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Research Article

Knowledge on melioidosis among healthcare workers of Bangladesh

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Abstract

***Background and objectives**:* Despite being a definite endemic zone for melioidosis, very few cases have been reported from Bangladesh. Lack of awareness among clinicians, microbiologists and medical technologists might be a major concern. To combat this, a training workshop was launched to refine diagnostic and management skills among healthcare professionals of Bangladesh.

***Materials and methods**:* Initially, a pre-test was conducted with a questionnaire containing 20 multiple choice questions focusing on epidemiology, diagnosis and management of *Burkholderia pseudomallei* infection. Following the pre-test, training sessions containing lectures on melioidosis (including video demonstration) were held and at the end of the sessions, assessment of the knowledge was acquired by a post-test with the same questionnaire.

***Results**:* A total of 113 clinicians, microbiologists and medical technologists from 20 public and private medical college and hospitals around Bangladesh participated in pre-test and 87 in post-test after the workshop. Our results documented that the mean percentage of pre-test score was 62.4 ± 22.9 which indicates a considerable gap of knowledge among healthcare professionals regarding melioidosis and *B. pseudomallei*. The mean percentage of post-test score significantly ($p = 0.0001$) increased to 79.2 ± 16.5 after the training session.

***Conclusion**:* Awareness and skill development programs could play vital role to reduce the knowledge gaps among health care providers about melioidosis. This will increase the yield of diagnosis of this notorious infection and many lives could be saved.

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Introduction

Melioidosis is a neglected tropical disease (NTD) caused by a highly pathogenic gram-negative bacterium, *Burkholderia pseudomallei* (BP), and is an important cause of sepsis globally [1,2]. Although the disease is endemic in Southeast Asia and northern Australia, many cases have also been reported in non-endemic zones [3,4]. About 20% of community-acquired sepsis in Thailand is caused by melioidosis, and around 2,000 to 3,000 new cases are detected each year [5,6]. However, the true global burden of melioidosis remains poorly understood due to a large number of undetected cases in endemic regions [7].

In 2011, *B. pseudomallei* was first isolated from soil in different regions of Bangladesh, and since then, the country has been considered a definite endemic zone for melioidosis [8,9]. A regression model estimated approximately 16,931 cases annually with a mortality rate of 56% (around 9,500 deaths) in Bangladesh [7]. Despite this, only a few cases have been reported so far [8]. Several small-scale awareness activities and isolated training efforts have been undertaken in Bangladesh to address this gap. However, these programs have often lacked nationwide coverage, consistent reinforcement, or structured follow-up, which limits their long-term impact. Consequently, awareness and diagnostic capacity among healthcare professionals remain inadequate, resulting in underreporting and misdiagnosis of melioidosis cases.

Similar gaps in knowledge and awareness have also been observed in other endemic countries such as Thailand and northern Australia, where comprehensive, repeated training and targeted community awareness programs have shown to be effective in improving diagnosis and management of melioidosis [10,11].

To help bridge this gap in Bangladesh, our study aimed to conduct a pre-test and post-test assessment of knowledge on melioidosis among healthcare providers following a virtual training workshop. The objectives were to evaluate baseline knowledge among clinicians, microbiologists, and medical technologists, provide targeted training, and assess knowledge improvement after the program. The training was organized through collaboration among the Centers for Disease Control and Prevention (CDC), Ibrahim Medical College, BIRDEM General Hospital, Bangabandhu Sheikh Mujib Medical University, and the Bangladesh Society of Tropical and Infections Disease (BSTID), supported by the CDC-HSP capacity development project on melioidosis. The findings of this study can guide the design of future awareness and capacity-building campaigns to improve diagnosis and management of this neglected but potentially deadly infection.

