How much does it cost?

A guide to estimating costs in health care

with a focus on TB diagnostics

Hojoon Sohn & Olivia Oxlade

July 8th, 2011

Agenda

- Defining costs
- Time preference issues in costing - discounting
- Types of costs
- Importance of study perspectives
- Identifying and quantifying costs
- Costing TB diagnostic interventions
- Assessing patient costs

How do we define Costs?

- It is a process of 'valuation' in monetary terms
- In more detail, it is "a **value** of money that has been used to **produce something**; therefore, it is not available for use anymore"
- Accounting/Financial cost

versus

- Economic/Opportunity cost

Accounting/Financial Cost

- Actual monetary flows on goods and services PURCHASED - more of a book-keeping process

- Usually evaluated in projects as capital costs + recurrent costs

- This is how normally people value certain goods and often are misleading - Why?

Answer

- Opportunity Cost!

Borne by spending money in present and future periods

What is opportunity cost?

- The cost of a good or service as measured by alternative uses that are foregone by producing the good or service

- Spending money (investing) on a good (e.g. New Gene-Xpert Machine) or services (paying for TB laboratory test) present day measured as the foregone opportunity of investing money and earning interest over expected life years of the goods and services purchased

"Time Preference"

- Future value of a good is ALWAYS less than present value - WHY?
- We generally have a 'time preference' - future cost are worth less, and hence "discounted" more, to reflect the individual and societal PREFERENCE to have resources and money NOW than in the future

$$Cost = f(time)$$

$$Cost_{today} = \frac{Cost_t}{(1+r)^r}$$

r = discount rate

Concept of annualization

- When recurrent costs are similar, it's useful to compute an equivalent annual cost of a project
- There are often difference in timing related to when costs of certain inputs are incurred and when they are used over the life time of a program

Two ways to annualize 'costs'

- Depreciation and financial costs
  - Capital costs are equally divided based on its expected life years
  - Concept of "depreciation" equate to how much is "consumed" over one year
- Economic annualization of cost
  - Capital costs are annualized based on discount rate, thereby taking into account the value of alternative opportunities for using the resources tied-up in the capital inputs as part of "cost"

Financial cost - example

Item	Year 1	Year 2	Year 3	Year 4	Year 5
Capital Item: MGIT Machine	$70000	0	0	0	0
Recurrent Item: Consumables	$15000	$15000	$15000	$15000	$15000
Recurrent Item: Labor	$20000	$20000	$20000	$20000	$20000
Total Annual Expenditure	$105000	$35000	$35000	$35000	$35000
Total Expenditure Over 5 years			$245000		

Straight-line depreciation/ discounting

Item	Year 1	Year 2	Year 3	Year 4	Year 5
Capital Item: MGIT Machine	$14000	$14000	$14000	$14000	$14000
Recurrent Item: Consumables	$15000	$15000	$15000	$15000	$15000
Recurrent Item: Labor	$20000	$20000	$20000	$20000	$20000
Total Annual Expenditure	$49000	$49000	$49000	$49000	$49000
Total Expenditure Over 5 years			$245000		

Annualization Factor

$$a(r,n) = \frac{r(1+r)^n}{(1+r)^n - 1}$$

where, r is discount rate and n is expected life years

Discount factor

- Allows us to evaluate “true” economic cost by factoring the opportunity cost of foregone income interest (r) from investing in a bank and earning interest INSTEAD of purchasing the capital

Now, what is the economic equivalent annual cost (r = 3%) from previous example?

Item	Year 1
Capital Item: MGIT Machine	$15288
Recurrent Item: Consumables	$15000
Recurrent Item: Labor	$20000
Total Annual Expenditure	$50288

MGIT machine cost over 5 years = $76,440

$76,440 ≠ $81,149

Factors depreciation @ 5 year life-expectancy

Total value after 5 years in bank deposit at r = 3%

$81,149 − $76,440 = $4,719

Cost of equipment depreciation

Choosing discount/interest rate

- Use discount rate set by the Economic Planning Office or Finance Ministry of the country in question
- Calculate the real rate of interest (e.g. the rate of interest that would be obtained by depositing the money in the bank minus the rate of interest)
- Choose between 3 - 5%: generally recommended value for health interventions (Gold et al., 1996; Drummond et al., 1997)
- May require sensitivity analysis

Application in costing

- Remember that annualization allowed us to evaluate cost of a capital item per YEAR (time) over its expected life years

- This time 'unit' aspect of annualized 'costs' are useful in micro-costing, particularly in time-motion studies

