

Biosafety Challenges in a TB Containment Facility

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Biosafety Quality Improvement Forum

Workplace Safety & Health session

8th Healthcare Quality Improvement Conference

Singapore




10th October, 2011



Agenda

- § Background
- § Lab-acquired TB infection
- § Biohazards in the lab
- § Risk assessment and management
- § TB infection control measures in the lab :Work practice
:Personal Protective Equipment (PPE)
- § Government policies/guidelines for biosafety in Singapore
- § Conclusions

Why is biosafety important for a TB lab?

- § **Biosafety:** The application of knowledge, techniques and equipment to prevent personal, laboratory and environmental exposure to potentially infectious agents or biohazards.
- § A study done in UK 1980-89, incidence of TB infection/disease among post-mortem, and microbiology technical staff was higher than in other pathology disciplines (Grist & Emslie, J Clin Pathol 1994). Similar finding was observed in US, Japan, and other low and medium income countries.
- § Risk of contracting TB is higher for TB lab staff who are handling higher concentration of *M. tuberculosis* compared to non-TB lab staff 
- § Globally MDR-TB rates have been increasing, especially in SEA countries 
- § Lab staff who have been infected with HIV or diabetes may be working with TB 

Lab-acquired TB infection among TB laboratory staff

LAI is defined as all infections acquired through lab or lab-related activities regardless of whether they are symptomatic or asymptomatic in nature

LA-TB infection

It is difficult to conclude with certainty that TB is lab-acquired due to potential for exposure outside of the workplace and the long incubation period before symptomatic disease develops

Relative risk of LA-TB disease among staff from 13 TB labs in S. Korea (1970-1994)

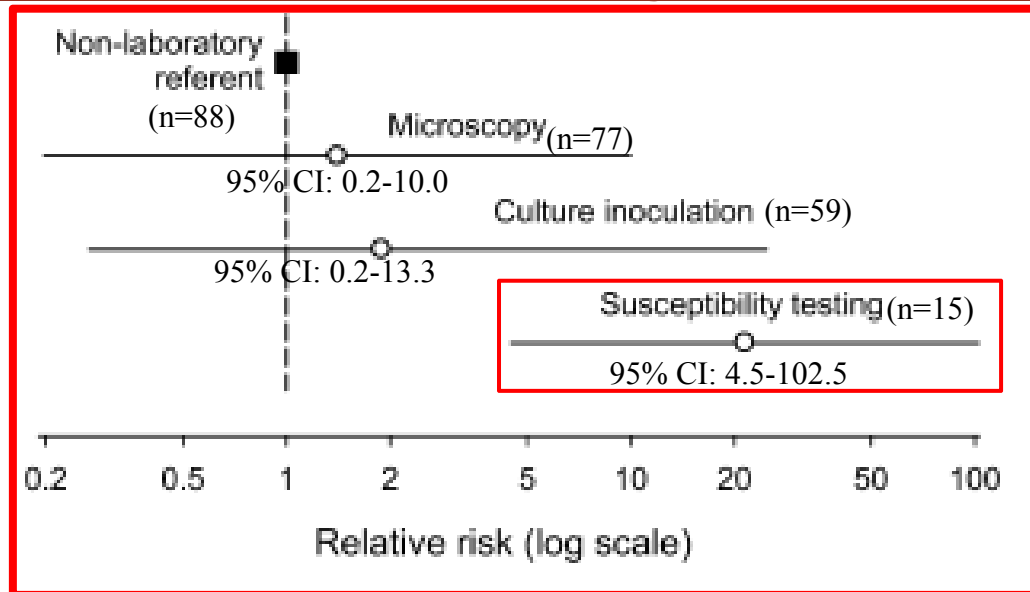
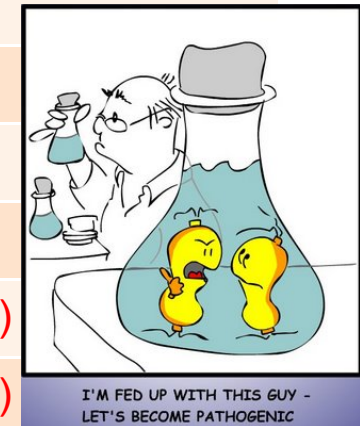


Figure Relative risk and 95% confidence intervals of tuberculosis among laboratory technicians compared to administrative staff, by type of laboratory work.

Ref: Kim SJ et al, Int J Tuberc Lung Dis 2007

Rising MDR-TB prevalence in some SEA and Asian countries

Country	% MDR among new TB cases (95% CI)	% MDR among previously treated TB cases (95% CI)
Bangladesh	2.2 (0.0-5.6)	14.7 (0.0-39.6)
China	5.7 (5.0-6.6)	26.0 (23.0-28.0)
India	2.3 (1.8-2.8)	17.2 (14.9-19.5)
^Indonesia	1.8 (1.0-2.6)	17 (8.1-26.0)
^Malaysia	0.1 (0.0-0.6)	0.0 (0.0-19.0)
Myanmar	4.2 (3.2-5.6)	10.0 (7.1-14.0)
^Singapore	0.1(0.0-0.6)	2.9 (1.0-8.2)
Thailand	1.7 (1.1-2.6)	38.5 (28.2-41.5)
Vietnam	2.7 (2.0-3.6)	19.3 (14.5-25.2)



