CME LIVE OPEN ACCESS

CME Journal of Medical Microbiology

Research Article ISSN: 3070-3638

Extrapulmonary Non-Tuberculous Mycobacterial Infections: A Decade Review in a Belgian Tertiary-Care Hospital

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Received: 2025 Nov 27 **Accepted:** 2025 Dec 17 **Published:** 2025 Dec 30

1. Introduction and Background

Nontuberculous mycobacteria (NTM) are a heterogeneous group of bacteria under the genus Mycobacterium, excluding the M. tuberculosis complex [1]. NTM are characterized by exceptional adaptability and durability and are found worldwide in aquatic and soil environments, especially watery reservoirs such as tap water and showerheads [2]. More than 200 species with variable pathogenicity are described [3,4]. NTM can be identified as incidental organisms from the skin, upper respiratory tract, genital region, and intestinal tract of asymptomatic individuals without being part of the microbiota [5,6]. The large majority of NTM are not pathogenic for humans, however some species are associated with various clinical syndromes, depending on prior exposure, host immune response interaction, and specific species characteristics [1,7]. Pulmonary disease is the most common clinical presentation, essentially in patients with underlying pulmonary disease or cystic fibrosis [7]. Still, extrapulmonary (EP) manifestations such as lymphadenitis, skin and soft tissue infections, osteoarthritis, and disseminated disease in immunocompromised patients are increasingly recognized [6,8].

The incidence and prevalence of NTM infections seems to be increasing worldwide, including in Belgium [6,10-14]. Determining the precise burden of EPNTM disease is challenging as there exist difficulties in discriminating between "transient isolation" in non-sterile body sites and true infection [10]. Additionally, systematic reporting is not notifiable to public health authorities [15,16]. Factors predisposing to NTM disease are systemic immunodeficiency (acquired or genetic), malignancies under chemotherapy, organ transplantation, alcoholism, malnutrition, aging, or the use of immunosuppressive therapy [16]. Multiple natural reservoirs of NTM may act as a transition zone to aid in infecting humans [5]. Contaminated water sources, particularly showerheads, are the most proven environmental source of NTM infection [16]. The ability of NTM to form different morphotypes and robust biofilms may play a role in pathogenesis [2]. Microbiological diagnosis is difficult, yet essential to determine species and drug susceptibility testing. Culture is the gold standard for laboratory diagnosis [7]. The variability in growth patterns of different NTM species and the limitation of expertise to some centers leads to mis- and underdiagnosis [17]. NTM are typically classified into rapidly growing mycobacteria (RGM) and slowly growing mycobacteria (SGM) based on their ability to produce mature colonies on solid media in less than or more than seven days, respectively. Besides the length of growth, RGM and SGM differ in their antimicrobial susceptibility and clinical manifestations [9].

Treatment of NTM is arduous as it needs a competent immune function (when possible) and a good choice of antibiotics, knowing that there is a paucity of active drugs that are efficient to NTM due to the high level of natural resistance [18]. Combination of antibiotics and prolonged therapy are required to maximize efficacy and prevent the emergence of resistance. This results in possible potential adverse events, pharmacological interactions and poor patient compliance. Additionally, there are few randomized controlled trials related to EP-NTM, and the only existing guidelines are specific for lung disease [19,20] which further complicates the management of these infections. These diagnostic and therapeutic challenges are particularly pronounced in immunosuppressed patients. A multidisciplinary harmonious approach is the key to the proper management of a patient with EP-NTM. This study aims to analyze and describe the recent epidemiological situation of EP NTM infections in our hospital with a particular focus on risk

factors, management, and outcomes.

