

January 2, 2001

Participant

Centers for Disease Control and Prevention (CDC)

Susceptibility Testing of *Mycobacterium tuberculosis* and Nontuberculous Mycobacteria
Performance Evaluation Program

Subject: Analyses of Participant Laboratory Results for the June 2000 Shipment

Dear Participant:

Enclosed are analyses of laboratory test results reported to the Centers for Disease Control and Prevention (CDC) by participant laboratories for the strains of *Mycobacterium tuberculosis*-complex, *M. malmoense* and *M. abscessus* shipped in June 2000. Participant laboratories received either three *M. tuberculosis* complex strains or all five *M. tuberculosis* and nontuberculous mycobacteria (NTM) strains. Testing results were received and analyzed from 148 of 155 (95%) of laboratories participating in this shipment. Eighteen participating laboratories are located in countries other than the United States.

The enclosed aggregate report is prepared in a format that will allow laboratories to compare their results with results obtained by other participants for the same strain using the same method, drug, and concentration. The first three pages contain descriptive information about the participant laboratories. We encourage you to circulate this report to personnel who are involved with drug susceptibility testing, reporting, or interpretation for *M. tuberculosis* and NTM.

The addition of NTM strains to this performance evaluation is intended to provide an assessment of the various methods, drugs, and interpretations that are reported by laboratories that perform drug susceptibility testing for these different strains. The test results for NTM strains also provide information on interlaboratory agreement with different test methods and will assist with efforts to develop standard methods for NTM drug susceptibility testing. By reporting these practices and test results CDC is neither recommending nor endorsing these testing practices. Some of the test results reported by participants, may in fact, provide inappropriate or misleading information to the clinician. A consensus report by the American Thoracic Society and the new National Committee for Clinical Laboratory Standards (NCCLS) tentative standard are referenced to provide participants with recommendations for NTM test methods and drugs that have clinical relevance.

Page 2 - Participants, TB/NTM Program

If you have any comments or suggestions on the results in this report or have questions regarding the changes in this program, you may call us (770) 488-8133.

Sincerely yours,

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Enclosures

Analyses of the June 2000 Performance Evaluation Results for *M. tuberculosis* complex and Nontuberculous Mycobacteria Drug Susceptibility Testing Reported to the Centers for Disease Control and Prevention by Participating Laboratories

This report is an analysis of laboratory test results reported to the Centers for Disease Control and Prevention (CDC) by participant laboratories for the three *Mycobacterium tuberculosis* complex and one strain of *M. abscessus* and *M. malmoense* shipped in June 2000. Participant laboratories either received three *M. tuberculosis* or all five *M. tuberculosis* and NTM strains. Testing results were received and analyzed from 148 of 155 (95%) laboratories participating in this shipment.

Descriptive Information on Participant laboratories

Figure 1 shows the laboratory classification reported by 148 of the participants. Participants consisted of 78 health departments, 53 hospitals, 12 independents, and 5 “other” type of laboratories.

Figure 2 provides the distribution of the annual volume of *M. tuberculosis* isolates tested for drug susceptibilities by participating laboratories in calendar year 1999.

Figure 3 lists the biosafety levels reported by participant laboratories for *M. tuberculosis*. All laboratories are strongly encouraged to consult the CDC/NIH manual, Biosafety in Microbiological and Biomedical Laboratories (4th edition) for recommendations and to determine their correct biosafety level.

Figure 4 provides a breakdown of the test procedures used by the participating laboratories for *M. tuberculosis* drug susceptibility testing. Participants were asked to check all of the test methods used. Some methods, such as the proportion method with Lowenstein-Jensen (L-J) media, may reflect procedures used by international participants. The three other methods listed were the E-test, micro dilution MIC, and L-J resistance ratio methods. Figure 5 provides a breakdown of the test procedures used by the participating laboratories for *M. malmoense*. Figure 6 provides a breakdown of the test procedures used by the participating laboratories for *M. abscessus*.

M. tuberculosis test results:

The aggregate test results are provided in separate tables, representing cultures F, G, H, I, and J to facilitate comparison among laboratories. Table 1 for the *M. tuberculosis* complex cultures F, G and H is constructed to include the results for the radiometric (BACTEC), agar proportion, Lowenstein Jensen (L-J) proportion, and other methods at each concentration of drug. The results for 3 “other” methods are grouped together and include the E-test, L-J resistance ratio, and micro dilution MIC. The test results are listed in the appropriate (susceptible or resistant) columns with a corresponding total number of tests (Sum) column provided as a denominator for determining the level of consensus. This report contains all results reported by participating laboratories, including many drug concentrations with only one result.

In Table 1 the concentrations recommended by CDC and the NCCLS for the primary (isoniazid, rifampin, pyrazinamide, ethambutol, and streptomycin) and secondary (ethionamide, kanamycin, capreomycin, cycloserine, p-amino-salicylic acid) antituberculosis drugs are highlighted for the conventional and radiometric method. Participants should note that the new NCCLS tentative standard (Susceptibility Testing of Mycobacteria, Nocardia, and Other Aerobic Actinomycetes; Tentative Standard-second Edition, NCCLS document M24-T2 [ISBN 1-56238-423-6] NCCLS, 940 West Valley Road, Suite 1400, Wayne Pennsylvania 19087-1898, USA, 2000) recommends testing streptomycin as a secondary drug and also adds ofloxacin and rifabutin to the list of recommended secondary drugs. Participants should note that these recommended combinations reflect the critical concentrations of antituberculosis drugs in 7H10 agar and those concentrations for the BACTEC method that directly correlate with the critical concentrations in the conventional method (1-5). When two concentrations are highlighted, such as for isoniazid, ethambutol and streptomycin, the lower concentration is the critical concentration that should always be included to determine whether the *M. tuberculosis* isolate is resistant.

Strain F was resistant to isoniazid and ethambutol, strain G was fully susceptible to the antituberculosis drugs. Strain H was a culture of *M. bovis-BCG*. For strain H, 97.5% (78/80) of participants detected pyrazinamide resistance with the BACTEC method. For strain H, 8.7% (9/104) of participants also detected isoniazid resistance at the critical concentration (0.1 µg/ml) in the BACTEC method. Overall there was good agreement in detecting resistance among laboratories and methods for both *M. tuberculosis* strains and *M. bovis-BCG*.

Our providing test results for all drugs that are reported to CDC should not be construed as a recommendation or endorsement for testing particular drugs or concentrations with patient isolates of *M. tuberculosis*-complex. It is assumed that some of the drugs are being tested for research purposes or potential use in the few referral institutions that may treat patients with *M. tuberculosis* isolates resistant to almost all standard drugs. Laboratories should not add drugs to their testing regimen without the consultation of physicians having expertise in treating multi-drug resistant tuberculosis. Laboratories may contact their local TB control program for referrals of physicians with experience and expertise in treating multi-drug resistant tuberculosis.

Nontuberculous Mycobacteria test results:

The aggregate test results are provided in Tables 2 and 4 for culture I, *M. malmoense* and Tables 3 and 5 for culture J, *M. abscessus* to facilitate comparison among laboratories. Tables 2 and 3, for *M. malmoense* and *M. abscessus*, respectively, represent either single or multiple drug concentrations with “breakpoint” susceptibility test results. In Tables 3 and 4, the participant laboratories reported an interpretation of either susceptibility or resistance for each drug concentration that was reported. The results varied among laboratories on the drugs tested. Tables 4 and 5 represent all minimum inhibitory concentrations (MICs) susceptibility test results, for *M. malmoense* and *M. abscessus*, respectively, reported by participant laboratories. Tables 4 and 5 include all the quantitative MIC test results, regardless of whether the laboratory provided a test interpretation of resistant or susceptible for the reported MIC.

Table 6 is a breakdown of NTM and drug susceptibility test methods that participants reported

are performed in-house. There were 68/138 (49.3%) participants that indicated they perform some in-house drug susceptibility testing of NTM.

A total of 36 participants provided test results on culture I, *M. malmoense*; 28 participants reported breakpoint test results and 8 participants reported MIC test results. Table 2, representing all of the breakpoint susceptibility test results for *M. malmoense*, includes results reported for the agar proportion, BACTEC, disk elution, microtiter, L-J proportion, and other test methods. The species *M. malmoense* has been increasingly recognized in Northern Europe, Scotland, Wales, Sweden, and France (10) although it remains rare in the United States. The new NCCLS tentative standard recommends testing drugs and concentrations suggested for *M. kansasii* which includes clarithromycin, ethambutol and rifampin among others. The commercial radiometric system (BACTEC), the modified proportion method in 7H10 agar, and broth micro dilution have all been used for testing with the primary treatment drugs. Resistance to rifampin was reported by 3/14 (21%) of participants testing 1.0 µg/ml in agar proportion and 2/7 (28.6%) testing 2.0 µg/ml of rifampin in BACTEC.

