of surface water reaching Grade III and above (β=-0.135) were negatively correlated to the incidence of type A and B intestinal infectious diseases in Jiangsu Province, the accumulative number of households using sanitary toilets has a greater impact on the incidence of intestinal infectious diseases of Type A and B than surface water quality. The accumulative households using sanitary toilets (β=-0.016) and sanitary public toilets (β=-0.059) are negatively correlated with dysentery($P<0.05$), the more use of sanitary toilets, the lower the incidence of dysentery. The accumulative households using sanitary public toilets has a greater impact on the Type A and B intestinal infectious diseases.

Table 9: Multiple linear regression analysis between intestinal infectious diseases and various factors in Jiangsu Province

	Simple linear regression			Multiple linear regression						
	Type A and B IID									
Variables	**β**	**SE**	***p* value**	**β**	**SE**	***p* value**	**95.0% CI Lower Bound**	**95.0% CI Upper Bound**	**R Square**	**Adjusted R Square**
Accumulative households using sanitary toilets	-0.060	0.009	0.001	-0.036	0.003	<0.001	-0.043	-0.029		
Surface water （Meets Class III standards and above）	-0.239	0.033	<0.001	-0.135	0.011	<0.001	-0.164	-0.107	0.996	0.994
	Dysentery									
Accumulative households using sanitary toilets	-0.036	0.004	<0.001	-0.016	0.002	0.001	-0.020	-0.012		
Accumulative households using sanitary public toilets	-0.260	0.027	<0.001	-0.159	0.011	<0.001	-0.191	-0.128	0.998	0.997

4.6.2 City level

Among the 13 cities in Jiangsu Province, 10 cities (Nanjing, Wuxi, Changzhou, Suzhou, Nantong, Yancheng, Yangzhou, Zhenjiang, and Taizhou) have significant differences between the incidence of Type A and B intestinal infectious diseases and annual average temperature. Besides Zhenjiang and Suqian, the incidence of Type A and B intestinal infectious diseases was negatively correlated with the minimum temperature in other 8 cities plus Huaian. The mosquito density in Wuxi and Suzhou is positively correlated with the incidence of Type A and B intestinal infectious diseases, while the density of flies in Lianyungang and Yangzhou is also positively correlated with it. In addition, the incidence of Type A and B intestinal infectious diseases in Wuxi City and Lianyungang City were also significantly correlated with cockroach density and rainfall, respectively.

The results of multiple regression analysis showed the relationship between the incidence of intestinal infectious diseases of Type A and B in the final 7 cities and related factors. Among them, the highest frequency and similar effect on each city is the average temperature, which is negative correlated to the incidence of Type A and B intestinal infectious diseases in Nanjing (β=-5.091), Nantong(β=-4.692), Yangzhou(β=-1.919) and Zhenjiang(β=-22.644), respectively（P<0.05）.

Table 10: The association between the total incidence of Type A and B intestinal infectious diseases and various factors in each city

	Simple linear regression			Multiple linear regression			
			Nanjing city				
Variables	**β**	**SE**	***p* value**	**β**	**SE**	***p* value**	**Adjusted R Square**
Density of mice	15.990	11.076	0.199				
Density of fly	-1.476	0.651	0.064				
Average temperature	-7.357	2.181	0.012*	-5.091	1.756	0.034	0.860
Minimum temperature	-1.540	0.690	0.067				
Population density	-0.033	0.008	0.003*	-0.023	0.007	0.019	
			Wuxi city				
Density of cockroach	9.918	2.867	0.013*				
Density of mosquito	5.115	1.462	0.013*				
Average temperature	-7.515	1.962	0.006*				
Minimum temperature	-2.274	0.656	0.013*				
Population density	-0.032	0.008	0.004*				
			Xuzhou city				
Density of cockroach	2.980	1.363	0.071				
Population density	0.047	0.028	0.136				
			Changzhou city				
Average temperature	-12.306	2.827	0.005*				
Minimum temperature	-1.900	1.215	0.169				
Population density	-0.048	0.021	0.055				
			Suzhou city				
Density of mosquito	1.717	0.445	0.006*	1.965	0.211	0.001	
Density of fly	0.823	0.467	0.121	-0.538	0.139	0.018	
Average temperature	-6.114	2.387	0.043*				0.984
Minimum temperature	-1.505	0.587	0.043*				
Population density	-0.017	0.005	0.015*	-0.011	0.001	0.000	
			Nantong city				
Density of cockroach	1.786	0.967	0.114				
Density of fly	-4.822	2.314	0.082				
Average temperature	-7.404	1.184	0.001*	-4.692	0.705	0.001	0.973
Minimum temperature	-1.842	0.771	0.054				
Population density	0.029	0.009	0.018*	0.018	0.003	0.003	