2. Methods

2.1. Study Design and Data Collection

This retrospective study reviewed electronic medical records of adult patients with positive EP-NTM samples at Cliniques Universitaires Saint-Luc (Brussels, Belgium), a 973-bed academic tertiary-care hospital, from January 2010 to December 2019. The cohort was identified using chronological (positive mycobacterial polymerase chain reaction (PCR) results or cultures classified by year) and alphabetical (patient names associated with positive mycobacterial results) laboratory records, with both sets cross-verified for accuracy. Data extraction included patient characteristics (gender, age, country of birth), immune status (underlying transplant, human immunodeficiency virus (HIV) status, auto-immune disease), risk factors (alcohol, smoking, hypertension, cardiac conditions, respiratory disease, renal disease, diabetes, cancer), external risk factor (injury, aquarium), prior immunosuppressant treatment, initial presentation (fever, fatigue, skin lesion…), biological characteristics (C-reactive protein, neutrophils, lymphocytes, renal function, liver enzymes), site of infection (disseminated, lymphadenitis, skin, osteoarthritis), specimen of NTM isolation, name of NTM isolated, susceptibility testing, antimicrobial therapy (antibiotic name, start and discontinuation dates, side effects), surgical interventions and clinical outcomes. The most recent follow-ups were recorded on the 28th of January 2021. Ethical approval was obtained from the hospital's Clinical Research.

Ethics Committee (reference number 2019/29AOU/377). All patients aged over 18 years old with confirmed EP-NTM-positive samples from January 2010 to December 2019 were included. Two species, M. gordonae et M. paragordonae were directly excluded from this study as considered as non-pathogenic species [1,11]. The other species identified were classified into pathogenic or contaminant depending on the clinician's decision. NTM infection was defined as cases where treatment was initiated, or clinical judgment deemed the isolated pathogenic, even without any treatment. An NTM sample was considered a colonizer or contaminant if the medical team in charge of the patient decided so. We classified EP infections into lymphadenitis, skin and soft tissue infections, osteoarthritis, disseminated (one positive sample from blood culture or bone marrow, or various positive samples from more than two non-contiguous sterile sites), and others. Immunosuppression criteria included HIV positivity with CD4 <200/mm3 or acquired immunodeficiency syndrome (AIDS) stage, solid organ transplantation, hematopoietic stem cell transplantation, active malignancy, ongoing radio-chemotherapy, auto-immune disease, immunosuppressive treatment, pregnancy, complicated diabetes, terminal renal failure, end-stage liver disease, splenectomy. Cure was defined as the absence of evidence of infection at the end of treatment and/or significant clinical improvement observed at the end of follow-up. Failure was defined as the lack of clinical improvement. Relapse was defined as the recurrence of infection with the same pathogen after clinical resolution.

2.2. Sample Processing and Microbiological Identification

Acid-fast bacilli (AFB) staining and culture for mycobacteria remain the core of the diagnostic process. Samples are inoculated in the BACTEC MGIT 960 tube following manufacturer's instructions (Becton Dickinson) and incubated at 37°C. In parallel, three Lowenstein–Jensen medium are incubated at 37°C, 30°C, and 42°C. From the MGIT-positive tube, a smear is prepared for Ziehl– Nielsen/auramine fluorescence staining and a drop inoculated into a blood agar plates for checking any contamination (defined as growth after 48 h of incubation at 37°C). Isolates were identified by Matrix-Assisted Laser Desorption/Ionization Time-of-Flight (MALDI-TOF) mass spectrometry according to the manufacturer's instructions (Bruker Daltonics GmbH Germany). If needed, conventional PCR was performed. Antibiograms were performed by microdilution (Sensititre®) and interpreted according to the CLSI criteria [21].

2.3. Statistical Analysis

Descriptive statistics were presented as medians with interquartile ranges (IQR) or means ± standard deviations (SD) for continuous variables and as counts and frequencies (n, %) for categorical variables. Fisher's exact test was used to compare dichotomous or qualitative variables, as chi-square tests were unsuitable due to the small sample size. The Kruskal Wallis test was applied to compare continuous or quantitative variables.

3. Results

3.1. Incidence

During the study period, 43 different EP-NTM positive samples were identified. Figure 1 shows the annual distribution of cases.