Ref:

^Global tuberculosis control report 2010 , WHO

The rests of the data are from: M/XDR 2010 Global report on surveillance and response. WHO 2010

Impact of diabetes in the SEA WHO region

Table 2. Estimated prevalence (all ages) of diabetes mellitus in SEAR countries in 1998 (SCN, WHO, SEARO)

Country	Per cent	Number	Source
Bangladesh	2.2	2 700 000	National estimate, survey U, R
Bhutan	0.4	2 430	National estimate
DPR Korea	0.7	15 000	National estimate
India	2.9	28 415 100	National estimate, survey U, R
Indonesia	2.0	4 117 000	National estimate, survey U, R
Maldives	5.5	14 900	National estimate
Myanmar	1.4	622 960	National estimate, hospital data
Nepal	1.3	314 360	Personal com.
Sri Lanka	4.9	907 000	National estimate, survey U, R
Thailand	2.3	1 380 000	National survey
SEAR	2.6	<u>38 488 650</u>	Regional estimate

U = urban; R= rural

Table 15: Number of people (in thousands) with diabetes mellitus (DM) and impaired glucose tolerance (IGT) in the 20-79 age group in countries of the South-East Asia Region, 2007–2025

Country	DM 2007	DM 2025	IGT 2007	IGT 2025
Bangladesh	3 848	7 419	6 819	10 647
Bhutan	54	67	34	59
DPR Korea	807	1 082	1 284	1 624
India	40 851	69 882	35 906	56 228
Indonesia	2 888	5 129	14 144	20 597
Maldives	10	29	20	38
Myanmar	873	1 566	725	1 086
Nepal	497	1 009	542	1 100
Sri Lanka	1 187	1 786	1 708	2 272
Thailand	3 162	4 660	1 896	2 399
Timor-Leste	7	13	46	84
Total	<u>54 184</u>	<u>92 642</u>	63 124	96 134

Source: International Diabetes Federation 2006. Diabetes Atlas (3rd Edition).

Biohazards in the lab

- **M. tuberculosis**: Low infectious dose (1-10 CFU)

: Long viability

- 45 days on clothing
- 90-120 days on dust
- 6-8 months in sputum (cold, dark room)

: Heat resistant: Survive in 48% of flame-fixed smears (Cardoso et al 2001
Mem Inst Oswaldo Cruz)

Hazard is the substance/situation which potentially causes harm to the wellbeing of person

- **Biohazard (substance source)**: M. tuberculosis containing samples, naturally or experimentally TB infected non-human primates and other animals
- **Biohazard (situation)**: Procedures that create M. tuberculosis contaminated aerosols:
Abundant at the lab especially during manipulating liquid culture
- **Biohazard (situation)**: Procedure that puncture the skin: Not rare incident in the lab
eg. using a needle in the BACTEC™ 460TB System for growing Mycobacteria
and animal experiments

Aerosol generating procedures in the lab

Lab activity

➤ **Manipulate an inoculating-loop**

➤ **Use of pipette**



➤ **Use of sonicator/electroporator/homogenizer/vortex/centrifuge/cell dispenser/aspirator**



➤ **Needle and syringe manipulation**

➤ **Flowcytometer**

Example

-Streaking inoculum on agar plate



-Mixing microbial suspension

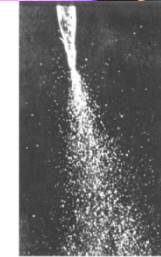
-Expelling the last drop of microbial suspension

-Disintegrating microbes

-Mixing bact. suspension

-Dispensing bact. suspension

- Separating microbes

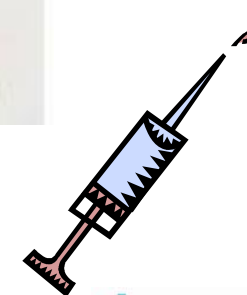


Manipulate infectious fluids carefully to avoid spills and the production of aerosols and droplets. This shows the copious production of aerosols and droplets when the last drop in a pipette is blown out. This can be remediated by such practices to create an infectious dose of some agents. Courtesy: Centers for Disease Control and Prevention.

-Expelling air from syringe

-Injecting animals

-Needle separates from syringe



-Sorting cells

Aerosol generating procedures in the lab

Lab activity

- **Pouring/decanting**
- **Opening culture containers**
- **Heating/boiling**
- **Spills of TB bacilli suspension**
- **Animal experiments**
- **Preparing and manipulation of frozen sections**

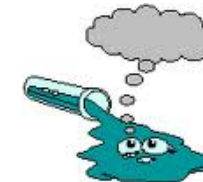
Example

- Decant supernatant after centrifugating microbial suspension
- Removing a cap from a test tube containing microbial suspension immediately after vigorous shaking/vortexing
- Opening culture plates abruptly

- Loop flame sterilization



- Spill on hard surfaces



- Cage changing and animal handling

- Using a microtome to cut the frozen tissue sections

Risk assessment and risk management

Risk perception

Risk= Damage caused by a hazard x Probability of damage happening

Before performing any procedure in the BSL-3 lab

- Identify hazard and evaluate risk (Risk assessment)
- Remove/mitigate the risk (Risk management)

Both assessing risk and judging the acceptability of risk is subjective because it involves personal experience and value

