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Original Article

Healthcare-Associated Mycobacterial Port-Site Infections Following Laparoscopic Surgery: Clinical Characteristics and Epidemiological Evidence from a Multicenter Cohort in Bangladesh

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Abstract

Introduction: Healthcare-associated mycobacterial infection is an uncommon but important complication of minimally invasive surgery. Delayed port-site infection after laparoscopy may be misclassified as persistent bacterial surgical-site infection, especially in settings where mycobacterial culture and molecular testing are not routinely available. This study reanalyzes a multicenter Bangladeshi cohort of delayed non-healing port-site lesions using a more conservative epidemiological framework of probable healthcare-associated mycobacterial infection.

Methods: This retrospective multicenter observational cohort study reviewed 483 laparoscopic procedures performed by six experienced laparoscopic surgeons in five hospitals in Narayanganj, Bangladesh, from September 2020 to January 2021. Patients with delayed non-healing port-site ulcers, abscesses, or discharging sinuses who underwent histopathological evaluation and improved after anti-tubercular therapy were included. Categorical variables were analyzed using the Pearson chi-square test and Cramer's V.

Results: Among 483 laparoscopic procedures, 87 patients developed port-site infection and 66 fulfilled the inclusion criteria. Female patients accounted for 64 cases (96.97%). Laparoscopic cholecystectomy was the most common associated procedure (54/66, 81.82%), followed by laparoscopic appendectomy (9/66, 13.64%). Abscess was the commonest presentation (41/66, 62.12%), followed by discharging sinus (25/66, 37.88%). Histopathology showed granulomatous inflammation in 56 patients (84.85%) and non-specific inflammation in 10 patients (15.15%). The highest number of cases occurred after operations performed in October 2020 (45/66), and the interval from surgery to presentation ranged from 28 to 65 days. The month of operation was significantly associated with port-site involvement (Pearson chi-square = 33.82, p = 0.0133). Perioperative antibiotic regimen was also associated with the type of subsequent intervention (Pearson chi-square = 23.68, p = 0.0006), although this association was considered non-causal and confounded by operative indication and clinical severity. All patients improved after anti-tubercular therapy.

Conclusion: The delayed onset, temporal clustering, granulomatous histopathology, and response to anti-mycobacterial therapy strongly suggest a probable healthcare-associated mycobacterial outbreak after laparoscopic surgery. In the absence of microbiological confirmation, the broader term "probable mycobacterial port-site infection" is more scientifically defensible than "confirmed port-site tuberculosis". Strengthening instrument reprocessing, outbreak surveillance, and mycobacterial diagnostic capacity is essential for patient safety in high-burden, resource-limited settings.

Keywords: Port-site infection; laparoscopic surgery; healthcare-associated infection; mycobacterial infection; nontuberculous mycobacteria; surgical-site infection; Bangladesh; outbreak investigation.

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Introduction

Minimally invasive surgery has changed the practice of modern general surgery by reducing incision size, postoperative pain, wound morbidity, and length of hospital stay. However, the advantages of laparoscopy are accompanied by procedure-specific complications, including trocar-site bleeding, port-site hernia, thermal injury, and port-site infection[1]. Surgical-site infection remains one of the commonest healthcare-associated infections worldwide and is associated with avoidable morbidity, additional procedures, prolonged antibiotic use, increased cost, and loss of patient confidence in surgical services [2,3].

Most early port-site infections are caused by conventional bacterial pathogens and respond to drainage, wound care, and standard antimicrobial therapy. A smaller but clinically important group presents late, often several weeks after surgery, as persistent induration, nodules, abscesses, discharging sinuses, or non-healing ulcers. These delayed infections are frequently caused by mycobacteria, particularly rapidly growing nontuberculous mycobacteria (NTM) such as Mycobacterium fortuitum, M. chelonae, M. abscessus, and M. massiliense[4-8]. In tuberculosis-endemic countries, Mycobacterium tuberculosis must also remain in the differential diagnosis, although many post-laparoscopic outbreaks historically labelled as port-site tuberculosis may in fact represent NTM infection when microbiological speciation is performed [7-10].