Table 10 (Continued)

Variables	β	SE	*p* value	β	SE	*p* value	Adjusted R Square
Lianyungang city							
Density of fly	-0.951	0.289	0.017*				
Rainfall	0.011	0.005	0.048*				
Population density	0.063	0.042	0.174				
Huaian city							
Density of mosquito	-0.766	0.353	0.073	-0.675	0.223	0.029	0.742
Minimum temperature	-0.682	0.375	0.119				
Rainfall	0.004	0.003	0.173				
Population density	0.057	0.025	0.057	0.050	0.016	0.024	
Yancheng city							
Density of mice	-12.015	5.175	0.059				
Density of fly	2.300	1.320	0.132				
Average temperature	-5.251	1.222	0.005*				
Minimum temperature	-0.979	0.652	0.184				
Yangzhou city							
Density of mice	20.036	9.345	0.076	11.866	2.312	0.007	0.966
Density of mosquito	2.931	1.232	0.055				
Density of fly	1.894	0.604	0.020*				
Average temperature	-3.529	0.851	0.006*	-1.919	0.462	0.014	
Minimum temperature	-1.282	0.284	0.004*	-0.531	0.171	0.036	
Zhenjiang city							
Density of fly	2.581	1.564	0.143	6.382	1.468	0.007	0.851
Average temperature	-5.905	2.117	0.027*	-22.644	4.259	0.003	
Population density	-0.103	0.051	0.082	0.500	0.115	0.007	
Taizhou city							
Density of mice	1.054	0.566	0.112	1.533	0.179	0.000	0.934
Density of mosquito	5.882	3.981	0.190	9.268	1.172	0.001	
Density of fly	-4.215	2.521	0.146				
Average temperature	-8.395	2.204	0.007*				
Minimum temperature	-1.221	0.766	0.162				
Population density	0.106	0.061	0.123				
Suqian city							
Density of cockroach	-4.670	1.984	0.065				
Average temperature	-4.358	1.861	0.058				

Chapter 5
Discussion

5.1 Distribution of Intestinal infectious disease

5.1.1 Province level

Although the incidence of Type A and B intestinal infectious disease was relatively low compare the population density but these diseases still important because it can cause serious condition and may lead to death. The total incidence of Type A and B intestinal infectious diseases in Jiangsu Province and the incidence of each diseases except typhoid and paratyphoid during 2011 to 2019 showed a downward trend. The variation trend of the incidence of infectious diseases is basically the same as the research in other regions of China, but the incidence of specific diseases is different from other studies. The results were similar to the trend that observed in Haidian district of Beijing which found that the incidence was decrease year by year and the top 3 diseases that have highest incidence rates were bacterial dysentery, hepatitis E and hepatitis A (Cai-yun et al.,2018). Our observation also consistent with a study in Tianjin which found a significant downward trend of Type A and B intestinal infectious diseases (Yan,2019). However, the overall incidence of intestinal infectious diseases in these two areas was very high, with an average annual incidence of 120.07/100,000 and 87.20/100,000, respectively, which accounting for almost half of the incidence of Type A and B infectious diseases in the region, while Jiangsu Province has only 13.09/ 100,000.

In Zhejiang Province, which is adjacent to Jiangsu Province, the incidence of intestinal infectious diseases is similar to that in Jiangsu Province. In Shaoxing City, Zhejiang Province, the annual incidence of Type A and B intestinal infectious diseases from 2008 to 2018 was 16.03/100,000. The most frequent cases were viral hepatitis and dysentery, which accounted for 84.75% of the total number of cases. The incidence of intestinal infectious diseases of Type A and B in the region has dropped from 35.33/100,000 in 2008 to only 5.79/100,000 in 2018, a large decline. The study speculated that the declining incidence may be related to the region's emphasis on water and toilet improvement (Qi-feng et al.,2019).

