



Health Risk in Hot Springs: A Literature Review

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Abstract

Natural hot spring is one of the recreational water. The public used it for recreation, relaxation, and therapy. The water quality should meet standards, such as free from microorganisms to prevent the onset of health complaints. This paper aimed to identify the pathogenic microorganisms and recreational water illness in natural hot spring users from worldwide studies. **Method:** This systematic review analysis use PRISMA Protocol as a guide to provide this article and PEO Framework to specified the criteria. Various database used to find those article is NCBI, Google Scholar, and Science Direct. In total of 10 eligible articles to analyse from 2010 -2020. **Discussion:** The result showed that hot spring users experienced health complaints after using hot springs contaminated with pathogenic microorganisms. The microorganisms identified were *Naegleria* spp, *Naegleria fowleri*, *Legionella pneumophila*, *Vittaforma corneae*, *Mycobacterium avium-intracellulare* Complex (MAC), *Pseudomonas aeruginosa*, and *Mycobacterium phocaicum*. Recreation water illnesses identified were Primary Amebic Meningoencephalitis (PAM), *Legionella pneumonia*, *Pseudomonas folliculitis*, *Pseudomonas mastitis*, *Microsporidial keratitis*, Hot tub lung (HTL), and *P. aeruginosa pneumonia*. Besides the water quality, age, comorbid, and frequency of visiting hot springs were risk factors of recreational water illness. **Conclusion:** The onset of recreational water illness in users of hot springs was influenced by the quality of water microbiology and age.

Introduction

Hot spring water thermal spring is a spring whose temperature is higher than the surrounding air temperature, more precisely above 36.7 °C or 98 °F. These hot springs generally come from underground, which is located close to volcanic areas (1). Hot springs were also found to contain minerals, gases, and certain elements such as K, Na, F, Cl, SO₄²⁻, Mn, and Fe (2). Hot springs are widely used as water recreation, either naturally flowing into rivers or intentionally channeled into man-made facilities such as pools, hot tubs, and natural spas (3,4).

The minerals contained in hot spring baths have been shown to cure several ailments (5). The therapeutic benefits obtained after soaking for 3-4 weeks in a hot pool include repairing and stimulating the immune system, mental and body relaxation, increasing the production of endorphins, and detoxifying toxins in the body through sweat and urine. Hot springs, especially those containing sulfur, cure skin diseases such as psoriasis, dermatitis, and other skin diseases caused by bacteria (6). Hot springs have become a popular tourist attraction. Public interest in hot springs is found in various continents, such as Europe (42.3%), Asia (26.3%), and Africa (21.7%) (7). In 2017, China contributed 31.2% of global tourism revenue due to visits to its hot springs/minerals (8).

However, it should also be noted that the water in hot springs is a habitat for several microorganisms (9). A study conducted in the East Asian region found the presence of the microorganisms such as *Legionella* spp, *Acanthamoeba*, *Naegleria* spp, *Microsporidia*, *Enterovirus*, and *Human Adenovirus* in hot spring water (10-14). Another study located in the West Asia region identified *Acanthamoeba* contamination (15,16), while *Naegleria* spp, *Acanthamoeba*, and *Bacillus* spp were found in a study conducted in the Southeast Asia region (4,17). A study in Indonesia revealed that thermophilic bacteria that were successfully isolated from hot springs include *Vibrio* sp and *Bacillus* sp (18). Based on the

guidelines issued by the WHO entitled *Guidelines for Safe Recreational Water Environments Volume 2: Swimming Pools and Similar Environments*, the various types of microorganisms identified are classified as a danger of microbial infection through ingestion, inhalation, or physical contact (19).

Between 2000 and 2014, public health officials from 46 states in the United States and Puerto Rico reported 493 extraordinary incidents related to water recreation. This extraordinary incident resulted in at least 27,219 cases and 8 deaths. According to confirmed data, among the 363 outbreaks accompanied by infections, there were 57 (16%) cases caused by *Legionella spp* (20). The occurrence of infectious diseases due to the use of hot springs is a rare occurrence. However, there have been many reports in several countries reporting on the presence of infectious diseases caused by bacterial infections in hot springs. For this reason, the presence of microorganisms is an important consideration so that it is used as an indicator to assess the quality of hot spring water. Furthermore, the level of contact with the use of hot springs between water and users of hot springs is whole-body contact as the whole body is in contact with water (19). Therefore, the topic related to the presence of bacteria and diseases caused by hot springs had drawn the authors' interest to conduct a systematic literature review.