A total of 31 participants reported testing results for culture J, *M. abscessus*: 18 participants reported breakpoint test results and 15 participants reported MIC test results. Table 3, representing all of the breakpoint susceptibility test results for *M. abscessus*, includes results reported for the agar proportion, BACTEC, microtiter, L-J proportion and other methods. The NCCLS tentative standard (7) recommendations for the rapid growers include testing amikacin, cefoxitin, ciprofloxacin, clarithromycin, doxycycline and sulfamethoxazole. A broth micro dilution method is recommended for rapid growers (7,8). The standard antituberculosis drugs (streptomycin, isoniazid, rifampin ethambutol and pyrazinamide) should not be tested. The test isolate (culture J) of *M. abscessus* was susceptible to amikacin, clarithromycin, doxycycline, and intermediate to cefoxitin using the recommended NCCLS guidelines. Using a variety of methods with MIC results (Table 5), 3/16 (19%) of laboratories found culture J to be clarithromycin resistant, 3/14 (21%) found it to be amikacin resistant, and 1/11(9%) found it to be doxycycline resistant. *Mycobacterium abscessus* (formerly *M. chelonae subspecies abscessus*) is a non-pigmented, rapidly growing mycobacterium that is most closely related to *M. chelonae*. This species is responsible for most cases of chronic lung disease due to rapidly growing mycobacteria species (11).

Many laboratories perform drug susceptibility testing for NTM in the absence of clinical studies demonstrating the efficacy of particular drugs and/or drug concentrations and methods (6). The addition of NTM strains to this performance evaluation program should not be interpreted as recommendations for laboratories to adopt NTM drug susceptibility testing, especially if the laboratory has limited experience with these tests and methods. We encourage laboratories that perform NTM drug susceptibility testing to consult recommendations, references, and physicians with expertise in infectious diseases when selecting test methods, drugs, and test interpretations.

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REFERENCES

1. **Inderlied, C. B. and M. Salfinger.** 1995. "Antimicrobial Agents and Susceptibility Tests: Mycobacteria", p. 1385-1404. In Murray, Patrick R., Baron, Ellen Jo, Pfaller, Michael A., Tenover, Fred C., Tenover, Robert C. (ed.) Manual of Clinical Microbiology, 6th ed. American Society for Microbiology, Washington, D.C.
2. **David, H. L.** 1971. Fundamentals of Drug Susceptibility Testing in Tuberculosis. DHEW Publication No. (CDC) 712165. Center for Disease Control, Atlanta.
3. **Kent, P.T and G.P. Kubica.** 1985. Public Health Mycobacteriology: A Guide for the Level III Laboratory. Centers for Disease Control, Atlanta.
4. **Siddiqi, S.H., J.E. Hawkins, and A. Laszlo.** 1985. Interlaboratory drug susceptibility testing of *Mycobacterium tuberculosis* by a radiometric procedure and two conventional methods. J. Clin. Microbiol. 22:919-923.
5. **Hawkins, Jean E., Wallace, Richard J. Jr., Brown, Barbara A.** 1991. Antibacterial Susceptibility Tests: Mycobacteria, p. 1138-1152. In Balows, Albert, Hausler, William J. Jr., Herrmann, Kenneth L., Isenberg, Henry D., Tenover, Fred C. (ed.) Manual of Clinical Microbiology, 4th ed. American Society for Microbiology, Washington, D.C.
6. **American Thoracic Society.** 1997. Diagnosis and treatment of disease caused by nontuberculous mycobacteria. Am.J.Respir.Crit.Care Med. 156:S1-S25.
7. **National Committee for Clinical Laboratory Standards Committee on Antimycobacterial Susceptibility Testing.** 2000. Susceptibility Testing of Mycobacteria, Nocardia, and Other Aerobic Actinomycetes; Tentative Standard-Second Edition. NCCLS. Wayne, PA.
8. **Brown, B.A., J.M. Swenson, and R.J. Wallace Jr.** 1994. Broth Micro dilution MIC Test for Rapidly Growing Mycobacteria. P.5.11.1. In H.D. Isenberg (ed.) Clinical Microbiology Procedures Handbook. American Society for Microbiology Washington D.C.
9. **Wallace, R.J., V.A. Silcox, M. Tsukamura, B.A. Brown, J.O. Kilburn, W.R. Butler and G. Onyi.** 1993. Clinical significance, biochemical features, and susceptibility patterns of sporadic isolates of the *Mycobacterium chelonae-like* organism. J. Clin. Microbiol 31:3231-3239.
10. **Yates, M.D., A. Pozniak, A.H. C. Uttley, R. Clarke, and J. M. Grange.** 1997. Isolation of environmental mycobacteria from clinical specimens in south-east England:1973-1993. Int. J. Tuberc. Lung Dis.1:75-80.
11. **Metchock, B.G., F.S. Nolte and R.J. Wallace, Jr.** 1999 Mycobacterium, page 399-437. In P.R. Murray, E.J. Barron, M.A. Pfaller, F.C. Tenover, R. H. Tenover, R. H. Yolken(ed) Manual of Clinical Microbiology, 7th ed. American Society for Microbiology, Washington, D.C.