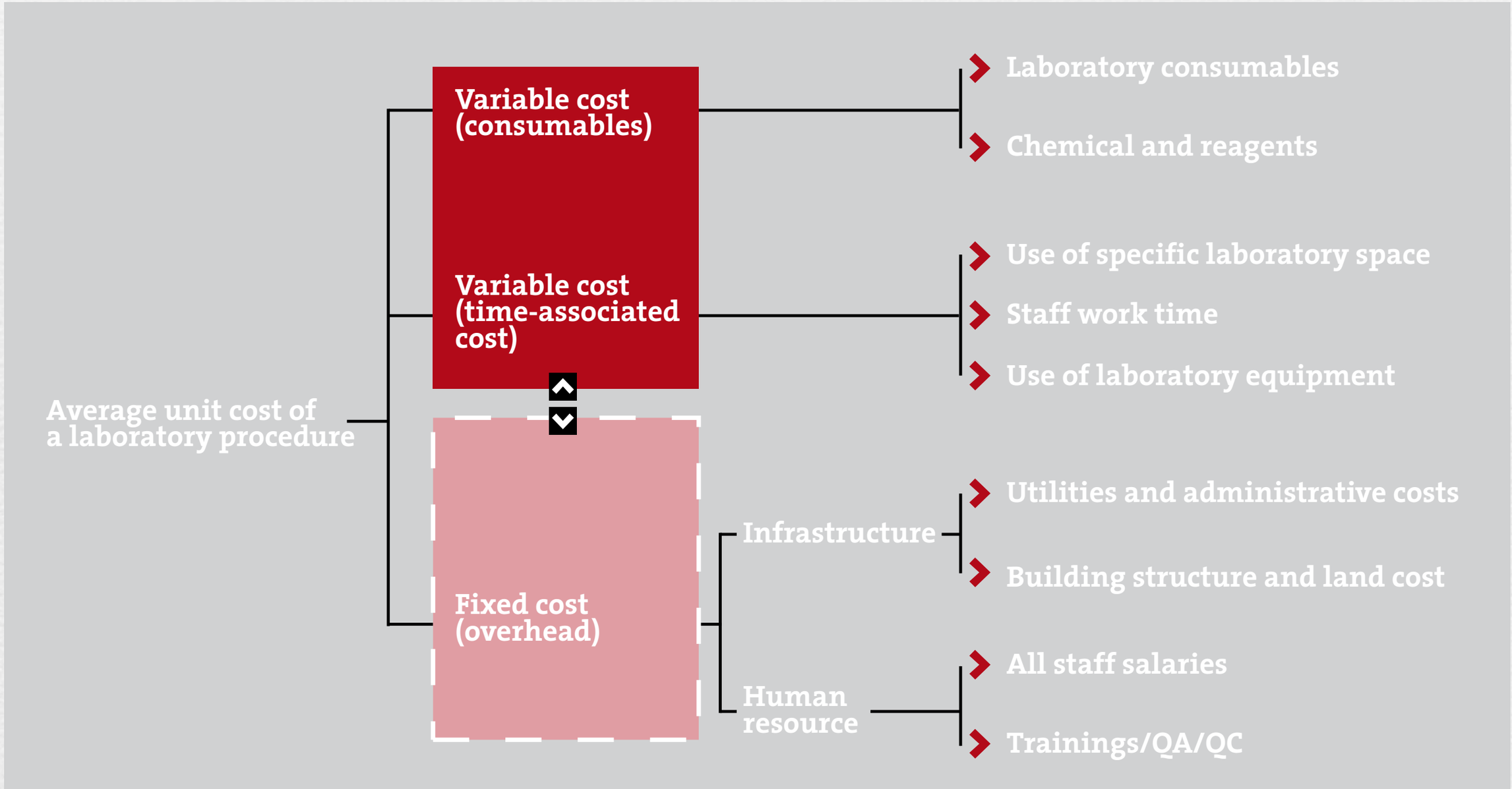
- Once we calculate annual cost (annualized capital cost + recurring cost), we can divided this number by total time 'observed' in equipment usage to process # of specimen (expressed in relevant time units)

$/year x year/minute x # minutes/use (or specimen) = $/specimen

Types of costs

- Direct - drugs, procedures, lab tests, hospital stay, ancillary services, out-of-pocket expenses, etc.
- Indirect - Time off from work, caregiver, production losses
- Intangible - pain, suffering
- Fixed cost - costs that are not dependent on the level of goods or services produced
- Variable cost - volume related costs that change in proportion to the activity (e.g. laboratory test)

Components of a unit cost of a laboratory procedure



Source: Sohn H et al. (2009). TB diagnostic tests: how do we figure out their costs? *Expert Review of Anti-Infective Therapy*, 7(6) 723-733(11).

Importance of study perspective

- In perfectly competitive market, unit cost represents the "true" value of resources - observed transaction prices equal the opportunity cost to society for the resources consumed ("societal perspective")
- Determines what relevant costs needs to be identified
- Unit cost depends on the stakeholder (next slide)

Perspectives of economic evaluation in health interventions	
Provider perspective	*Examples*
Direct costs associated with laboratory and other types of diagnostic services	Detailed cost of diagnostic services, laboratory staff costs, consumables costs and overhead costs (details presented in cost analysis section)
Direct costs associated with medical services	Detailed cost on hospital admission costs and treatment costs
Patient perspective	
Direct costs incurred by patient	All types of out-of-pocket payments for drugs and other types of treatment following diagnosis, cost of travel and income transfer payments
Time costs to patients and their families	Patient's time spent for travel and receiving treatment, lost time (salary) at work by patient and family
Productivity	Lost productivity due to illness resulting in reduced working capacity, costs to employer to hire and train replacement worker for patient

Perspective of the evaluation

- **Societal perspective:** aimed at capturing all costs associated for the general public - Generally, for public health projects, a societal perspective is recommended
- **Provider's perspective:** all costs associated for providing particular services
- **Patient's perspective:** all costs incurred by patients by partaking in a particular activity/ intervention/program (ex. Patient's costs associated with committing to DOTS/DOTS-plus program)

Diagnostic studies - study perspectives

In TB diagnostic studies, we are often limited to examining provider's perspective

1. Most studies focus on diagnostic accuracy

2. Differences in patient health outcomes as result of differences in diagnosis (e.g. use of Xpert result vs. routine) not often studied

3. Generally, it is difficult to accurately capture overall societal cost

Identifying and Quantifying costs

Micro-costing

- Identify specific components of intervention under study
- May require time and motion study (highly recommended in absence of prior standardized costs for compared interventions)
- Need to establish unit costs for resources

Macro-costing

- Identify "service bundles"
- Pre-supposes availability of unit cost
- Use of databases and payment transaction (or step-down accounting) or cost function regression

In TB diagnostics, micro-costing should be carried when possible

EXPERT REVIEWS

TB diagnostic tests: how do we figure out their costs?