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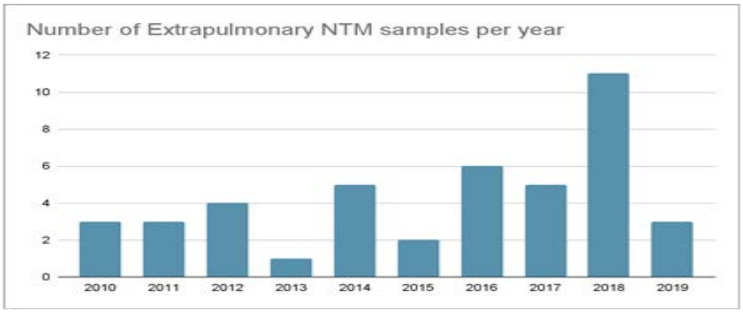

Figure 1: Number of Extrapulmonary NTM Samples Per Year (Total = 43)

3.2. General Characteristics of Patients

A total of 43 EP-NTM isolates were identified from 41 patients. Of them, 35 were considered to have true infections while six were considered to have contaminants. Generally, one species was isolated per patient, except in two cases where two different species were associated to the same patient. The first patient had a cutaneous NTM infection, and at the end of treatment, another NTM was isolated from a test-of-cure biopsy. This result was deemed a contaminated sample due to the patient's favourable clinical evolution. The second patient had a concomitant disseminated infection with two different NTM species: one isolated from a lymph node and the other from a urine sample. Both were considered pathogens by the medical team based on the patient's severe immunosuppression and compatible clinical presentation. Baseline characteristics and comorbidities of the 41 patients are summarized in Table 1. Of the 35 infected patients, immunosuppression was prevalent in 71% of cases (n=25).

Variables	Total patients, 41	Infected patients, 35
Age in years, mean +/- SD	58 +/- 18	57 +/- 18
Female (%)	15 (40)	15 (43)
Considered immunosuppressed (IS) [a,b] (%)	30 (73)	25 (71)
HIV positive (%)	10 (24)	10 (29)
Median CD4 cell count	41 cells/mm3 (IQR 21-160)	41 cells/mm3 (IQR 21-160)
Underlying transplant (%)	5 (12)	5 (14)
Kidney transplant	3	3
Kidney-pancreas transplant	1	1
Hematopoietic Stem Cell Transplant	1	1
Active malignancy (%)	5 (12)	3 (9)
Active chemotherapy (%)	2 (4)	2 (6)
Autoimmune disease (%)	12 (29)	7 (20)
Rheumatoid arthritis	3	2
Mixed connective tissue disease	6	3
Vasculitis	2	1
Hemolytic anemia	1	1
Immunosuppressants (%)	20 (49)	14 (40)
Corticosteroids [c]	20	14
Calcineurin inhibitors	4	4
Mycophenolate mofetil	7	6
mTOR inhibitors	1	1
Monoclonal antibodies/immunotherapy	5	5
Splenectomy (%)	1 (2)	1 (3)
End-stage renal disease (%)	5 (2)	3 (9)
End-stage liver disease (%)	2 (4)	2 (6)
Diabetes with chronic complications (%)	4 (9)	2 (6)
Pregnancy (%)	1 (2)	1 (3)
External risk factor identified (%)	13 (32)	13 (37)

Categorical Variables are Summarized as the Number (%) of Patients

a IS: immunosuppression

b HIV positive (CD4 <200/mm3, VL detectable (>40cp/mL) or AIDS), solid transplantation, hematopoietic transplantation, active malignancy, radio-chemotherapy, auto-immune disease, immunosuppressive treatment including corticosteroids (>20mg prednisone or equivalent for more than 14 days), pregnancy, complicated diabetes, terminal renal failure, end-stage liver disease, splenectomy.

C More than 20mg prednisone or equivalent for more than 14 days.

Table 1: Number of Extrapulmonary NTM Samples Per Year (Total = 43)

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3.3. Clinical presentation and NTM

Species of the 43 positive samples, 18 distinct NTM species and subspecies were identified with M. chelonae (n=9, 20%), M. avium (n=7, 16%) and M. abscessus (n=4, 9%) being the most common followed by M. marinum (n=3, 7%) and M. xenopi (n=3, 7%) as illustrated in Figure 2. Of the 43 positive samples, 36 were classified as true infections involving 35 infected patients (one patient had a double disseminated NTM infection). Seven samples were deemed contaminants, including six from a urine sample and one from a cutaneous test-of-cure biopsy. Six of the eight urinary-positive samples were contaminants, and two were found in disseminated disease. Among the 35 infected patients, clinical manifestations included 14 cutaneous infections, 13 disseminated infections, five osteoarticular infections, two lymphadenitis cases, and one peritonitis. Table 2 describes NTM species classification and clinical presentation. No central nervous system infections were observed in our cohort. All disseminated infections occurred in immunosuppressed (IS) patients (p-value <0.05). M. marinum infections were exclusively found in non-immunosuppressed patients. Only about one-third of patients presented with fever or fatigue, and no specific biological markers were identified.

