Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Correspondence

Increasing cases of Naegleria fowleri during the time of COVID 19; an emerging concern of Pakistan

Dear Editor,

Naegleria fowleri is an amoebic pathogen distributed throughout the world that causes deadly brain infection known as primary amoebic meningoencephalitis (PAM). It is lethal in most cases, with a mortality rate of 98%. Male genders are predominantly affected [1]. The pathogen is found in fresh waters and moist soils. It causes symptoms similar to meningitis (fever, neck rigidity, nausea, vomiting) as soon as it reaches the brain through the nose, possibly due to water activity. Death occurs due to edema and brain herniation after 3–7 days of the appearance of signs and symptoms [2]. The first case was reported in 2008 in Pakistan. This amoeba has led to an emerging concern in Karachi, the largest city of Pakistan, and a major coastal area in 2022. The first death due to this pathogen in 2022 was reported on May 2, 2022. The patient was a 59-year-old who lived in Kemari, a district of Karachi [3]. Another case was reported in the last week of June 2022. Two additional deaths of men were reported on July 1, 2022. One of them was 59-year-old, and the other one was 38-year-old. Both died at different hospitals in the city [4]. The total number of cases reported up to July 1, 2022, was four [4]. Every year, cases increase in summer seasons. According to Dr. Bahoto, Director-General of the Sindh Health Department, all four patients had no history of recreational water activity, and they were likely to be infected by domestic water supply [5]. The infection could also be associated with nasal irrigation utilizing neti pots and ablution practices [6]. The medical literature shows that most cases in the US were children less than 14 years of age [7]. In contrast, the highest number of cases in Pakistan were between 26 and 45 years of age [1]. Thus, there is a possibility that a genetically unique strain is responsible for recurrent outbreaks of Naegleria fowleri in Pakistan almost every year.

Unfortunately, there is no database that can affirm the exact number of deaths due to PAM in the recent past several years, and the majority of cases went unreported [1]. The available data showed the number of deaths has increased during the past few years. In 2017, there were six deaths, followed by seven in 2018. In 2019, fifteen deaths were reported till October [8,9]. No deaths were reported in 2020, but there is no certainty due to a lack of data collection with missing cases. Six deaths were reported in 2021 [10]. The number of deaths in 2022 has reached four as of July 1, 2022 [4]. No case has so far been reported after that. Fig. 1 shows the total number of deaths reported in Pakistan due to PAM in 2022 [3,4].

N. fowleri is thermophilic and hence thrives in hot temperature conditions. PAM cases are most frequently reported in summer from April to September. With global climate change, summers are getting longer, and humid conditions make water bodies the perfect habitat for amoebas, and the prevalence of Naegleria fowleri in water bodies is increasing [11].

N. fowleri cannot survive in chlorinated water. However, public water pools, lakes, and other freshwater bodies are not properly chlorinated. Hence, these become a source of infection [1]. In addition, even domestic water has been found to be contaminated with the organism, which is alarming. In a recent study, water samples were taken from various sites throughout Karachi, including two main reservoirs and the areas supplied by these distribution networks. Water samples were sent to detect Naegleria fowleri through PCR and culture, which came positive [6], leading to the conclusion that N fowleri is present in the water reserves of Karachi. This is surprising, given that Karachi's water is often salty, and amoebas cannot thrive in salty water, showing that the N fowleri strain encountered in Pakistan to be distinct from those reported in the remainder of the world, or it may have evolved a resistance to the saline surroundings [11].

Evidence has suggested that Naegleria cannot spread to a person through the oral route, and it is only known to do so through the olfactory pathway. The infection moves to the brain after entering the nasal cavity and lives on nerve tissues there. Swimmers and those who participate in water activities are more likely to come in contact with the pathogen [2,12,13].

To date, all the reported cases of PAM in Pakistan were in Muslims. Among these, only two were in people who had previously participated in recreational water activities. Others had no such exposure. The infection is attributed to ablution, which includes rinsing the nose with water. As ablution is a necessary ritual for Muslims, the incidence of infection is higher in them [1]. Other procedures that include nasal irrigation, such as cleaning nasal sinuses, could also lead to infection [12].

There is no study that can fully describe the cases of N. fowleri infections that have occurred in Pakistan over the past eight years. The majority of the country's information is either unreported or missing [1].

Pakistan's healthcare system is already overburdened. The system is understaffed and faces financial constraints. As PAM is a rapidly progressive disease; by the time diagnosis is confirmed, most patients have deteriorated clinically. According to CDC, because of the rarity of the disease, diagnosis is confirmed in 75% of cases after the death of patients upon autopsies [14].

The patient only has a very brief window of time after the onset of clinical symptoms for therapy to be successful. Given PAM's extremely high death rates (nearly 100%), it is likely that many patients are already in a stage where current treatments are ineffective when they seek medical attention [15].