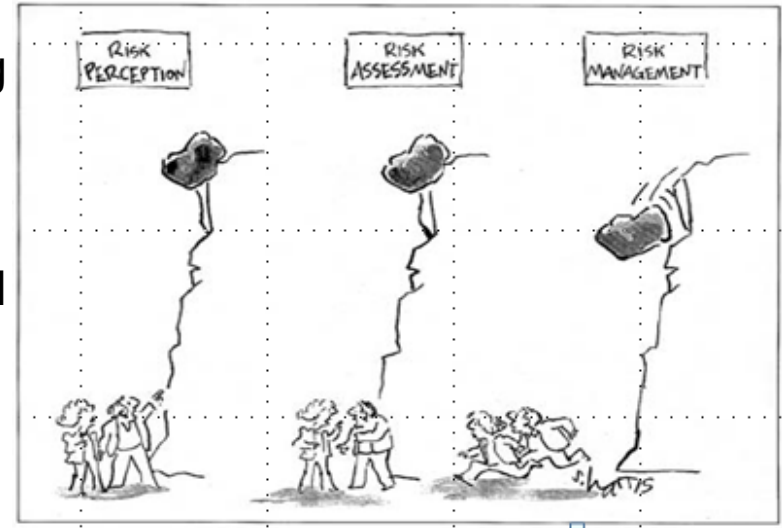


BSL-3 | Business Use Only

Risk assessment and risk management

Who should be involved?

- Single and few persons assessing and managing risks are not acceptable
- Not use a “top-down” or “bottom-up” approach
- All stakeholders should be involved (planned and structured team efforts)
- Risk assessment/management should be done periodically



Benefits

- Help in priority setting for infection control (high, medium and low risk)
- Determine suitable control measures needed for different risks

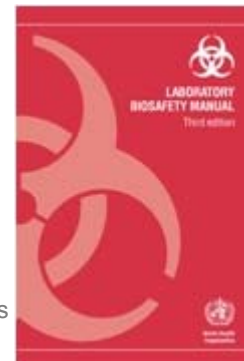
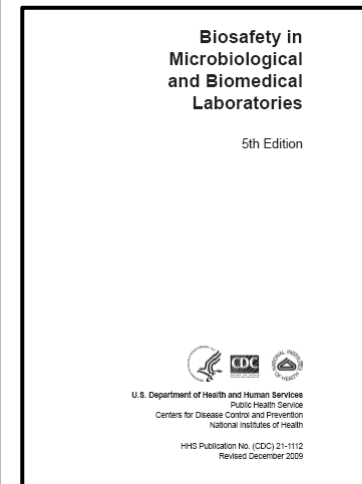
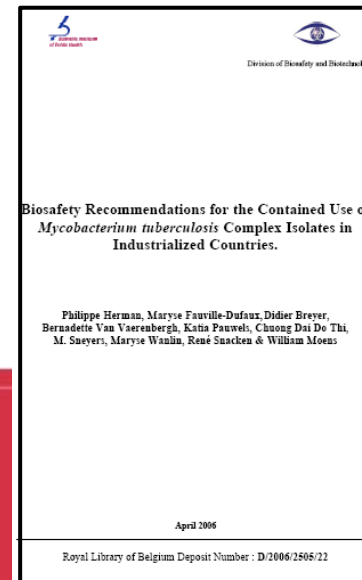
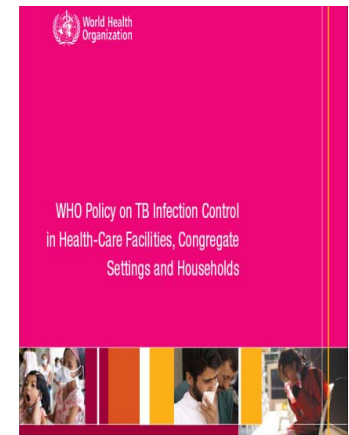
Likelihood of happening	Severity of damaging lab/personnel			
	Insignificant	Minor	Moderate	Major
Very unlikely could happen, but may happen (in exceptional circumstances)	Low risk	Medium risk	High risk	High risk
Unlikely could happen (rarely)				
Likely could happen (sometimes)	High risk	High risk	High risk	High risk
Very likely could happen (anytime)	High risk	High risk	High risk	High risk

TB infection control measures in the lab

Preventing risk of spreading TB in a laboratory and to the community

1. Administrative control and training: policies including OH surveillance for staff, SOPs and practice enforcement
2. Primary barriers (Engineering control)
3. **Personal Protective Equipment (PPE)**
4. **Work practice (Good Laboratory Practice)**
5. Secondary barriers (Engineering control)

Applying only one control measure is inadequate and not cost effective in any setting



Work practice

Minimizing aerosols

- ❖ All aerosol generating procedures must be performed using a well contained equipment such as BSC, aerosol tight centrifuge bucket



BSC

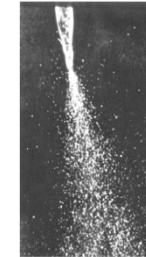


FIGURE 12 Manipulate infectious fluids carefully to avoid spills and the production of aerosols and droplets. This photograph shows the copious production of aerosols and droplets when the last drop in a pipette is blown out. Enough material can be aerosolized by such practices to create an infectious dose of some agents. Courtesy: National Institutes of Health.