Comparing to Type A and B, the incidence of Type C intestinal infectious disease is much higher. Although it has lower degree of severity and different management protocol compared to Type A and B, but they must be managed in accordance with the monitoring methods stipulated by the health administrative department of the State Council. The different management and monitoring protocol may lead to the high incidence of Type C intestinal infectious diseases compared to Type A and B.

The incidence of other infectious diseases in Type C intestinal infectious disease is increasing year by year which opposite to the trend of Type A and B. This result was comparable to another study in Lanzhou city of Gansu Province which observed an increasing trend of diseases from 2006 to 2017. The reason may be the increase in the types of pathogens, the import of new enteroviruses, the improvement of the diagnosis level of medical staff and the improvement of infectious disease monitoring networks (Xiao-gin et al.,2019).

Hand foot and mouth disease (HFMD) is the most common intestinal infectious disease in Jiangsu province. The incidence of hand-foot-mouth disease shows an upward trend every other year, with a cycle every two years, rising first and then decreasing. This is consistent with the incidence and trend of hand-foot-mouth disease in other regions of China. There are many types of HFMD pathogens, and there is variability, resulting in a high incidence. Research in Luoshan county, Henan Province and Beihai city, Guangxi, both of them showed a similar variation trend of HFMD (Jin xia,2020, Lin et al.,2020). In particular, the study of Beihai city specifically explains the rule that the incidence showed a singular-year low and even-numbered-year high cyclic change.

Throughout the changes in the incidence of hand-foot-mouth disease in Jiangsu Province and other parts of China, there is a characteristic that the incidence is high every other year. The reason for this feature should be related to antibodies in the human body. People infected with hand-foot-mouth disease will get a specific period of immunity. A study conducted in Tianjin estimated that this specific antibody will last more than 6 months in the body (Dan,2020). So, when the antibody disappears, people's risk of infecting hand-foot-mouth disease increases again and again.

5.1.2 City level

The distribution map of intestinal infectious diseases of Type A and B shows that the incidence of intestinal infectious diseases of coastal cities is higher. Xuzhou City in northwestern Jiangsu has a highest incidence of intestinal infectious diseases, while the incidence of intestinal infectious diseases in Suzhou City in the southeast Jiangsu was the relatively lower, that in Huaian city is the lowest. The higher incidence in coastal cities were similar to other regions. In a coastal city in Shandong Province, China, the epidemic of viral hepatitis was investigated. The total proportion of hepatitis A, E, and untyped hepatitis exceeded 50%. The incidence of viral infections in coastal towns was significantly higher than in non-coastal towns (Xiao fen,2014). This observation may result from the water-borne and food-borne transmission as indicated in a study in Ningbo, a coastal city in eastern China. The epidemic of typhoid and paratyphoid were related to unqualified water quality and local residents' eating raw and semi-lived seafood. The production areas of some shellfish were contaminated and were secondary contaminated during the sales process (Yi et al.,2018).

The population movement of Jiangsu Province as a whole has flowed into the economically developed areas in eastern and southern Jiangsu Province. However, the impact of population movements on intestinal infectious diseases in Jiangsu Province does not present the obvious contrast to other cities. Especially in Suzhou City, Suzhou is the most populous city in Jiangsu Province, but the incidence of intestinal infectious diseases in this city is very low. This probably due to the economic, urbanization, and sanitary condition of this city (Meng yue and Yong feng,2018).

The incidence of intestinal infectious diseases of Type A and B in the three regions of Jiangsu province is ranked from small to large: Southern Jiangsu < Central Jiangsu < Northern Jiangsu. The observed rank may due to the different of the national income, increasing of individual's health concern and development of health care. A study Bijie City, Guizhou Province revealed that family income, health concerns of parents were important for the willingness to pay for hand-foot-mouth vaccination (Long jian,2019), which can imply that better economic status of the family and city can resulting to the lower incidence of diseases.