Figure 1. Primary Classification of Participating Laboratories

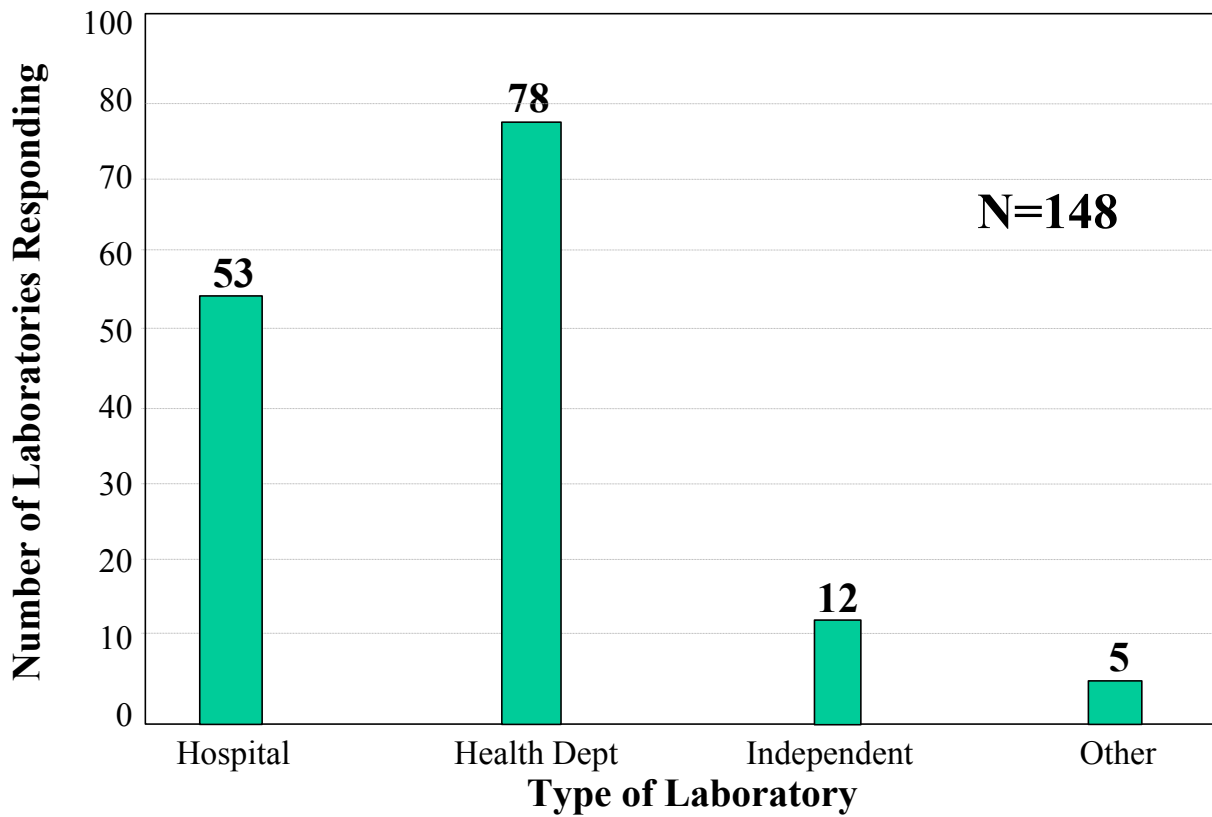
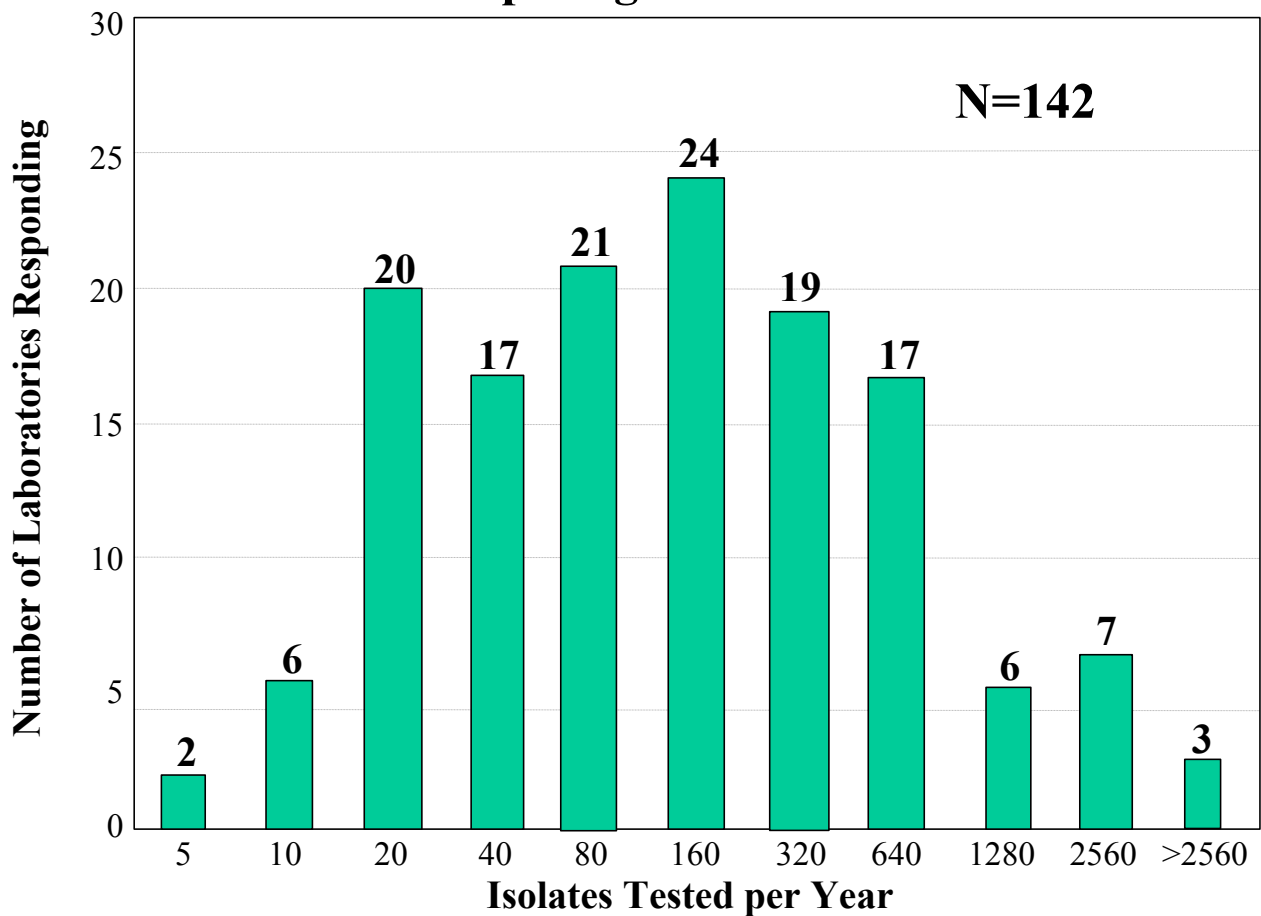
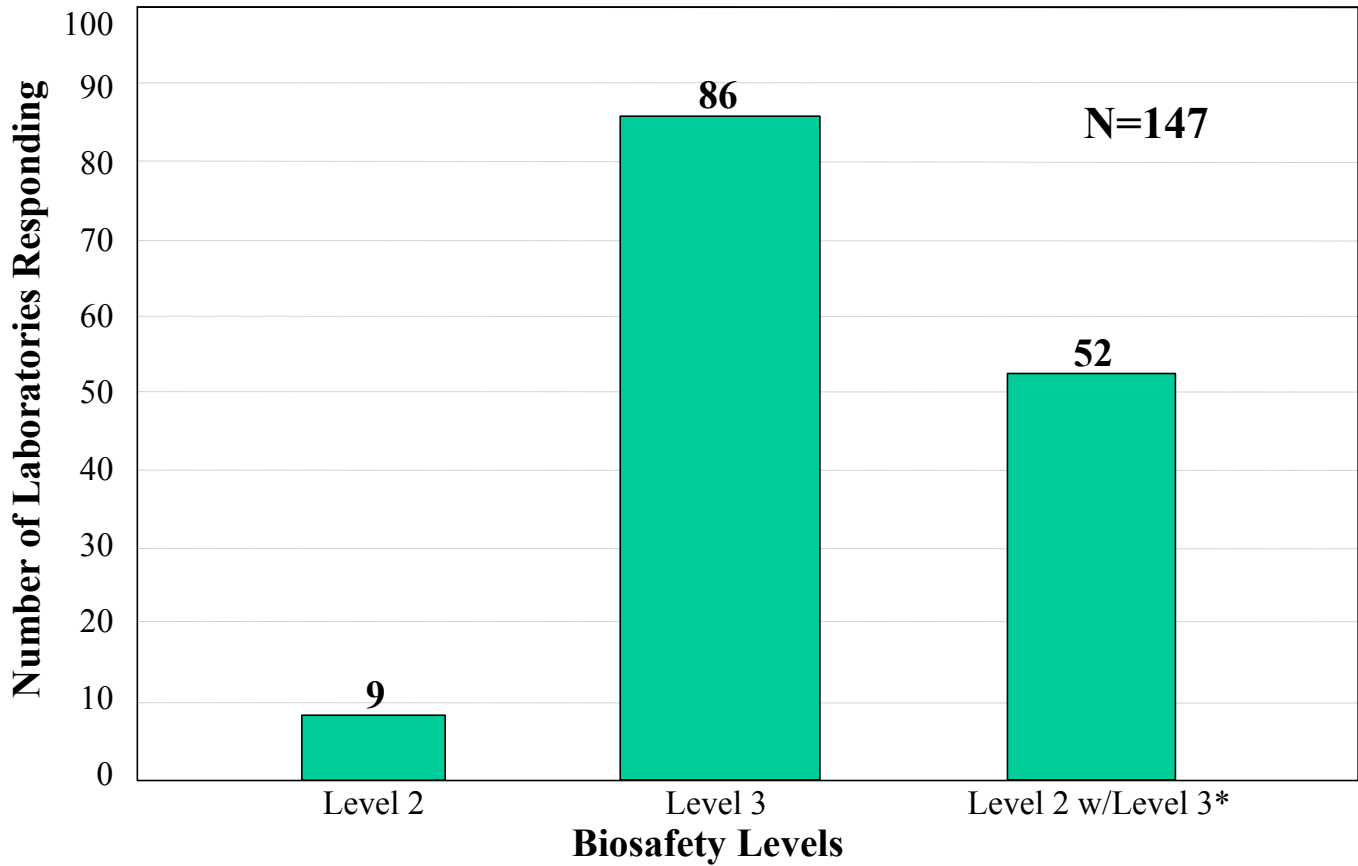


Figure 2. 1999 Annual Volume of *M. tuberculosis* Isolates for Participating Laboratories



Group labels indicate upper limit of the group.