- ❖ Minimizing aerosols

- Use pipette carefully: No blowout, no pressure ejection, use wall contact
- Use filtered pipette tips
- Use a bench guard
- Use capped tubes while vortexing, mixing, shaking etc
- Pour liquid carefully
- Wipe up spills promptly with appropriate disinfectant
- Use double containers while carrying sample tubes/cups within the lab
- Use triple packaging practice while carrying sample tubes/cups outside of the lab

AEROSOL AND SURFACE RECOVERY FROM 10 PIPETTING OPERATIONS OF 10^9 /ML *B. SUBTILIS* (AVERAGE TIME 3 MIN; 1 ML PIPETTE; 2 ML BULB PIPETTER)

Summary Data from 6 runs	Airborne CFU	Settled CFU	
		Hands	Area
▪ Lowest count	388	6,900	550
▪ Average count	1,820	52,800	1,970
▪ Highest count	5,110	228,000	3,700

Adapted from Chatigny, 1979

Work practice

Safe use of centrifuges

- Use sealed tubes, rotors and buckets that are sealed with o-ring



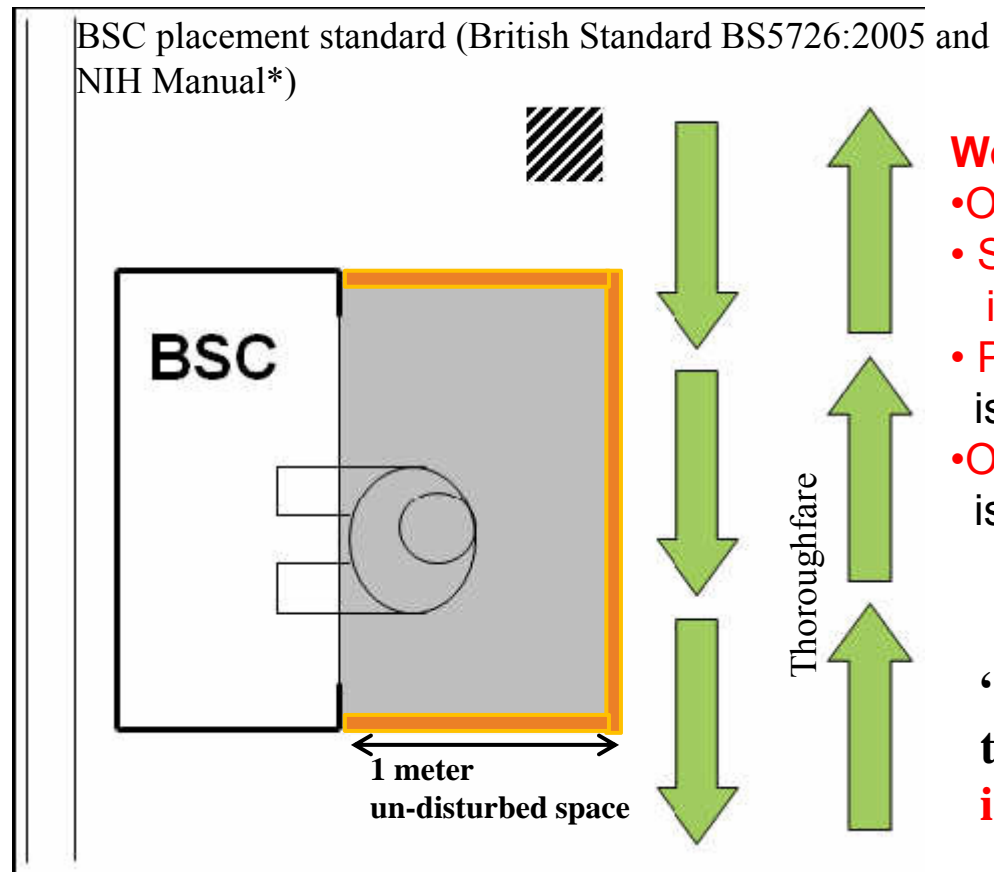
- Regular check rotors/buckets for wear and tear
- Clean and maintain or change gaskets and o-ring of centrifuges
- Load/unload centrifuge tubes in a BSC
- Use matched tubes and buckets/rotor
- Do not overfill tubes
- Balance buckets/tubes before centrifugation
- Clean the buckets/rotor of the centrifuge at the end of the day

Work practice

Correct use of BSC

- ❖ BSC will not provide protection against TB that results from choosing incorrect type of BSC, wrong positioning of the BSC, lack of maintenance of BSC and poor lab practices

<http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DesignRequirementsManualPDF.htm>



Work etiquettes

- Optimally only one person should use at a time
- Should not walk within un-disturbed space in front of the BSC while someone is working
- Pass gently in front of the BSC when someone is working with the BSC
- Open and close the doors gently when someone is working with the BSC

“A biosafety cabinet is only as safe as the person using it and as colleagues in the room.”

Work practice

Correct use of BSC

❖ Use of open flame

- Fire hazard since substances that could facilitate fire eg. alcohol soaked cotton wool
- Can damage HEPA filter
- Interferes with proper air flow
- Can create TB containing aerosols while loop flame sterilization



❖ External surfaces of items are chemically disinfected before taking them out from the BSC eg. waste bags, sample vials, pipette tip boxes, pipettes etc

- 5% NaClO, 2% chlorine, 5% phenol, 2% glutaraldehyde, 70% ethyl alcohol or isopropyl alcohol, 0.5% H₂O₂, iodine+alcohol and quaternary ammonium cpd+alcohol



Work practice

Disinfectant use

Reducing the number of pathogenic micrororganisms to the point where they no longer cause disease. Usually involves the removal of vegetative or non-endospore forming pathogens.