Materials and methods

The study was designed as a pre- and post-test study and conducted online through the Zoom Cloud Meetings application during the COVID-19 pandemic. A structured questionnaire containing 20 multiple-choice questions (MCQs) was prepared and validated by experienced clinicians and microbiologists specializing in melioidosis. The questionnaire focused on the epidemiology, diagnosis, and management of *Burkholderia pseudomallei.* A total of 113 clinicians, microbiologists, and medical technologists from 20 public and private medical colleges and hospitals in 13 districts participated in the pre-test before the training program. The training consisted of a four-day series of interactive lectures delivered via Zoom using PowerPoint presentations and video demonstrations, followed by interactive question-answer sessions. Participation was tracked through Zoom attendance records and submission of responses via Google Forms. The same questionnaire was administered as a post-test at the end of the training to assess knowledge retention.

Results

Pre-and post-test questionnaires included 20 multiple choice questions to test knowledge of healthcare professionals regarding melioidosis. A total of 113 participants responded to the pre-test questionnaires, while only 87 of them attended the post-test questionnaire, indicating a post-test dropout rate of approximately 23%. Male (61, 54%) participants were more in number than female (52, 46%). More than half of the participants (64,

56.6%) were microbiologists, followed by 33 (29.2%) clinicians, and 16 (14.2%) medical technologists. The gender distribution of the participants and their occupation are shown in Table-1. Answering patterns to the questions are shown in Table-2.

Table-1: *Gender and occupation of the study population (N = 113)*

Category	Number (%)
Gender	
Male	61 (54)
Female	52 (46)
Occupation	
Clinician	33 (29.2)
Microbiologist	64 (56.6)
Medical technologist	16 (14.2)

Epidemiology of *Burkholderia pseudomallei*: During pre-test, 98.1% of the respondents could identify that BP is the causative agent of melioidosis and 98.1% could state that the organism is a bacterium. Only 60.2% of the responders knew that Bangladesh is a definite endemic country for melioidosis on pre-test. Most participants (90.8%) could correctly identify skin penetration as one of the routes of transmissions. Nevertheless, ingestion (66.3%) and inhalation (83.2%) were not known to be common routes of transmission, which showed promising improvement on post-test. Most of the participants could state that soil exposure (97.1%) is a source of infection. However, the majority of the respondents did not know of food (65%) and cattle (74.7%) as the sources of BP infection. Many respondents were not aware that dog and pig can also be infected by this bacterium and were ameliorated (51.9% and 83.1% respectively) after the training session on post-test. Almost all participants (98.9%) could answer correctly that agricultural workers are the high-risk group for melioidosis on post-test, whereas only 35.1% of the participants were aware of construction workers as high-risk population. Thalassemia, as a common co-morbid association with melioidosis, was commonly missed by 48.3% of the participants, which showed better results on post-test (28%).

Clinical and laboratory diagnosis of *Burkholderia pseudomallei* infection: Participants on pre-test knew that melioidosis can present with abscess (97%), pneumonia (92.9%), septicemia (89.7%), and septic arthritis (70.2%); however, only 40.7% of them could answer that BP may also present with urinary tract infection. Participants' knowledge on these variables was developed further after the training session.

Most of the participants were well oriented that blood, sputum, pus, joint fluid and urine samples could yield to growth of BP for laboratory diagnosis. More than 97% of the health care workers of this study knew that culture is the gold standard laboratory test for the diagnosis of melioidosis; 87.4% stated correctly about the safety pin appearance of the bacteria in Gram stain and 91.7% knew Ashdown agar media is the selective media for isolation of this organism. Nonetheless, only 34.1% health care workers answered correctly on pre-test that MacConkey's agar media is a selective media for isolation of the organism and was improved to 41.8% on post-test. More than 90% heath care personnel mentioned tuberculosis as a differential diagnosis of melioidosis; on the other hand, only a negligible proportion of participants (20%) identified typhoid as a differential diagnosis for melioidosis, which increased to 39% on post-test. However, whereas 70% of the participants and 48.8% participants could identify brucellosis and leptospirosis as differentials for melioidosis in the pre-test, the post-test percentage was much lower (55.4% and 35.1% respectively). The participants' knowledge on case fatality rate of melioidosis was also very low in both pre-test and post-test.