Rapidly growing mycobacteria are environmentally resilient organisms found in water, soil, biofilms, and inadequately reprocessed medical equipment. They can survive in moist environments, colonize complex instrument surfaces, and show relative tolerance to some disinfectant practices when pre-cleaning, exposure time, concentration monitoring, rinsing, or drying are inadequate[11-15,25,26]. Several outbreaks after laparoscopic surgery have been linked to reusable instruments, contaminated rinse water, deficient high-level disinfection, and failure to mechanically remove organic material before chemical immersion [4,7,8,16].

Bangladesh has a high tuberculosis burden, and the WHO Global Tuberculosis Report continues to identify TB as a major public health challenge in South Asia[17,18]. This epidemiological background increases clinical suspicion when chronic surgical wounds show granulomatous inflammation. At the same time, emerging Bangladeshi evidence demonstrates that NTM can cause persistent surgical-site infections, including infections after laparoscopic surgery[19]. Therefore, scientific interpretation of delayed port-site infection in Bangladesh should distinguish between confirmed tuberculosis, confirmed NTM infection, and probable mycobacterial infection based on clinicopathological evidence.

The original cohort on which this manuscript is based included 483 laparoscopic procedures performed in five hospitals, of which 87 developed port-site infection and 66 developed persistent non-healing lesions with histopathological and clinical features compatible with mycobacterial disease. The current manuscript preserves the original dataset, tables, and statistics, but reframes the evidence as a probable healthcare-associated mycobacterial cluster. This terminology is more conservative and more appropriate because culture, GeneXpert, PCR, and environmental sampling were not available. The objective was to describe the clinical, operative, pathological, and temporal characteristics of this cluster and to discuss its implications for infection prevention, instrument reprocessing, and surveillance in resource-limited surgical settings.

Methods

This was a retrospective multicenter observational cohort study conducted in five hospitals in Narayanganj, Bangladesh. Hospital records of laparoscopic procedures performed between September 2020 and January 2021 were reviewed. The same source population and analyzed cohort as the original study were retained.

A total of 483 laparoscopic surgeries were performed by six surgeons during the study period. All participating surgeons had at least five years of experience in laparoscopic surgery. Eighty-seven patients developed port-site infection. Sixty-six patients who developed delayed non-healing port-site ulcers, abscesses, or discharging sinuses and improved after anti-tubercular therapy were included in the final analysis.

Perioperative management and instrument reprocessing

Patients were admitted on the morning of surgery, underwent laparoscopic procedures at noon, and were generally discharged on the following morning. Oral intake progressed from sips of water to a liquid diet 6 to 8 hours postoperatively. Three doses of ceftriaxone or cefuroxime were administered in all patients, with an additional single dose of metronidazole used perioperatively in selected patients with appendicitis, acute cholecystitis, empyema, or bile leakage. Laparoscopic instruments were immersed for 20 minutes in activated 2% glutaraldehyde solution (CIDEX) for chemical disinfection. Other surgical instruments were sterilized by the conventional autoclave method. Current infection-control standards emphasize that chemical disinfection must be preceded by complete dismantling, mechanical cleaning, validated exposure time, concentration monitoring, sterile rinsing, and safe drying/storage[13-15,20].

Data collection

Data were extracted from hospital records and entered into digital records for analysis. Variables included sex, operation type, indication for surgery, month of operation, postoperative day of presentation, port involved, clinical presentation, histopathology, perioperative antibiotic regimen, additional procedure required, and treatment outcome.