Methods

Scientific articles related to topics are searched by entering keywords into the database. The database used in this study consists of *NCBI*, *Science Direct*, and *Google Scholar*. The search keywords for each database affiliated with the topic are "hot spring" OR "hot tub" AND "disease" OR "outbreak". The characteristics of the scientific articles studied used the Population-Exposure-Outcome (PEO) framework. The population is devoted to hot spring users and there are no age or area restrictions; Exposure, identified or suspected bacteria-contaminated in hot springs; Outcomes reviewed the effects, diseases, and conditions experienced by users of hot springs. The selection of the articles under review was carried out by referring to the 2015 Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA) standard. The types of articles reviewed were original research or case reports, published in 2010-2020. In that year, both hot springs and hot tubs experienced rapid development as national and international tourism. The literature search process diagram is presented in Figure 1 below.

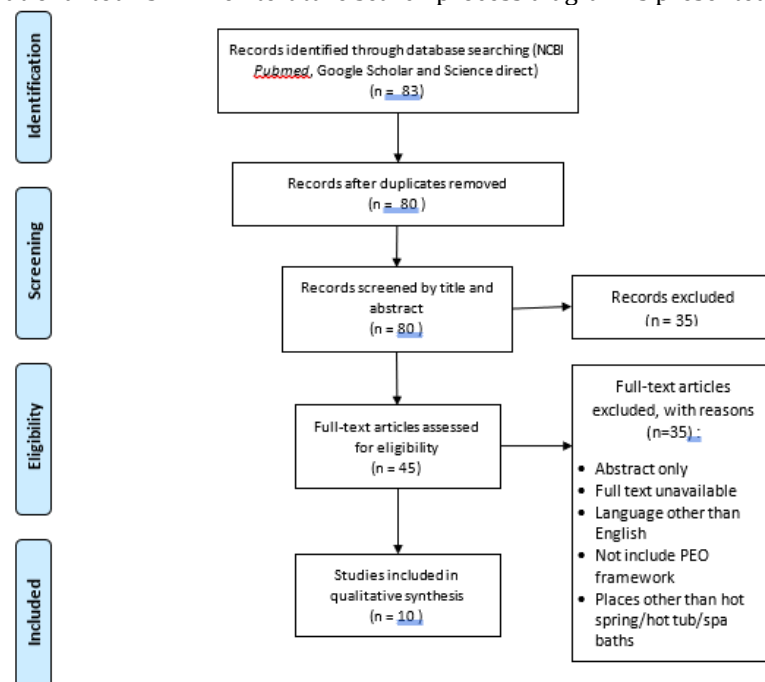


Figure 1 Flow Chart of Scientific Article Selection (PRISMA Protocol 2015)

Based on a search on the database using keywords, 83 scientific articles fit the topic. In the screening stage of scientific articles, taking into account the possibility of journal duplication, a total of 80 journals were obtained. The second filter was carried out by paying attention to the suitability of the titles and abstracts of scientific articles and leaving as many as 45 scientific articles. The third screening was carried out based on predetermined eligibility criteria, namely scientific articles in the form of scientific articles free access, full text, in English, having a PEO framework, and the research sites were hot springs, hot tubs, and spa baths. From this third screening, a total of 10 scientific articles were obtained to be reviewed.

Results

Most of the scientific articles obtained relating to water quality and diseases due to the use of hot springs are case reports. In the 10 selected articles, several factors that influence the incidence of disease in users after using hot springs were found, such as the type and quality of water in hot springs, characteristics of bath users, and bathing user behavior. Based on Table 1, it is written that the health complaints identified in this study are *Primary Ameba Meningoencephalitis (PAM)*, *L. pneumonia*, *Pseudomonal folliculitis*, *Pseudomonas Mastitis*, *Pseudomonas aeruginosa pneumonia*, *Mycobacterium avium-intracellulare complex (MAC)*, and *Microsporadial keratitis*. These cases occurred in different countries, including Japan, Taiwan, and the United States where each of these countries reported two cases, while other countries such as Costa Rica, the United Kingdom, Austria / Germany, and New Zealand each reported the existence of these cases. 1 case. As many as 6 out of 10 cases in the scientific articles reviewed occurred in a hot tub/spa bath.