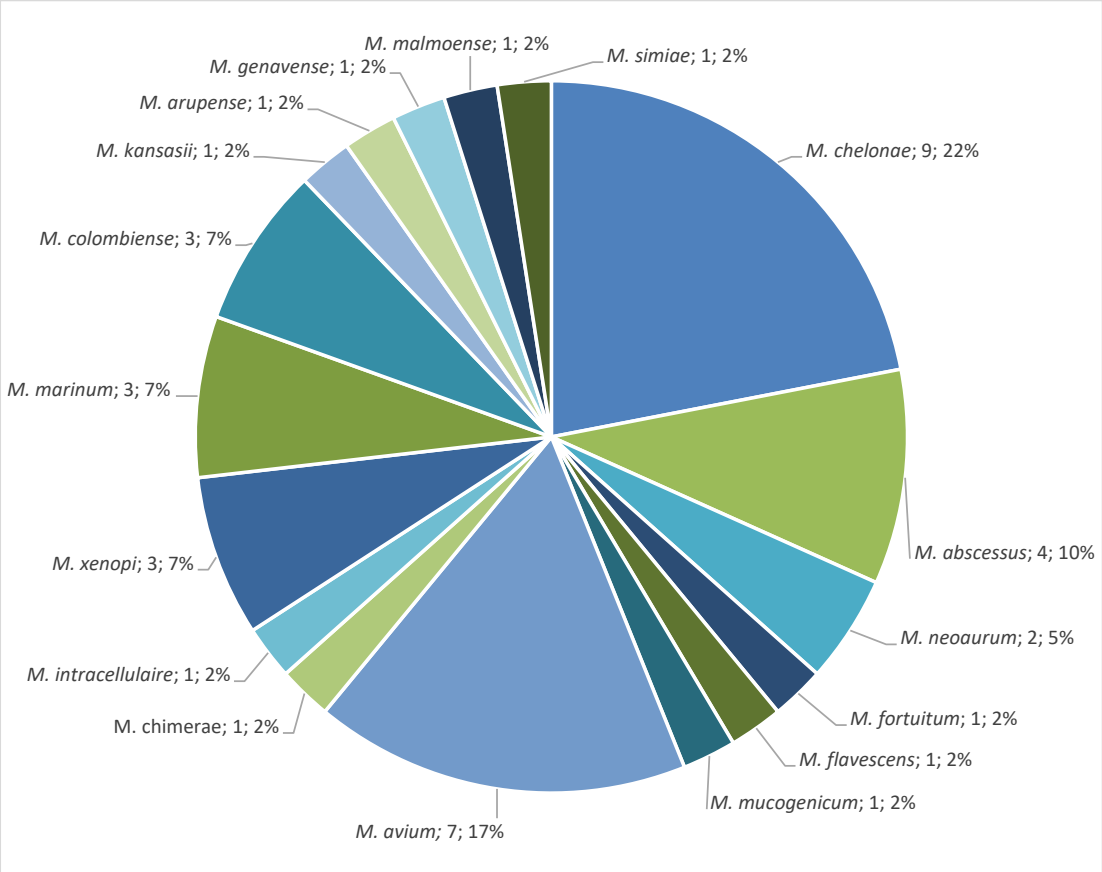

Figure 2: Distribution of the 43 Identified NTM Species

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NTM specie and number of episodes (N)	C[a]	OA[b]	D[c]	L[d]	Other	CONT[f]
M. chelonae (9)	8	-	-	-	1[e]	-
M. abcessus (4)	2	1	1	-	-	-
M. neoaurum (2)	-	-	2	-	-	-
M. fortuitum (1)	-	1	-	-	-	
M. flavescens (1)	-	-	-	-	-	1
M. mucogenicum (1)	-	-	-	-	-	1
M. avium (7)	-	-	4	2	-	1
M. chimerae (1)	-	-	1	-	-	-
M. intracellulaire (1)	-	-	1	-	-	-
M. xenopi (3)	-	-	1	-	-	2
M. marinum (3)	3	-	-	-	-	-
M. colombiense (3)	1	2	-	-	-	-
M. kansasii (1)	-	1	-	-	-	-
M. arupense (1)	1	-	-	-	-	-
M. genavense (1)	-	-	1	-	-	-
M. malmoense (1)	-	-	1	-	-	-
M. simiae (1)	1	-	-	-	-	-

