Economic Costing of bacteriology testing in Sierra Leone for Sustainability of AMR Surveillance: a micro-costing analysis

Supplementary Material 1

Comprehensive formula sheet for bacteriology test micro-costing (Tables 2–9)

Table 2. Per-test input costs for reagents and consumables

Equations

$$UnitCost\_i = BulkCost\_i \,/\, BulkQty\_i$$
$$CostPerTest\_i = UnitCost\_i * QtyPerTest\_i$$
$$TotalReagentsCost = \Sigma\_i \, CostPerTest\_i$$

Definitions of terms

i: reagent/consumable line item (e.g., blood agar base, antibiotic discs).
BulkCost_i: purchase cost of the bulk pack for item i (USD).
BulkQty_i: number of units in the bulk pack for item i (e.g., g, mL, discs).
UnitCost_i: unit price per unit of measure for item i (USD per unit).
QtyPerTest_i: quantity of item i used per test episode (in the same units as BulkQty_i).
CostPerTest_i: allocated cost of item i per test (USD/test).
TotalReagentsCost: sum of all reagent/consumable costs per test (USD/test).

Key assumptions

Quantities per test are based on the standard bacteriology workflow (e.g., culture media plates per episode etc.). Where composite consumables are tracked in bulk, per-test quantities are derived from average monthly acquisition divided by throughput.

Table 3. Per-test input costs for quality-control materials

Equations

$$CostPerQCEvent\_j = UnitCost\_j * QtyPerQCEvent\_j$$
$$AllocationFactor = QCEventsPerYear \,/\, TestsPerYear$$
$$QCCostPerTest\_j = CostPerQCEvent\_j * AllocationFactor$$
$$TotalQCCost = \Sigma\_j \, QCCostPerTest\_j$$

Definitions of terms

j: QC resource line item (e.g., control strain, QC plate inputs).
QtyPerQCEvent_j: quantity of QC resource j used per QC run (technical quantity).
CostPerQCEvent_j: cost of a single QC run for resource j (USD per QC event).
QCEventsPerYear: number of QC events conducted annually (events/year).
TestsPerYear: annual bacteriology test throughput (tests/year).
AllocationFactor: QC events allocated per test (dimensionless).
QCCostPerTest_j: per-test allocated QC cost for resource j (USD/test).

TotalQCCost: total allocated QC cost per test (USD/test).

Key assumptions

If QC is performed once per N tests, AllocationFactor = 1/N (e.g., N = 20 computes to 0.05). Where annual QC expenditure is used (e.g., for control strains), QCCostPerTest = AnnualQCCost / TestsPerYear.

Table 4. Time estimates per test for laboratory staff activities (manual and automated workflows)

Equations

$$Hours\_t = Minutes\_t / 60$$
$$TotalHours\_role = \Sigma\_\{t \in role\}\, Hours\_t$$
$$TotalHours\_Test = \Sigma\_roles\, TotalHours\_role$$

Definitions of terms

t: task within the standard operating procedure (e.g., Gram stain, plate reading).
Minutes_t: observed/assumed minutes required for task t.
Hours_t: task time expressed in hours.
role: staff category (e.g., technician, microbiologist).
TotalHours_role: total hours per test attributable to a given role.
TotalHours_Test: combined labour hours per test across roles.

Key assumptions

Task times reflect standard procedures and time-motion estimates used in the costing workbook. Manual and automated workflows are parameterised separately; differences reflect streamlined steps under automation.

Table 5. Labour cost per test

Equations

$$HourlyWage\_r = AnnualCompensation\_r / AnnualWorkingHours\_r$$
$$LabourCostPerTest\_r = HourlyWage\_r * TimePerTest\_r$$
$$TotalLabourCost = \Sigma\_r\, LabourCostPerTest\_r$$

Definitions of terms

r: staff category (e.g., Medical Laboratory Technician; Medical Laboratory Scientific Officer/Microbiologist).
AnnualCompensation_r: annual gross compensation (salary plus allowances) for staff category r (SLE/year or USD/year).
AnnualWorkingHours_r: annual paid working hours (hours/year).
HourlyWage_r: implied wage per hour (currency/hour).
TimePerTest_r: average time spent per test by staff category r (hours/test), from Table 4.
LabourCostPerTest_r: per-test labour cost for category r (currency/test).
TotalLabourCost: sum of labour cost across staff categories (currency/test).

Key assumptions
AnnualWorkingHours is set to 2,112 hours/year (or the value used in the workbook).
Wage inputs are taken from the selected salary source and converted consistently to the analysis currency.

Table 6. Annualised capital cost per test using the equivalent annual cost method

Equations

$$EAC\_k = P\_k * [\, r * (1 + r)\^\{n\_k\} \,] / [\, (1 + r)\^\{n\_k\} - 1 \,]$$
$$CapitalCostPerTest\_k = EAC\_k / TestsPerYear$$
$$TotalCapitalCost = \Sigma\_k\ CapitalCostPerTest\_k$$

Definitions of terms
k: capital equipment item (e.g., incubator, autoclave, biosafety cabinet).
P_k: replacement (landed/CIF-adjusted) price for equipment k (currency).
r: annual discount rate used for capital annualisation (decimal).
n_k: useful life of equipment k in years.
EAC_k: equivalent annual cost for equipment k (currency/year).
CapitalCostPerTest_k: allocated annualised capital cost per test (currency/test).
TestsPerYear: annual bacteriology test throughput (tests/year).
TotalCapitalCost: sum of annualised capital costs across equipment items per test.