Management of melioidosis: Majority of participants knew that melioidosis requires prolonged antibiotic therapy for three or more months. More than 90% of the responders could reply correctly on intrinsic antibiotic resistance pattern of BP on post-test (> 67% on pre-test). Majority of the participants had the knowledge regarding ceftazidime (90.3%) and meropenem (83.5%) being sensitive to BP as well as drug of choice for melioidosis, which also was seen to be enhanced after the training session (96.5% and 97.7% respectively).

Table-2: *Correct responses to the questions before and after the training amongst the participants*

Question	Pre-test			Post-test		
	Number of responses	Number of correct responses	% of correct responses	Number of responses	Number of correct responses	% of correct responses
1. Organism responsible for melioidosis-						
Burkholderia cepacia(False)	81	71	87.7	76	68	89.5
Burkholderia thailandensis(False)	80	73	91.3	76	69	90.8
Burkholderia pseudomallei (True)	108	106	98.1	87	86	98.9
Burkholderia mallei (False)	82	68	82.9	77	67	87.0
2. Etiological agent of melioidosis-						
Bacteria (True)	106	104	98.1	87	84	96.6
Virus (False)	91	90	98.9	75	74	98.7
Fungus (False)	81	77	95.1	76	74	97.4
Parasite (False)	78	77	98.7	76	72	94.7
Archaebacteria (False)	79	74	93.7	74	72	97.3
3. Common route of transmission of this organism-						
Ingestion (True)	86	57	66.3	83	69	83.1
Skin penetration (True)	98	89	90.8	86	81	94.2
Inhalation (True)	95	79	83.2	85	83	97.6
Person to person (False)	81	62	76.5	78	46	59.0
Transplacental (False)	79	72	91.1	74	60	81.1
4. Source of this organism-						
Soil (True)	103	100	97.1	87	87	100.0
Water (True)	92	76	82.6	84	73	86.9
Air (True)	84	46	54.8	79	45	57.0
Food (True)	80	28	35.0	76	29	38.2
Cattle (True)	79	20	25.3	77	44	57.1
5. Gold standard laboratory test for the diagnosis of melioidosis-						
Microscopy (False)	81	60	74.1	78	62	79.5
Culture (True)	103	100	97.1	87	86	98.9
Molecular test (False)	80	52	65.0	79	63	79.7
Serology (False)	79	70	88.6	77	70	90.9
Histopathology (False)	79	70	88.6	77	75	97.4
6. Microscopic appearance of Gram stain preparation of *Burkholderia pseudomallei*-						
Spherical (False)	76	71	93.4	76	74	97.4
Comma-shaped (False)	77	75	97.4	76	75	98.7
Safety pin shaped (True)	95	83	87.4	86	85	98.8
Club-shaped (False)	77	68	88.3	76	76	100.0
Filamentous (False)	77	67	87.0	77	71	92.2