Table 1 Disease Literature Review in Hot Springs

Author	The Title of Research	Population	Method	Findings	Conclusion
Susannah M. C. George, Jaspal Rattan, Katy Walker, Anil Garg (21)	<i>Pseudomonas Mastitis Caused by Hot Tub Exposure</i>	Female, 11 years old	Case report	Four days before going to the hospital, the patient used the hot tub together with her friends and relatives. 24 hours later, the patient developed breast engorgement and mastalgia. Pustules were also found on several parts of the patient's body. Dermatologists suspect that this may be related to <i>pseudomonas folliculitis</i> (a rash on the patient's body) and mastitis. Based on the results of taking the patient's pustule swab, <i>P. aeruginosa</i> was identified.	Little is known about the association of <i>Pseudomonas folliculitis</i> and mastitis in clinical circles. Mastitis in patients and breast swelling are influenced by the patient's puberty hormones so they are susceptible to infection. The number of hot tub users and the tightness of the patient's swimwear are also other factors that cause infection due to <i>Pseudomonas</i> .
Mohan Rudrappa, Laxmi Kokatnur (22)	<i>Hot Tub Lung: An Intriguing Diffuse Parenchymal Lung Disease</i>	Female, 37 years old	Case report	The results of these samples identified the presence of <i>Mycobacterium avium-intracellulare</i> . This finding is known from the patient's information that she has been doing hydrotherapy for about 3 months and using a hot tub for 3 hours every day. Based on these findings, the patient was diagnosed with a hot tub lung.	Even though the patient is diagnosed with hot tub lung, it is not possible to collect water samples from the source of exposure. Therefore, it is necessary to search more deeply socially in patients to diagnose accurately a very rare disease
James Wethasinghe, Sandra Hotu, Susan Taylor, Graeme Anderson, Conroy Wong (23)	<i>Mycobacterium phocaicum and Mycobacterium avium-intracellulare in a patient with hot tub lung</i>	Female, 77 years old	Case report	The patient has a history of osteoarthritis in the discharge and uses the indoor spa two to 4 times a day to relieve knee pain. From the culture of the patient's water and sputum samples, nontuberculous mycobacterium and <i>M.phocaicum</i> were detected.	The patient's pneumonia is believed to be related to the <i>M. phocaicum</i> bacteria. This is because these bacteria are detected, both in the patient and in the water sample. This incident is the first case of hot tub lung associated with exposure to <i>M. phocaicum</i> in a spa.
Toshiko Kuroki, Junko Amemura-Maekawa, Hitomi Ohya, et.al.(24)	<i>An outbreak of Legionnaire's Disease Caused by Legionella pneumophila Serogroups 1</i>	7 males with an average age of 66.3 years	Case report	Epidemiological results showed that the patient visited the spa before showing symptoms. In the sputum of 4 patients, <i>L. pneumophila serogroup 1</i>	Colonization of <i>L. pneumophila</i> was found in water samples at the spa house visited by patients where the bacteria was the cause of the infection.

Author	The Title of Research	Population	Method	Findings	Conclusion
	and 13			was detected and 1 patient was detected with <i>L. pneumophila</i> serogroup 1 and 13. These bacteria were also confirmed to be detected in water in the spa house. The results of epidemiological searches and laboratory results revealed negligence in the chlorination of bathing water and the water circulation system which resulted in <i>legionella</i> colonization at the spa location.	
Hajime Kurosawa, Masahiro Fujita, Satoshi Kobatake, Hirokazu Kimura, et.al.(25)	<i>A Case of Legionella Pneumonia Linked to a Hot Spring Facility in Gunma Prefecture, Japan</i>	Male, 64 years old	Case report	The patient had a history of diabetes mellitus and was known to frequently use hot tub facilities. A sampling of the patient's urine and sputum revealed the presence of <i>Legionella</i> bacteria. Besides, <i>L. pneumophila</i> was also detected in water samples from the hot spring visited by the patient.	This case report serves as a reminder of the risk of exposure to <i>L. pneumophila</i> and the importance of disinfection of water in hot spring facilities. The use of closed circulating water systems to avoid pathogens is also very important to implement
Nai-Wen Fan, Chih-Chiau Wu, Te-Li Chen, et.al(26)	<i>Microsporidial Keratitis in Patient with Hot Springs Exposure</i>	6 men and 3 women, with an average age of 54.6 years for men and 49 years for women	Case report	All patients had direct eye contact with water while soaking in the hot spring spa. As many as 2/9 patients often soaked in the hot spring. The chemical composition of the two hot springs visited by the patient contained sulfates and carbonates. The epithelium specimen was taken from the patient and analyzed by PCR. The results obtained show that there is a 98% similarity with <i>Vittaforma corneae</i>	<i>Vittaforma corneae</i> is a species that can cause keratitis in hot spring visitors. However, other factors influence keratitis in patients requires further research.
S. Huhulescu, M. Simon, Lubnow, et.al(27)	<i>Fatal Pseudomonas aeruginosa pneumonia in a previously healthy woman was most likely associated with a contaminated hot tub</i>	Female, 49 years old	Case report	The patient was rushed to the hospital after 2 days back from a spa holiday at a hotel in Austria. Blood samples and respiratory specimens were taken from the patient showed the presence of <i>P. aeruginosa</i> . On the 9th day of treatment, the patient died. Two lung specimens taken for autopsy showed the presence of <i>P. aeruginosa</i> . In environmental samples, <i>P. aeruginosa</i> was detected in hot tub water samples used by patients	The increasing popularity of hot tubs in hotels and private homes necessitates increased awareness of the potential health hazards associated with hygiene care.
Mei-Yu Su, Ming-Sih Lee, Ling-Yuh Shyu, et.al (28)	<i>A Fatal Case of Naegleria fowleri</i>	Male, 75 years old	Case report	PCR analysis results confirmed the presence of <i>N. fowleri</i> . On day 21, the	This is the first case of PAM in Taiwan as a result of bathing in a hot spring.