Expert Rev. Anti Infect. Ther. 7(6), 723–733 (2009)

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Tuberculosis continues to be a major global health problem. Lack of accurate, rapid and cost-effective diagnostic tests poses a huge obstacle to global TB control. While several new diagnostic tools are being developed and evaluated for TB, it is important that new tools are introduced for widespread use only after careful validation of accuracy, impact as well as cost–effectiveness in real-world settings. While there are large numbers of studies on the accuracy of TB diagnostic tests, there are few studies that are focused on cost and cost–effectiveness. There are currently no widely accepted standards on how to evaluate costs of a TB test. In this review, we describe the basic approach for computing the costs of TB diagnostic tests, and provide templates for various data elements and parameters that go into the costing analysis. We hope this will pave the way for a standardized methodology for costing of TB diagnostic tests. Such a tool would enable improved and more generalizable costing analyses that can provide a strong foundation for more sophisticated economic analyses that evaluate the full economic and epidemiological impact resulting from the implementation and routine use of performance-verified new and innovative diagnostic tools. This, in turn, will facilitate evidence-based adoption and use of new diagnostics, especially in resource-limited settings.

KEYWORDS: cost • cost–effectiveness • diagnostic tests • TB

Planning cost analysis for TB diagnostic test

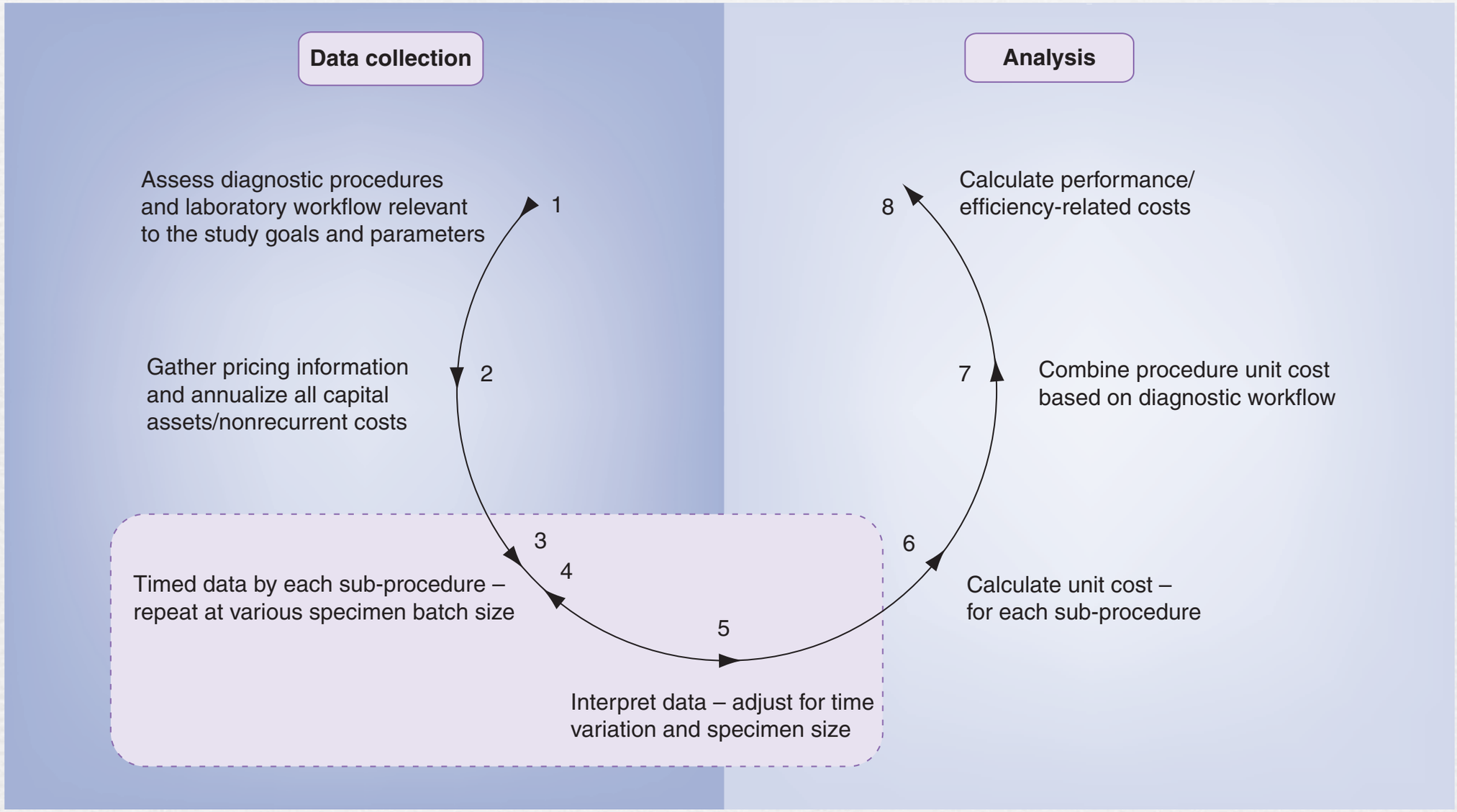


Figure 1. Planning for cost analysis in TB laboratory diagnostics. This diagram provides a step by step plan for cost analysis in evaluating TB diagnostic tests in various study settings. Steps 3, 4 and 5 should be undertaken for all the methods evaluated and relevant sub-procedures and repeated to capture data variations caused by specimen loads (and/or specimen batch size). In step 7, the investigator should consult laboratory experts regarding diagnostic workflow to reflect local laboratory practice in combining procedure unit costs.