Figure 3. Biosafety Levels of Participating Laboratories for *M. tuberculosis*



* Biosafety level 2 for facilities with level 3 containment equipment

Figure 4. Test Procedures used by Laboratories for *M. tuberculosis*

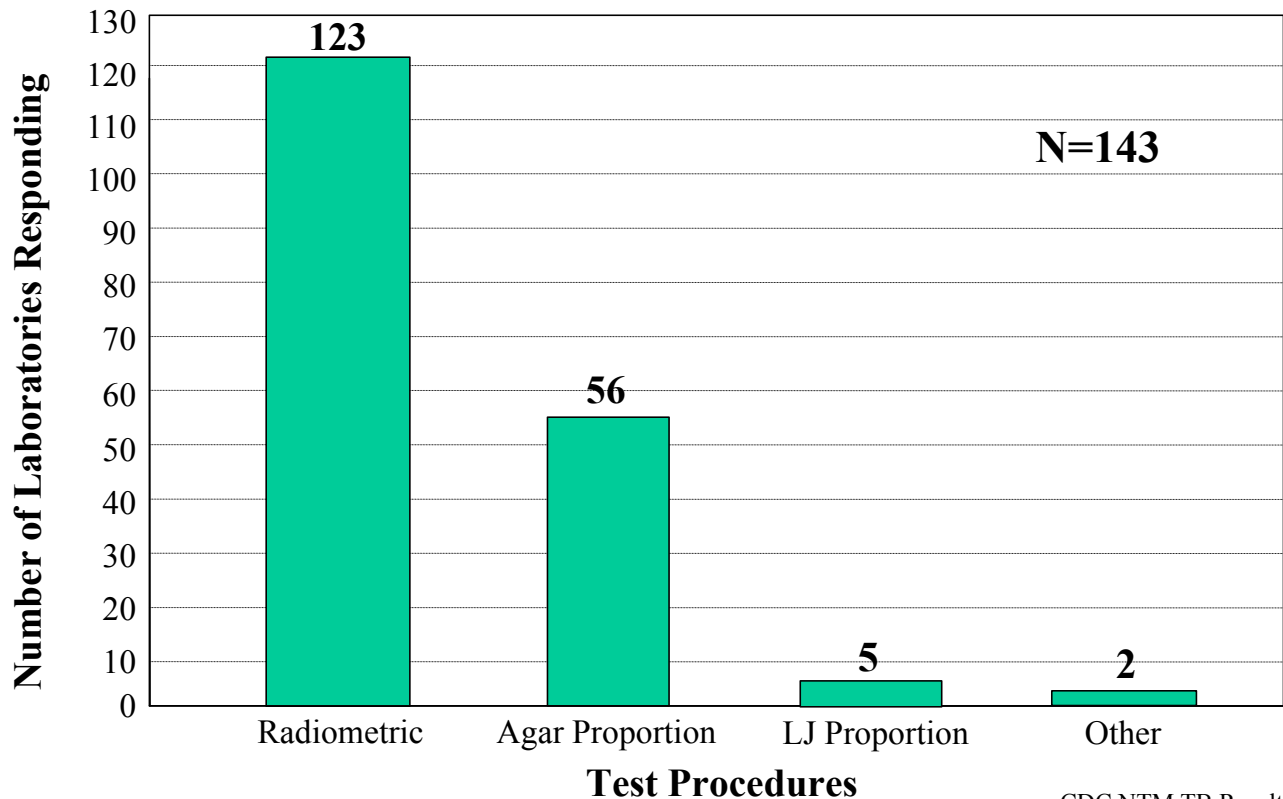
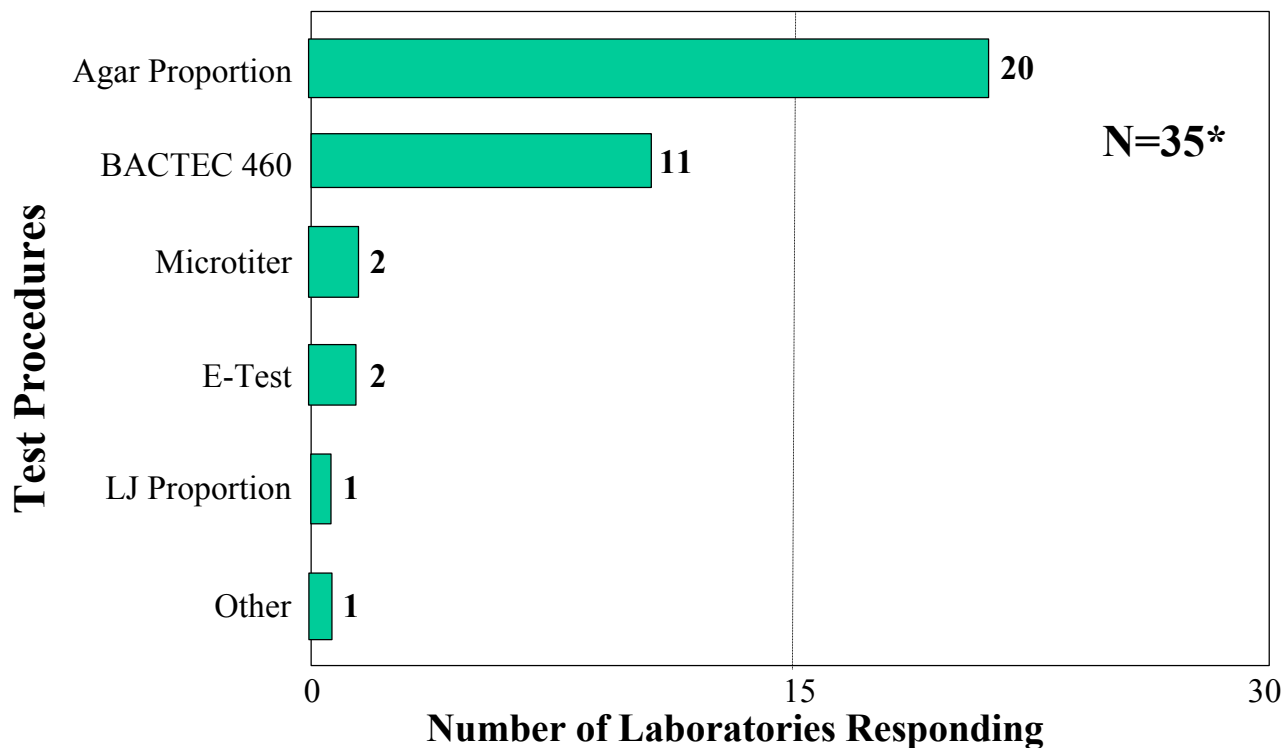
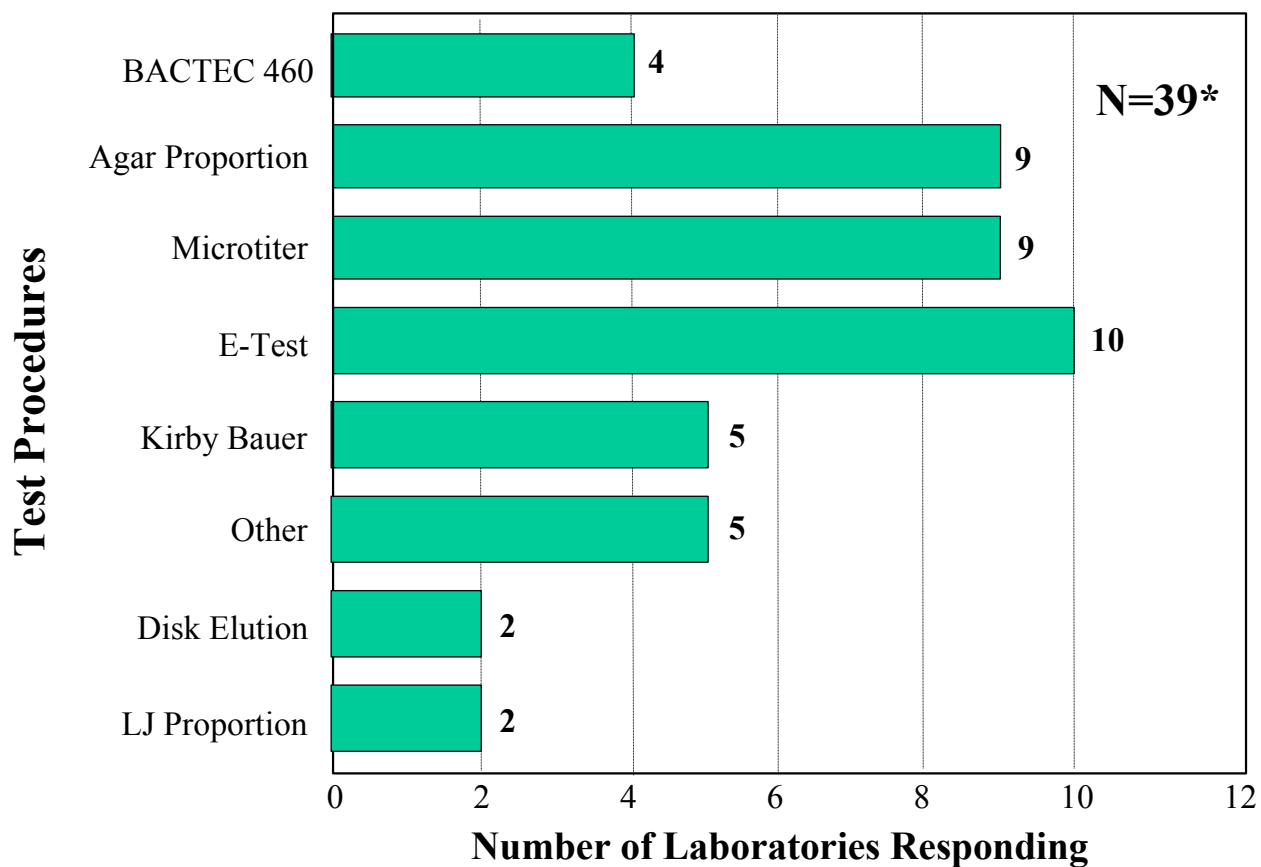