Author	The Title of Research	Population	Method	Findings	Conclusion
	<i>Meningoencephalitis in Taiwan</i>			patient's condition was unstable and brain dead. On day 25, the patient went into severe shock, followed by PAM, and failure of several organs in the body leading to the patient's death.	The results of the diagnosis are supported and confirmed by the PCR results. The relationship between public hygiene and water quality in hot springs requires further investigation in the future.
Elizabeth Abrahams-Sandi; Lissette Retana-Moreira; Alfredo Castro-Castillo; Maria reyes-Battle; Jacob Lorenzo-Morales (29)	<i>Fatal Meningoencephalitis in Child and isolation of Naegleria fowleri from Hot Springs in Costa Rica</i>	Male, 11 years old	Case report	Water samples were taken from various places such as swimming pools, rivers, and hot springs visited by the patient. The results obtained revealed the existence of <i>tropozoites</i> with the characteristics of <i>Naegleria spp</i> in hot springs and river ponds.	Investigations carried out found the presence of <i>Naegleria spp</i> in the water at a resort visited by patients who died from PAM due to infection with <i>Naegleria spp</i> .
Joanne S. Jacob; Jaime Tschen (30)	<i>Hot Tub – Associated Pseudomonas Folliculitis: A Case Report and Review of Host Risk Factors</i>	Female, 50 years old	Case report	Itchy rash develops on the patient's body after soaking in the hot tub longer and more frequently than other family members. Physical examination reveals papules and pustules on the chest, back, and buttocks. This area is the part covered by a swimsuit. Culture samples from these wounds showed the presence of <i>P. aeruginosa</i> .	Various factors can affect individuals affected by <i>P. aeruginosa</i> folliculitis that result from environmental exposure. These risks can include skin flora, women, length of exposure, and skin trauma. Besides, guidance should also be given to patients who have diabetes, skin trauma, and who have low immune status.

Table 2 presents the identification of microorganisms that cause health complaints based on age, sex, and frequency of using the hot springs. The microorganisms identified and the most common in patients confirmed in the hot springs where the patients visited were *Pseudomonas aeruginosa* which consisted of 3 cases, followed by *Legionella pneumophila* and *Naegleria fowleri* bacteria each as many as 2 cases. *Pseudomonas aeruginosa* bacteria cause three types of diseases such as folliculitis, mastitis, and pneumonia. Other microorganisms identified in this study were the amoeba *Vittiforma corneae*, and the *Mycobacterium* bacteria (*Mycobacterium avium-intracellulare* Complex/MAC and *Mycobacterium phocaicum*) where each was identified as many as 1 case. However, *Primary Amoebic Meningoencephalitis (PAM)*, *Legionella* pneumonia, and Hot tub lung or also known as hypersensitivity pneumonitis-like disease is the disease most experienced by users of hot springs, each with two cases. In cases with a diagnosis of PAM disease, the patient is declared dead during treatment, where this case of *Legionella* pneumonia is an outbreak. In most of the cases analyzed in this study, the patients were elderly over 50 years of age. Overall, the total number of patients in the 10 cases reviewed was 24 consisting of male patients (16 people; 66.7%) and women (8 people; 33.3%). The frequency of patient visits to hot springs is balanced between those who visit once or more than cases.