Pakistan's healthcare system is already overburdened with numerous communicable and non-communicable diseases of public health significance. Pakistan is one of the few countries where poliovirus is still rampant, and the addition of COVID-19 has already stretched the

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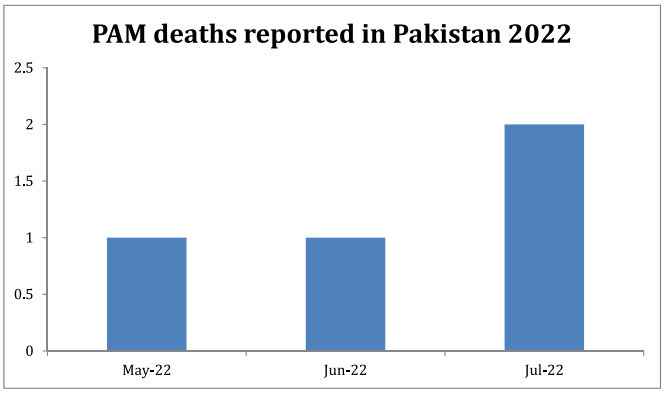

Fig. 1. PAM deaths reported in Pakistan 2022.

bow to its limit. At this point, if an outbreak of Naegleria occurs to a wider population, it would only cause the existing cracks in the healthcare system to widen beyond control [16].

The world is already highly affected by Monkeypox and COVID-19 [21]. In this scenario, any other outbreak is creating a massive pressure on a country's health system. Early prevention is highly important. The Pakistan Health System should form an expert team and a standard operating protocol [SOPs] should be prepared as early as possible.

Of the 20 Naegleria strains, only N fowleri is harmful to humans. Given that details on the etiology of N fowleri is still uncertain and may involve multiple factors, a thorough understanding of its genetic origin can provide light on the cause of this severe and quickly lethal disease. Specifically, the detection of the unique sequences of genes and genetic markers can help to better understand the mechanisms of the disease. With this approach, if the genome sequence of the recently discovered resistant strain in Pakistan is discovered, this will aid in early illness detection and prevention [11].

The Water and Sewerage Board (KWSB) is the principal agency in Karachi which oversees issues with water distribution and chlorination in the city. Water resources must receive properly regulated chlorination and biological treatment to ensure good quality water. The KWSB has been ordered by the health authorities to ensure that the municipal water supply is adequately chlorinated with the WHO recommendations, and preventive actions have also been developed to stop the spread of this sickness, [17,18].

Additionally, underground water storage should be regularly cleaned twice a year and treated with chlorine tablets (1 tablet for 5 L of water). The Karachi Metropolitan Corporation being responsible for maintaining the cleanliness and proper chlorination of all the city's swimming pools, and it should ensure that the task is properly done [1].

Numerous preventive strategies used at home can reduce the incidence of Naegleria infection. People should develop the habit of using boiled water for cleaning purposes. Filtered or boiled water should be used for drinking, ablution, brushing, and gargling. To prevent entry via the nose, people should keep their faces away from showers [1].

It is strongly advised that individuals should only utilize swimming pools that have been adequately chlorinated and disinfected, and to always ask about the sanitary facilities. Avoiding freshwater bodies like lakes, rivers, and ponds is necessary, particularly in summer when the water temperature is high. People should be advised to refrain from jumping into freshwater bodies or splashing to prevent N. fowleri from entering the nasal passages. People should use nasal clips to lessen the possibility of contaminated water entering the nose if such activities cannot be avoided. After swimming in freshwater bodies of water, some people would advise cleaning the nose and nasal passages with clean water, however, the efficacy of this practice is uncertain at this time. The CDC advises using distilled or filtered bottled water for sinus rinsing. It also advises boiling or filtering water with 1 μm or smaller pores to prepare water for sinus rinsing in the absence of the options mentioned above [19].

Preventing the disease in the first place is the key solution, as the treatment is not effective and the disease is deadly. For this purpose, in addition to print and electronic media advertisements, social media is a powerful instrument for raising public knowledge of this deadly infection. Only through public education of people can we prevent the disease and eliminate it [20].

To combat this deadly infection, a collaborative work is important. Drinking water should be chlorinated regularly and should pass lab tests. Regular inspection is important. It is important to prepare a proper standard operating procedure as early as possible. With the recommendations as mentioned above, we are expecting to see a N fowleri-free Pakistan.

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Appendix A. Supplementary data

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References

[1] Epidemiology of primary amoebic meningoencephalitis-related deaths due to Naegleria fowleri infections from freshwater in Pakistan: an analysis of 8-year dataset - archives of Pharmacy Practice [Internet] [cited 2022 Aug 8]. Available from: https://archivepp.com/article/epidemiology-of-primary-amoebic-meningoencephalitis-related-deaths-due-to-naegleria-fowleri-infections-from-freshwater-in-pakistan-an-analysis-of-8-year-dataset.