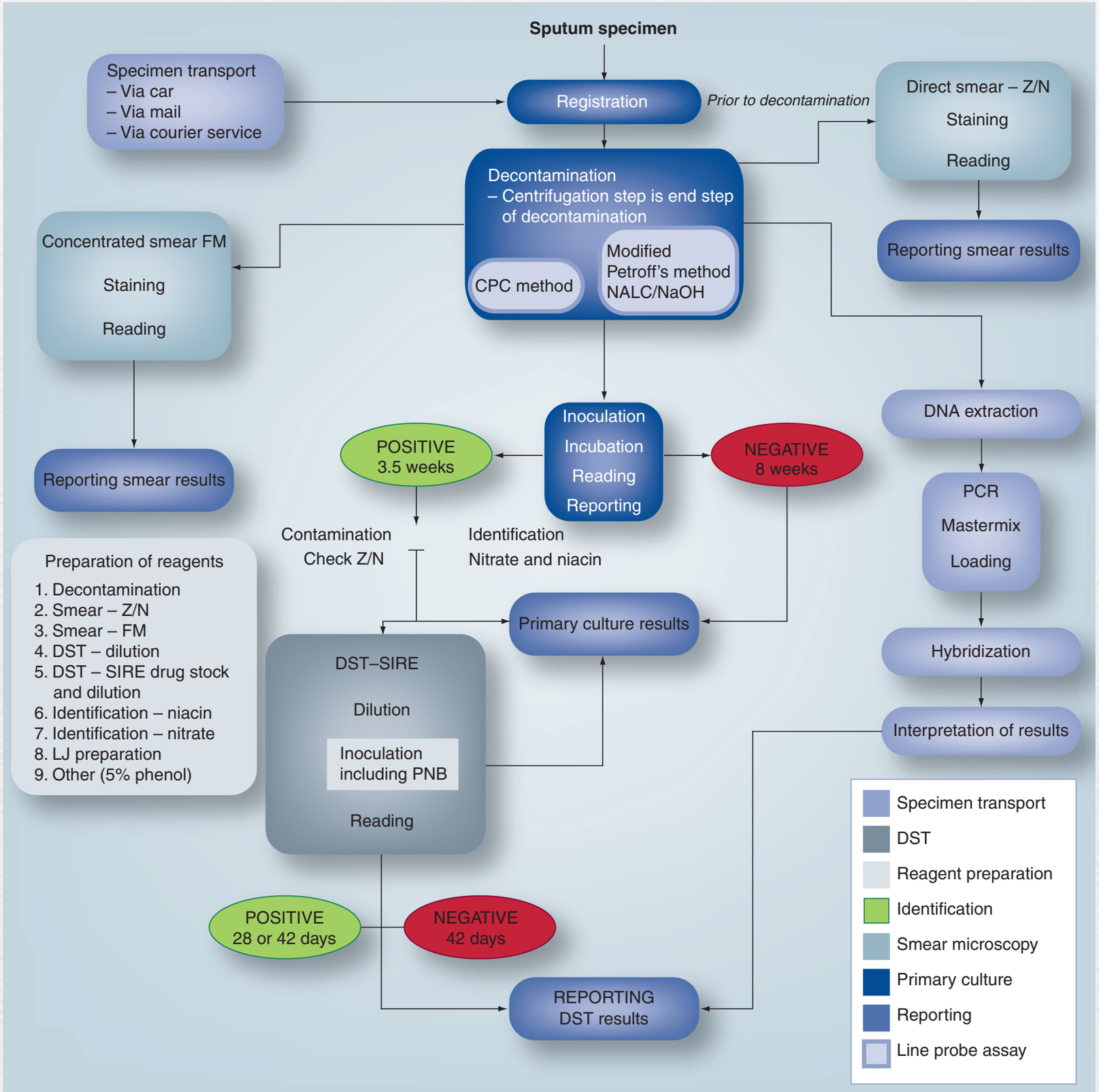


Figure 2. Example of diagnostic workflow of a TB culture laboratory with molecular diagnostic capacity. When first planning for a costing study, evaluating diagnostic workflow is essential in capturing all aspects of laboratory activities that need to be evaluated for costs. Shown is a generalized workflow observed in a laboratory where molecular testing for MDR-TB using a line probe assay is being evaluated against the conventional culture method using LJ in a demonstration study. Actual workflow at different laboratories may vary.

CPC: Cetylpyridinium chloride; DST: Drug susceptibility testing; FM: Fluorescent microscopy; LJ: Löwenstein Jensen; MDR: Multidrug resistance; NALC: *N*-acetyl-L-cysteine; Z/N: Ziehl-Neelsen.

Table 2. Cost data elements for cost analysis of TB diagnostics and suggested data sources.

Data element	Cost items	Suggested sources of data
Physical infrastructure	Construction	Construction contractors/government estates and building planning office/recent laboratory construction budget
	Maintenance contracts for all laboratory equipment requiring periodic maintenance	Laboratory financial records/laboratory or hospital accounts office/service contractors
Chemicals and reagents, and consumables	All types of chemicals and reagents utilized for diagnostic methods evaluated	Laboratory financial records/manufacturer catalog (must include all costs associated with procurement, usually at 25% of the catalog price)
	All types of general laboratory consumables (e.g., latex gloves, micropipette tips)	Laboratory financial records/manufacturer catalog (must include shipping costs)
Human resources	Laboratory staff salaries	Government salary scale/laboratory or hospital accounts office
	Laboratory staff allowances and benefits	Government salary scale/laboratory or hospital accounts office
	Staff training off-site	Laboratory records/interview
Training and quality assurance	Orientation training for new staff	Laboratory staff records
	External QA/QC for various laboratory diagnostic activities	Pricing/cost available through laboratory/hospital accounts office. List of QA/QC programs can be found in the general SOP
	Internal QA/QC	Cost can be evaluated as part of the general cost analysis using 'ingredients' approach. The full list of internal QA/QC procedures can be found in the general SOP
Specimen transport	Cost of a vehicle used for specimen transport – evaluated as purchased 'new'	Accounting office/autodealer
	Average distance traveled – annual figure	List of locations referring specimens to the laboratory
	Average driver salary	Accounting office
	Quantity of fuel used	Accounting office
	Fuel price	General market research, accounting office
	Insurance of vehicle	Accounting office
	Other consumables used in specimen transport	Accounting office