Jiangsu Province has always had a gap between rich and poor, showing a clear gradient from south to north. Since ancient times, southern Jiangsu has been a rich and prosperous area. Although the economic development of northern Jiangsu is also relatively fast, there is still a big gap with southern Jiangsu, and the GDP of southern Jiangsu accounts for about 60% of Jiangsu Province (Hui lin,2016). According to the latest 2018 GDP data released by the Jiangsu Provincial Statistics Bureau, looking at the five cities in southern Jiangsu alone, the ranking of GDP from high to low is: Suzhou (1859.75 billion)>Nanjing (1282.04 billion)>Wuxi (1143.86 billion)> Changzhou (705.21 billion)> Zhenjiang (405 billion), which coincides with the nine-year average incidence of intestinal infectious diseases in these five cities: Suzhou (8.72/100,000)<Nanjing(10.23/100,000)<Wuxi(11.09/100,000)<Changzhou(16.92/100,000)<Zhenjiang (17.47/100,000).

The incidence of Type A and B intestinal infectious diseases is the lowest in Huaian City. Compared with other cities, Huai'an's cockroach density, temperature (average temperature, maximum temperature and minimum temperature), rainfall and population density are relatively low, which may explain the low incidence. In addition, Huai'an is close to the inland, and the four adjacent cities are relatively not areas with high incidence of intestinal infectious diseases. In other words, Huai’an City is in a stable environment and there are no special factors that can cause high incidence of diseases.

The incidence of intestinal infectious diseases of Type A and B in Xuzhou has been high, which may be related to flood disasters. From 1983 to 2017, flood disaster occurred in Jiangsu province with the highest frequency and the greatest loss. The high frequency of rainstorms and floods in Jiangsu is mainly concentrated in most of Huaibei, floods occur frequently in nearly half of Xuzhou, the frequency of rainstorms and floods in neighboring Suqian, Yancheng city on the east coast, northeastern Changzhou in the south of Jiangsu Province, and the center of Nantong is also quite high. The incidence of intestinal infectious diseases of Type A and B in these cities is very high (Ying et al.,2019).

In this study. In 2016, the rainfall of nine cities in Jiangsu province suddenly increased, and the overall annual average rainfall of Jiangsu Province reached 1612.3mm. According to the report of the Top ten Weather and climate Events in 2016 issued by Jiangsu Meteorological Bureau, due to the strong El Nino, the climate of Jiangsu Province is abnormal. The rainfall in 2016 reached the highest level since 1951, the average number of heavy rain days was the highest since 1961, and the total amount and intensity of precipitation during the plum rain season also set a new record for this period. Heavy rain has caused excessive flooding in all rivers and embankments in southern Jiangsu, including the Taihu Lake, and the Qinhuai River in Nanjing. Meanwhile, the incidence of hand-foot-mouth disease, typhoid and paratyphoid, and other infectious diarrhea all increased in 2016.

During floods, surface water and groundwater may be contaminated, bringing fecal contaminants containing bacteria and viruses into the water source. Flooding can promote the growth of pathogens, which can spread through contaminated food and water, and flood will also affect the living environment. A study in northwestern Anhui showed that there were more cases of infectious diarrhea when floods occurred than when non-disasters occurred. After adjusting for other meteorological factors, the incidence of flooding and diarrhea increased significantly (Guoyong et al.,2013). Flooding causes people to be directly exposed to contaminated surface water, and it is also the main cause of contamination of groundwater drinking water supplies. The concentration of intestinal pathogens in groundwater increased significantly after the flood (Andrade et al.,2018). People are exposed to pathogens in the flood during the process of evacuating during the flood and cleaning their "property" after the flood is pushed down until it is clean and dry. Especially the cleaning process will bring major health risks to the people (Fewtrell et al.,2011).

5.2 The coverage of sanitary toilet and harmless sanitary toilet

According to the data, we observed that the coverage rates of sanitary toilet and harmless sanitary toilet was increase over time since 2011. It was clearly seen from the accumulate number of toilet use over the past years. The local government tried to survey and built more sanitary and harmless toilet for the people in the

Province. The new toilet covered both in the households and in the public places. The increasing trend of sanitary toilet used in Jiangsu Province showed the successfulness of toilet improvement policy which local government has been worked closely with the community.