7. Selective media used for the isolation of this organism-						
Monsur's media (False)	78	77	98.7	75	75	100.0
Blood Agar (False)	83	65	78.3	77	51	66.2
Ashdown Agar (True)	96	88	91.7	86	82	95.3
MacConkey Agar (True)	82	28	34.1	79	33	41.8
Mannitol salt agar (False)	79	75	94.9	77	76	98.7
8. Characteristic features of *Burkholderia pseudomallei* colony-						
Umbonate (False)	75	67	89.3	75	45	60.0
Medusa head colony (False)	77	64	83.1	74	68	91.9
Wrinkled colony with metallic sheen (True)	84	72	85.7	85	77	90.6
Haemolytic (False)	77	63	81.8	75	73	97.3
Pin-point (False)	78	55	70.5	78	58	74.4
9. Incubation period of melioidosis-						
14 days (False)	78	46	59.0	75	63	84.0
1-2 months (False)	73	56	76.7	71	63	88.7
6 months (False)	68	62	91.2	72	70	97.2
Days to years (True)	84	58	69.0	83	73	88.0
10. Melioidosis could be manifested as-						
Pneumonia (True)	99	92	92.9	86	81	94.2
Abscess (True)	101	98	97.0	87	87	100.0
Septicemia (True)	97	87	89.7	86	84	97.7
Urinary tract infection (True)	86	35	40.7	85	66	77.6
Septic arthritis (True)	94	66	70.2	86	82	95.3
11. *B. pseudomallei* can infect-						
Human (True)	102	100	98.0	86	86	100.0
Sheep (True)	89	61	68.5	83	73	88.0
Goat (True)	88	61	69.3	84	75	89.3
Dog (True)	83	32	38.6	77	40	51.9
Pig (True)	80	40	50.0	83	69	83.1
12. *Burkholderia pseudomallei* exhibits intrinsic resistance to the following antibiotics-						
Ceftazidime (False)	81	66	81.5	74	70	94.6
Meropenem (False)	81	68	84.0	71	67	94.4
Colistin (True)	94	73	77.7	85	78	91.8
Cotrimoxazole (False)	83	56	67.5	73	71	97.3
Gentamicin (True)	94	75	79.8	85	81	95.3
13. Melioidosis can be treated with the following antibiotics-						
Ceftazidime (True)	93	84	90.3	86	83	96.5
Azithromycin (False)	79	69	87.3	73	70	95.9
Meropenem (True)	97	81	83.5	87	85	97.7
Co-amoxiclav (True)	87	55	63.2	85	78	91.8
Ceftriaxone (False)	82	56	68.3	76	64	84.2
Cotrimoxazole (True)	87	69	79.3	86	85	98.8

14. Total duration of antibiotic therapy for melioidosis is-						
5-7 days (False)	74	68	91.9	75	73	97.3
2-3 weeks (False)	79	49	62.0	76	61	80.3
1-2 months (False)	73	62	84.9	73	65	89.0
3-4 months or more (True)	64	58	90.6	86	70	81.4
15. Case fatality rate of melioidosis is approximately-						
5-10% (False)	81	60	74.1	73	68	93.2
10-50% (True)	82	48	58.5	79	44	55.7
60-70% (False)	83	56	67.5	78	44	56.4
100% (False)	77	72	93.5	73	69	94.5
16. High-risk group for melioidosis-						
Agriculture farmers (True)	102	100	98.0	87	86	98.9
Construction workers (True)	81	38	46.9	77	27	35.1
Doctors (False)	79	54	68.4	77	49	63.6
Teachers (False)	75	75	100	75	75	100.0
Microbiology laboratory personnel (True)	88	66	75.0	82	68	82.9
17. Co-morbid conditions associated with melioidosis are-						
Diabetes mellitus (True)	102	102	100.0	86	85	98.8
Alcoholism (True)	91	65	71.4	84	64	76.2
Hypercholesterolemia (False)	79	74	93.7	75	68	90.7
Thalassemia (True)	87	45	51.7	82	59	72.0
Chronic kidney disease (True)	95	87	91.6	87	82	94.3
18. For melioidosis Bangladesh is considered as-						
Definite country (True)	93	56	60.2	86	75	87.2
Probable country (False)	80	49	61.3	75	65	86.7
Possible country (False)	81	54	66.7	75	67	89.3
Non-endemic country (False)	80	65	81.3	75	71	94.7
19. Differential diagnoses of melioidosis are-						
Tuberculosis (True)	99	93	93.9	84	83	98.8
Typhoid (True)	80	16	20.0	77	30	39.0
Brucellosis (True)	90	63	70.0	83	46	55.4
Malaria (False)	79	71	89.9	77	72	93.5
Leptospirosis (True)	82	40	48.8	77	27	35.1
20. Clinical specimens taken for culture for the diagnosis of melioidosis are-						
Pus (True)	101	99	98.0	87	87	100.0
Sputum (True)	99	97	98.0	86	84	97.7
Urine (True)	88	55	62.5	85	77	90.6
Blood (True)	100	93	93.0	87	87	100.0
Joint fluid (True)	91	60	65.9	87	81	93.1