[a] C: cutaneous infection. [b] OA: osteo-arthritis. [c] D: disseminated infection. [d] L: lymphadenitis. [e] Peritonitis (dialysis). [f] CONT: contamination. Rapidly growing mycobacteria (RGM) in blue and slowly growing mycobacteria (SGM) in green.

Table 2: NTM Species Classification and Clinical Presentation

3.4. Treatment and Outcomes

Among the 35 infected patients, 23 received medical treatment, two underwent surgery alone, and eight received a combination of medical and surgical treatment. One patient did not receive treatment, and one was lost to follow-up. Two patients from the group of six initially classified as having contaminants received medical treatment before their samples were reclassified. Of the 33 patients who received medical treatment, 28 (84%) had a combination of antibiotics. Treatment was initiated before susceptibility testing results were available in 27 (77%) patients. The duration of treatment varied widely, with a median of 156 days (IQR 52– 434). The length of treatment was not clearly associated with the NTM species or clinical presentation. Additionally, no correlation was observed between the medical treatment and the in-vitro susceptibility of antibiotics (prescriptions divided evenly among susceptible, resistant, and unknown or untested results). In-vitro susceptibility testing had no significant influence on the initial choice of therapy or subsequent modifications. Because of a lack of data, no analysis could be done concerning outcomes related to the antibiotics used. Of the 33 treated patients, 17 (55%) completed their treatment as planned, while six individuals had their treatment discontinued due to toxicities. Significant toxicities were reported in 15 patients, including diarrhea (n=7), nephrotoxicity (n=5), elevated liver enzymes exceeding five times the upper limit of normal (n=5), thrombopenia (n=3), leucopenia (n=2), anemia (n=1), peripheral neurotoxicity (n=3), and optic neuritis (n=1). Immunosuppression was reduced in 14 patients. Of the 35 infected patients, 23 were considered cured, two experienced relapses, and eight were lost to follow-up. By the end of the data recording (28th January 2021), eight patients had died, with only two deaths directly attributable to NTM infections, both involving disseminated presentations.

4. Discussion

We report 43 cases of EP-NTM-positive samples from 41 patients, with 35 confirmed infections over 10 years in a Belgian tertiary-care hospital. The most frequent clinical presentation was skin and soft tissue infection, followed by disseminated infection, osteoarthritis, and lymphadenitis. The most prevalent species identified were M. chelonae, M. avium complex, M. abscessus, M. marinum, and M. xenopi. Most patients were immunosuppressed, confirming the usual opportunistic character of NTM species [1,10]. HIV-positive patients who often had low CD4 counts were associated with disseminated infections, as frequently reported in the literature (22,23). Conversely, M. marinum infections were observed exclusively in non-immunosuppressed patients,

consistent with its clinical spectrum being dependent on the route of exposure (e.g., aquatic environments) [24]. Interestingly, no M. chimerae cardiovascular infections were detected in our cohort, as described by Soetaert et al. in 2016 [25,26].

Although we cannot provide an exact incidence rate or a statical trend, we observed a tendency toward increasing cases over the past decade, consistent with global reports [10-15]. This may reflect a growing immunocompromised population and the development of molecular methods that have improved NTM diagnosis and identification. It is still unclear whether the increase in NTM disease is in part due to a change in pathogen virulence over time and/or due to the participation of climatic changes [15, 27]. The ubiquitous nature of NTM, the challenging laboratory identification methods, the variety of pathogenicity combined with the absence of mandatory reporting complicates efforts to determine the accurate prevalence and incidence of NTM infections, which is likely underestimated. Additionally, positive cultures do not always indicate disease, underscoring the need for careful clinical and microbiological correlation. There is a pressing need for systematic surveillance and global studies concerning NTM to better understand the burden of these infections. Clinical awareness is crucial as identifying NTM infections in laboratory is fastidious and requires specialized techniques. Moreover, accurate species identification is essential for guiding treatment and advancing our understanding of NTM-associated pathologies. Furthermore, molecular sequencing techniques continue to change the landscape of mycobacterial taxonomy. In this way, continued collaboration between clinicians and microbiologists plays a crucial role in improving outcomes for these challenging infections. Another important challenge to highlight is translating susceptibility data into clinical decision-making for NTM infections.