The number of scientific articles related to health complaints about users of hot springs is very limited. Disease cases related to hot springs are relatively rarely researched and published. This is evident from the search results for articles in this study. Of the 10 articles analyzed, half did not even explain laboratory results regarding water samples or the environment in hot springs where there were findings of health complaints. In this study, some articles completely explain case findings, results of epidemiological investigations, laboratory results of patient specimens, laboratory results of bathwater samples, disease history, and demographic information. This completeness of the information is very helpful in analyzing existing health complaint reports so that detailed and systematic information can be obtained.

Table 2 Reported Disease Risk Demographics

Demographics	Category	Number of Cases	
		N	%
Identified bacteria	<i>Naegleria spp</i>	1	10,00
	<i>Naegleria fowleri</i>	1	10,00
	<i>Legionella pneumophila</i>	2	20,00
	<i>Vittaforma corneae</i>	1	10,00
	<i>Mycobacterium avium-intracellulare</i> Complex (MAC)	1	10,00
	<i>Pseudomonas aeruginosa</i>	3	30,00
	<i>Mycobacterium phocaicum</i>	1	10,00
Age	10 – 20	2	11,11
	21 – 30	1	5,56
	31 – 40	1	5,56
	41 – 50	3	16,67
	51 – 60	4	22,22
	61 – 70	4	22,22
	71 – 80	3	16,67
Gender	Male	16	66,67
	Female	8	33,33
Frequency of using hot springs	≤ 1 time	5	50,00
	> 1 time	5	50,00
Health Complaints Reported	<i>Primary Amebic Meningoencephalitis</i> (PAM)	2	20,00
	<i>Legionella</i> pneumonia	2	20,00
	<i>Pseudomonas</i> folliculitis	1	10,00
	<i>Pseudomonas</i> mastitis	1	10,00
	<i>Microsporadial</i> keratitis	1	10,00
	Hot tub lung (HTL)	2	20,00
	<i>P. aeruginosa</i> pneumonia	1	10,00

Discussion

The articles reviewed in this study present diseases associated with water quality in hot springs in Japan, Taiwan, United States, England, Germany, New Zealand, and Costa Rica. As many as 6 out of 10 cases reported in the scientific article, occurred in a hot tub/spa bath. In the Asia Pacific and Europe, hot tubs are very popular among the public so that the number of hot tub facilities is very large, be it in hotels, salons, resorts, medical spas, and others. In 2017, Japan and Taiwan were included in the Top Twenty Thermal / Mineral Springs Markets (8). The purpose of visitors to visit the hot springs varies. This depends on their respective regions. In western countries, visitors to hot springs generally focus more on social factors, while in the Asian region there is more to the influence of Chinese culture in the form of visiting hot springs for therapy or relaxation. Therefore, visitors not only pay attention to the water in the hot springs but also the surrounding environment. Visiting hot springs in Japan has become a culture, namely for bathing or recreation (31). Thus, the reason for visiting hot springs is because it is influenced by climatic and cultural factors in a country.

Most of the hot springs are used by the community for water recreation, either naturally where the hot water flows into a river or intentionally where the hot water is channeled to man-made facilities such as pools, hot tubs, and natural spas (3,4). The hot tub consists of a hot tub intended for 1 person and a public hot tub. Hot tubs, which are small tubs filled with hot water, can only accommodate 1 to 2 people, while public hot tubs are the size of a pool that can be used for large crowds (10,11). Natural spas are pristine natural water facilities that are rich in mineral content and have a higher temperature than common public baths. Besides, the treatment of water used in natural spas is kept to a minimum due to its natural characteristics and can be a special attraction. However, the water in hot springs must be protected and free from contamination by pollutants and disease-carrying animals and be treated so that it does not become a place for vector development that can cause health problems to its users (32). Therefore, the management and treatment of water in hot springs and the surrounding environment need to be considered so that the quality of hot water and the natural hot spring is maintained.

