Journal of Associated Medical Sciences 2027; 60(1): 122-129

JAMS
Journal of Associated Medical Sciences

Scopus Indexed & Thai-Journal Citation Index Centre (TCI)

Journal of Associated Medical Sciences

Journal homepage: https://www.tci-thaijo.org/index.php/bulletinAMS/index



Landscape of fungal diagnosis in Thailand: A national survey in 2024-2025

Napaporn Sriden[1*], Rinrapas Autthateinchai[2], Pornpanna Chonnakijkul[2], Praeploy Sewisit[2], Watcharaporn Kamjumphol[2], Orapan Sripichai[2], Archawin Rojanawiwat[2]

[1]Faculty of Medicine, Praboromarajchanok Institute, Nonthaburi, Thailand.
[2]National Institute of Health of Thailand, Department of Medical Sciences, Ministry of Public Health, Nonthaburi, Thailand.

ARTICLE INFO

ORCID of all authors
Napaporn Sriden: https://orcid.org/0009-0001-2747-6995
Rinrapas Autthateinchai: https://orcid.org/0009-0002-1719-0464
Pornpanna Chonnakijkul: https://orcid.org/0000-0002-6918-8617
Praeploy Sewisit: https://orcid.org/0009-0005-5865-7034
Watcharaporn Kamjumphol: https://orcid.org/0009-0006-9083-6523
Orapan Sripichai: https://orcid.org/0000-0002-0798-8934
Archawin Rojanawiwat: https://orcid.org/0009-0006-8585-7047

Correspondence
Napaporn Sriden
Faculty of Medicine, Praboromarajchanok Institute, Nonthaburi, Thailand.
Email: napaporn.sr@pi.ac.th

Article history
Received 26 February 2026
Accepted as revised 10 September 2026
Available online 23 September 2026

Keywords
Fungal diagnostics, laboratory capacity, Thailand, national survey

doi: 10.66285/JAMS.2027.012
E-ISSN: 2539-6056

ABSTRACT

Background: Fungal infections pose a significant global health threat, particularly in Asia, with Thailand experiencing high prevalence due to its tropical climate. Increased capacity for fungal diagnosis leads to the appropriate diagnosis and treatment, and most importantly, a reduction in illness and death.

Objectives: To assess and update the current status of fungal diagnosis capacity in Thailand.

Materials and methods: This study utilized an online platform to conduct a survey. The questionnaires collected the relevant information of the laboratory capacity including the capability of the on-site fungal identification, methods for fungal identification, the most commonly identified fungal pathogen and the availability of antifungal susceptibility testing (AFST).

Results: There were 206 healthcare facilities across country participated in this survey, including both government and private hospitals, as well as one reference laboratory. Nearly all high-tier hospitals utilized advanced automated systems for yeast identification; however, mold identification remained limited, primarily relying on traditional culture and microscopy methods. According to the survey results, the most commonly identified yeast was *Candida albicans*, while the most commonly identified mold was *Aspergillus* spp. Although many laboratories could identify fungal pathogens, they often struggled to specify the species, which is essential for effective treatment and managing antifungal resistance. AFST was accessible in high-tier hospitals, but low-tier hospitals did not have this capability.

Conclusion: These findings underscore the importance of enhancing the capacity for fungal diagnosis, which will help elucidate the national burden of fungal diseases and improve resource allocation in Thailand.