Figure 5. Test Procedures used by Laboratories for Strain I - *M. malmoense*



* Some participants reported more than one test method

Figure 6. Test Procedures used by Laboratories for Strain J - *M. abscessus*



* Some participants reported more than one test method

Table 1. Participant Results for Culture F, *M. tuberculosis*

DRUG	Conc.	Test Method												
		Agar Prop. Results			BACTEC Results			LJ Prop. Results			Other Tests Results			
		S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum	
Isoniazid	0.01				1	1								
Isoniazid	0.02		1	1										
Isoniazid	0.05											1	1	
Isoniazid	0.10				1	107	108					1	1	
Isoniazid	0.12					1	1							
Isoniazid	0.20		44	44		5	5		4	4		1	1	
Isoniazid	0.25								1	1				
Isoniazid	0.40				1	26	27							
Isoniazid	0.50								1	1				
Isoniazid	1.00		45	45		6	6		2	2				
Isoniazid	2.00					2	2							
Isoniazid	5.00		6	6		2	2							
Isoniazid	10.00									2	2			
Isoniazid	100.00							1			1			
Rifampin	0.50				1	1								
Rifampin	1.00	44		44	8	8			1	1				
Rifampin	2.00	2		2	111	111								
Rifampin	5.00	6		6	1	1		1		1				
Rifampin	14.00											1		1
Rifampin	28.00											1		1
Rifampin	40.00							4		4				
Rifampin	50.00							1		1				
Rifampin	56.00											1		1
Pyrazinamide	25.00	1		1										
Pyrazinamide	50.00				1	1								
Pyrazinamide	64.00											1		1
Pyrazinamide	100.00				83	83		1		1				
Pyrazinamide	300.00				2	2								
Ethambutol	1.00								1	1				
Ethambutol	1.50					1	1							
Ethambutol	1.60											1		1
Ethambutol	2.00								5	5				
Ethambutol	2.50				2	102	104							
Ethambutol	3.20											1		1
Ethambutol	3.75					3	3							
Ethambutol	4.00					1	1							
Ethambutol	5.00	2	39	41	1	8	9	1		1				
Ethambutol	6.00		1	1										
Ethambutol	6.40											1		1
Ethambutol	7.50	1	6	7		17	17							
Ethambutol	9.50					1	1							
Ethambutol	10.00	1	13	14		1	1							

Table 1. Participant Results for Culture F, *M. tuberculosis*

DRUG	Conc.	Test Method														
		Agar Prop. Results			BACTEC Results			LJ Prop. Results			Other Tests Results					
		S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum			
Streptomycin	1.00				1		1	1			1					
Streptomycin	2.00	40	4	44	103	1	104									
Streptomycin	4.00				1		1	4			4					
Streptomycin	5.00							1			1					
Streptomycin	6.00				19		19									
Streptomycin	10.00	32		32				1			1					
Streptomycin	15.00											1				1
Streptomycin	30.00											1				1
Ethionamide	1.25				3	1	4									
Ethionamide	2.50				2		2									
Ethionamide	5.00	33		33	5		5									
Ethionamide	8.00												1			1
Ethionamide	10.00	4		4										1		1
Ethionamide	16.00															
Ethionamide	20.00							1			1					
Ethionamide	30.00							1			1					
Ethionamide	40.00							1			1					
Kanamycin	2.50				1		1									
Kanamycin	5.00	14		14	5		5									
Kanamycin	6.00	22		22												
Kanamycin	10.00							1			1					
Kanamycin	20.00							1			1					
Kanamycin	40.00							1			1					
Capreomycin	0.50											1				1
Capreomycin	1.00											1				1
Capreomycin	1.25				2		2									
Capreomycin	2.50				2		2									
Capreomycin	5.00				6		6									
Capreomycin	10.00	22		22												
Capreomycin	16.00							1			1					
Capreomycin	25.00											1				1
Capreomycin	50.00											1				1
Cycloserine	12.00											1				1
Cycloserine	16.00							1			1					
Cycloserine	20.00							1			1					
Cycloserine	24.00											1				1
Cycloserine	25.00	1		1												
Cycloserine	30.00	15		15				2			2					
Cycloserine	40.00							1			1					
Cycloserine	48.00											1				1
Cycloserine	50.00	1		1												
Cycloserine	60.00	2		2												

Table 1. Participant Results for Culture F, *M. tuberculosis*

DRUG	Conc.	Test Method												
		Agar Prop. Results			BACTEC Results			LJ Prop. Results			Other Tests Results			
		S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum	
p-Aminosalicylic	0.50								1		1			
p-Aminosalicylic	1.00								1		1			
p-Aminosalicylic	2.00	16		16										
p-Aminosalicylic	4.00				1		1							
p-Aminosalicylic	5.00	1		1										
p-Aminosalicylic	8.00	3		3										
p-Aminosalicylic	10.00	4		4										
Amikacin	0.50											1		1
Amikacin	1.00				1		1					1		1
Amikacin	2.00	1		1	1		1							
Amikacin	2.50				1		1							
Amikacin	4.00	4		4	1		1							
Amikacin	5.00	1		1										
Amikacin	6.00	5		5										
Amikacin	8.00	1		1										
Amikacin	12.00	2		2										
Ofloxacin	0.50												1	1
Ofloxacin	1.00	3	1	4		1	1					1		1
Ofloxacin	1.25					1	1							
Ofloxacin	2.00	4		4	7	2	9							
Ofloxacin	2.50											1		1
Ofloxacin	4.00	2		2	1		1					1		1
Ofloxacin	5.00											1		1
Ofloxacin	8.00					1	1							
Ciprofloxacin	0.50												1	1
Ciprofloxacin	1.00	2		2	2	1	3					1		1
Ciprofloxacin	2.00	12		12	2		2							
Ciprofloxacin	2.50				1		1							
Ciprofloxacin	3.20											1		1
Ciprofloxacin	6.40											1		1
Levofloxacin	2.00				1		1							
Rifabutin	0.50	1		1	2		2					1		1
Rifabutin	1.00	4		4	1		1					1		1
Rifabutin	2.00	7		7										
Clofazimine	0.12				1		1							
Clofazimine	0.50				2		2					1		1
Clofazimine	1.00	1		1								1		1

Table 1. Participant Results for Culture G, *M. tuberculosis*

DRUG	Conc.	Test Method											
		Agar Prop. Results			BACTEC Results			LJ Prop. Results			Other Tests Results		
		S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum
Isoniazid	0.01				1		1						
Isoniazid	0.02	1		1									
Isoniazid	0.05											1	1
Isoniazid	0.10				108		108					1	1
Isoniazid	0.12				1		1						
Isoniazid	0.20	39		39	4		4	4		4		1	1
Isoniazid	0.25							1		1			
Isoniazid	0.40				26		26						
Isoniazid	0.50							1		1			
Isoniazid	1.00	40		40	5		5	2		2			
Isoniazid	5.00	5		5									
Isoniazid	10.00							2		2			
Isoniazid	100.00							1		1			
Rifampin	0.50				1		1						
Rifampin	1.00	41	1	42	8		8		1	1			
Rifampin	2.00	2		2	112		112						
Rifampin	5.00	5		5				1		1			
Rifampin	14.00										1		1
Rifampin	28.00										1		1
Rifampin	40.00							4		4			
Rifampin	50.00							1		1			
Rifampin	56.00										1		1
Pyrazinamide	25.00	1		1									
Pyrazinamide	50.00				1		1						
Pyrazinamide	64.00										1		1
Pyrazinamide	100.00				77	4	81	2		2			
Pyrazinamide	300.00				2		2						
Pyrazinamide	400.00							1		1			
Ethambutol	1.00							1		1			
Ethambutol	1.50				1		1						
Ethambutol	1.60										1		1
Ethambutol	2.00							5		5			
Ethambutol	2.50				100	2	102						
Ethambutol	3.20										1		1
Ethambutol	3.75				3		3						
Ethambutol	4.00				1		1						
Ethambutol	5.00	34		34	8		8	1		1			
Ethambutol	6.00	1		1									
Ethambutol	6.40										1		1
Ethambutol	7.50	6		6	14		14						
Ethambutol	9.50				1		1						
Ethambutol	10.00	10		10									