The increasing number of sanitary toilets use in Jiangsu Province was similar to other region of China such as in Jilin Province. The coverage rate of sanitary toilet and harmless sanitary toilets in Jilin Province continuously increased, the intestinal infectious diseases (i.e. hepatitis A, untyped hepatitis, and bacterial dysentery) showed a downward trend which possibly related to the popularity of sanitary toilets, but there is no further investigation (Ni,2013). The increasing to sanitary toilet was also observed in Fuzhou. A study found that the popularity of using toilet is increasing year by year and it was negatively associated with the IDD (Yu qin and Mei xia,2002).

5.3 Association between sanitary toilet coverage and intestinal infectious diseases

Regression analysis results showed that the accumulative households using various types of sanitary toilets (sanitary toilets, harmless sanitary toilets and sanitary public toilets) was negatively correlated with the total incidence of Type A and B intestinal infectious diseases, viral hepatitis and dysentery in Jiangsu Province.

There are few early studies on toilet improvement in China, but in the end of the 20th century, a study on the disease prevention effect of toilets was carried out in Fuzhou. The sanitary toilet coverage rate has increased year by year, and the incidence of dysentery, typhoid fever and viral hepatitis has decreased by about 67 %. Correlation analysis results show that the sanitation toilet cove rage rate is negatively correlated with the incidence of intestinal infectious diseases, and the correlation coefficients of dysentery, typhoid fever and viral hepatitis are -0.558, -0.799, -0.940, respectively. The correlation coefficient between the total incidence of three intestinal infectious diseases and the popularity of sanitary toilets is -0.957. The popularity of sanitary toilets has obvious effects on disease prevention (Yu qin and Mei xia,2002). During the period 2010-2014 in Lin'an City, Zhejiang Province, sanitary toilet coverage rate continued to increase, and the incidence of viral hepatitis, dysentery, typhoid and paratyphoid had declined to varying degrees. Correlation analysis results show that increased investment in sanitary toilet construction can reduce the incidence of intestinal infectious diseases (Jun et al.,2016).

With the increase of the surface water quality compliance rate in Jiangsu Province, the total incidence of Type A and B intestinal infectious diseases and the incidence of viral hepatitis and dysentery have declined accordingly.

At the beginning of the 21st century, relevant personnel of the Chinese Center for Disease Prevention and Control studied and found that the incidence of hepatitis A, typhoid and paratyphoid gradually decreased with the compliance rate of drinking water quality, but dysentery was not found to be relevant (Yan lin,2008).

Yuxi City conducted an analysis of Type A and B infectious diseases for 20 year period (1996 to 2015). The incidence of dysentery and hepatitis A has decreased significantly, especially dysentery, from 65.80/100,000 in 1996 to 5.30/100,000 in 2015. The variation in the incidence of intestinal infectious diseases in this area is divided into two stages. From 1996 to 2010, the incidence rate showed an upward trend, from 106.10/100,000 to 173.70/100,000. The second stage is from 2011 to 2013, during this period, typhoid and paratyphoid outbreaks continued in the region until 2013. The reason has much to do with the improvement of toilets, because in the process of changing from a dry toilet to a more hygienic water flushing public toilet, there is no reasonable establishment of a sewage discharge system, which causes the toilet sewage to penetrate into the surface water and eventually vegetables are also contaminated by feces. The renovation of the sewage system and the implementation of a series of prevention measures were only controlled in 2013 (Hong-giang et al.,2017).

The change of the total incidence of Type A and B intestinal infectious diseases, viral hepatitis and dysentery in Jiangsu Province was negatively correlated with the annual average temperature, that is, the higher the average annual temperature, the lower the incidence rate. There is no significant difference between the incidence of intestinal infectious diseases and rainfall, and 9 out of 13 cities have the same results, which is very different from the results of studies conducted in other regions. Meteorological factors will affect the pathogens, hosts, vectors of infectious diseases, and susceptible people. Temperature will affect the replication and survival of pathogens in the environment, as well as people's living habits (Zuhua et al.,2019).