Introduction

Fungal diseases are one of the serious health problems. Approximately one billion people have skin, nail, and hair fungal infections, while more than two million people are reported to have fungal diseases globally each year.[1] Fungal infections can be primary or opportunistic, especially in immunocompromised patients.[2] In 2022, WHO launched the first fungal priority pathogens list (WHO FPPL) to outline the importance of fungal diseases surveillance, public health interventions, as well as research and development, and innovation to respond to fungal infections.[3] According to WHO FPPL, there are three fungal pathogen priority groups, including critical group (*Cryptococcus neoformans*, *Candida auris*, *Aspergillus fumigatus* and *Candida albicans*), high risk group (*Nakaseomyces glabrata*, *Histoplasma* spp., Eumycetoma causative agents, Mucorales, *Fusarium* spp., *Candida tropicalis*, *Candida parapsilosis*) and medium group (*Scedosporium* spp., *Lomentospora prolificans*, *Coccidioides* spp., *Pichia kudriavzeveii*, *Cryptococcus gatti*, *Talaromyces marneffei*, *Pneumocystis jirovecii*, *Paracoccidioides* spp.). Consequently, fungal identification plays an essential role in fungal disease diagnosis, which is also an important step before disease intervention.

In Thailand, while surveillance systems exist for viral and bacterial pathogens, no such system has been established for fungal diseases within the country. The true fungal disease burden remains elusive since there is no mandate to report fungal disease cases to the Department of Disease Control. This gap may increase the economic burden of disease prevention, detection, and response. Given the lack of information on fungal laboratory capabilities, we conducted a national survey to comprehensively address and update the current status of fungal diagnostic laboratory capacity. This study provides critical evidence for enhancing laboratory capacity and informing future resource allocation for fungal disease management.

Materials and methods

A survey was conducted from January, 2024 to September, 2025 using the JotForm online platform. The questionnaire was distributed across all 12 health regions in the country. A representative of laboratory personnel was responsible for answering and completing the questionnaire. A total of 206 respondents participated in this survey, including both government and private hospitals. The questionnaire gathered the pertinent information including the capability of the on-site fungal identification, methods for fungal identification, the most commonly identified fungal pathogen and the availability of antifungal susceptibility testing (AFST).

Data analysis

The collected data was scrutinized and analyzed by descriptive statistics using R statistical program.

Results

Respondents and overall landscape of fungal diagnosis laboratory capacity in the country

A total of 206 respondents participated in this survey, including 177 government hospitals, 11 private hospitals, 10 university-affiliated hospitals, one reference laboratory, and seven regional medical sciences centers. The participating government hospitals comprised 20 regional hospitals, 57 general hospitals, 92 community hospitals and 8 sub-district health promoting hos-

pitals, which operate under the authority of the Office of the Permanent Secretary, Ministry of Public Health. The university-affiliated hospitals are also government hospitals but operate under the authority of the Ministry of Higher Education, Science, Research and Innovation.

Overall, approximately one-third of the surveyed laboratories perform on-site fungal identification (68/206, 33.0%; Figure 1A). Among the laboratories that do not offer this service, 91 laboratories (44.2%) refer specimens to external facilities; however, this survey did not collect the external facility names and identification methods. The remaining 47 laboratories (22.8%) lack any fungal identification services (Figure 1A). The National Institute of Health of Thailand-recognized as the national reference laboratory by the Royal Thai Government Gazette-provides on-site fungal identification. Most of the laboratories that offer on-site fungal identification are regional hospitals (20/20, 100.0%), followed by university-affiliated hospitals (9/10, 90.0%), general hospitals (34/57, 57.9%), community hospitals (4/92, 4.3%) and private hospitals/private medical laboratories (1/11, 9.1%; Figure 1B). Notably, sub-district health promoting hospitals and Regional Medical Sciences Centers do not provide fungal identification services (Figure 1B). The three most common received specimens for the purpose of fungal identification are blood (37.4%), followed by urine (21.7%), and sputum (21.4%; Figure 1C)