Overview of pre-and post-test assessment score: Our results documented a significant increase ($p = 0.0001$) in the mean percentage of post-test score compared with the mean percentage of pre-test score (79.2 ± 16.5 vs. 62.4 ± 22.9) (Table-3). The calculated Cohen's d for the knowledge improvement is approximately 0.82, indicating a large effect. In 79.2% of questions the respondents obtained higher marks in post-test than in pre-test (Table-2).

Table-3: *Descriptive statistics for pre-test and post-test*

Numberof participants in pre-test	Number of participants in post-test	Mean% (± SD) marks obtained in pre-test	Mean% (± SD) marks obtained in post-test	*p* value (by student's t test)
113	87	62.4 ± 22.9	79.2 ± 16.5	0.0001

Discussion

Pre- and post-test studies are gaining popularity worldwide in enhancing attentiveness, and focusing towards better understanding and long-term retention of knowledge on a specific topic. However, to our knowledge, this is the first study reported from Bangladesh to assess the refinement of knowledge, in addition to improvising diagnostic and management skills regarding melioidosis by training the healthcare providers along with pre-test and post-test evaluation. In our study, significant improvement in post-test scores among participants was observed compared with pre-test scores (p = 0.0001).

BP is a saprophytic, zoonotic, environmental organism, mainly found in soil, plants of tropical region and unchlorinated water [12]. BP is transmitted through percutaneous inoculation, ingestion and inhalation, and causes a wide spectrum of diseases [13]. In most endemic regions, the organism has been observed to have seasonal predilection with higher infection rates during monsoon [8]. Most of the participants in this study were observed to have satisfactory performance regarding the causative agent and modes of transmission. While almost all respondents could correctly identify agriculture farmers as high-risk people, most of the participants did not know about the other high-risk population. Diabetes mellitus, heavy alcoholism, chronic renal failure, chronic kidney disease, thalassemia, glucocorticoid use and malignancy are common predisposing factors for melioidosis [8,12,14]. In this study it was found that the participants only knew about diabetes mellitus as the commonest risk factor. They were quite unaware of the other established risk factors. A survey conducted in Australia among medical students, healthcare workers, and hospital admitted melioidosis patients also demonstrated similar results. They also observed an awareness gap regarding the risk factors and protective factors of melioidosis among the three groups [10]. These knowledge gaps might be a hindrance for clinicians to identify at-risk population and cloud their diagnostic skills in clinical setting.

Due to the wide range of clinical presentations, melioidosis is known as the 'great imitator' that can be mistaken for other diseases such as tuberculosis, pneumonia or cancer [8,15]. The commonest clinical manifestation of melioidosis is pneumonia, followed by abscess formation (most commonly prostate, spleen, liver and kidney), skin and soft tissue infection, genitourinary infection, septicemia, musculoskeletal and neurological infection [16]. While pneumonia, abscess, septic arthritis and septicemia were mentioned as clinical manifestations by more than 70% of participants, 59.3% missed urinary tract infection. This reflects why in Bangladesh ourphysicians are missing the cases. Through this study it is also evident that our physicians struggle to consider the relevant differentials of melioidosis.

For laboratory diagnosis of BP, use of selective media, such as Ashdown agar media, MacConkey agar media, *B. pseudomallei* selective agar media (BCSA) or *B. cepacia* selective agar media (BCPA) are recommended for at least four days [17,18]. In case of laboratory diagnosis, the performance of the participants on pre-test was praiseworthy, which was seen to be further enhanced on post-test. This finding supports the fact that the healthcare providers of this country know about the diagnostic characteristics of this organism, although the rate of diagnosis is still very low. People infected with BP are more commonly the rural people, who have very limited access even to a simple diagnostic facility. Even if they get access to a higher facility center, lack of experience of the microbiologists might contribute to the lower rates

of diagnosis from our country [19]. It was a common notion amongst our medical community that the clinicians and microbiologists often missed the diagnosis of melioidosis in Bangladesh. Through this study it is revealed that our healthcare providers are not aware of the endemicity of the disease, many patients may go misdiagnosed or undiagnosed. Similar results were observed in previous studies, where the healthcare workers were observed to have significant lack of awareness of melioidosis despite the endemicity of the disease [11,20].