Statistical analysis

Categorical variables were summarized as frequencies and percentages. Continuous variables were summarized as mean, standard deviation, minimum, and maximum, where available from the original dataset. Differences in categorical distributions were assessed using the Pearson chi-square test. Strength of association was assessed by Cramer's V, with values above 0.3 considered moderate and above 0.5 considered strong. A p-value less than 0.05 was considered statistically significant. Statistical analysis was performed using Stata 14 (Stata Corp LP, Texas, USA).

Results

During the study period, 483 laparoscopic operations were performed and 87 patients developed port-site infection. Of these, 66 patients fulfilled the inclusion criteria for probable mycobacterial port-site infection and were included in the final analysis.

Female patients accounted for 64 of 66 cases (96.97%), while two patients (3.03%) were male (Table I). The marked female predominance most likely reflected the high proportion of laparoscopic cholecystectomy in the cohort rather than a biological susceptibility to mycobacterial infection.

Abscess was the most common clinical presentation, occurring in 41 patients (62.12%), while discharging sinus was documented in 25 patients (37.88%) (Table II). Histopathological examination showed granulomatous inflammation in 56 patients (84.85%) and non-specific inflammation in 10 patients (15.15%).

The largest cluster was associated with operations performed in October 2020 (45 cases), followed by November 2020 (13 cases), December 2020 (5 cases), and January 2021 (3 cases). Mean time from procedure to presentation ranged from 33.6 to 43.3 days across operative months, with an overall range of 28 to 65 days (Table III). This delayed presentation pattern is typical of mycobacterial surgical-site infection [5,6,9].

Table I: Sex distribution among patients.

Sex	Frequency	Percentage (%)
Female	64	96.97
Male	2	3.03
Total	66	100.00

Table II: Clinical presentation among patients.

Presentation	Frequency	Percentage (%)
Abscess	41	62.12
Discharging sinus	25	37.88
Total	66	100.00

Table III: Presentation following the procedure according to the month of operation.

Month of operation	Number of patients	Mean days from procedure	SD	Minimum days	Maximum days
October 2020	45	38.867	7.491	28	60
November 2020	13	43.308	11.331	29	65
December 2020	5	33.600	1.817	32	36
January 2021	3	40.000	8.660	35	50

POD: postoperative day; SD: standard deviation.

Laparoscopic cholecystectomy was the commonest associated procedure (54/66, 81.82%), followed by laparoscopic appendectomy (9/66, 13.64%). Diagnostic laparoscopy, laparoscopic ovarian cystectomy, and combined laparoscopic appendectomy with cholecystectomy accounted for one case each (Table IV). Cholelithiasis was the most frequent operative indication (42/66, 63.64%), followed by acute appendicitis (6/66, 9.09%) and chronic cholecystitis (4/66, 6.06%) (Table VIII).

Port distribution showed a concentration of cases at the epigastric port. Pearson chi-square analysis demonstrated a statistically significant association between month of operation and port involvement (chi-square = 33.82, p = 0.0133), suggesting temporal clustering of anatomical port involvement (Table V).

Perioperative antibiotic regimen was significantly associated with the type of additional procedure required (chi-square = 23.68, p = 0.0006) (Table VI). This association should be interpreted cautiously because antibiotic choice was related to operative indication and clinical context; it should not be interpreted as evidence that a specific antibiotic regimen caused mycobacterial infection. All patients received Category I anti-tubercular therapy and all improved clinically. The favorable therapeutic response supported a mycobacterial etiology but did not distinguish M. tuberculosis from NTM, as microbiological confirmation was unavailable.

Table IV: *Type of operation among patients.*

Name of operation	Frequency	Percentage (%)
Diagnostic laparoscopy	1	1.52
Laparoscopic ovarian cystectomy	1	1.52
Laparoscopic appendectomy	9	13.64
Laparoscopic appendectomy with cholecystectomy	1	1.52
Laparoscopic cholecystectomy	54	81.82
Total	66	100.00

Table V: *Chi-square test between the month of operation and the ports involved.*

Month	All 3 ports	Epigastric	Epigastric + right iliac	Hypogastric	Multiple	Right hypochondriac	Right iliac	Total
October 2020	4	22	2	0	1	4	12	45
November 2020	2	7	0	1	1	1	1	13
December 2020	0	4	0	0	1	0	0	5
January 2021	0	1	2	0	0	0	0	3
Total	6	34	4	1	3	5	13	66

Pearson chi-square = 33.82; probability = 0.0133.