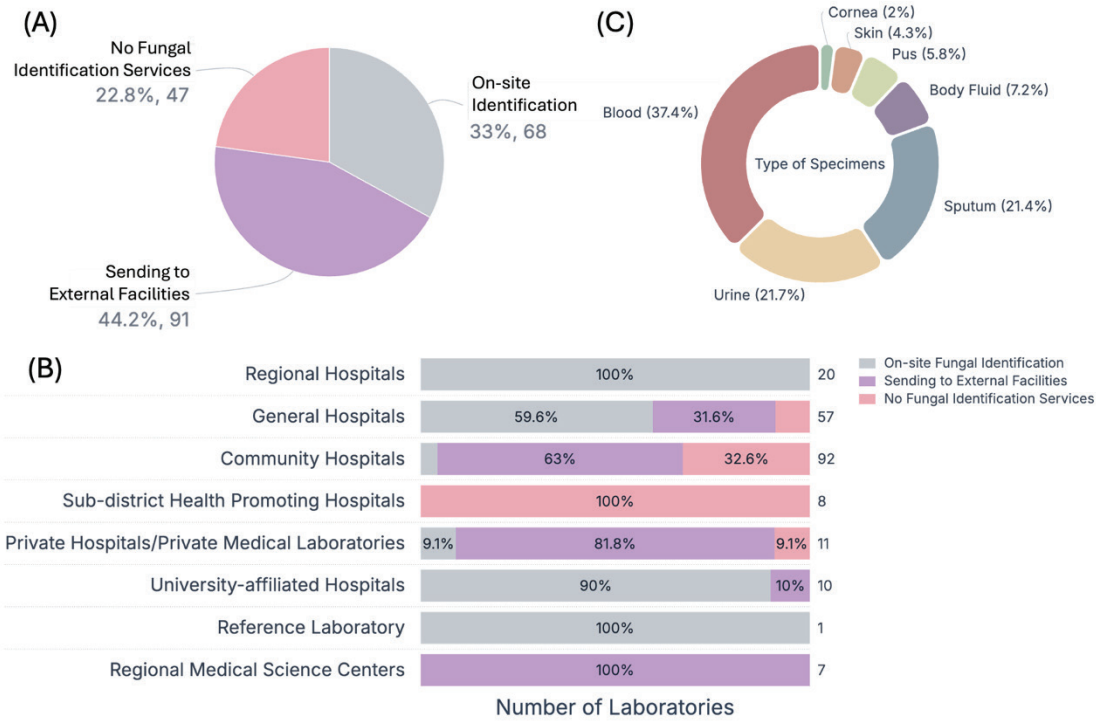


Figure 1. Fungal identification capacity among the laboratories participating in this survey. (A) Distribution of overall fungal identification capacity in country. (B) Distribution of fungal identification capacity according to tiered level of hospitals. (C) Type of specimens received by the laboratories for the purpose of fungal identification.

Table 1. Subgroup analysis of fungal identification capacity across hospital tiers in Thailand