Fujian Province studied the association between intestinal infectious diseases and climate change from 2006 to 2015, and the results showed that dysentery, typhoid and paratyphoid, hepatitis A and hepatitis E are positively correlated with temperature (average temperature, maximum temperature, minimum temperature), bacillary dysentery, typhoid and paratyphoid, and hepatitis E were also positively correlated with rainfall (Wenjing et al.,2018). A 30-year study (1981 to2010) in Dalian has similar result, the incidence of bacillary dysentery increased with increasing temperature (average temperature, average maximum and minimum temperature, extreme temperature), the temperature between 1-2 months before the onset and the incidence of bacillary dysentery were significantly higher than at other times (Qing yu et al.,2012). But because of this, it can be explained that perhaps the increase in the annual average temperature should have caused the incidence of Type A and B intestinal infectious diseases to rise, but in fact the incidence has declined because of the increase in the accumulative households using sanitary toilet and the improvement of sanitary conditions. The effect of temperature on intestinal infectious diseases was reduced by the effect of sanitary toilet.

The control of the four pests in Jiangsu Province and cities was not very good. The incidence of cholera, viral hepatitis and other infectious diarrhea in Jiangsu Province was positively correlated with the density of flies and cockroaches, respectively. But there are a few cities that have a negative correlation. Pests often carry a variety of pathogens. In 2007-2008, viruses in and on fly organisms were detected at Fujian Mawei Port. The results showed that the positive rate of Coxsackie virus was 1.9%, the positive rate of rotavirus was 5.08%, the untyped enterovirus was 6.79%, and the enterovirus EV71, hepatitis A and hepatitis E viruses were negative. The positive rate of canteen fly viruses was the highest, about 50%, and the detection rate in public toilets was 2/9. Invasion of alien flies leads to an increased risk of input of fly-borne infectious diseases (Si wei,2010).

The most common breeding ground for flies is toilets, cesspools, rotting animal carcasses, etc. It can fly 6-8 kilometers per hour, and can be passively moved with vehicles, especially in high temperature weather, and it will invade indoors in large numbers during the cool autumn season. Typhoid bacillus can be stored in feces for one month, Vibrio cholera can survive in feces for 17 days, and dysentery bacillus can survive for up to one year. The mane on flies can stick to these viruses, carrying the pathogen to the food as it travels between the feces and the food (Jian zhong and Jin hua,2006).

The Beijing Military Region Center for Disease Control and Prevention evaluated the risk of vector-borne diseases at Zhu Rihe Training Base in 2013 and 2014. The Zhu Rihe training base is a source of many natural epidemic diseases. The density of flies in the base is extremely high, far exceeding the national standard, so the risk of dysentery, typhoid and other diseases is very high (Hui et al.,2017). In the early 21st century, the relationship between intestinal infectious diseases and vector density was studied in Shenzhen. The density of cockroaches, mosquitoes and flies are all positively correlated with the incidence of intestinal infectious diseases, especially cockroaches and flies are more closely related to intestinal infectious diseases (Xu et al.,2007).

In Type C infectious diseases in Jiangsu Province, the incidence of other infectious diarrhea is increasing year by year. The results of simple linear regression analysis show that there is a statistical difference between the incidence of other infectious diarrhea and surface water quality and annual average temperature, which is positive related. This is inconsistent with intestinal infectious diseases of Type A and B, but is consistent with the findings of other regions in China.

A study in Lanzhou, Gansu Province found the incidence of other infectious diarrhea will increase under the conditions of high average temperature, heavy precipitation and high humidity. Especially the average temperature has the strongest correlation. The average temperature increases by a quartile interval, the number of patients will increase by about 66.71% (Yan et al.,2015). Another study in Beijing also found that both high and low temperatures will affect the incidence of other infectious diarrhea. The average temperature in the warm season exceeds 19℃ and lower than -2℃ in the cold season will increase the risk of other infectious diarrhea., the effect of high temperature is more significant (Jing,2019).

Studies have shown that surface water quality was negatively correlated to the incidence of Type A and B intestinal infectious diseases, but is positively correlated with other infectious diarrhea. Generally, the better the water quality, the lower the risk of intestinal infections. Surface water is one of the main sources of drinking water. Although people do not drink it directly, there are still many opportunities for direct and indirect contact. Residents in some rural areas are still using surface water to irrigate the land, or spraying pesticides mix with surface water with. Fish and shrimp in surface water are an important source of food, and many people also like fishing. Although people basically cook fish, crayfish, etc., fishing itself can touch surface water. In addition, due to improper treatment of river silt, some people fill ponds with river silt, which may pollute the soil. People believe that silt is rich in organic matter and is a good fertilizer, so that agricultural products such as vegetables are grown on the silt. People eventually come into contact with pathogens in the original local surface water through inhalation, oral and dermal routes.

