Procalcitonin-Guided Antimicrobial Stewardship for Sepsis and Lower Respiratory Tract Infections: A Budget Impact Analysis for the Perspective of the Patients in India

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Background

- Antimicrobial resistance (AMR) is a global health priority, causing millions of deaths each year. LMICs, including India, carry a disproportionate share of the AMR burden.
- In India, AMR is fueled by inappropriate antibiotic use, prolonged hospitalizations, self-medication, over-the-counter access, and weak regulation.
- Sepsis and lower respiratory tract infections (LRTIs) are major drivers of antibiotic use and AMR, with high mortality and economic burden.
- National guidelines for antimicrobial stewardship exist, but programs remain fragmented and mostly limited to tertiary hospitals.
- Procalcitonin (PCT) distinguishes bacterial from non-bacterial infections and supports rational antibiotic use.
- The kinetics of PCT (rapid rise and short half-life) make it a reliable marker to monitor treatment response in sepsis and LRTI.
- The clinical and economic consequences of PCT-guided stewardship in India have not been evaluated.

Objectives

To evaluate the clinical and economic impact of PCT-guided antimicrobial stewardship in ICU patients with suspected sepsis and hospitalized patients with LRTI in India

Methods

Model design: Adapted a published decision tree model (Mewes et al, 2019) to the Indian context to evaluate PCT-guided antimicrobial stewardship vs. standard care.

Settings and populations:
- ICU patients with suspected sepsis
- Hospitalized ward patients with LRTI

Perspective & horizon: Indian patient perspective; 1-year horizon (no discounting applied).

Clinical outcomes: Antibiotic treatment duration and number of antibiotic-resistant cases avoided.

Economic outcomes: Annual economic impact at system level (₹) and per 1,000 patients.

Model inputs: Derived from literature (local & international) and validated by an expert panel of Indian infectious disease clinicians.

Key assumptions:
- All suspected sepsis patients admitted to ICU and treated empirically with antibiotics.
- LRTI patients managed in wards, not uniformly started on antibiotics at admission.
- Average of 3 PCT tests per patient in both groups.

Cost inputs: Based on private hospitals and diagnostic labs across multiple Indian regions; values adjusted to March 2025 INR.

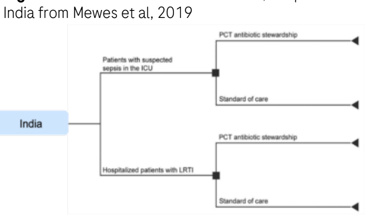
Sensitivity analyses:
- Deterministic (univariate; tornado plots) to identify key drivers.
- Probabilistic & scenario analyses planned to test robustness under uncertainty.

Scenario analyses were performed to explore the robustness of the model under alternative assumptions
- Scenarios for Sepsis:
  - Including savings only from reduction in antibiotic use
  - Reduction due to PCT in length of stay in general ward, 3.5 days[1] instead of 0
  - Reduction due to PCT in length of stay in ICU, 2.05 days[1] instead of 0
  - Reduction due to PCT in days on antibiotic therapy, 0.99 days[2] instead of 2.79
  - Reduction due to PCT in days on antibiotic therapy, 1.79 days[3] instead of 2.79
- Scenarios for LRTI:
  - Assuming no reduction in antibiotic prescription rate
  - Assuming no reduction in antimicrobial resistance
  - Including savings only from reduction in antibiotic use
  - Assuming an antibiotic prescription rate of 100% in the standard of care

Results

- **Antibiotic use:** 49.0 million treatment days avoided annually.
- **Resistance cases:** 1.1 million fewer antibiotic-resistant infections each year.
- **Cost savings:**
  - ₹18,024.5 per sepsis case
  - ₹15,650.7 per LRTI case
- **System impact:**
  - ₹302.18 billion saved annually
  - ₹18.0 million per 1,000 sepsis patients
  - ₹15.7 million per 1,000 LRTI patients
- **Probabilistic analysis:** Cost-saving in all scenarios
- **Key drivers (deterministic analysis):** Antibiotic days reduced, number of PCT tests, antibiotic and PCT test costs
- **Scenario analysis:** Savings were sustained across all tested assumptions in both sepsis and LRTI settings, confirming robustness even under conservative conditions.

Figure 1: Decision tree model structure, adapted for India from Mewes et al, 2019



ICU=intensive care unit; LRTI=lower respiratory tract infection; PCT=procalcitonin

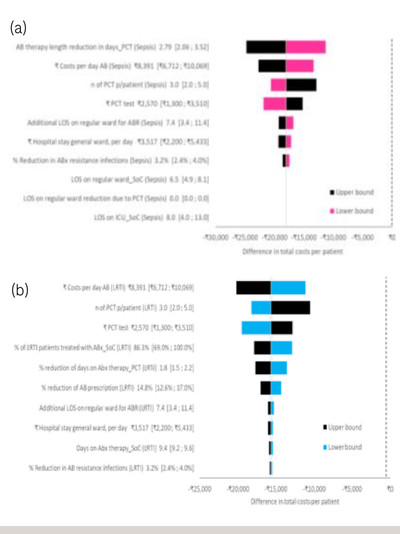


Figure 2: Tornado diagram depicting deterministic sensitivity analysis showing the impact of parameter variations on costs results per patient (a) with suspected sepsis admitted in ICU and, (b) hospitalized with LRTI. India, 2025.