Parameters	Regional sospitals (N=20)		General hospitals (N=57)		Community hospitals (N=92)		Sub-district health promoting hospitals (N=8)		Private hospitals/ private medical laboratories (N=11)		University-affiliated hospitals (N=10)		Reference laboratory (N=1)	
Number of specimens per year														
>100	20.0%	(4/20)	1.8%	(1/57)	0.0%	(0/92)	0.0%	(0/8)	0.0%	(0/11)	10.0%	(1/10)	0.0%	(0/1)
10-100	80.0%	(16/20)	59.6%	(17/57)	3.3%	(3/92)	0.0%	(0/8)	0.0%	(0/11)	40.0%	(4/10)	100.0%	(1/1)
<10	0.0%	(0/20)	66.7%	(39/57)	96.7%	(89/92)	0.0%	(0/8)	100.0%	(11/11)	50.0%	(6/10)	0.0%	(0/1)
Identification of yeast	100.0%	(20/20)	59.6%	(34/57)	4.3%	(4/92)	0.0%	(0/8)	9.1%	(1/11)	90.0%	(9/10)	100.0%	(1/1)
Culture and microscopy	35.0%	(7/20)	21.1%	(12/57)	1.1%	(1/92)	0.0%	(0/8)	9.1%	(1/11)	50.0%	(5/10)	100.0%	(1/1)
Chromogenic agar medium	45.0%	(9/20)	29.8%	(17/57)	0.0%	(0/92)	0.0%	(0/8)	0.0%	(0/11)	40.0%	(4/10)	100.0%	(1/1)
BD Phoenix™	5.0%	(1/20)	3.5%	(2/57)	0.0%	(0/92)	0.0%	(0/8)	0.0%	(0/11)	0.0%	(0/10)	0.0%	(0/1)
MALDI-TOF	50.0%	(10/20)	8.8%	(5/57)	0.0%	(0/92)	0.0%	(0/8)	9.1%	(1/11)	60.0%	(6/10)	0.0%	(0/1)
VITEK®	50.0%	(10/20)	28.1%	(16/57)	3.3%	(3/92)	0.0%	(0/8)	0.0%	(0/11)	10.0%	(1/10)	0.0%	(0/1)
DNA sequencing	0.0%	(0/10)	0.0%	(0/10)	0.0%	(0/10)	0.0%	(0/10)	0.0%	(0/10)	0.0%	(0/10)	100.0%	(1/1)
Identification of mold	60.0%	(12/20)	12.3%	(7/57)	0.0%	(0/92)	0.0%	(0/8)	0.0%	(0/11)	80.0%	(8/10)	100.0%	(1/1)
Culture and microscopy	55.0%	(11/20)	12.3%	(7/57)	0.0%	(0/92)	0.0%	(0/8)	0.0%	(0/11)	70.0%	(7/10)	100.0%	(1/1)
MALDI-TOF	30.0%	(6/20)	3.5%	(2/57)	0.0%	(0/92)	0.0%	(0/8)	0.0%	(0/11)	30.0%	(3/10)	0.0%	(0/1)
PCR	0.0%	(0/20)	0.0%	(0/57)	0.0%	(0/92)	0.0%	(0/8)	0.0%	(0/11)	10.0%	(1/10)	0.0%	(0/1)
DNA sequencing	0.0%	(0/20)	0.0%	(0/57)	0.0%	(0/92)	0.0%	(0/8)	0.0%	(0/11)	0.0%	(0/10)	100.0%	(1/1)
Antifungal susceptibility testing (AFST)	35.0%	(7/20)	7.0%	(4/57)	0.0%	(0/92)	0.0%	(0/8)	0.0%	(0/11)	30.0%	(3/10)	100.0%	(1/1)
Sensititre™	15.0%	(3/20)	3.5%	(2/57)	0.0%	(0/92)	0.0%	(0/8)	0.0%	(0/11)	20.0%	(2/10)	100.0%	(1/1)
AutoMic-i600	0.0%	(0/20)	0.0%	(0/57)	0.0%	(0/92)	0.0%	(0/8)	0.0%	(0/11)	10.0%	(1/10)	0.0%	(0/1)
VITEK®	20.0%	(4/20)	3.5%	(2/57)	0.0%	(0/92)	0.0%	(0/8)	0.0%	(0/11)	0.0%	(0/10)	0.0%	(0/1)

Yeast identification capacity

Regarding yeast identification capacity, 100.0% (20/20) of the surveyed regional hospitals and 90.0% (9/10) of the university-affiliated hospitals are capable of yeast identification (Table 1). The most prevalent method is the automated systems, i.e., VITEK®, MALDI-TOF MS, and BD Phoenix™. Typically, VITEK® (30/206, 14.6%) is more frequently used than MALDI-TOF MS (22/206, 10.7%) and BD Phoenix™ (3/206, 1.5%) for yeast identification. Culture and microscopy (27/206, 13.1%) are commonly used for yeast identification. Chromogenic agar medium, a selective medium for identifying *Candida* spp., is utilized in the laboratories in regional hospitals (9/20, 45.0%), general hospitals (17/57, 29.8%), and university-affiliated hospitals (4/10, 40.0%). Except for yeast identification by automated systems, the reference laboratory is capable of yeast identification using culture and microscopy, as well as DNA sequencing, which is available upon clinician request (Table 1). The commonly identified yeasts are *C. albicans*, *C. tropicalis*, and *C. neoformans*, respectively (Figure 2A).