- >160 disinfectants have been registered as tuberculocidal disinfectants with US Environmental protection Agency (EPA 2009)
<http://www.epa.gov/oppad001/chemregindex.htm>
- ~30 disinfectants have been registered as effective disinfectants against TB, HIV-1 and Hep B virus with US EPA (2009)

Are they effective as they claim in your setting? (EPA's standard for tuberculocidal disinfectant is based on a carrier test using *M. bovis* (BCG))

Factors influencing effectiveness of disinfectant

- Concentration of disinfectant
- Shelf life of disinfectant
- Time of exposure
- Composition of the medium (pH, organic sub etc)
- Temperature
- Nature and number of organisms
- Others – hardness of water, relative humidity, **use of a disinfectant soaked cloth**

TB and disinfectants

TABLE 1. Activities of disinfectants after 1 min of contact

Disinfectant (concn used)	Organic load	Reduction in CFU of <i>M. tuberculosis</i>		Rating ^a	
		Suspension test	Carrier test	Suspension test	Carrier test
Phenol (5% wt/vol)	Absent	$>(5.60 \pm 1.05) \times 10^5$ $>(1.63 \pm 0.12) \times 10^5$	$(7.67 \pm 0.58) \times 10^4$ $(9.67 \pm 0.58) \times 10^4$	Pass	Pass
	Sputum	$>(1.10 \pm 0.10) \times 10^5$ $>(1.60 \pm 0.26) \times 10^5$	$(1.40 \pm 0.06) \times 10^4$ $(2.30 \pm 0.10) \times 10^4$	<u>Pass</u>	<u>Pass</u>
Sodium hypochlorite (10,000 ppm of Av Cl/ml)	Absent	$(1.10 \pm 0.11) \times 10^3$ $(1.17 \pm 0.07) \times 10^3$	$(1.59 \pm 0.02) \times 10^3$ $(1.47 \pm 0.03) \times 10^3$	Pass	Pass
	Sputum	$(1.77 \pm 0.04) \times 10^3$ $(1.04 \pm 0.02) \times 10^3$	$(1.67 \pm 0.01) \times 10^3$ $(1.56 \pm 0.04) \times 10^3$	<u>Pass</u>	<u>Pass</u>
Sodium hypochlorite (6,000 ppm of Av Cl/ml)	Absent	$(2.54 \pm 0.15) \times 10^2$ $(5.48 \pm 0.09) \times 10^2$	$(1.20 \pm 0.10) \times 10^2$ $(1.30 \pm 0.05) \times 10^2$	Fail	Fail
	Sputum	$(1.26 \pm 0.02) \times 10^2$ $(2.03 \pm 0.50) \times 10^2$	$(2.33 \pm 1.53) \times 10^2$ $(1.90 \pm 0.44) \times 10^2$	Fail	Fail
Sodium dichloroisocyanurate (6,000 ppm of Av Cl/ml)	Absent	$(1.33 \pm 0.10) \times 10^4$ $(1.10 \pm 0.20) \times 10^4$	$(1.50 \pm 0.08) \times 10^3$ $(1.41 \pm 0.06) \times 10^3$	Pass	Pass
	Sputum	$(1.87 \pm 0.03) \times 10^4$ $(1.90 \pm 0.10) \times 10^4$	$(2.01 \pm 0.02) \times 10^2$ $(7.40 \pm 1.27) \times 10^2$	Pass	Fail
Ethanol (70% vol/vol)	Absent	$(3.63 \pm 0.29) \times 10^3$ $(3.00 \pm 0.10) \times 10^3$	$(9.96 \pm 0.40) \times 10^1$ $(8.65 \pm 0.73) \times 10^1$	Pass	Fail
	<u>Sputum</u>	$(1.30 \pm 0.23) \times 10^2$ $(2.67 \pm 0.47) \times 10^2$	7.00 ± 0.42 3.00 ± 0.15	<u>Fail</u>	<u>Fail</u>
Quaternary ammonium compound (0.04% dimethyl benzylammonium chloride)	Absent	1.93 ± 0.12 6.57 ± 0.06	ND ^b ND	Fail	
	Sputum	ND ND	ND ND		

Best M et al, J. Clin Microbiol 1990; 28: 2234-9

Work practice

Inactivating TB contaminating samples

❖ Inactivating pathogens for further processing eg. formalin fixed tissue, extracted DNA/RNA/protein from *M. tuberculosis*

- Mycobacterium containing tissue samples fixed with 10% buffered formalin (formaldehyde 4%)

20 part formalin +1 part tissue keep at least 24 hrs

Is it safe? 