The diseases identified by those who use hot springs in this study attack vital organs, such as the brain and lungs, the skin and eyes, and some even cause death. However, the severity of the disease that arises in hot spring users also seems to be influenced by other factors. The users of public hot springs who suffer from the disease according to this study are elderly people who are more than 50 years old. As you age, a person will experience a decrease in the immune system. In this case, a person's body's ability to respond and adapt will affect susceptibility to disease (33,34). This is in line with one of the articles reviewed in this study, where there was a patient in Taiwan who was confirmed to have PAM. After being treated for 25 days in the hospital, the patient died. The patient had previously soaked in a hot spring. This case later became the first case of PAM in Taiwan due to soaking in a hot spring. However, bathing users under 50 years of age may experience the same health complaints after using hot springs. From the results of the study conducted, it was found that as many as 4 out of 10 studies showed that a user of hot springs under 50 also experienced health complaints after using hot springs in the form of pseudomonal mastitis, hot tub lung, pseudomonas aeruginosa pneumonia, and PAM.

One study in the United States that examined the use of hot springs showed that a woman using a hot spring who experienced hot tub lung had a smoking habit. Smoking habits can affect the forced vital capacity of the lungs, where the vital force capacity of the lungs will decrease with increasing smoking duration and the number of cigarettes smoked per day. This can result in changes to the bronchi and elasticity of the lungs which in turn result in a restrictive type of lung damage (35). This situation will worsen the condition of the patient who is exposed to the disease agent *Mycobacterium* — the bacteria that causes hot tub lung disease — in which the main target of these bacteria is the respiratory tract.

Hot spring users who are elderly and have immune disorders should be accompanied when they are soaking in a hot spring. This is done to avoid the risk of drowning when soaking in a hot spring (36). Based on the results of the study, it was found that some hot spring users have a history of congenital or comorbid diseases, such as bilateral involvement, mild leukocytosis, iodine allergy, diabetes mellitus, cirrhosis of the liver, and liver cancer. These comorbid or comorbid diseases can then affect the ability of a person's body to respond so that they are susceptible to a disease (33).

The underlying medical conditions included cardiovascular disease (23.9%) and diabetes (11.0%) where this comorbid had the highest prevalence. *Legionella* pneumonia cases commonly involve individuals who have risk factors such as smoking and comorbid medical conditions that result in decreased immune defenses. A history of heavy smoking was the most common risk factor for *Legionella* pneumonia (37). *Legionella pneumonia* can affect anyone. Risk factors that influence a person's susceptibility to this disease are age, disease, immune suppression, and smoking habits (38).

The frequency of patient visits to hot springs in this study was balanced, between those who visited one or more times (Table 2). The frequency of visits is the number of visits to the baths divided into the categories never, infrequently, regularly on average at least once a year, and regularly on average at least once a month. This frequency provides background information on the activity level of the respondent (39). In one article where the research location was in Japan, it was reported that some hot spring users who were already showing symptoms of health complaints still visited the hot springs. This biases the incubation period of the diseases experienced by users of hot springs. Based on the results of the study, it is known that the goals of visitors visiting hot springs are recreation, therapy, and the habit of visiting regularly.

Hot water contaminated with microorganisms such as *Legionella* spp, *Naegleria fowleri* and *Acanthamoeba* can quickly form aerosols that are small enough to be inhaled. Aerosols that are contaminated with these microorganisms can be inhaled while breathing and can infect the respiratory tract. Thus, the longer a person uses a hot spring that is contaminated with microorganisms, the longer a person will be exposed to microorganisms mixed in aerosols (38).

In this study, it is stated that the presence of *Naegleria fowleri* in public hot springs is very dangerous. The presence of *Naegleria fowleri* in the water environment is related to temperature. These amoebae are generally found in warm fresh water such as lakes, rivers, and hot springs and rarely infect humans. Infection can occur when water containing amoebae enters the body through the nose and usually occurs in contaminated recreational water. PAM is a deadly brain infection caused by the amoeba *Naegleria fowleri* (40). After entering the nose and gaining access to the brain, these amoebae will then migrate along the olfactory nerve through the cribriform plate and damage brain tissue (41). In PAM, the incubation period is 5 days on average. The most common clinical symptoms of PAM are headache, fever, nausea, and vomiting. However, the diagnosis of this disease is often considered slow despite its high mortality rate (40). Efforts to reduce the risk of being infected with PAM include holding nose or wearing a nasal plug when jumping or diving (42).