Table 1. Participant Results for Culture G, *M. tuberculosis*

DRUG	Conc.	Test Method													
		Agar Prop. Results			BACTEC Results			LJ Prop. Results			Other Tests Results				
		S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum		
Streptomycin	1.00				1		1	1		1					
Streptomycin	2.00	41		41	102		102								
Streptomycin	4.00				1		1	4		4					
Streptomycin	5.00							1		1					
Streptomycin	6.00				18		18								
Streptomycin	7.50											1		1	
Streptomycin	10.00	28		28				1		1					
Streptomycin	15.00											1		1	
Streptomycin	30.00											1		1	
Ethionamide	1.25				2		2								
Ethionamide	5.00	27		27	4		4								
Ethionamide	8.00												1	1	
Ethionamide	10.00	4		4											
Ethionamide	16.00												1	1	
Ethionamide	20.00							1		1					
Ethionamide	30.00							1		1					
Ethionamide	32.00												1	1	
Ethionamide	40.00							1		1					
Kanamycin	5.00	13		13	2		2								
Kanamycin	6.00	19		19											
Kanamycin	10.00							1		1					
Kanamycin	20.00							1		1					
Kanamycin	40.00							1		1					
Capreomycin	0.50											1		1	
Capreomycin	1.00											1		1	
Capreomycin	1.25				1		1								
Capreomycin	5.00				4		4								
Capreomycin	10.00	20		20											
Capreomycin	12.50												1	1	
Capreomycin	16.00							1		1					
Capreomycin	50.00											1		1	
Cycloserine	12.00											1		1	
Cycloserine	16.00							1		1					
Cycloserine	20.00							1		1					
Cycloserine	24.00											1		1	
Cycloserine	25.00	1		1											
Cycloserine	30.00	13		13				2		2					
Cycloserine	40.00							1		1					
Cycloserine	48.00											1		1	
Cycloserine	50.00	1		1											
Cycloserine	60.00	1		1											

Table 1. Participant Results for Culture G, *M. tuberculosis*

DRUG	Conc.	Test Method												
		Agar Prop. Results			BACTEC Results			LJ Prop. Results			Other Tests Results			
		S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum	
p-Aminosalicylic	0.50								1		1			
p-Aminosalicylic	1.00								1		1			
p-Aminosalicylic	2.00	11		11										
p-Aminosalicylic	5.00	1		1										
p-Aminosalicylic	8.00	2		2										
p-Aminosalicylic	10.00	3		3										
Amikacin	0.50											1		1
Amikacin	1.00											1		1
Amikacin	2.00	1		1	1		1							
Amikacin	4.00	3		3	1		1							
Amikacin	5.00	1		1										
Amikacin	6.00	3		3										
Amikacin	12.00	1		1										
Ofloxacin	0.50											1		1
Ofloxacin	1.00	3	1	4								1		1
Ofloxacin	2.00	3		3	6		6							
Ofloxacin	2.50											1		1
Ofloxacin	4.00	2		2	1		1							
Ofloxacin	5.00											1		1
Ofloxacin	8.00				1		1							
Ciprofloxacin	0.50											1		1
Ciprofloxacin	1.00	1		1	2		2					1		1
Ciprofloxacin	2.00	10		10	2		2							
Ciprofloxacin	3.20											1		1
Ciprofloxacin	6.40											1		1
Levofloxacin	2.00				1		1							
Rifabutin	0.50	1		1								1		1
Rifabutin	1.00	3		3	1		1					1		1
Rifabutin	2.00	7		7										
Clofazimine	0.12				1		1							
Clofazimine	0.50												1	1
Clofazimine	1.00	1		1								1		1

Table 1. Participant Results for Culture H, *M. bovis*

DRUG	Conc.	Test Method												
		Agar Prop. Results			BACTEC Results			LJ Prop. Results			Other Tests Results			
		S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum	
Isoniazid	0.01				1		1							
Isoniazid	0.02	1		1										
Isoniazid	0.05											1		1
Isoniazid	0.10				95	9	104					1		1
Isoniazid	0.12				1		1							
Isoniazid	0.20	39		39	4		4	4		4		1		1
Isoniazid	0.25								1		1			
Isoniazid	0.40				27		27							
Isoniazid	0.50							1			1			
Isoniazid	1.00	40		40	5		5	2			2			
Isoniazid	5.00	5		5										
Isoniazid	10.00							2			2			
Isoniazid	100.00							1			1			
Rifampin	0.50				1		1							
Rifampin	1.00	42		42	7		7		1		1			
Rifampin	2.00	2		2	112		112							
Rifampin	5.00	5		5				1			1			
Rifampin	14.00											1		1
Rifampin	28.00											1		1
Rifampin	40.00							4			4			
Rifampin	50.00							1			1			
Rifampin	56.00											1		1
Pyrazinamide	25.00		1	1										
Pyrazinamide	50.00					1	1							
Pyrazinamide	64.00											1		1
Pyrazinamide	100.00				2	78	80			2	2			
Pyrazinamide	300.00					3	3							
Pyrazinamide	400.00								1		1			
Ethambutol	1.00								1		1			
Ethambutol	1.50				1		1							
Ethambutol	1.60											1		1
Ethambutol	2.00							4	1		5			
Ethambutol	2.50				96	4	100							
Ethambutol	3.20											1		1
Ethambutol	3.75				3		3							
Ethambutol	4.00				1		1							
Ethambutol	5.00	35		35	8		8	1			1			
Ethambutol	6.00	1		1										
Ethambutol	6.40											1		1
Ethambutol	7.50	7		7	14		14							
Ethambutol	9.50				1		1							
Ethambutol	10.00	10		10										

Table 1. Participant Results for Culture H, *M. bovis*

DRUG	Conc.	Test Method														
		Agar Prop. Results			BACTEC Results			LJ Prop. Results			Other Tests Results					
		S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum			
Streptomycin	1.00				1		1	1		1						
Streptomycin	2.00	41		41	102		102									
Streptomycin	4.00				1		1	4		4						
Streptomycin	5.00							1		1						
Streptomycin	6.00				18		18									
Streptomycin	7.50											1				1
Streptomycin	10.00	28		28				1		1						
Streptomycin	15.00											1				1
Streptomycin	30.00											1				1
Ethionamide	1.25					3	3									
Ethionamide	5.00	26	1	27	2	2	4									
Ethionamide	8.00												1			1
Ethionamide	10.00	4		4												
Ethionamide	20.00							1		1						
Ethionamide	30.00							1		1						
Ethionamide	32.00											1				1
Ethionamide	40.00							1		1						
Kanamycin	5.00	13		13	4		4									
Kanamycin	6.00	19		19												
Kanamycin	10.00							1		1						
Kanamycin	20.00							1		1						
Kanamycin	40.00							1		1						
Capreomycin	0.50											1				1
Capreomycin	1.00											1				1
Capreomycin	1.25				1		1									
Capreomycin	5.00				5		5									
Capreomycin	10.00	20		20												
Capreomycin	12.50											1				1
Capreomycin	16.00							1		1						
Capreomycin	25.00											1				1
Capreomycin	50.00											1				1
Cycloserine	12.00												1			1
Cycloserine	20.00															
Cycloserine	25.00	1		1												
Cycloserine	30.00	12	1	13												
Cycloserine	40.00							1		1						
Cycloserine	48.00											1				1
Cycloserine	50.00	1		1												
Cycloserine	60.00	1		1												

Table 1. Participant Results for Culture H, *M. bovis*

DRUG	Conc.	Test Method												
		Agar Prop. Results			BACTEC Results			LJ Prop. Results			Other Tests Results			
		S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum	
p-Aminosalicy	0.50								1		1			
p-Aminosalicy	1.00								1		1			
p-Aminosalicy	2.00	11		11										
p-Aminosalicy	4.00				1		1							
p-Aminosalicy	5.00	1		1										
p-Aminosalicy	8.00	2		2										
p-Aminosalicy	10.00	3		3										
Amikacin	0.50											1		1
Amikacin	1.00				1		1					1		1
Amikacin	2.00	1		1	1		1							
Amikacin	4.00	3		3	1		1							
Amikacin	5.00	1		1										
Amikacin	6.00	3		3										
Amikacin	12.00	1		1										
Ofloxacin	0.50											1		1
Ofloxacin	1.00	4		4								1		1
Ofloxacin	1.25											1		1
Ofloxacin	2.00	3		3	8		8							
Ofloxacin	2.50											1		1
Ofloxacin	4.00	2		2	1		1							
Ofloxacin	5.00											1		1
Ofloxacin	8.00				1		1							
Ciprofloxacin	0.50											1		1
Ciprofloxacin	1.00	1		1	2		2					1		1
Ciprofloxacin	1.60											1		1
Ciprofloxacin	2.00	10		10	2		2							
Ciprofloxacin	3.20											1		1
Ciprofloxacin	6.40											1		1
Levofloxacin	2.00				1		1							
Rifabutin	0.50	1		1	1		1					1		1
Rifabutin	1.00	3		3	1		1					1		1
Rifabutin	2.00	7		7										
Clofazimine	0.12				1		1							
Clofazimine	0.50												1	1
Clofazimine	1.00	1		1								1		1