Table VI: *Chi-square test between perioperative antibiotic regimen and additional procedure.*

Perioperative antibiotics	Incision and drainage	I&D with port excision	I&D with surgical debridement	Total
Ceftriaxone	35	5	2	42
Ceftriaxone + metronidazole	12	4	1	17
Cefuroxime	0	6	0	6
Cefuroxime + metronidazole	1	0	0	1

Pearson chi-square = 23.68; probability = 0.0006. I&D: incision and drainage.

Table VII: *Indications for Surgery.*

Indication of operation	Frequency	Percentage (%)
Acute appendicitis	6	9.09
Acute cholecystitis with cholelithiasis	3	4.55
Chronic cholecystitis with cholelithiasis	3	4.55
Cholelithiasis	42	63.64
Chronic cholecystitis	4	6.06
Empyema of gallbladder	1	1.52
Mucocele of gallbladder	1	1.52
Ovarian cyst	1	1.52
Recurrent appendicitis	3	4.55
Recurrent appendicitis with chronic calculus cholecystitis	1	1.52
Secondary infertility	1	1.52
Total	66	100.00

Table VIII: *Histopathological findings*

Histopathology	Frequency	Percentage (%)
Granulomatous inflammation	56	84.85
Non-specific inflammation	10	15.15
Total	66	100.00

Table IX: *Epidemiological interpretation of key findings.*

Finding	Interpretation
Delayed presentation at 28-65 days	Consistent with reported incubation pattern of mycobacterial surgical-site infection rather than typical early bacterial SSI.
Temporal concentration in October-November 2020	Supports possible common-source exposure or focal outbreak.
Predominant epigastric port involvement	Suggests possible relationship with repeated instrument use, extraction port, or local contamination pathway.
Granulomatous inflammation in 84.85%	Strong supportive evidence of mycobacterial disease but not species-specific.
Universal clinical improvement after anti-tubercular therapy	Supports mycobacterial etiology but does not differentiate tuberculosis from NTM.

Discussion

This multicenter cohort describes a substantial cluster of delayed port-site infections after laparoscopic surgery in Bangladesh. The observed pattern is best interpreted as probable healthcare-associated mycobacterial port-site infection rather than confirmed port-site tuberculosis. This distinction is important because the cohort lacked culture, GeneXpert, PCR, acid-fast bacilli confirmation, drug susceptibility testing, and environmental sampling. Nevertheless, the combination of delayed onset, non-healing wounds, granulomatous histopathology, temporal clustering, and response to anti-mycobacterial therapy provides a coherent clinicopathological and epidemiological signal [5,8,19].

Delayed presentation is central to the diagnosis. Conventional bacterial surgical-site infections usually manifest within days of surgery, whereas mycobacterial port-site infections frequently appear after three to eight weeks. In the present cohort, the minimum documented interval was 28 days and the maximum was 65 days, with mean presentation around one month after surgery. This pattern corresponds closely to the incubation period described for rapidly growing mycobacteria after laparoscopic procedures and cosmetic surgery [4-9]. The delayed nature of disease may explain why patients often receive repeated courses of standard antibiotics before mycobacterial infection is suspected.

The temporal clustering of cases is one of the strongest epidemiological features. Forty-five cases were associated with procedures performed in October 2020, followed by a decline over the following months. Such a short-period concentration is difficult to explain by sporadic endogenous tuberculosis alone. It is more compatible with a common-source healthcare-associated event, such as contaminated instruments, contaminated rinse water, ineffective disinfectant exposure, biofilm formation, or a transient breach in reprocessing practice [7,8,16,21]. Outbreak investigations in Brazil and India have repeatedly linked similar infections to rapidly growing mycobacteria and instrument-processing failures [4,7,8,16].