A national study in China showed that the correlation coefficient between the incidence of other infectious diarrhea and drinking water quality is positive (Yan lin,2008). Other infectious diarrhea in China are caused by the combination of life contact transmission and contamination of food and drinking water, of which drinking water contamination accounts for 25.84% (Xi jun et al.,2019). The analysis in Suzhou showed that Current measures to improve hygiene cannot effectively control other infectious diarrhea, because the transmission route of other infectious diarrhea is more complicated, air droplets and close contact can be transmitted, and the existing disinfection technology cannot play a role in some pathogens (Haibing et al.,2018). The incidence of other infectious diarrhea in rural residents in Sichuan Province in 2018 is related to drinking habits, pests and sewage discharge methods. Families with cockroaches, mice and flies found in the kitchen and residents who are used to drinking raw water and bottled water are more likely to get sick. The excretion of feces into the river can cause pollution of drinking water and soil, increasing the risk of diarrhea (Zhang et al.,2019). So even if the coverage rate of sanitary toilets increases, the better the water quality, it may eventually lead to an increase in the incidence of other infectious diarrhea due to waste disposal methods and drinking habits.

5.4 Limitation

In this study have several limitations that needs to be mentioned. First is missing data. Due to the lack of data on sanitary toilet coverage rate in each of 13 cities, the study could not specifically study the association between sanitary toilet coverage rate and intestinal infectious diseases of each city. In addition, the data on intestinal infectious diseases of Type C in each city was not available. Therefore, there may be an error in the distribution of the incidence of intestinal infectious diseases in Jiangsu Province.

Another limitation is the research period. The study only analyzed the situation of Jiangsu Province from 2011 to 2019, with a relatively short period of time. Some variables such as the coverage rate of sanitary toilets, temperature, and water quality have not changed much, and may not reveal the actual distribution of the data.

There are many predisposing factors for intestinal infectious diseases. Except for sanitary toilets, only four pests' densities, water quality (only surface water and drinking water) and environmental factors (only temperature and rainfall) are included in the study.

Lack of personal information. The research used ecological study design, lacking personal characteristics and habits of using toilet, it's unable to analyze and give recommendations at the individual level, and there are missing data in 2019.

5.5 Recommendation

Formulating disease prevention and control measures based on the distribution characteristics of the incidence of intestinal infectious diseases, especially in areas with high incidence, special strategies should be formulated according to local characteristics, economy, environment, geographical location, etc.

In the national patriotic sanitation campaign, the toilet improvement part must not only meet the annual mission goals, but also ensure quality. The pass rate of the year-end assessment should be used as the main evaluation item, damaged sanitary toilets should repair in time. While built the sanitary toilet, the water pipe and sewage system should be improved to ensure the water supply of the sanitary toilet and the reasonable discharge of sewage. In the end, it is guaranteed that every toilet built will be used really, which will benefit the people.

Strengthen the monitoring and control of vector organisms, increase the layout of monitoring points, especially in rural areas. The control effect in recent years has been poor, and the technology for eliminating the four pests should be improved.

Strengthen the technical research and development, quality control of the intestinal infectious disease vaccine and the release of information on the effectiveness of the vaccine.

Strengthen the monitoring of health and infectious diseases in key places. For example, in schools and nursery institutions, children have a high incidence of intestinal infectious diseases, especially bacterial dysentery, other infectious diarrhea, hand-foot-mouth disease have a great impact on children aged 0-3 years, schools have a large population. It is easy to cause a cluster of outbreaks.

Strengthen hygiene promotion and let residents take the initiative to participate in toilet improvement. Because the renovation of sanitary toilets takes the form of government persuading residents to participate voluntarily, many residents are reluctant to participate because they are concerned about the quality of the toilet construction, the cost of toilet maintenance, and the troubles in the pipeline reconstruction process.

People should develop health living habits, do not drink raw water, and clean up their homes in time. Proactively learn about the supply and safety of intestinal infectious disease vaccines from CDC and other institutions.