Key assumptions
Capital prices are valued at replacement (landed) cost, where required, CIF/landed adjustment factors are applied at an assumed rate of 1.12. The base-case discount rate is r = 0.03, with sensitivity analysis at alternative rates. Useful life (n) is set per assumption 7 years.

Table 7. Utilities allocation per test (water-only and electricity-inclusive scenarios)

Equations

$$AnnualUtilityCost\_u = MonthlyBill\_u * 12$$
$$AllocatedUtilityCost\_u = AnnualUtilityCost\_u * AllocationShare\_u$$
$$UtilityCostPerTest\_u = AllocatedUtilityCost\_u / TestsPerYear$$
$$TotalUtilitiesCost = \Sigma\_u\ UtilityCostPerTest\_u$$

Definitions of terms
u: utility type (e.g., water, electricity, generator fuel if treated as a utility input).
MonthlyBill_u: monthly utility expenditure for utility u (SLE/month or USD/month).
AnnualUtilityCost_u: annual utility expenditure for utility u (currency/year).
AllocationShare_u: proportion of total utility cost attributable to bacteriology activity (decimal).
AllocatedUtilityCost_u: annual utility cost attributed to bacteriology (currency/year).
UtilityCostPerTest_u: allocated utility cost per test (currency/test).
TotalUtilitiesCost: sum of allocated utility costs per test across utilities.

Key assumptions

AllocationShare is based on the agreed allocation rule of 0.3. Electricity-inclusive scenarios incorporate generator-backed power costs consistent with the scenario definition.

Table 8. Base-case unit cost build-up and overhead allocation

Equations

$$DirectCost = UnitReagentsCost + UnitLabourCost + UnitEquipmentCost + UnitUtilitiesCost + UnitQCCost$$

$$Overhead = OverheadRate * DirectCost$$

Definitions of terms

DirectCost: total direct cost per test (currency/test).
OverheadRate: fixed overhead allocation rate applied to direct costs (decimal).
UnitCost: per-test costs computed with consideration for 10,000 sample throughput

Key assumptions

OverheadRate is set to 0.10 (10% of total direct costs) unless otherwise specified.

Table 9. Scenario analysis modifiers (automation, inflation, and power-reliability assumptions)

Equations

$$DirectCost\_s = \Sigma\_c\ ComponentCost\_\{c,s\}$$

$$Overhead\_s = OverheadRate * DirectCost\_s$$

$$UnitCost\_s = DirectCost\_s + Overhead\_s$$

$$ComponentCost\_\{c,s\} = ComponentCost\_\{c,base\} * (1 + InflationRate\_s)$$

$$\Delta UnitCost\_s = UnitCost\_s - UnitCost\_base$$

Definitions of terms

s: scenario (e.g., manual base case; automated; automated + generator; inflation scenarios).
c: cost component category (reagents, labour, capital, utilities, QC).
ComponentCost_{c,s}: cost per test for component c under scenario s.
InflationRate_s: scenario-specific inflation assumption applied to affected prices.
UnitCost_s: total unit cost per test under scenario s (currency/test).
ΔUnitCost_s: incremental change in unit cost relative to base case (this is where comparisons to the base-case have been made)

Key assumptions

- Automation scenarios modify labour time inputs (Table 4) and may change utilities depending on power requirements.
- Generator scenarios include electricity/fuel-related utilities as specified.
- Inflation scenarios apply uniform price uplifts to the designated affected input categories in the workbook.

Final combined formula for per-test unit cost (all components)

$$UnitCost = [\Sigma\_i(UnitCost\_i * QtyPerTest\_i) + \Sigma\_r(HourlyWage\_r * TimePerTest\_r) + \Sigma\_k(EAC\_k/TestsPerYear) + \Sigma\_u((MonthlyBill\_u * 12) * AllocationShare\_u/TestsPerYear) + \Sigma\_j(CostPerQCEvent\_j * AllocationFactor)] * (1 + OverheadRate)$$

This expression sums

(i) reagents/consumables,
(ii) labour,
(iii) annualised capital,
(iv) utilities, and
(v) quality-control allocations

to obtain the direct cost per test, and then applies the overhead rate multiplicatively to yield the full unit cost per test.

Global assumptions used in the base case

1. Exchange rate: as specified in the analysis (SLE per USD).
2. CIF/landed adjustment factor: as specified for replacement pricing of capital equipment and imported inputs.
3. Discount rate for capital annualisation (EAC): base case r = 3% with sensitivity analysis at alternative rates.
4. Annual throughput (TestsPerYear): base case = 10,000 tests/year (modify for district laboratories as appropriate).
5. Overhead allocation: 10% of total direct costs.