The predominance of laparoscopic cholecystectomy among affected patients likely reflects both procedural volume and instrument-sharing patterns. Cholecystectomy is one of the most frequently performed laparoscopic operations in general surgical practice and often uses reusable cannulas and graspers repeatedly during high-throughput operating lists. Previous outbreaks and case series similarly found laparoscopic cholecystectomy to be a common antecedent procedure [4,5,7,9]. The female predominance in this cohort should therefore be interpreted cautiously; it likely reflects the high frequency of gallstone disease and cholecystectomy among female patients rather than a true sex-related predisposition.

The concentration of infection at the epigastric port is also epidemiologically meaningful. In laparoscopic cholecystectomy, the epigastric port commonly serves as an instrument port and may also be related to specimen extraction or frequent exchange of instruments. Repeated introduction of contaminated instruments through a particular port could explain anatomical clustering. However, definitive attribution requires instrument tracking, procedure-level exposure mapping, and environmental microbiology, none of which were available in the retrospective dataset. The significant association between month of operation and port involvement strengthens suspicion of a focal contamination pathway, but does not establish causality.

Histopathology revealed granulomatous inflammation in 84.85% of cases. Granulomatous inflammation is compatible with tuberculosis and NTM infection, but it is not species-specific. In a tuberculosis-endemic setting, granulomatous surgical wounds often lead clinicians to initiate anti-tubercular therapy. However, rapidly growing NTM such as M. fortuitum, M. chelonae, M. abscessus, and M. massiliense are now increasingly recognized as causes of delayed surgical-site infection and chronic port-site disease [6,8,19,22,23,24]. A contemporary Bangladeshi study detected NTM in persistent surgical-site infections and reported M. abscessus and M. fortuitum among common species, reinforcing the relevance of NTM in the local context [19].

The terminology used for such cases matters. The original clinical label of port-site tuberculosis is understandable in a high-TB-burden country, especially when granulomatous inflammation and therapeutic response are present. However, from an international publication perspective, confirmed tuberculosis requires microbiological or molecular evidence of M. tuberculosis complex. Without such confirmation, the more appropriate term is probable mycobacterial port-site infection. This terminology includes both tuberculosis and NTM in the differential diagnosis and prevents overstatement of evidence. It also aligns with modern outbreak interpretation, where NTM is often the more plausible pathogen in healthcare-associated clusters involving instruments and water exposure [8,13,19,21].

Instrument reprocessing is the most important modifiable issue raised by this cohort. The protocol used 20 minutes of immersion in activated 2% glutaraldehyde for laparoscopic instruments. Glutaraldehyde can provide high-level disinfection when properly used, but its effectiveness depends on complete pre-cleaning, correct activation, adequate concentration, full surface contact, appropriate exposure time, avoidance of excessive reuse, sterile rinsing, drying, and proper storage [13-15,20]. Mycobacteria may persist when organic material remains in joints, lumens, insulation defects, or cannula channels. Several older and contemporary reports have raised concern about glutaraldehyde tolerance or survival of mycobacteria under suboptimal conditions [11,12,15].

International infection-prevention guidance emphasizes that reusable semi-critical and critical instruments require validated reprocessing workflows. For complex laparoscopic devices, best practice includes dismantling, immediate bedside removal of gross contamination, enzymatic or detergent cleaning, brushing and flushing of channels, ultrasonic cleaning when available, inspection under adequate lighting, validated sterilization when feasible, and sterile or filtered rinse water if high-level disinfection is used [13-15,20]. Ethylene oxide, hydrogen peroxide gas plasma, and other validated low-temperature sterilization technologies may be preferable for heat-sensitive instruments, but access and cost remain barriers in low- and middle-income settings.