- Heat inactivation

- Inactivation of TB culture at 80 °C for 20 mins and subsequently treated with CTAB-NaCl for extraction of DNA:

77% of tested cultures have live *M. tuberculosis* (Somerville et al J Clin Microbiol 2005)
but no viable bacilli in all tested samples (Blockwood KS et al BMC Infect Dis 2005)

- Inactivation of TB culture at 100 °C waterbath 10 mins:

No viable *M. tuberculosis* (Blockwood KS et al BMC Infect Dis 2005)

All samples contaminated with TB must be inactivated using a validated method before handling at a lower biosafety level

Viable *Mycobacterium* species in 10% of tissues fixed with formalin

TABLE 1. Cases Yielding Viable Mycobacteria

Case No.	Clinical Diagnosis	No. Bacilli per 5 HPF	Days fixed in Formalin	Incubation Time Until Growth Detected (d)	Type of Acid-Fast Bacilli
1	Cavitary PTB	>20	31	16	<i>Mycobacterium tuberculosis</i> , confirmed
2	Miliary PTB	>20	45	39	<i>Mycobacterium tuberculosis</i> , confirmed
3	HIV	15	41	38	<i>Mycobacterium</i> species
4	Multi-drug resistant PTB	>25	74	38	<i>Mycobacterium</i> species
5	Miliary PTB	>25	22	31	<i>Mycobacterium avium</i> , confirmed
6	Miliary PTB	30	>10	86	<i>Mycobacterium</i> species
7	Miliary PTB	20	>10	56	<i>Mycobacterium</i> species
8	HIV	15	32	72	<i>Mycobacterium tuberculosis</i> , confirmed
9	Miliary PTB	20	27	21	<i>Mycobacterium</i> species
10	Miliary PTB	>25	80	36	<i>Mycobacterium</i> species
11	HIV	>25	36	36	<i>Mycobacterium</i> species
12	Fibrocaceous TB	30	38	56	<i>Mycobacterium</i> species

Abbreviations: HPF, high-power fields; HIV, human immunodeficiency virus; PTB, pulmonary tuberculosis; TB, tuberculosis.

Ref: Gerston et al Human Patho 2004;35:571-4

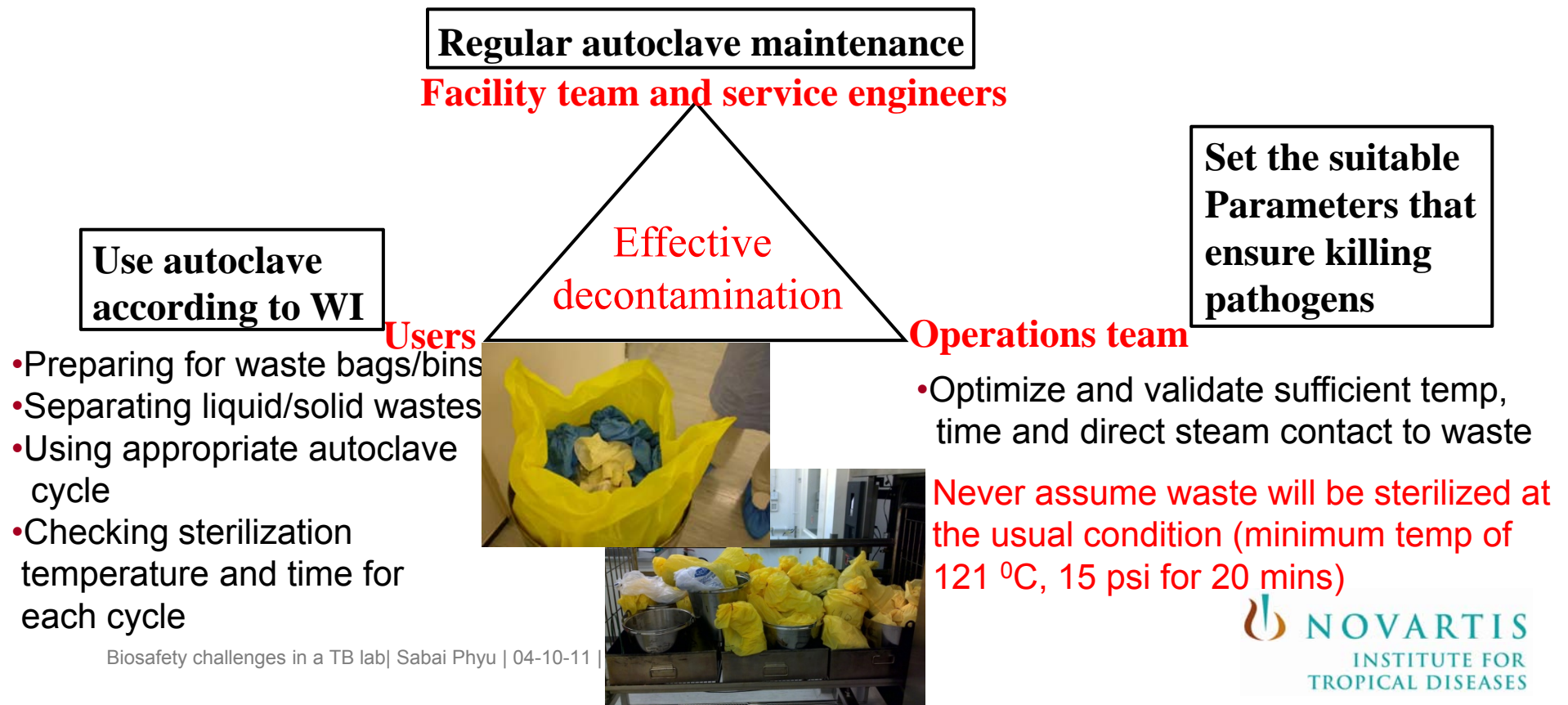
Work practice

Waste disposal

Infectious waste must be autoclaved or treated with chemicals on site prior to sending them out for incinerating or discarding into the drains