[2] M. Jahangeer, Z. Mahmood, N. Munir, U.E.A. Waraich, I.M. Tahir, M. Akram, et al., Naegleria fowleri: sources of infection, pathophysiology, diagnosis, and management; a review, Clin. Exp. Pharmacol. Physiol. 47 (2) (2020 Feb) 199–212.

[3] Pakistan: first Naegleria fowleri death recorded in 2022 in Sindh - outbreak news today [internet] [cited 2022 Aug 8]. Available from: http://outbreaknewstoday.com/pakistan-first-naegleria-fowleri-death-recorded-in-2022-in-sindh-51816/.

[4] Pakistan: two additional Naegleria fowleri deaths reported in Karachi - outbreak news today [Internet]. [cited 2022 Aug 8]. Available from: http://outbreaknewstoday.com/pakistan-two-additional-naegleria-fowleri-deaths-reported-in-karachi-41589.

[5] Karachi reports third death, Fourth case this year of deadly 'brain-eating amoeba' | Arab News PK [Internet] [cited 2022 Aug 8]. Available from, https://www.arabnews.pk/node/2114861/pakistan.

[6] N. Ghanchi, Increasing cases of Naegleria fowleri infections from Karachi Pakistan, Int. J. Infect. Dis. 73 (2018 Aug) 185.

[7] Case report data & graphs | Naegleria fowleri | CDC [internet] [cited 2022 Aug 8]. Available from, https://www.cdc.gov/parasites/naegleria/graphs.html.

[8] Karachi: 11 Naegleria fowleri deaths in 2019 through july according to Pakistan media [internet]. Outbreak news today [cited 2022 Aug 8]. Available from: http://outbreaknewstoday.com/karachi-11-naegleria-fowleri-deaths-in-2019-through-july-according-to-pakistan-media-15269/, 2019.

[9] Pakistan: 15th Naegleria fowleri death reported in Karachi - outbreak news today [internet] [cited 2022 Aug 8]. Available from, http://outbreaknewstoday.com/pakistan-15th-naegleria-fowleri-death-reported-in-karachi-97298/.

[10] PMA urges people to take precautions to avoid 'brain-eating' amoeba - Pakistan - DAWN.COM [Internet] [cited 2022 Aug 8]. Available from: https://www.dawn.com/news/1635136.

[11] M. Ali, S.B. Jamal, S.M. Farhat, Naegleria fowleri in Pakistan, Lancet Infect. Dis. 20 (1) (2020 Jan) 27–28.

[12] A.G. Ordemann, J.K. Stanford, D.C. Sullivan, J.M. Reed, Can contaminated water be rendered safe for nasal saline irrigations? Laryngoscope 127 (7) (2017 Jul) 1513–1519.

[13] A. Güémez, E. García, Primary amoebic meningoencephalitis by Naegleria fowleri: pathogenesis and treatments, Biomolecules 11 (9) (2021 Sep 6) 1320.

[14] Diagnosis & detection | Naegleria fowleri | CDC [internet] [cited 2022 Aug 8]. Available from, https://www.cdc.gov/parasites/naegleria/diagnosis.html.

[15] Pediatric Naegleria treatment & management: medical care, surgical care, Mar 15 [cited 2022 Aug 8]; Available from: https://emedicine.medscape.com/article/972044-treatment, 2022.

[16] A. Khalid, S. Ali, COVID-19 and its challenges for the healthcare system in Pakistan, Asian Bioeth Rev 12 (4) (2020 Dec) 551–564.

[17] KWSB – Karachi water & sewerage board [internet] [cited 2022 Aug 8]. Available from, https://www.kwsb.gos.pk/.

[18] P. Qi, C. Hu, X.C. Xing, Z.H. Bi, Z.S. Li, [Synergistic control of nitrogenous disinfection by-products and opportunistic pathogens in drinking water by iron-modified quartz sand filtration], Huan Jing Ke Xue Huanjing Kexue 43 (2) (2022 Feb 8) 887–895.

[19] E. Grace, S. Asbill, K. Virga, Naegleria fowleri: pathogenesis, diagnosis, and treatment options, Antimicrob. Agents Chemother. 59 (11) (2015 Nov) 6677–6681.

[20] N.A. Khan, J.S. Muhammad, R. Siddiqui, Brain-eating amoebae: is killing the parasite our only option to prevent death? Expert Rev. Anti Infect. Ther. 20 (1) (2022 Jan) 1–2.

[21] D. Mukherjee, S. Roy, V. Singh, S. Gopinath, N.B. Pokhrel, V. Jaiswal, Monkeypox as an emerging global health threat during the COVID- 19 time, Ann Med Surg (Lond) 79 (2022), 104075, https://doi.org/10.1016/j.amsu.2022.104075.

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