Mold identification capacity

Regarding mold identification capacity, most of the surveyed regional hospitals (12/20, 60.0%) and university-affiliated hospitals (8/10, 80%) are capable of performing this service. Culture and microscopy are the most frequently used methods for mold identification (26/206, 12.6%). MALDI-TOF MS is the only automated system utilized by both regional (6/20, 30.0%) and university-affiliated hospitals (3/10, 30.0%). PCR is performed in one university-affiliated hospital. For the reference laboratory, mold identification primarily relies on culture and microscopy, while DNA sequencing is available upon clinician request (Table 1). The three most commonly identified molds were *Aspergillus* spp., dematiaceous molds, and dermatophytes, whereas others included *Scedosporium*, *Paecilomyces*, *Sporothrix*, and other dimorphic fungi (Figure 2B).

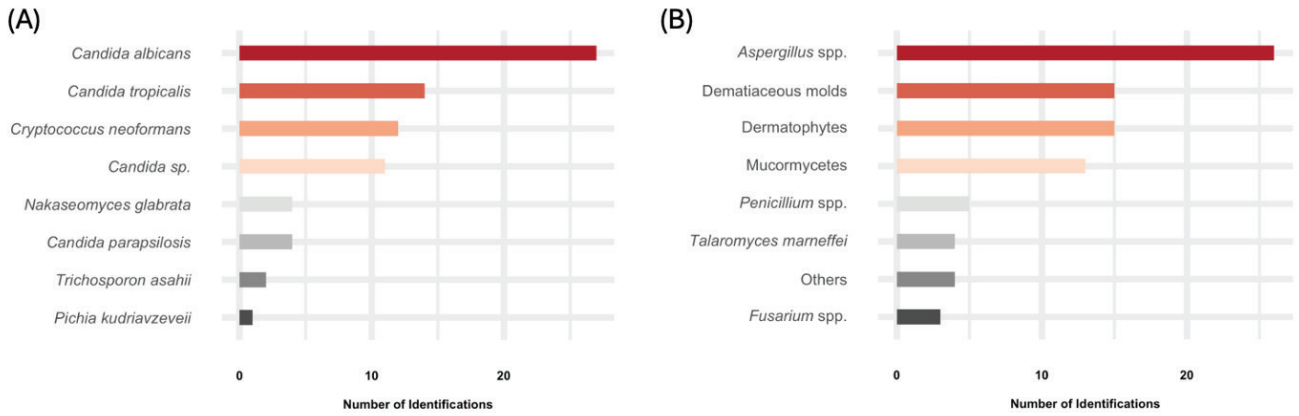


Figure 2. Number of the common fungi identified by laboratories offering on-site fungal identification. (A) Yeast. (B) Mold.

Antifungal susceptibility testing (AFST)

The availability of antifungal susceptibility testing (AFST) is limited in regional hospitals (7/20, 35.0%), university-affiliated hospitals (3/10, 30%), and general hospitals (4/57, 7.0%). The VITEK® system and Sensititre™ are the most commonly used methods for AFST, while the AutoMIC-i600 is utilized in one university-affiliated hospital. In contrast, the reference laboratory performs AFST using Sensititre™ and E-test® for research purposes only (Table 1).