Table 2. Participant Results for Culture I, *M. malmoense*

DRUG	Conc.	Test Method											
		Agar Prop. Results			BACTEC Results			LJ Prop. Results			Other Tests Results		
		S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum
Amikacin	1.00		1	1									
Amikacin	2.00				1		1						
Amikacin	4.00	2		2									
Amikacin	6.00	2		2									
Amikacin	8.00	1		1	1		1						
Amikacin	12.00	1		1									
Azithromycin	8.00				1		1						
Clofazimine	1.00	1		1									
Clarithromycin	1.00							1		1			
Clarithromycin	2.00					1	1						
Clarithromycin	3.00	4		4									
Clarithromycin	4.00				1		1						
Clarithromycin	8.00	1		1									
Capreomycin	10.00	4	3	7									
Ciprofloxacin	1.00		1	1									
Ciprofloxacin	1.60											1	1
Ciprofloxacin	2.00	5	4	9									
Ciprofloxacin	3.20											1	1
Ciprofloxacin	4.00	2		2									
Ciprofloxacin	6.40										1		1
Ciprofloxacin	8.00				1		1						
Cycloserine	30.00	1	3	4									
Ethambutol	1.60											1	1
Ethambutol	2.00				1		1	1		1			
Ethambutol	2.50				4	1	5						
Ethambutol	3.20										1		1
Ethambutol	3.75				1		1						
Ethambutol	5.00	1	12	13									
Ethambutol	7.50	1		1									
Ethambutol	8.00				1		1						
Ethambutol	10.00	3	2	5									
Imipenem	4.00					1	1						
Isoniazid	0.02		1	1									
Isoniazid	0.05											1	1
Isoniazid	0.10					5	5						
Isoniazid	0.20		9	9					1	1		1	1
Isoniazid	0.40					2	2						
Isoniazid	0.50					1	1						
Isoniazid	1.00		14	14									
Isoniazid	5.00	2		2									
Kanamycin	5.00	1		1									
Kanamycin	6.00	7	1	8									
Levofloxacin	2.00				1		1						

Table 2. Participant Results for Culture I, *M. malmoense*

DRUG	Conc.	Test Method												
		Agar Prop. Results			BACTEC Results			LJ Prop. Results			Other Tests Results			
		S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum	
Ofloxacin	1.00		1	1										
Ofloxacin	1.25											1		1
Ofloxacin	2.00	1	1	2		1	1							
Ofloxacin	2.50											1		1
Ofloxacin	4.00	1		1										
Ofloxacin	5.00											1		1
p-Aminosalicylic acid	0.50							1		1				
p-Aminosalicylic acid	2.00		4	4										
p-Aminosalicylic acid	8.00		2	2										
Pyrazinamide	25.00	1		1										
Pyrazinamide	100.00					1	1							
Rifabutin	0.12				1		1							
Rifabutin	0.50	1		1										
Rifabutin	1.00	2		2	1		1							
Rifabutin	2.00	3		3										
Rifabutin	40.00							1		1				
Rifampin	0.50				1		1							
Rifampin	1.00	11	3	14										
Rifampin	2.00				5	2	7							
Rifampin	5.00	4		4										
Rifampin	14.00												1	1
Rifampin	28.00												1	1
Rifampin	40.00							1		1				
Rifampin	56.00											1		1
Streptomycin	2.00	7	7	14	4	2	6							
Streptomycin	3.00					1	1							
Streptomycin	4.00							1		1				
Streptomycin	7.50												1	1
Streptomycin	10.00	8	1	9										
Streptomycin	30.00												1	1
Sulfamethoxazole	32.00	1		1										
Ethionamide	5.00	7		7										
Ethionamide	10.00	4		4										

Table 3. Participant Results for Culture J, *M. abscessus*

DRUG		Conc.		Test Method																	
				Agar Prop. Results			BACTEC Results			Microtiter Results			Disk Elution Results			LJ Proportion Results			Other Test Results		
				S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum
Amikacin	0.25																				
Amikacin	0.50							1		1											
Amikacin	1.00							1		1											
Amikacin	4.00							1		1											
Amikacin	6.00			1		1							2		2						
Amikacin	8.00																	1	1		
Amikacin	12.00	2				2															
Amikacin	30.00	3				3							2		2			3	3		
Augmentin	64.00									1	1										
Azithromycin	16.00							2	1	3											
Azithromycin	32.00								1	1											
Clarithromycin	1.00							1		1					1	1					
Clarithromycin	2.00																	1	1		
Clarithromycin	3.00	1	1	2								2		2				1	1		
Clarithromycin	4.00	1				1			1	1											
Clarithromycin	6.00			1		1												1	1		
Clarithromycin	8.00								1	1											
Clarithromycin	9.00			1		1															
Clarithromycin	15.00																				
Clarithromycin	20.00																				
Clarithromycin	24.00																	1	1		
Capreomycin	10.00			1		1															
Ciprofloxacin	2.00	1	2	3				1		1			1	1				1	1		
Ciprofloxacin	5.00																	2	2		
Ciprofloxacin	6.40																	1	1		
Ciprofloxacin	8.00			1		1				1	1										
Cycloserine	40.00															1	1				
Cefoxitin	30.00	3	2	5									1	1	2			2	1	3	
Cefoxitin	32.00							1		1											
Cefoxitin	256.00																				
Doxycycline	0.03																				
Doxycycline	5.00	1				1															
Doxycycline	6.00	2				2							1	1				1	1		
Doxycycline	30.00	1				1												1	1		
Ethambutol	2.00														1	1					
Ethambutol	2.50						4	4													
Ethambutol	5.00			1		1									1	1					
Ethambutol	6.40																	1	1		
Ethambutol	10.00			1		1															
Erythromycin	3.00			1		1															
Erythromycin	15.00																	2	2		
Erythromycin	16.00									1	1										

Table 3. Participant Results for Culture J, *M. abscessus*

DRUG		Test Method																			
		Agar Prop. Results			BACTEC Results			Microtiter Results			Disk Elution Results			LJ Proportion Results			Other Test Results				
		S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum		
Gentamicin	4.00		1	1				1		1											
Gentamicin	10.00																				
Gentamicin	30.00	1		1																	
Imipenem	1.00																	1	1		
Imipenem	8.00	1		1								1	1	2				2	2		
Imipenem	10.00		1	1														1	1		
Imipenem	32.00																				
Isoniazid	0.10					4	4														
Isoniazid	0.20		1	1											1	1		1	1		
Isoniazid	1.00		1	1																	
Isoniazid	100.00														1	1					
Kanamycin	2.00								1		1										
Kanamycin	6.00		1	1																	
Kanamycin	20.00														1	1					
Kanamycin	30.00	1		1																	
Minocycline	2.00								1		1										
Minocycline	6.00	1		1								2		2							
Minocycline	10.00		1	1																	
Minocycline	30.00																				
Ofloxacin	1.25																	1	1		
Ofloxacin	4.00		1	1														1	1		
Ofloxacin	5.00																	2	2		
Ofloxacin	8.00								1		1										
Ofloxacin	16.00								1		1										
p-Aminosalicylic acid	0.50														1	1					
Pyrazinamide	100.00					1	1														
Rifabutin	1.00		1	1																	
Rifabutin	4.00																	1	1		
Rifabutin	16.00								1		1										
Rifabutin	32.00								1		1										
Rifabutin	40.00														1	1					
Rifampin	1.00		2	2																	
Rifampin	2.00					4	4														
Rifampin	5.00	1		1											1	1					
Rifampin	8.00																	1	1		
Rifampin	40.00														1	1					
Rifampin	50.00														1	1					
Sulfisoxazole	50.00		1	1																	
Streptomycin	2.00		1	1		4	4								1	1					
Streptomycin	4.00																				
Streptomycin	10.00		2	2																	
Streptomycin	30.00																	1	1		
Streptomycin	100.00														1	1					