PCT=procalcitonin; ABx=antibiotics; LOS=Length of stay; SOC=Standard of care; ICU=intensive care unit; LRTI=lower respiratory tract infection; AMR=antimicrobial resistance

Table 1: Model parameters for sepsis and LRTI. Epidemiological, resource use, effectiveness of PCT-guided antimicrobial stewardship and unit costs.

Parameter	Base Case	Lower Bound	Upper Bound	Source
A. Patients With Suspected Sepsis in ICU				
1. Epidemiology				
Number of cases per year	9,719,505	7,452,148	13,214,061	(1, 2)
AMR prevalence in general population, %	44.8%	23.0%	67.0%	(2)
2. Resource use				
Average antibiotic treatment duration (days)	10.0	7.0	28.0	Expert opinion, based on (3, 4)
Average LOS in regular ward (days)	6.5	4.9	8.1	(5)
Average LOS in ICU (days)	8.0	4.0	13.0	(5)
Additional LOS in regular ward because of AMR (in days)	7.4	3.4	11.4	(6)
Average number of PCT tests per patient	3.0	2.0	5.0	Expert opinion, based on (7)
3. Effectiveness of PCT-guided antimicrobial stewardship				
Expected difference in days on antibiotic therapy (days)	2.79	2.06	3.52	(8)
Reduction in general population AMR prevalence per 1% reduction in antibiotic days	3.2%	2.4%	4.0%	(9)
Expected difference in days in the general ward due to PCT*	0	0	0	Assumption, based on (10)
Expected difference in days in ICU due to PCT*	0	0	0	Assumption, based on (10)
B. Hospitalized LRTI Patients				
1. Epidemiology				
Number of cases per year	8,113,985	7,991,373	8,216,665	(11)
AMR prevalence in general population, %	33.9%	20.5%	46.6%	(12)
2. Resource use				
Antibiotic prescription, %	86.3%	69.0%	100.0%	(10)
Days on antibiotic therapy (days)	9.4	9.2	9.6	(10)
Average LOS in regular ward (days)	7.0	5.6	8.4	Expert opinion
Additional LOS in regular ward because of AMR (days)	7.4	3.4	11.4	(6)
Patients admitted to ICU, %	8.7%	7.0%	10.4%	(13)
Average LOS in days in ICU (days)	13.3	12.8	13.8	(10)
Number of PCT tests, per patient	3.0	2.0	5.0	Expert opinion, based on (7)
3. Effectiveness of PCT-guided antimicrobial stewardship				
Reduction of antibiotic prescription, %	14.8%	12.6%	17.0%	(10)
Reduction of days on antibiotic therapy (days)	1.83	1.50	2.15	(10)
Reduction in general population AMR prevalence per 1% reduction in antibiotic days	3.2%	2.4%	4.0%	(9)
Average difference in days in the general ward due to PCT*	0	0	0	(10)
Average difference in days in ICU due to PCT*	0	0	0	(10)
C. Unit Costs				
Cost per day of staying in general ward (average from 3 sources)	₹3,517	₹2,200	₹5,433	Public sources
Cost per day of ICU stay (average from 3 sources)	₹9,233	₹8,667	₹9,583	Public sources
Cost per day on mechanical ventilation	₹15,733	₹15,167	₹16,083	Public sources
Cost per day of hospital stay in isolation	₹10,000	₹6,256	₹15,450	Public sources
Costs per day on antibiotic therapy (sepsis)	₹8,391	₹6,712	₹10,069	(14)
Costs per day on antibiotic therapy (LRTI)	₹8,391	₹6,712	₹10,069	(14)
Cost per PCT Test (average from 3 sources)	₹2,570	₹1,300	₹3,510	Public sources

*Assumed no effect. ICU=intensive care unit; LOS=Length of stay; AMR=antimicrobial resistance; PCT=procalcitonin; LRTI=lower respiratory tract infection

Table 2: Expected base case results: Healthcare, cost, economic impact of using PCT-guided antimicrobial stewardship compared to SOC in sepsis & LRTI patients at the end of 1 year.