Use of autoclave

- Very effective decontamination equipment if **all parties involved use the autoclave in correct way**



Work practice

Emergency situations

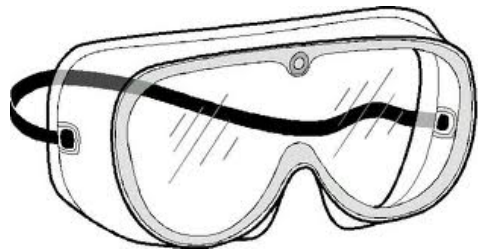
- Develop and implement written procedures for dealing with emergency situations
eg. fire, spills, medical emergency etc
- Clearly mention the responsibilities of staff involved in dealing with incidents in the SOP
- Have suitable supplies available for dealing with emergency situations
- Clarify who to report to about incidents
- Clarify follow-up procedures for staff involved in incidents
- Always re-analyse the incident and prepare the prompt corrective actions
- Regularly train staff for dealing with emergency situations



Work practice

Use of PPE effectively

- § Protection materials eg. scrubs, lab coat, gloves, face shield or goggles, respirators
- § To protect from contaminating with blood borne pathogens: puncture-resistant gloves



- Change gloves frequently
- Remember to take out gloves after using gloves to handle contaminated materials
- **PPE should not leave the lab**

Respirators for TB lab staff

- **Surgical masks do not provide any protection** from TB bacilli containing droplet nuclei (<5µm in diameter)
- Particulate mask respirator eg. N-95, P-95

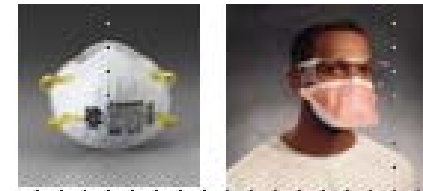
The minimum level of respiratory protection for TB recommended by NIOSH is the N-95 half-mask respirator.

Disadvantages

1. The respirator is a negative-pressure device using the suction produced by inhalation to draw air through the filter. The inhalation process, even under the best of circumstances, will allow some contaminated air to leak into the facepiece.



Ref: TB Respiratory protection program in health care facilities. Administrator's guide. US Department of Health and Human Services, Public Health Service, CDC & Prevention, National Institute for Occupational Safety & Health, 1999



- N-100, P-100 respirators is ideal? (NIOSH recommended in 1993)



- Half- or full-facepiece elastomeric mask

- Powered Air Purifying Respirator (PAPR): Better protection than N-95, N-100 and elastomeric mask but it is not feasible to be used for some circumstances



Work practice

Disposable respirator performance at work

§ Fit-testing

- How well a given respirator fits a given person by assessing leakage around the face seal
- To ensure at least the expected level of protection (The concentration of airborne contaminant inside the respirator is less than or equal to 10% of ambient levels)

NIOSH 1995

- Maintenance and care
- Training
- Programme evaluation

§ User seal-check

- Unreliable in detecting leakage

HK study in 2005 compared the user seal check and quantitative fit-testing (Derrick JL et al J Hospital Infect 2005: 59:152-5)

- Wrongly passed (mask fitted): 18–31% of occasions
- Wrongly not-passed (mask did not fit): 21–40% of occasions
- Its usefulness has been questioned

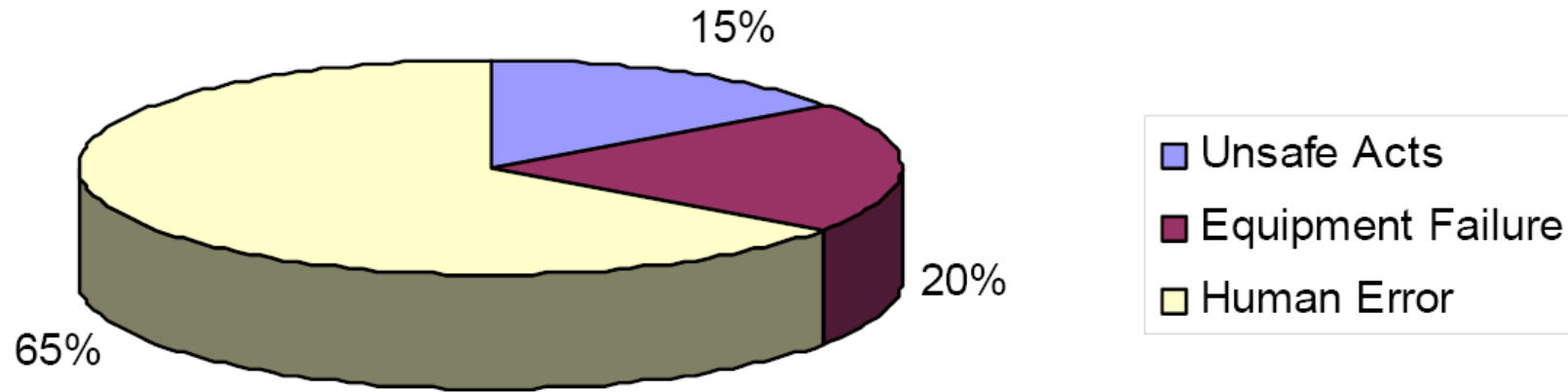
Government policies/guidelines for biosafety in Singapore