Discussion

Fungal infections are a significant global concern, with Asia having the largest burden of fungal diseases.[4] Thailand, as a tropical country in Southeast Asia, experiences high humidity and temperatures, which is a favorable condition for fungal growth and likely contributes to the high prevalence of fungal infections in the country. In 2017, a previous study estimated that an approximately 1.93% of the Thai population was affected by serious fungal diseases.[5] As a result, an accurate fungal diagnosis plays a crucial role in effective treatment and disease management. An ideal fungal diagnosis system should provide access to necessary laboratory facilities and support a fungal disease surveillance system.[6] Previously, there was an effort to assess fungal laboratory capacity in Southeast Asia, which included participation from only seven laboratories in Thailand.[4] Given the lack of current information on fungal diagnosis laboratory capacity, this study provided the first and largest nationwide survey. This study included 206 laboratories, ranging from the highest-tier hospitals to primary hospitals, as well as private hospitals and the reference laboratory, thereby representing the laboratory capacity across all levels of healthcare facilities in the country.

In this study, the results revealed that fungal diagnosis laboratory capacity in Thailand varies across different tiers of hospital. Remarkably, in high-tier hospitals, all surveyed regional hospitals and most university-affiliated hospitals have access to automated systems for fungal identification, specifically

MALDI-TOF MS, which allow for accurate and rapid diagnosis. MALDI-TOF MS is the preferred method for yeast identification due to its cost-effectiveness and the lower level of technical expertise required.[7] Another automated system, VITEK®, is commonly used in general hospitals and some community hospitals because it is highly reproducible and provides accurate yeast identification.[8,9] Culture and microscopy, which is the gold standard method recommended by the WHO, are also utilized in many hospitals and reference laboratory. With the advancements in sequencing technology in this era, DNA sequencing offers the most accurate fungal species identification and has the potential to reveal new endemic fungal species. However, survey results indicate that the use of DNA sequencing for routine yeast and mold identification in laboratories is limited. This suggests an opportunity for improvement to enhance the fungal diagnosis capabilities of laboratories. Moreover, the survey results also indicates that laboratories in the high tier-level hospital are more capable of providing on-site fungal identification. Some general and community hospitals, however, have send the specimens to the external facilities since their laboratories do not offer on-site fungal identification. Unfortunately, the questionnaire did not include information about the methods used by these external facilities to identify fungal species. This may hinder the overall capacity for fungal identification in Thailand to some extent. Altogether, our findings suggest that the nationwide laboratory capacity for fungal diagnosis seem well-equipped to serve routine services and potential disease outbreaks, with the exception of sub-district health promoting hospitals that focus primarily on fundamental medical treatments and health promotion.

Identifying fungal pathogens at the species level is crucial due to the rising threat of fungal infections, as highlighted by the WHO Fungal Priority Pathogens List (FPPL).[3] Individuals with underlying health issues or those who are immunocompromised are more susceptible to invasive fungal diseases.[1] This study reveals that the most commonly identified fungi are in line with the WHO FPPL classifications: critical group (including *C. albicans*, *C. neoformans*, and *Aspergillus*), high group (including *N. glabrata*, *C. tropicalis*, *C. parapsilosis*, *Fusarium*, and Mucormycetes), and medium group (including *P. kudriavzeveii* and *T. marneffei*). Interestingly, our finding shows that many laboratories can identify fungal pathogens; however, they somehow can not specify the species. For example, *Candida* spp. or *Aspergillus* spp. are often reported, despite the fact that these pathogens are classified as critical group in the WHO FPPL. It is important to emphasize that accurate fungal species identification is essential according to the WHO FPPL since only specific species, such as *C. albicans*, *C. neoformans*, and *A. fumigatus*, are of critical concern. Each pathogen is associated with different diseases, leading to distinct treatments and medication options. Additionally, various fungal species exhibit different levels of susceptibility to antifungal drugs; therefore, precise identification at the species level is crucial. Previous research had indicated that aspergillosis and mucormycosis were emerging fungal diseases in developing countries.[10] Recently, Onchan and colleagues (2025) reported that *A. fumigatus* was the most prevalent *Aspergillus* species identified at a tertiary hospital in Bangkok, Thailand.[11] However, to our knowledge, there has not been a comprehensive study or a national surveillance system that collects data on identified fungal species or the underlying factors that limit laboratory capacity for species-level identification. This highlights a significant knowledge gap regarding the burden of fungal diseases at the national level, which may also impact the understanding of the situation at the international level.