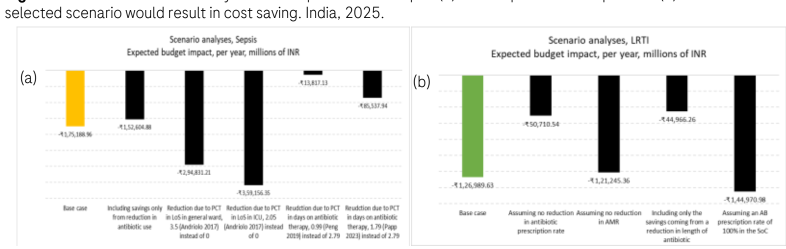
	Suspected Sepsis in ICU			Hospitalized LRTI			Total
	Standard of care	PCT-guided antimicrobial stewardship	Difference *(95% CI)*	Standard of care	PCT-guided antimicrobial stewardship	Difference *(95% CI)*	Difference (95% CI)
Clinical Impact, Per Year, MILLIONS							
Antibiotic days	97.2	70.1	-27.1 *(-34.2 to -21.2)*	65.8	43.9	-21.9 *(-19.0 to -15.2)*	-49.0 *(-51.4 to -38.2)*
Antibiotic resistant cases	4.4	3.5	-0.9 *(-1.2 to -0.6)*	2.4	2.2	-0.2 *(-0.2 to -0.1)*	-1.1 *(-1.4 to -0.7)*
Cost Categories, Per Patient, Per Event (in INR)							
PCT test cost	₹0	₹7,710	₹7,710.0 *(₹3,879.0 to ₹13,860.0)*	₹0	₹7,710.0	₹7,710.0 *(₹3,816.0 to ₹14,031.0)*	-
Antibiotics cost	₹83,910	₹60,499	-₹23,410.9 *(-₹31,207.0 to -₹16,916.0)*	₹68,069	₹45,417	-₹22,652.8 *(-₹22,113.0 to -₹14,063.0)*	
Hospital cost (including regular ward + ICU)	₹96,725	₹96,725	₹0 *(₹0 to ₹0)*	₹35,303.0	₹35,303.0	₹0 *(₹0 to ₹0)*	
Mechanical ventilation cost	₹86,532	₹86,532	₹0 *(₹0 to ₹0)*	₹7,528.0	₹7,528.0	₹0 *(₹0 to ₹0)*	
AMR cost (including difference in hospital LOS)	₹11,665	₹9,341	-₹2,323.6 *(-₹4,289.0 to -₹918.0)*	₹ 7,614	₹ 6,906	-₹707.9 *(-₹821.0 to -₹167.0)*	
Total cost difference	-	-	**-₹18,024.5 (-₹27,732.0 to -₹8,819.0)**	-	-	**-₹15,650.7 (-₹16,276.0 to -₹3,302.0)**	
Economic Impact, Per Year, MILLIONS (in INR)							
Impact on health system	-	-	-₹175,189.0 *(-₹269,545.2 to -₹85,726.0)*	-	-	-₹126,989.6 *(-₹132,064.8 to -₹26,792.1)*	**-₹302,178.6 (-₹374,456.9 to -₹139,890.5)**
Impact per 1,000 patients	-	-	**-₹18.0 (-₹27.7 to -₹8.8)**	-	-	**-₹15.7 (-₹16.3 to -₹3.3)**	-
Probability of Saving Budget	100%			100%			100%

All costs expressed in INR. LRTI=lower respiratory tract infection; PCT=procalcitonin; INR=Indian Rupee; LOS=Length of stay; ICU=intensive care unit; AMR=antimicrobial resistance

Discussion

- PCT-guided antimicrobial stewardship reduced unnecessary antibiotic use in both sepsis & LRTI, delivering clinical & economic benefits in Indian setting.
- These benefits included fewer antibiotic treatment days, fewer resistant infections, and substantial savings for patients and the healthcare system.
- Deterministic and probabilistic sensitivity analyses confirmed the robustness of the findings, even when key parameters were varied.
- Validation of model inputs by Indian infectious disease experts further enhanced the credibility and contextual relevance of the results.
- Our findings align with the 2022 ISCCM guidelines, which recommend PCT for antibiotic de-escalation in sepsis and severe CAP, but not for initial diagnosis.
- Similar studies in Argentina, the US, and Belgium also reported reductions in antibiotic use and cost savings, reinforcing the generalizability of our findings.
- Sepsis and LRTI represent different severities of illness and care settings, yet consistent savings were demonstrated in both groups.
- Despite existing national guidelines, stewardship programs in India remain fragmented; PCT-guided algorithms provide a structured, evidence-based tool to close this gap.
- PCT-guided stewardship is not a standalone solution to AMR, but it represents a feasible, scalable intervention that could be prioritized in ICUs and later extended to general wards.

Figure 3: Results of scenario analyses for ICU patients with sepsis (a) and hospitalized LRTI patients (b). Each of the selected scenario would result in cost saving. India, 2025.



PCT=procalcitonin; LOS=Length of stay; ICU=intensive care unit; LRTI=lower respiratory tract infection; AMR=antimicrobial resistance; SOC=Standard of care

Conclusions

- PCT-guided antimicrobial stewardship has a strong potential to substantially reduce antibiotic consumption, prevent resistance, and save costs in Indian patients with sepsis and LRTI.
- These results provide actionable evidence to support the integration of PCT algorithms into national stewardship strategies, offering a practical step toward combating AMR and preserving antibiotic effectiveness.

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Disclosures

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