Our study has several limitations. First, the small, monocentric cohort and the retrospective design limited the scope and comprehensiveness of data collection and analysis. Furthermore, we assume that some patients received follow-up care at other hospitals, potentially resulting in incomplete data. Additionally, the exclusion of pulmonary samples is associated with a notable statistical bias in the selection of specimens. Nonetheless, this study shows real-life situations concerning EP-NTM infections, adding considerable clinical and microbiological diversity that participates valuably into the epidemiology and management of EP-NTM infections, contributing to the growing body of knowledge on this complex and emerging clinical challenge.

References

1. Tortoli, E. (2009). Clinical manifestations of nontuberculous mycobacteria infections. *Clinical Microbiology and Infection, 15*(10), 906-910.
2. Pavlik, I., Ulmann, V., Hubelova, D., & Weston, R. T. (2022). Nontuberculous mycobacteria as sapronoses: a review. *Microorganisms, 10*(7), 1345.
3. Parte, A. C. (2014). LPSN—list of prokaryotic names with standing in nomenclature. *Nucleic acids research, 42*(D1), D613-D616.
4. Armstrong, D. T., Eisemann, E., & Parrish, N. (2023). A brief update on mycobacterial taxonomy, 2020 to 2022. *Journal of clinical microbiology, 61*(4), e00331-22.
5. Falkinham III, J. O. (2015). Environmental Sources of Nontuberculous. *Nontuberculous Mycobacteria, An Issue of Clinics in Chest Medicine, 36*(1), 35-41.
6. Baldwin, S. L., Larsen, S. E., Ordway, D., Cassell, G., & Coler, R. N. (2019). The complexities and challenges of preventing and treating nontuberculous mycobacterial diseases. *PLoS neglected tropical diseases, 13*(2), e0007083.
7. Griffith, D. E., Aksamit, T., Brown-Elliott, B. A., Catanzaro, A., Daley, C., Gordin, F., ... & Winthrop, K. (2007). An official ATS/IDSA statement: diagnosis, treatment, and prevention of nontuberculous mycobacterial diseases. *American journal of respiratory and critical care medicine, 175*(4), 367-416.
8. Cassidy, P. M., Hedberg, K., Saulson, A., McNelly, E., & Winthrop, K. L. (2009). Nontuberculous mycobacterial disease prevalence and risk factors: a changing epidemiology. *Clinical Infectious Diseases, 49*(12), e124-e129.
9. Brown-Elliott, B. A., & Woods, G. L. (2019). Antimycobacterial susceptibility testing of nontuberculous mycobacteria. *Journal of clinical microbiology, 57*(10), 10-1128.
10. Dahl, V. N., Mølhave, M., Fløe, A., van Ingen, J., Schön, T., Lillebaek, T., ... & Wejse, C. (2022). Global trends of pulmonary infections with nontuberculous mycobacteria: a systematic review. *International Journal of Infectious Diseases, 125*, 120-131.
11. Tortoli, E. (2014). Microbiological features and clinical relevance of new species of the genus Mycobacterium. *Clinical microbiology reviews, 27*(4), 727-752.
12. Ratnatunga, C. N., Lutzky, V. P., Kupz, A., Doolan, D. L., Reid, D. W., Field, M., ... & Miles, J. J. (2020). The rise of non-tuberculosis mycobacterial lung disease. *Frontiers in immunology, 11,* 303.
13. Pedersen, A. A., Løkke, A., Fløe, A., Ibsen, R., Johansen, I. S., & Hilberg, O. (2024). Nationwide increasing incidence of nontuberculous mycobacterial diseases among adults in Denmark: eighteen years of follow-up. *Chest, 166*(2), 271-280.
14. Soetaert, K., Subissi, L., Ceyssens, P. J., Vanfleteren, B., Chantrenne, M., Asikainen, T., ... & Mathys, V. (2019). Strong increase of true and false positive mycobacterial cultures sent to the National Reference Centre in Belgium, 2007 to 2016. *Eurosurveillance, 24*(11), 1800205.
15. Bhanushali, J., Jadhav, U., Ghewade, B., Wagh, P., & JADHAV, U. (2023). Unveiling the clinical diversity in nontuberculous mycobacteria (NTM) infections: a comprehensive review. *Cureus, 15*(11).
16. Rath, S., Firdaus, S., Nayak, G., Mohanty, M., & Nayak Jr, G. (2025). Extrapulmonary Nontuberculous Mycobacteria Infection: The New-Age Neglected Infectious Disease. *Cureus, 17*(3).
17. Martin, A., Colmant, A., Verroken, A., & Rodriguez-Villalobos, H. (2019). Laboratory diagnosis of nontuberculous mycobacteria in a Belgium Hospital. *The*