In 2019, the WHO initiated antimicrobial resistance (AMR) surveillance for invasive fungal infections. This program, known as the Global Antimicrobial Resistance Surveillance System for Fungi (GLASS-FUNGI), focuses on bloodstream infections caused by *Candida* species. The effective implementation of this surveillance requires the collection of epidemiological, clinical, and microbiological data, including isolate-level identification and interpretation of antifungal susceptibility testing (AFST). Thailand has been an active member of the GLASS-AMR program for bacteria since 2016, but it has not yet enrolled as a pilot country for GLASS-FUNGI. According to the findings of this study, the availability of AFST is limited to only a small number of laboratories in high-tier hospitals and reference laboratory. AFST is costly and usually requires technical expertise to perform and interpret the susceptibility testing results. Therefore, it is essential to understand the guidelines for deciding which yeast or mold isolates should perform AFST. Notably, there have been several reports of multidrug resistance in *Candida* species from various countries, including Thailand such as multidrug resistance in *C. albicans*[12,13] and *C. auris*.[14-16] These findings emphasize the urgent need for AFST to be incorporated into routine services, particularly in high-tier hospitals and reference laboratory, to effectively address the issue of AMR in fungi.

Taken together, the primary challenge for fungal diagnosis in Thailand is enhancing laboratory capacity in sub-regional hospitals. On-site fungal identification can provide timely results to clinicians, which is crucial for designing effective treatment plans and ensuring patient safety. Further surveys could explore the need for improving microbiology laboratories, including the requirements for fungal reference materials and proficiency testing (PT) programs. Additionally, having a sufficient number of operational staff with the necessary competencies is essential for ensuring accurate laboratory results. Staff training programs

could focus on yeast and mold identification using conventional or automated systems, as well as advanced techniques such as qPCR, and fungal genotyping through DNA sequencing. In parallel, training in antifungal susceptibility testing (AFST) and its integration into routine services is also critical for tackling the issue of antifungal resistance. Ultimately, the results of the survey can guide policymakers in budget allocation to enhance the overall capacity for fungal diagnosis in Thailand.

Limitations

The scope of this survey is focused on assessing the capabilities and methodologies of AFST, which limits the study's ability to provide a comprehensive understanding of the national capacity for fungal identification.

Conclusion

This study provides the first comprehensive national survey on the capacity for fungal diagnosis in Thailand. We emphasize the importance of enhancing laboratory capabilities, particularly in high-tier hospitals and reference laboratory, for fungal identification and antifungal susceptibility testing. Strengthening these areas will help address the rising threat posed by fungal infections in the future.

Ethical approval

Not applicable. This study conducted a survey of healthcare facility laboratory capacity without collecting personal or identifiable information. Therefore, informed consent was not required.

Declaration of generative AI and AI-assisted technologies

The authors declare used generative AI for only preparing the graphical abstract. The authors have reviewed and edited the contents and took full responsibility for the accuracy and originality.

Funding

None

Conflicts of interest

The authors declare no conflicts of interest.

CRediT authorship contribution statement

Napaporn Sriden: conceptualization, statistical analysis, data interpretation, writing: original draft, review and editing. **Rinrapas Autthateinchai, Pornpanna Chonnakijkul, Praeploy Sewisit:** methodology, investigation. **Watcharaporn Kamjumphol, Orapan Sripichai, Archawin Rojanawiwat:** conceptualization, supervision, writing: review and editing.

Acknowledgements

We would like to sincerely thank the directors of the 12 health regions for coordinating the distribution of our questionnaire to the network hospitals. We are also grateful to all the respondents for contributing their valuable insights to this survey.