Legionella spp is also a microorganism that was identified as contaminating hot water public baths in this study. Referring to the Guideline for Safe Recreational Water Environment, the maximum contamination limit for *Legionella* spp is <1CFU / 100ml (19). The presence of *Legionella* spp as an infectious agent can cause Legionnaires disease (LD) and Pontiac Fever (PF). Legionnaires disease is generally characterized by acute pneumonia and infects extrapulmonary, although this is rare. Pontiac

Fever is a mild disease that resolves on its own, like influenza, which resolves within a few days (37). A person can experience *Legionella* pneumonia if they inhale aerosols contaminated with *Legionella spp*, where these bacteria will infect and then spread and are detected in the liver, kidneys, myocardium, bones, joints, and digestive system. The period on which the symptoms of this disease are known is between 2 and 21 days. The symptoms of the disease caused by *Legionella* pneumonia are non-specific. However, some common symptoms that usually appear are fever, dizziness, weakness, dry cough, muscle aches, diarrhea, and vomiting. If bath users experience these complaints after use of hot springs, a more detailed doctor's diagnosis and examination of sputum and urine samples to determine the possibility of *Legionella spp* infection are needed (38).

Microsporidia are infectious pathogens. This can be identified through various clinical manifestations, such as diseases of the eyes, sinuses, kidneys, intestines, lungs, and muscles. In this study, ocular microsporidiosis emerged as keratitis (43). *Microsporidial* keratitis generally occurs in immunocompetent individuals. Predisposing factors for *Microsporidia* keratitis include exposure to soil or mud in water (dirty water), dust particles, use of contact lenses, insect bites, bathing in unclear river waters, and has also been reported due to exposure to hot springs. Humans are hosts for *Microsporidia*, where spores will infect the eye when the eye comes in direct contact with hot spring water contaminated with *microsporidia* (43). Taxonomically, *Vittaforma corneae* is a species from the *Nosematidea* family. In most cases, this type of fungus is closely related to soil or mud (44). Microsporidial incidence in hot springs is considered to need to be considered and to obtain further research considering that there is only a small amount of literature that discusses the presence of this fungus in water and the growing trend of interest in hot spring tourism.

Even in chlorinated water, *Pseudomonas aeruginosa* bacteria can still be detected. From the results of the case reports, it was found that three diseases were caused by these bacteria, namely *Pseudomonas pneumonia*, *Pseudomonas folliculitis*, and *Pseudomonas mastitis*. According to WHO, the most common disease associated with the presence of *pseudomonas* in hot tubs is folliculitis. However, infections of the respiratory tract, wounds, cornea, and otitis externa were also found (45). Infection of the hair follicles on the skin caused by *Pseudomonas aeruginosa* can cause pustular acne and severe itching in the area covered by the swimsuit. Anyone can get folliculitis or mastitis, but some people are more susceptible to infection because their bodies have a weak immune system due to certain diseases, such as HIV, diabetes, and leukemia.

In this study, hot tub lung disease was experienced by two hot spring visitors who suffered from dyspnea. In both cases, water sampling could not be carried out at the hot spring location visited. However, these mycobacteria were found in lung samples of sufferers. Apart from MAC, one case of hot tub lung also detected the presence of *Mycobacterium phocaicum* in the patient's lung sample. The existence of this type of mycobacteria is new because in general MAC is the cause of hot tub lung disease. However, previous studies have also identified the presence of *Mycobacterium phocaicum* in the respiratory tract and the patient's blood after exposure to a special treatment pool, although it has been described as a rare case (46).

Colonization of *mycobacteria* in spa tubs / hot tubs is caused by negligence in facility maintenance, for instance filter replacement, inadequate ventilation, and water aerosolization during filter cleaning (47). Changing water, checking pH levels and irregular disinfecting the ponds are also factors in the emergence of *mycobacteria* (48). Along with the increasing trend of hot springs, both hot springs, and hot tubs, there is the possibility of developing infectious diseases if maintenance is not carried out according to guidelines.

The emergence of health complaints in users of hot springs can be influenced by the sanitary conditions of the bathing environment, disinfection, filtration, and also water circulation (19). There are special challenges in maintenance and maintenance because the change of visitors to hot springs, especially hot tubs for 1 person, needs to get attention from hot water bath officers so that the tub that has been used by visitors can immediately change the water before the next visitor uses the tub. Besides, if the number of bathing users in the public hot tub exceeds the recommended number, this will result in the hot tub's water losing its disinfectant concentration faster. Another factor that affects the depletion of disinfectant concentrations is high temperature, as it is known that hot tubs have high temperatures (49). The temperature has a major influence on biological activity, growth, and the types of organisms present in water (50).