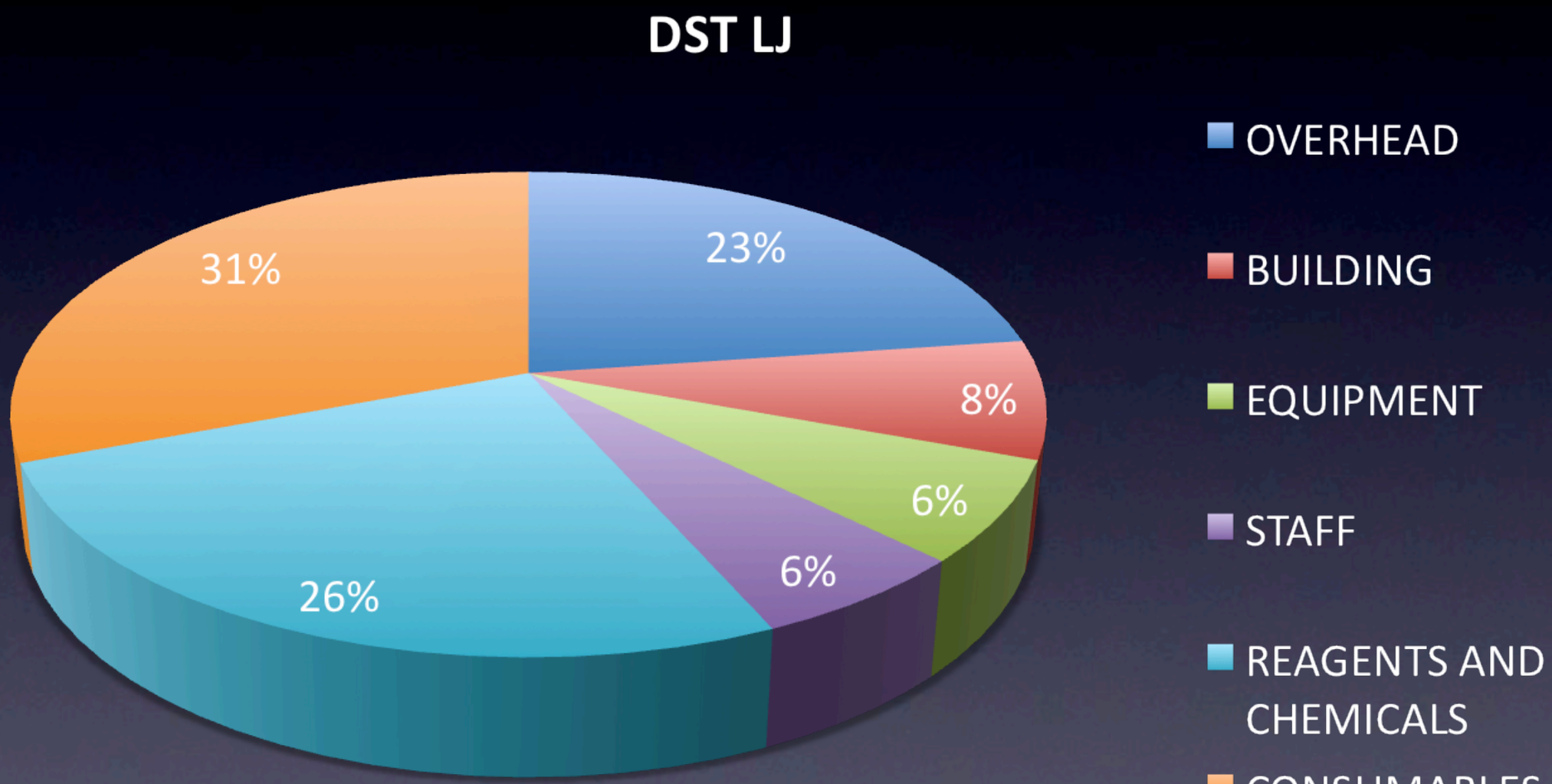
QA: Quality assurance; QC: Quality control; SOP: Standard operating procedure.

‘Cost *per* Test’ in USD (2007) - Thailand

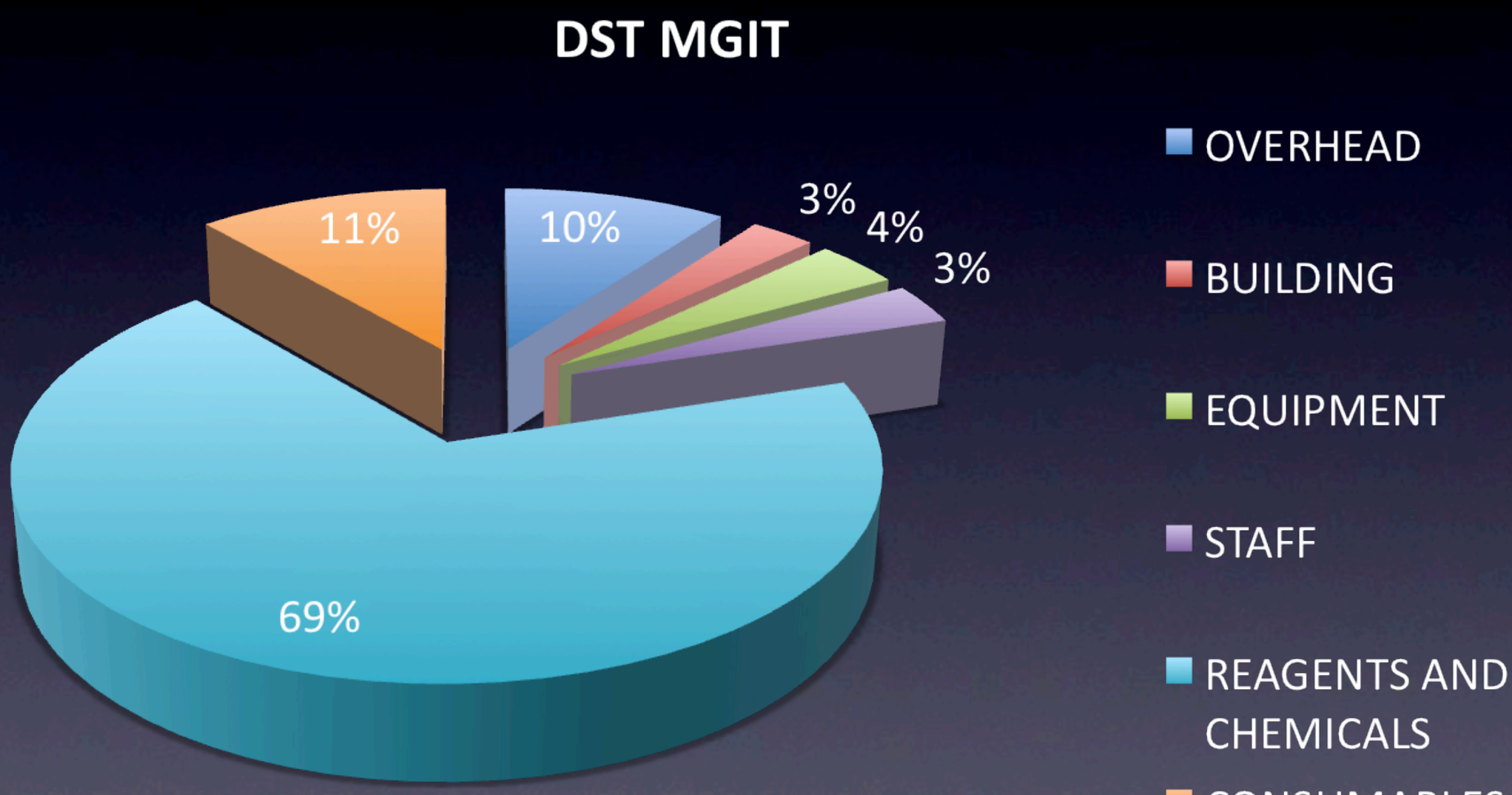
CASE FINDING	Preparation + Decon (Petroff’s)	SMC media prep	Microscopy	Subculture	MTB ID	TEST	Total
SMC	1.61	1.40	1.16	N/A	8.78	3.92	16.88
LMC	1.61	1.40	1.16	1.89	8.78	9.53	24.38