- ❖ Biological Agents and Toxin Act (BATA), **MOH**: M. tuberculosis complex agents (1st Sch, Part I)
: Environmental Mycobacterial (3rd Sch)
 - Regulates the following: possessing, handling, working and transporting biological agents/ toxin safety
<http://www.biosafety.moh.gov.sg/home/guidelines.aspx>
- ❖ Import & Export Regulation Division, **AVA, MND**: M. avium subsp. avium
: M. bovis
: M. paratuberculosis
 - Regulates import/export of biological agents
<http://www.ava.gov.sg/AnimalsPetSector/ImportExportTransOfAnimalRelatedPrd/VeterinaryBiologicsAndPathogens/>
- ❖ Workplace Safety and Health Act, **MOM**
 - Regulates the safety, health and welfare of persons at work in workplaces.
 - Covers any laboratory or other premises where the testing, examination or analysis of any article is carried out.
http://statutes.agc.gov.sg/non_version/cgi-bin/cgi_retrieve.pl?actno=REVED-354A
- ❖ Genetic Modification **Advisory Committee** (GMAC):
 - Biosafety guidelines for research on Genetically Modified Organisms (GMOs)
http://www.gmac.gov.sg/Index_Singapore_Biosafety_Guidelines_for_Research_on_GMOs.html

Laboratory acquired infections

Laboratory Acquired Infections

Adapted from: Phillips, G.B. *In Lab Safety: Principles & Practices*, 1st Ed.



Conclusions

- Mindset of the organization is important
 - Safety is not about inspection and penalties
 - **Safety is about inspection, monitoring, giving feedback and improving working practices**
 - Improve safety culture of the whole organization rather than focusing on lab safety only
 - Understanding some weak links in the laboratory
 - Relying a lot on engineering controls
 - :Negative pressure room and BSC will not be helpful if administrative, PPE and work practice controls are weak
 - :Use of autoclave without validating suitable parameters that ensure killing pathogens
 - Lack of verification when choosing suitable disinfectants,
 - Lack of verification when inactivating TB contaminated samples
 - **Laboratory staff shortage** (knowledgeable, skillful, motivated and committed staff)
 - Monitor and evaluate the effectiveness of current biosafety measures is important
- Are current biosafety measures practiced in the lab increasing or decreasing the risk of TB infection among lab staff?



Questions/Suggestions



Respirators

Efficiency of respirators

Different standard of respirators according to their filter efficiency

United States NIOSH standards define the following categories of particulate filters:

Minimally

Oil resistance	Rating	Description	Filter efficiency is tested against
Not oil resistant	N95	Filters at least 95% of airborne particles	0.3 µm particles
	N99	Filters at least 99% of airborne particles	
	N100	Filters at least 99.97% of airborne particles	
Oil Resistant	R95	Filters at least 95% of airborne particles	
	R99*	Filters at least 99% of airborne particles	
	R100*	Filters at least 99.97% of airborne particles	
Oil Proof	P95	Filters at least 95% of airborne particles	
	P99*	Filters at least 99% of airborne particles	
	P100	Filters at least 99.97% of airborne particles	

*No NIOSH approvals are held by this type of disposable particulate respirator.

European standard EN 143 defines the following classes of particle filters that can be attached to a face mask:

Class	Filter penetration limit (at 95 L/min air flow)
P1	Filters at least 80% of airborne particles
P2	Filters at least 94% of airborne particles
P3	Filters at least 99.95% of airborne particles

European standard EN 149 defines the following classes of "filtering half masks" (also called "filtering face pieces"), that is respirators that are entirely or substantially constructed of filtering material:

Class	Filter penetration limit (at 95 L/min air flow)	Inward leakage
FFP1	Filters at least 80% of airborne particles	<22%
FFP2	Filters at least 94% of airborne particles	<8%
FFP3	Filters at least 99% of airborne particles	<2%

Respirators

Choosing respirators

Choosing respirators depend on

1. Risk of exposure to biological agent
2. Durability and appropriateness for the task
3. Fitting
4. Comfortability

All re-usable respirators must be routinely inspected, cleaned, disinfected, repaired and maintained

Low risk procedure

- Sputum smear microscopy
- N95 (Not HEPA filter mask)

Medium risk procedure

- Decontaminate sputum
- Inoculate concentrated decontaminate sputum on media
- N95 or N100 or P100 mask (equivalent to HEPA filter)

High risk procedure

- Processing culture for smear, ID, subculture, DST, molecular testing
- Bronchoscopy or autopsy done on TB patients
- N-100 or Half- or full-facepiece elastomeric mask or loose fitting or hood PAPR

Route of exposure of lab-acquired TB disease

§ Most common routes of exposure:

- Inhaling aerosols



- Inoculation: Cut and puncture with contaminated sharps object
contamination of broken/non-intact skin
- Contamination of mucus membrane: Splash contaminated sample

§ However, causes cannot be identified for most cases with lab-acquired TB infection (*Pike and Sulkin* 1930 – 1978, 1979-2004 studies)

Engineering control

- Ventilation system (secondary barrier)



- Containment lab (secondary barrier)



- Biosafety cabinet (BSC) (primary barrier)

- Animal containment cage system (primary barrier)

- Other safety equipment eg. Effluent treatment system (primary barrier)



Autoclave



Centrifuge