BP has a unique sensitivity pattern to certain antibiotics. It is sensitive to ceftazidime, meropenem, imipenem and co-amoxiclav, doxycycline, trimethoprim-sulfamethoxazole. On the other hand, it exhibits intrinsic resistance to penicillin, aminoglycosides, first and second generation cephalosporins, macrolides, and colistin [21,22]. More than 30% respondents erroneously indicated cotrimoxazole as resistant drug for melioidosis. In addition, 31.7% of health care personnel did not know that ceftriaxone is not an appropriate choice of antibiotic to treat melioidosis and more than one-third of participants had misconception regarding co-amoxiclav which can be used to treat melioidosis patient. This knowledge gap might create difficulty in treating patients appropriately and contribute to higher mortality rates. Therefore, during the training session, elaborative lectures on these specific topics were ensured to help the participants improvise their knowledge gaps. The participants came into consensus that, while reporting a culture, it should be mentioned that only carbapenems and ceftazidime shall be prescribed for intensive phase. The antibiotic choice for maintenance phase also needs to be notified in the culture report.

Pre- and post-test studies are done mainly to assess the impact of an intervention among a group of people. Our study has concluded with significant improvement in knowledge regarding epidemiology, risk factors, clinical presentation, laboratory diagnosis, and management of melioidosis on post-test compared with the pre-test scores. However, there was low retention of knowledge regarding the case fatality rate, differential diagnoses, and high-risk population identification regarding melioidosis. To address these gaps, future workshops and in-person training sessions can be organized to provide more interactive learning and practical discussion, which may help improve knowledge on case fatality rate, differential diagnosis, and high-risk populations.In a previous study conducted in Thailand, video clips were found to be more beneficial in increasing adherence among the participants and could positively influence their awareness regarding preventive behaviors for melioidosis [23]. Hence, audio-visual representation of the preventive measures could be a potential mode of raising awareness of this NTD among healthcare workers, as well as the general population. Awareness campaigns are very crucial to refine knowledge about the infectious diseases in tropical regions. This is the key to improving the diagnostic yield, and treatment modalities, as well as reducing mortality of medically important NTDs like melioidosis in endemic zones.

Conclusion

Increasing knowledge through training among clinicians, microbiologists and lab personnel is a vital tool to control melioidosis in our country. To increase awareness among healthcare providers, it is mandatory to organize effective education campaigns and hospital-based training program all over the country. This will not only aid in circulating knowledge, but also improvise the diagnostic and management skills of the skilled professionals. We suggest dissemination of knowledge about epidemiology, diagnosis and management of BP to health professionals through regular hands-on training programs.

Limitations

We believe our study has certain limitations. First, the sample size was very small. Larger studies can be done in future to critically compare pre-test and post-test performance. Secondly, only 87 out of 113 people participated in post-test assessment. Thirdly, as the session was carried out online, the level of engagement of the participants could not be evaluated although, the performance improvement in post-test analysis indicates

towards sufficient engagement of the respondents. Assessing after six months could give a better retention status, which should be considered in future.

Abbreviations- NTD: Neglected Tropical Disease; BP: Burkholderia pseudomallei; CDC: Centers for Disease Control and Prevention; BSTID: Bangladesh Society of Tropical and Infections Disease; BSMM: Bangladesh Society of Medical Microbiologists; CDC-HSP: Centers for Disease Control and Prevention-Health Security Partners.

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Author contributions

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics approval and consent to participants

Informed consent was taken from all participants.

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