DST	Preparation + Decon (Petroff’s)	SMC media prep	Microscopy	Subculture	MTB ID	TEST	Total
SMC	1.61	4.91	1.16		8.78	15.35	31.81
LMC	1.61	1.40	1.16	1.89	8.78	40.11	54.95

Cost Drivers SMC - cost by resources



Cost Drivers LMC – cost by resources

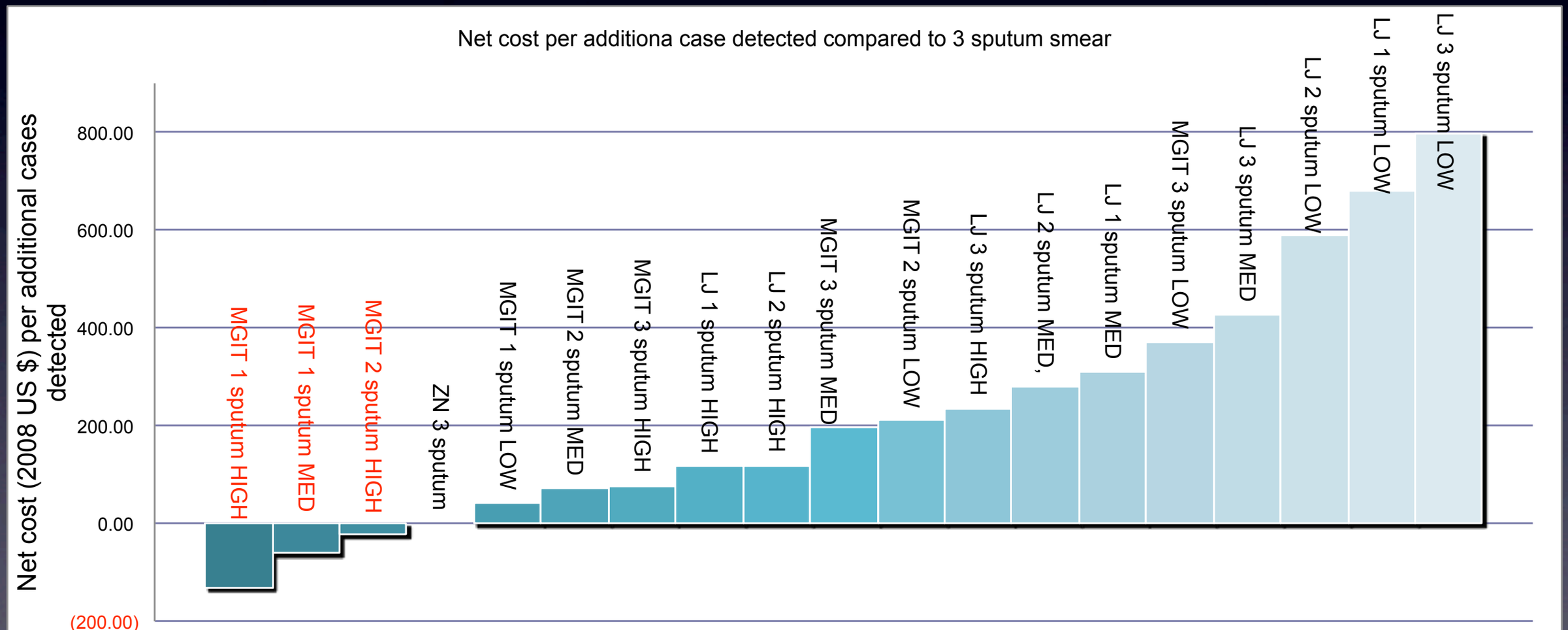


NET INCREMENTAL COST *per* 1000 MDR-TB patients treated – LJ DST as baseline

accounting for transmission/pricing/speed of diagnosis/false positives/cost of contamination

	MDR-TB Prevalence Groups				
Culture Methodology and LMC Pricing	**0.017**	**0.050**	**0.080**	**0.200**	**0.350**
MGIT	$6666	$1331	$501	$377	$126
MGIT 08	$5879	$1164	$434	$310	$88
MGIT 08 13% disc	$5698	$1125	$419	$294	$79
MGIT 08 17% disc	$5650	$1115	$415	$290	$77
MGIT 08 30% disc	$5461	$1074	$398	$273	$66
MGIT w/Capilia	$5915	$1095	$359	$144	-$85
MGIT 08 w/Capilia	$5105	$923	$290	$76	-$124

Net cost per additional cased detected - based on incremental yield study findings



A problem - no standard method in costing

Table 1. Summary of costing methodology utilized in various cost and cost–effectiveness studies evaluating TB diagnostics.