References

[1] Bongomin F, Gago S, Oladele RO, Denning DW. Global and Multi-National Prevalence of Fungal Diseases-Estimate Precision. J Fungi (Basel). 2017;3(4).
[2] Firacative C. Invasive fungal disease in humans: are we aware of the real impact? Memórias do Instituto Oswaldo Cruz. 2020;115:e200430.
[3] WHO. WHO fungal priority pathogens list to guide research, development and public health action. Geneva; 2022 25 October 2022.
[4] Chindamporn A, Chakrabarti A, Li R, Sun P-L, Tan B-H, Chua M, et al. Survey of laboratory practices for diagnosis of fungal infection in seven Asian countries: an Asia Fungal Working Group (AFWG) initiative. Medical mycology. 2018;56(4):416-25.
[5] Chayakulkeeree M, Denning DW. Serious fungal infections in Thailand. Eur J Clin Microbiol Infect Dis. 2017;36(6):931-5.
[6] Hieu VN, Hiep NL, Hang LM, Lau-Goodchild BA, Van Duong N, Linh NT, et al. Mycology laboratory diagnostic capacity for invasive fungal diseases in public hospitals in Vietnam. Medical Mycology. 2024;62(8):myae082.
[7] Dhiman N, Hall L, Wohlfiel SL, Buckwalter SP, Wengenack NL. Performance and cost analysis of matrix-assisted laser desorption ionization–time of flight mass spectrometry for routine identification of yeast. Journal of clinical microbiology. 2011;49(4):1614-6.
[8] Melhem M, Bertoletti A, Lucca H, Silva R, Meneghin F, Szeszs M. Use of the VITEK 2 system to identify and test the antifungal susceptibility of clinically relevant yeast species. Brazilian Journal of Microbiology. 2013;44(4):1257-66.
[9] Posteraro B, Martucci R, La Sorda M, Fiori B, Sanglard D, De Carolis E, et al. Reliability of the Vitek 2 yeast susceptibility test for detection of in vitro resistance to fluconazole and voriconazole in clinical isolates of *Candida albicans* and *Candida glabrata*. Journal of clinical microbiology. 2009;47(6):1927-30.
[10] Chakrabarti A, Singh R. The emerging epidemiology of mould infections in developing countries. Current opinion in infectious diseases. 2011;24(6):521-6.
[11] Onchan T, Langsiri N, Thammahong A. Clinical and Genomic Insights into Antifungal Resistance in *Aspergillus* Isolates from Thailand. Microorganisms. 2025;13(11):2495.
[12] Huet MAL, Muzahid NH, Lee CZ, Goh CBS, Dwiyanto J, Rahman S, et al. Molecular typing of multi-drug resistant *Candida albicans* isolated from the Segamat community, Malaysia. Brazilian Journal of Microbiology. 2021;52(4):2351-6.

[13] Dhasarathan P, AlSalhi MS, Devanesan S, Subbiah J, Ranjitsingh A, Binsalah M, et al. Drug resistance in *Candida albicans* isolates and related changes in the structural domain of Mdr1 protein. Journal of infection and public health. 2021;14(12):1848-53.
[14] Biagi MJ, Wiederhold NP, Gibas C, Wickes BL, Lozano V, Bleasdale SC, et al., editors. Development of high-level echinocandin resistance in a patient with recurrent Candida auris candidemia secondary to chronic candiduria. Open forum infectious diseases; 2019: Oxford University Press US.
[15] Ademe M, Girma F. *Candida auris*: From multidrug resistance to pan-resistant strains. Infection and drug resistance. 2020:1287-94.
[16] Opassathian K, Boonmee N, Swangkaew S, Jenjaroenpun P, Wongsurawat T, Kruasuwan W, et al. A study of genomic complexity underlying multidrug resistance in *Candida auris* strains in Thailand. Scientific Reports. 2025;15(1):41478.