International Journal of Mycobacteriology, 8(2), 157-161.
18. Conyers, L. E., & Saunders, B. M. (2024). Treatment for non-tuberculous mycobacteria: challenges and prospects. *Frontiers in Microbiology, 15*, 1394220.
19. Daley, C. L., Iaccarino, J. M., Lange, C., Cambau, E., Wallace Jr, R. J., Andrejak, C., ... & Winthrop, K. L. (2020). Treatment of nontuberculous mycobacterial pulmonary disease: an official ATS/ERS/ESCMID/IDSA clinical practice guideline. *Clinical Infectious Diseases, 71*(4), e1-e36.
20. Haworth, C. S., Banks, J., Capstick, T., Fisher, A. J., Gorsuch, T., Laurenson, I. F., ... & Floto, R. A. (2017). British Thoracic Society guidelines for the management of non-tuberculous mycobacterial pulmonary disease (NTM-PD). *Thorax, 72*(Suppl 2), ii1-ii64.
21. M62: Mycobacteria Susceptibility Testing Standards. Clinical & Laboratory Standards Institute.
22. Telles, J. P. M., Muniz Jr, R., Sztajnbok, J., & Cosme-de Oliveira, A. (2020). Disseminated Mycobacterium avium on HIV/AIDS: historical and current literature review. *Aids Rev, 22*(1), 1-7.
23. von Reyn, C. F., Arbeit, R. D., Tosteson, A. N., Ristola, M. A., Barber, T. W., Waddell, R., ... & International MAC Study Group. (1996). The international epidemiology of disseminated Mycobacterium avium complex infection in AIDS. *Aids, 10*(9), 1025-1032.
24. Castillo Almeida, N. E., Gurram, P., & Abu Saleh, O. (2019, October). 1384. Mycobacterium marinum infection: 21 years of experience at a tertiary-care hospital. In *Open Forum Infectious Diseases* (Vol. 6, No. Supplement_2, pp. S502-S503). US: Oxford University Press.
25. by Mycobacterium, E. I. C. I. (2015). Chimaera Potentially Associated with Heater-Cooler Units Used during Cardiac Surgery. *Rapid Risk Assessment. Available online: https://www. ecdc. europa. eu/sites/default/files/media/en/publications/Publications/mycobacterium-chimaera-infection-associated-with-heater-cooler-units-rapid-risk-assessment-30-April-2015. pdf (accessed on 30 April 2015).*
26. Soetaert, K., Vluggen, C., André, E., Vanhoof, R., Vanfleteren, B., & Mathys, V. (2016). Frequency of Mycobacterium chimaera among Belgian patients, 2015. *Journal of Medical Microbiology, 65*(11), 1307-1310.
27. Thomson, R. M., Furuya-Kanamori, L., Coffey, C., Bell, S. C., Knibbs, L. D., & Lau, C. L. (2020). Influence of climate variables on the rising incidence of nontuberculous mycobacterial (NTM) infections in Queensland, Australia 2001–2016. *Science of the Total Environment, 740*, 139796.