Focus of the study	Diagnostic systems evaluated	How was the cost of the diagnostic system evaluated?	Ref.
Comprehensive (performance and cost) comparison of ZN and FM in resource-poor setting	ZN and FM	Quoted separately as laboratory costs stratified by labor, investment (equipment), and running costs based on 50 ZN and 80 FM slides per day	[18]
Complete economic assessment of laboratory costs associated with ZN and FM in Thailand	ZN and FM	Comprehensive assessment of all economic costs (overhead, building, equipment, staff, chemicals, reagents and consumables) associated with each diagnostic tool based on direct observation and time analysis from a health services perspective	[19]
Costs and cost–effectiveness of use of liquid media culture in Zambia	LJ (home-made vs commercially purchased) and MGIT (automated vs manual)	Reported as culture specific (consumables, equipment and staff) and overhead (e.g., building, electricity and transportation) costs evaluating all costs associated with the laboratory only based on observation and review of expenditure logs	[24]
Cost–effectiveness of IFN-γ release assays in screening TB suspects and contacts in high-income countries	Tuberculin skin test, chest x-ray, QuantiFERON®-TB Gold, T-SPOT.TB®	Manufacturers' unit pricing and estimated cost of laboratory staff for relevant test	[20–22]
Cost and cost–effectiveness of rapid alternative diagnostic methods in screening for MDR-TB in Peru	Indirect LJ, direct LJ, INNO-LiPA, FASTPlaque-Response, MTT assay	Comprehensive assessment from a health services perspective of direct and indirect laboratory costs associated with each respective diagnostic method based on a time observation and 'ingredients' approach	[25]
Cost–effectiveness of molecular based diagnostic method for TB used routinely on smear-positive specimens	AMPLICOR *Mycobacterium tuberculosis* and Amplified *Mycobacterium tuberculosis* Direct (MTD) test	Manufacturers' unit pricing, accounting cost figures and estimated cost of laboratory staff for relevant test	[23]

DST: Drug susceptibility testing; FM: Fluorescent microscopy; LJ: Löwenstein–Jensen; MDR: Multidrug resisant; MGIT: *Mycobacterium* growth indicator tube; MTT: 3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide, a tetrazole; ZN: Ziehl-Neelsen.

Approaches to costing - capturing the patient perspective

Including the patient perspective

- In early 2000, few studies had included patient perspective in costing studies
- Developed a "Patient Cost Questionnaire" for active TB patients
- Based on world Bank questionnaire "Measuring the impact of fatal adult illness in Sub-Saharan Africa - An Annotated Household Questionnaire" by Ainsworth et al.

Since 2002 - survey has been used on TB patients in: Haiti, Dominican Republic, Ecuador, Zambia, Malawi, Brazil, China, India, Netherlands, UK, US (Miami & NY) and Canada

The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL ARTICLE

Domestic Returns from Investment in the Control of Tuberculosis in Other Countries

Kevin Schwartzman, M.D., M.P.H., Olivia Oxlade, M.Sc., R. Graham Barr, M.D., Dr.P.H., Franque Grimard, Ph.D., Ivelisse Acosta, M.D., Jeannette Baez, M.D., Elizabeth Ferreira, M.D., Ricardo Elías Melgen, M.D., Willy Morose, M.D., Arturo Cruz Salgado, D.D., M.P.H., Vary Jacquet, M.D., Susan Maloney, M.D., Kayla Laserson, Sc.D., Ariel Pablos Mendez, M.D., M.P.H., and Dick Menzies, M.D.

INT J TUBERC LUNG DIS 12(8):928–935

Cost of tuberculosis diagnosis and treatment from the patient perspective in Lusaka, Zambia

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BMC Public Health

BioMed Central

Research article

Open Access

Impact of DOTS expansion on tuberculosis related outcomes and costs in Haiti

Vary Jacquet†1, Willy Morose†1, Kevin Schwartzman†2, Olivia Oxlade†2, Graham Barr†3, Franque Grimard†4 and Dick Menzies*†2

Assessing Patient Costs due to Tuberculosis (TB)

Questionnaire 1-2 months treatment

Principal Investigator: Dr Dick Menzies
Respiratory Epidemiology Unit
McGill University, Montreal

Funded by: The Canadian Institute for Health Research
January 2007

- Interviewer administered
- Diagnosed active TB cases
- Administered at 2 months following diagnosis (to aid with recall)

Types of patient costs

- Patients' families' out-of-pocket=direct expenditures
- lost wages (including time caring for ill family members)=indirect costs
- plus productivity losses resulting from disability and death

Considered costs by phase of disease

- Pre-diagnostic period
- Diagnostic period
- Hospitalization period
- DOTS/medical follow up period
- Events throughout illness (i.e. additional help and other “intangible costs”)

Pre-diagnostic Period

- Number of visits to different "health facilities" prior to diagnosis
- Related out of pocket/direct expenditures (prescriptions, syrups, etc.)