Table 3. Participant Results for Culture J, *M. abscessus*

		Test Method																	
		Agar Prop. Results			BACTEC Results			Microtiter Results			Disk Elution Results			LJ Proportion Results			Other Test Results		
DRUG	Conc.	S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum	S	R	Sum
Sulfamethoxazole	0.25																		
Sulfamethoxazole	25.00																	1	1
Sulfamethoxazole	100.00																	1	1
Sulfamethoxazole	512.00							1	1										
Thiacetazone	5.00														1	1			
Tetracycline	6.00											1	1						
Tetracycline	30.00																		
Ethionamide	10.00		1	1															
Ethionamide	40.00														1	1			
Trimethoprim-S	1.50											1	1						
Trimethoprim-S	5.00																	1	1
Trimethoprim-S	20.00		1	1															
Trimethoprim-S	25.00																	1	1
Trimethoprim-S	30.00		2	2								1	1					1	1
Trimethoprim-S	32.00																		
Tobramycin	6.00		1	1															
Tobramycin	8.00		1	1								2	2					1	1
Tobramycin	10.00	1		1															
Vancomycin	30.00	1		1															

Table 4. Minimum Inhibitory Concentrations for Culture I, *M. malmoense*

DRUG	Test Method	MIC	S	R	None	Sum
Amikacin	Agar proportion	<5.00	1			1
Amikacin	BACTEC 460	<2.00	1			1
Amikacin	BACTEC 460	<4.00	1			1
Amikacin	BACTEC 460	<8.00	1			1
Amikacin	Microtiter	2.00			1	1
Amikacin	Microtiter	16.00		1		1
Capreomycin	Agar proportion	>16.00		1		1
Ciprofloxacin	Agar proportion	<2.50	1			1
Ciprofloxacin	BACTEC 460	<2.00	1			1
Ciprofloxacin	BACTEC 460	<4.00	1			1
Ciprofloxacin	BACTEC 460	<8.00	1			1
Ciprofloxacin	E-test	>32.00		1		1
Ciprofloxacin	Microtiter	0.50			1	1
Ciprofloxacin	Microtiter	8.00		1		1
Clarithromycin	Agar proportion	<0.12	1			1
Clarithromycin	BACTEC 460	<2.00	1			1
Clarithromycin	BACTEC 460	<4.00	1			1
Clarithromycin	BACTEC 460	<8.00	1			1
Clarithromycin	BACTEC 460	<16.00	1			1
Clarithromycin	E-test	1.00	1			1
Clarithromycin	Microtiter	0.12			1	1
Clarithromycin	Microtiter	0.25	1			1
Clofazimine	Agar proportion	<0.10	1			1
Clofazimine	Microtiter	0.06			1	1
Ethambutol	Agar proportion	<5.00		1		1
Ethambutol	Agar proportion	>8.00		1		1
Ethambutol	BACTEC 460	<2.00	2			2
Ethambutol	BACTEC 460	<4.00	1			1
Ethambutol	BACTEC 460	<8.00	1			1
Ethambutol	Microtiter	2.00			1	1
Ethambutol	Microtiter	8.00		1		1
Ethionamide	Agar proportion	<4.00	1			1
Isoniazid	Agar proportion	4.00	1			1
Isoniazid	Microtiter	4.00			2	2
Kanamycin	Agar proportion	<8.00	1			1
Rifabutin	Agar proportion	<0.10	1			1
Rifabutin	BACTEC 460	<0.50	1			1
Rifabutin	Microtiter	0.50			1	1
Rifampin	Agar proportion	4.00	1			1
Rifampin	Agar proportion	<1.00	1			1
Rifampin	Microtiter	4.00			1	1
Rifampin	Microtiter	16.00		1		1
Streptomycin	Agar proportion	<8.00	1			1
Sulfamethoxazole	Microtiter	>32.00		1		1
Trimethoprim-Sulfamethoxazole	Agar proportion	<2.50	1			1

Table 5. Minimum Inhibitory Concentrations for Culture J, *M. abscessus*

DRUG	Test Method	MIC	S	R	None	Sum
Amikacin	Agar proportion	10.00	1			1
Amikacin	Agar proportion	>16.00		1		1
Amikacin	E-test	0.75	1			1
Amikacin	E-test	2.00	1			1
Amikacin	E-test	6.00	1			1
Amikacin	E-test	32.00		1		1
Amikacin	E-test	64.00			1	1
Amikacin	Microtiter	8.00	5			5
Amikacin	Microtiter	≤16.00	2			2
Azithromycin	E-test	1.00	1			1
Azithromycin	E-test	16.00		1		1
Cefoxitin	E-test	64.00	1			1
Cefoxitin	E-test	>256.00		4	1	5
Cefoxitin	Microtiter	8.00	1			1
Cefoxitin	Microtiter	32.00			1	1
Cefoxitin	Microtiter	64.00		1	1	2
Ciprofloxacin	Agar proportion	10.00	1			1
Ciprofloxacin	Agar proportion	>16.00		1		1
Ciprofloxacin	E-test	>32.00		4	1	5
Ciprofloxacin	Microtiter	8.00		2		2
Ciprofloxacin	Microtiter	16.00		1		1
Ciprofloxacin	Microtiter	>2.00		1		1
Ciprofloxacin	Microtiter	>8.00		2		2
Ciprofloxacin	Microtiter	≥16.00		2		2
Clarithromycin	Agar proportion	0.50	1			1
Clarithromycin	Agar proportion	>128.00		1		1
Clarithromycin	E-test	0.03	1			1
Clarithromycin	E-test	0.25	1			1
Clarithromycin	E-test	0.38	1			1
Clarithromycin	E-test	0.50	2			2
Clarithromycin	E-test	2.00			1	1
Clarithromycin	E-test	<0.38	1			1
Clarithromycin	E-test	<2.00	1			1
Clarithromycin	Microtiter	0.50	2			2
Clarithromycin	Microtiter	1.00	2			2
Clarithromycin	Microtiter	8.00		2		2
Doxycycline	Agar proportion	5.00	1			1
Doxycycline	E-test	<1.00	1			1
Doxycycline	E-test	0.50	2			2
Doxycycline	E-test	24.00		1		1
Doxycycline	Microtiter	≤0.50	3			3
Doxycycline	Microtiter	1.00	2			2
Doxycycline	Microtiter	2.00	1			1

Table 5. Minimum Inhibitory Concentrations for Culture J, *M. abscessus*

DRUG	Test Method	MIC	S	R	None	Sum
Ethambutol	Agar proportion	>64.00		1		1
Imipenem	E-test	≥32.00		5	1	6
Imipenem	Microtiter	4.00	1			1
Imipenem	Microtiter	8.00			1	1
Imipenem	Microtiter	16.00		1		1
Imipenem	Microtiter	32.00		1		1
Imipenem	Microtiter	106.00		1		1
Levofloxacin	E-test	≥32.00		2		2
Levofloxacin	Microtiter	>4.00		1		1
Minocycline	E-test	0.12			1	1
Minocycline	E-test	0.19	1			1
Minocycline	Microtiter	<0.50	1			1
Minocycline	Microtiter	1.00	1			1
Minocycline	Microtiter	2.00	1			1
Ofloxacin	E-test	>32.00		1		1
Rifampin	Agar proportion	>32.00		1		1
Rifampin	Microtiter	>4.00		1		1
Sulfamethoxazole	Microtiter	>64.00		2		2
Tetracycline	Microtiter	4.00	1			1
Tobramycin	E-test	1.50	1			1
Tobramycin	Microtiter	4.00	4			4
Trimethoprim-Sulfamethoxazole	Agar proportion	5.00		1		1
Trimethoprim-Sulfamethoxazole	E-test	>4.00		1		1
Trimethoprim-Sulfamethoxazole	E-test	>32.00		3	1	4
Trimethoprim-Sulfamethoxazole	Microtiter	>2.00		1		1
Trimethoprim-Sulfamethoxazole	Microtiter	>8.00		1		1
Trimethoprim-Sulfamethoxazole	Microtiter	>80.00		1		1

Table 6.

Participants performing in-house susceptibility testing on nontuberculous mycobacteria

Organism	# testing in-house	Agar proportion	BACTEC 460	E Test	Microtiter	Disk Elution	L-J Proportion	Kirby Bauer	other
<i>M. abscessus</i>	40	10	8	8	7	4	3	7	7
<i>M. avium complex</i>	37	13	20	4	2	-	2	1	2
<i>M. chelonae</i>	41	10	7	8	8	4	3	7	7
<i>M. fortuitum</i>	41	10	7	8	8	4	3	7	7
<i>M. genavense</i>	10	5	4	-	1	-	1	-	-
<i>M. goodii</i>	20	13	6	1	2	1	2	1	1
<i>M. kansasii</i>	55	39	20	1	2	1	4	1	1
<i>M. malmoense</i>	36	22	14	3	2	1	1	1	-
<i>M. marinum</i>	38	25	10	1	4	2	1	1	2
<i>M. mucogenicum</i>	37	11	8	8	6	4	1	7	4
<i>M. terrae complex</i>	23	14	7	1	2	1	2	1	2
<i>M. xenopi</i>	41	29	11	-	2	1	3	1	1