The significant association between perioperative antibiotic regimen and additional procedure should be interpreted as an observed statistical association, not a biological causal effect. Ceftriaxone, cefuroxime, and metronidazole do not prevent mycobacterial infection, and antibiotic choice was likely influenced by underlying disease severity, operative indication, and surgeon preference. The finding is useful as a signal for audit but should not be used to infer that any standard perioperative antibiotic regimen increases the risk of mycobacterial port-site infection.

From a public health perspective, this cluster highlights the need for surveillance of delayed surgical-site infections. Many patients are discharged early after laparoscopy and may present weeks later to different clinicians. Without a registry or reporting mechanism, outbreak recognition may be delayed. In Bangladesh, where TB remains a major public health concern and NTM diagnostics are not universally available, delayed non-healing laparoscopic wounds should trigger a structured diagnostic pathway, including tissue biopsy, acid-fast bacilli staining, mycobacterial culture, nucleic acid amplification testing, and species identification where possible [17-19].

The burden on patients is substantial. Delayed port-site infection can require repeated outpatient visits, incision and drainage, port excision, debridement, prolonged wound care, and prolonged anti-mycobacterial therapy. It may also create psychological distress and reduce confidence in minimally invasive surgery. Because prevention depends mainly on reliable reprocessing systems, institutional investment in infection prevention is likely to be more cost-effective than treating established outbreaks.

The findings of this cohort should prompt practical institutional actions: immediate audit of laparoscopic reprocessing protocols, documentation of disinfectant activation and concentration, staff training, instrument tracking, sterilization logs, periodic microbiological surveillance of rinse water and equipment, and a policy for early reporting of delayed port-site lesions. When clusters are detected, operating lists, instruments, disinfectants, water sources, and environmental reservoirs should be investigated systematically.

The study has important limitations. Its retrospective design limits causal inference. Microbiological confirmation was not performed, so the causative organism cannot be identified. No mycobacterial culture, PCR, GeneXpert, acid-fast bacilli staining result, susceptibility testing, or environmental sampling was available. Histopathology and treatment response support mycobacterial disease but do not distinguish M. tuberculosis from NTM. Treatment response was part of the inclusion criteria, which may introduce confirmation bias. Instrument-level exposure data were unavailable, limiting definitive source attribution.

Conclusion

This multicenter Bangladeshi cohort demonstrates a clinically important cluster of delayed non-healing port-site infections after laparoscopic surgery. The epidemiological pattern, delayed presentation, granulomatous histopathology, and therapeutic response support a probable healthcare-associated mycobacterial etiology. Because microbiological confirmation was unavailable, the cases should be described as probable mycobacterial port-site infection rather than confirmed tuberculosis. The findings emphasize the need for improved laparoscopic instrument reprocessing, outbreak surveillance, mycobacterial diagnostic capacity, and national guidance for prevention and management of delayed port-site infections.

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Conflict of interest

The authors declare no conflict of interest

Ethical approval

The study was approved by the Institutional Ethics Review Board of Anwar Khan Modern Medical College (Ref: IERB-AKMMC/ECC/2020/09).