41. What did you or your accompanier have to pay for at this establishment or following your appointments?

WRITE ZERO here if patient had no expenditures:_____

WRITE TOTAL if patient only knows total amount:_____$

	Amount	Per Visit	Total
Parking		☐	☐
Travel		☐	☐
Registration fee		☐	☐
Paperwork fee		☐	☐
Consultation		☐	☐
Blood Tests		☐	☐
Medication (TB or Non-TB)		☐	☐
X-ray		☐	☐
Food		☐	☐
Other (Specify _____		☐	☐

Pre-diagnostic Period

- And indirect costs:
  - Travel time
  - Waiting time
  - Family accompanier time
- For each visit, to each health facility, prior to correct TB diagnosis

Diagnostic Period

- Similar to questions that related to pre-diagnostic period, but with emphasis on different out of pocket/direct expenditures (i.e. diagnostic test costs)
- Hospitalization costs during diagnosis captured in subsequent section
- Treatment and medical follow-up captured in subsequent sections

Translating time to money - indirect costs

- Originally tried to calculate wages for each individual patient - very difficult!!
  - Many patients changed jobs regularly
  - Some had changed work because of illness
  - Some were not working (related or unrelated to illness)
  - Trying to capture changes over time = complex
  - Trying to come up with average = impossible
  - One solution is to use average per capita GPD/average number of hours worked = average hourly wage
  - Representative of TB patients?

How does this translate into a total diagnostic and treatment cost?

((cmedicalvisit+cindirectmedicalvisit
+cdirectmedicalvisit)*avepdvisitDOTS)+((cmedicalvisit
+cindirectmedicalvisit+cdirectmedicalvisit+(clab))+
(chospital+cdirecthospital
+cindirecthospital)*avehospdayDOTS)+((ctreatmentDOTS
+cDOTvisit+cindirectDOTvisit+cdirectDOTvisit))*75+
((cfuvisit+cdirectfuvisit+cindirectfuvisit)*6)

How does this translate into a total cost?

PRE-DIAGNOSIS:
((cmedicalvisit+cindirectmedicalvisit+cdirectmedicalvisit)*avepdvisit))

DIAGNOSIS:
((cmedicalvisit+cindirectmedicalvisit+cdirectmedicalvisit+(clab))

HOSPITALIZATION:
((chospital+cdirecthospital+cindirecthospital)*avehospdayDOTS))

DOT VISITS:
((ctreatmentDOTS+cDOTvisit+cindirectDOTvisit+cdirectDOTvisit))*75

MEDICAL FOLLOW UP VISITS:
((cfuvisit+cdirectfuvisit+cindirectfuvisit)*6)

How does this translate into a total cost?

PRE-DIAGNOSIS:
((cmedicalvisit+cindirectmedicalvisit+cdirectmedicalvisit)*avepdvisit))

DIAGNOSIS:
((cmedicalvisit+cindirectmedicalvisit+cdirectmedicalvisit+(clab))

HOSPITALIZATION:
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((cmedicalvisit+cindirectmedicalvisit+cdirectmedicalvisit+(clab))

HOSPITALIZATION:
((chospital+cdirecthospital+cindirecthospital)*avehospdayDOTS))

DOT VISITS:
((ctreatmentDOTS+cDOTvisit+cindirectDOTvisit+cdirectDOTvisit))*75

MEDICAL FOLLOW UP VISITS:
((cfuvisit+cdirectfuvisit+cindirectfuvisit)*6)

Table 3: Summary of health system and patient costs in Haiti

	MEAN	(SD)	SOURCE
Pre-Diagnosis			
Total Time (onset of symptoms to diagnosis)	4.4 months	(3.5 months)	PCQ
Number of Visits	4.7	(7.2)	PCQ
Cost to health system for visits (total)	$16.31		
Lab costs (per patient – 3AFB smears)	$4.46	(--)	[53]
Patients out-of-pocket: for visits (total)	$40.55	($138)	PCQ
Miscellaneous	$22.87	($116.85)	PCQ
Lost income for patient/family: for visits	$6.19*		PCQ
Miscellaneous	$61.71*		PCQ
Hospitalization			
N (%) hospitalized	47 (56%)		
Average length of stay (for all 84)	21.3 days	(27.2)	PCQ
Health system costs (per patient)	$321.00	(--)	HFQ
Patient out-of-pocket (per hospitalization)	$92.69	($323.41)	PCQ
Lost income for patients and family	$29.40*	($44.37)	PCQ
Direct Observation of Treatment (DOT)			
Number of visits	75	--	NTP
N (%) on DOT	43 (51%)	--	
Health system costs: for DOT (total)	$48.75	--	HFQ
For drug costs (new case)	$20.93	--	**
Patient out-of-pocket expenses (total)	$56.25	($141.00)	PCQ
Lost income for patient and family	$20.40*	($25.50)	PCQ
Follow-up (Medical Check Up)			
Number of visits	6	--	NTP
Health system costs (total)	$20.82	--	HFQ
Patient out-of-pocket expenses	$1.88	($11.65)	PCQ
Lost income for patient and family	$2.35*	($3.67)	PCQ
Total cost per TB patient treated			
Health system	$432.27		
Patient and Family: out-of-pocket costs	$214.24		
Lost Income	$120.05		
Total patients and families	$334.29		

Notes:
* Income = $0.17 (US) per hour based on average per capita GNI ($440) (reference 9)/2496 hours (= 48 hours × 52 weeks)
PCQ = Patient cost questionnaire
HFQ = Health facility questionnaire
NTP = National TB programme guidelines
** = Prices for drugs in DOTS areas from [86], and 1.4 times higher in non-DOTS areas [15;16]

Jacquet et al, **Impact of DOTS expansion on tuberculosis related outcomes and costs in Haiti,** *BMC Public Health 2006,* ***6:209***

Events throughout illness - additional help

- Measured additional help sought from start of illness (e.g. either paid or unpaid help to cook & clean)
- Additional products purchased due to your illness:
  - energy drinks/vitamins
  - syrups
  - more meat in diet
- Incorporated into cost estimates

Events throughout illness - intangible costs

- Question: throughout your illness, how has your household routine changed since you have been diagnosed with TB? (This includes changing rooms to sleep, using different utensils and dishes)
- Question: How has TB affected your family (your children or between you and your partner)?