5.6 Conclusion

The increase in the popularity of various types of sanitary toilets can directly and effectively prevent and control the incidence of intestinal infectious diseases of

Type A and B, but the control effect for Type C diseases is not good. Surface water quality, average annual temperature, and vector density all have certain effects on the incidence of intestinal infectious diseases, but the impact of sanitary toilets is more significant. In view of the fact that the coverage rate of sanitary toilets and harmless sanitary toilets has almost achieved full coverage. The government should pay attention to the construction of supporting facilities such as sewage treatment system, etc., while checking for leaks and filling gaps and consolidating quality. In the next phase of the goal, new technologies can be studied and new construction standards can be proposed based on the current sanitary toilets' control of intestinal infectious diseases.

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Appendix

AF 01-12

The Research Ethics Review Committee for Research Involving Human Research Participants, Group I, Chulalongkorn University
Jamjuree 1 Building, 2 Floor, Phyathai Rd., Patumwan district, Bangkok 10330, Thailand,
Tel: 0-2218-3202, 0-2218-3049 E-mail: eccu@chula.ac.th

COA No. 102/2020

Certificate of Approval
Exemption for Ethics Review

Study Title No. 071/63 : ASSOCIATION BETWEEN SANITARY TOILET COVERAGE RATE AND INTESTINAL INFECTIOUS DISEASE IN JIANGSU PROVINCE, CHINA

Principal Investigator : TINGTING CHEN

Place of Proposed Study/Institution : College of Public Health Sciences, Chulalongkorn University

This Research proposal is exempted for ethics review in compliance with the Office for Human Research Protections (OHRP Exempt Categories) 45 CFR part 46.101(b).

Certified under condition: To conduct this research project, the researcher (s) must strictly adhere to research proposal approved by the committee. If there is any amendment, it must be sent to the committee for review before carry on the project.

Signature: Prida Tasanapradit
(Associate Professor Prida Tasanapradit, M.D.)
Chairman

Signature: Nuntaree Chaichanawongsaroj
(Associate Professor Nuntaree Chaichanawongsaroj, Ph.D.)
Secretary

Date of Exemption : 22 April 2020

Remark: Final report (AF 01-15) and abstract is required for a one year (or less) research/project and report within 30 days after the completion of the research/project.

江苏省卫生健康委员会

苏卫信息公开〔2019〕74号

政府信息公开申请答复告知书

陈婷婷：

您向我委提出的政府信息公开申请收悉。根据《中华人民共和国政府信息公开条例》第十条、第三十六条第（一）（二）（五）项等规定，告知如下：

1、您申请获取的“江苏省肠道传染病的患病率”可以公开，相关材料附后。

2、您申请获取的“江苏省农村无害化卫生户厕普及率”已通过我委门户网站发布的历年《江苏省卫生健康事业发展统计公报》予以公开，您可登录（网址：http://wjw.jiangsu.gov.cn）查询。

3、根据《中华人民共和国水污染防治法》第七十二条规定：“县级以上地方人民政府应当组织有关部门监测、评估本行政区域内饮用水水源、供水单位供水和用户水龙头出水的水质等饮用水安全状况。县级以上地方人民政府有关部门应当至少每季度向社会公开一次饮用水安全状况信息”。卫生健康部门主要负责用户水龙头出水的水质监测和安全状况公开等工作，省级卫生健康

部门不具体承担水质监测和安全状况公开任务，相关工作主要由市、县级卫生健康部门或相关部门承担。故您申请获取的“江苏省水质监测数据”我委无法提供，您可向各市、县级卫生健康部门查询相关数据。

4．您申请获取“江苏省除四害工作进展”，由于信息指向不够清晰，我委于12月10日联系您对信息进行补正，您补正申请获取“各地区除四害单项除害工作各项指标达标率，四害种群、密度监测数据，四害孳生地分布、数量”等信息，上述信息可以公开，相关材料附后。

如对本答复告知不服，可在收到本告知之日起60日内依法向江苏省人民政府或国家卫生健康委员会申请行政复议，或者在6个月内向南京市中级人民法院提起行政诉讼。

江苏省卫生健康委员会

2019年12月23日

VITA

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