References

1. Sasmal PK. Port site infection in laparoscopic surgery: a review of its management. World J Clin Cases. 2015;3(10):864-871.
2. European Centre for Disease Prevention and Control. Healthcare-associated infections: surgical site infections. Annual Epidemiological Report for 2018-2020. Stockholm: ECDC; 2023.
3. World Health Organization. Global guidelines for the prevention of surgical site infection. 2nd ed. Geneva: World Health Organization; 2018.
4. Duarte RS, Lourenco MCS, Fonseca LS, Leao SC, Amorim ELT, Rocha ILL, et al. Epidemic of postsurgical infections caused by Mycobacterium massiliense. J Clin Microbiol. 2009;47(7):2149-2155.
5. Faridi S, Siddiqui B, Singh K, Aslam M. Port site tuberculosis after laparoscopic cholecystectomy: a rare complication with review of literature. Int J Health Allied Sci. 2016;5(2):123-126.
6. Ramesh H, Prakash K, Lekha V, Jacob G, Venugopal A, Venugopal B. Port-site tuberculosis after laparoscopy: report of eight cases. Surg Endosc. 2003;17(6):930-932.
7. Vijayaraghavan R, Chandrashekhar R, Sujatha Y, Belagavi CS. Hospital outbreak of atypical mycobacterial infection of port sites after laparoscopic surgery. J Hosp Infect. 2006;64(4): 344-347.
8. Kannaiyan K, Ragunathan L, Sakthivel S, Sasidar AR, Muralidaran V, Venkatachalam GK. Surgical site infections due to rapidly growing mycobacteria in Puducherry, India. J Clin Diagn Res. 2015;9(3): DC05-DC08.
9. Chaudhary R, Singh R, Bhadoria AS, et al. Current trends in the management of port-site infections: a case series and review of published work. Cureus. 2023;15(6): e40655.
10. Ghani MT, Rehman IU, Sukh N, Tariq B, Khurshid A, Aadwani MA. Chronic laparoscopic port-site infection: a systematic review. J Coll Physicians Surg Pak. 2025;35(10):1313-1317.
11. Griffiths PA, Babb JR, Bradley CR, Fraise AP. Glutaraldehyde-resistant Mycobacterium chelonae from endoscope washer disinfectors. J Appl Microbiol. 1997;82(4):519-526.
12. Urayama S, Kozarek RA, Sumida S, Raltz S, Merriam L, Pethigal P. Mycobacteria and glutaraldehyde: is high-level disinfection of endoscopes possible? Gastrointest Endosc. 1996;43(5):451-456.
13. Rutala WA, Weber DJ. Disinfection, sterilization, and antisepsis: an overview. Am J Infect Control. 2019; 47S:A3-A9.
14. Centers for Disease Control and Prevention. Guideline for Disinfection and Sterilization in Healthcare Facilities. Atlanta: CDC; updated 2024.
15. World Health Organization. Decontamination and reprocessing of medical devices for health-care facilities. Geneva: WHO; 2016.
16. Pal N, Ray R, Kundu S, Maiti PK. Intervention strategy for Rapid Grower Mycobacteria outbreak among post-laparoscopic surgical site infection patients in a tertiary care hospital. Indian J Med Res. 2024;160(6):625-629.
17. World Health Organization. Tuberculosis profile: Bangladesh and South-East Asia Region. Geneva: WHO; 2024.
18. Government of Bangladesh. Sustainable Development Goals data: tuberculosis incidence in Bangladesh. Dhaka: Government of Bangladesh; 2023.
19. Nahar MR, Nasreen SA, Paul SK, Hoque MA, Aung MS, Haque N, et al. Prevalence and epidemiologic features of nontuberculous mycobacteria causing persistent surgical site infections in Bangladesh. IJID Reg. 2025; 16:100714.
20. Association for the Advancement of Medical Instrumentation. Comprehensive guide to steam sterilization and sterility assurance in health care facilities. ANSI/AAMI ST79. Arlington: AAMI; 2017.
21. Marwah S, Shivaran KD, Sen J, Marwah N. Port site tuberculosis presenting as nonhealing sinus after laparoscopic appendicectomy. Indian J Surg. 2015;77(Suppl 2):735-737.
22. Lahiri KK, Jena J, Pannicker KK. Mycobacterium fortuitum infections in surgical wounds. Med J Armed Forces India. 2009;65(1):91-92.
23. Sharma SK, Upadhyay V. Epidemiology, diagnosis and treatment of non-tuberculous mycobacterial diseases. Indian J Med Res. 2020;152(3):185-226.
24. Jan A, et al. Delayed port-site infections caused by nontuberculous mycobacteria after laparoscopic surgery. J Med Bacteriol. 2025; 13:1-8.