Sanitation is important in the use of safe and efficient hot springs. This is because the existing sanitation facilities in the hot spring environment will support the cleanliness and comfort of bathing users. These efforts can certainly minimize pathogen contamination in the bathwater (51). The World Health Organization (WHO) states that water recreation areas should have toilets that are easily accessible so that bathing users can urinate or defecate before using the hot spring pool. After that, visitors also need to rinse the body in the rinsing room that has been provided. Water filtration and circulation systems are also important to note. The filtration and circulation system that is used to filter and regulate the circulation of the bathwater which is not cleaned will become a place for the growth of

microorganisms (19). This is shown as described in one of the scientific articles reviewed in this study, where *Legionella* spp colonies were found in the bathtub filtration and circulation systems.

Another method that can be taken as an effort to keep hot springs clean is to frequently replace hot water through filters, photoirradiation, and treatment with hydrogen peroxide. Filtration is an effective effort to fight microbes, especially Free Living Amoeba (FLA), and contamination by opportunistic bacteria such as *Legionella* spp. Therefore, it is necessary to regularly test for microorganism contamination to prevent colonies in the filter (19).

Efforts to maintain personal hygiene before using the hot water baths include defecating or urinating before using the bath, rinsing the body before and after using hot water baths, and changing clothes with bathing suits before using the bath and changing after finishing bathing. The existence of trash bins, changing rooms, rinsing rooms, and bathrooms that are easily accessible and clean will affect the compliance of bath users in the behavior of disposing of garbage in its place, use of changing rooms, rinse rooms, and bathrooms before and after using the bath which is expected to be done as efforts to minimize the contamination of urine and feces in the bathwater (19). Another thing that should be considered in the use of hot springs is the footwear used by the users. In Japan, in general, there is special footwear that can be used in hot spring locations. The footwear used by bath users while inside and outside the hot spring will be different (36).

Hot springs carry almost the same health risks as any other water tourism. Several risk factors that can affect the occurrence of health complaints among users of hot water baths are the possibility of contamination of soil and groundwater through uncontrolled runoff and waste from water use in the hot springs itself. Strict controls must be put in place to maintain the quality of the water in the hot springs (52). WHO states in the Guidelines for safe recreational water environment Volume 2: Swimming Pool and Similar Environment that the possible dangers that can occur in hot springs are the risk of drowning, contamination of water quality and bathing facilities, and air quality (20). In this study, water contamination by bacteria/fungi can occur due to inadequate management of hot tub facilities, resulting in cases of infection. If a person experiences health complaints, it is necessary to carry out an in-depth history of the possible causes of the disease due to the use of hot springs. Good cooperation from researchers, bathing managers, and agencies authorized to monitor sanitation and quality of bathing water is required; health care centers and laboratories to get surveillance of diseases, risk factors, and efforts to prevent the occurrence of similar cases due to activities in public hot springs. Some literature states that strict action was imposed by the local government on providers of hot spring tours when infection cases were reported, such as in Japan, Taiwan, and Costa Rica (24,25,28,29). This positive effort is very meaningful to support the growing hot spring tourism industry while still prioritizing safety, health, and the comfort of visitors to hot spring tours.

Conclusion

Pathogenic microorganisms identified in public hot springs are *Naegleria* spp, *Naegleria fowleri*, *Legionella pneumophila*, *Vittaforma corneae*, *Mycobacterium avium-intracellulare* Complex (MAC), *Pseudomonas aeruginosa*, and *Mycobacterium phocaicum*. These microorganisms can cause various health complaints in bath users, such as *Primary Amebic Meningoencephalitis* (PAM), *Legionella* pneumonia, *Pseudomonas* folliculitis, *Pseudomonas* mastitis, *Microsporadial* keratitis, Hot tub lung (HTL), and *P. aeruginosa* pneumonia. The incidence of disease after using hot springs is not only influenced by the microbiological quality of the water and the sanitation of the hot spring environment itself, but can also be influenced by factors that come from individual users of hot springs, such as age, sex, comorbid diseases, smoking habits, and frequency of visits to hot springs.

Therefore, it is advisable for hot spring managers to regularly check the quality of the water and clean the hot spring environment every day. Meanwhile, users of hot springs are also expected to maintain personal hygiene by rinsing their bodies before and after using hot springs and obeying the existing regulations there.

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