Optimizing Healthcare Delivery for Society for Nutrition, Education, and Health Action (SNEHA), Mumbai

Introduction

For a non-profit like the Society for Nutrition, Education, and Health Action (SNEHA), every rupee and every staff hour count. Working on the front lines of healthcare in Mumbai's slums, the challenge is to make the most of limited resources. This report tackles this problem head-on, using quantitative analysis to provide clear, actionable answers to two key questions:

1. What is the perfect monthly mix of medical camps to achieve the greatest health impact?
2. What is the cheapest way to get medical supplies from storage to the people who need them?

Instead of relying on guesswork, we built two mathematical models based on SNEHA's real-world operational data. The first, a Linear Programming model, pinpoints the optimal camp strategy. The second, a Transportation model, creates a cost-effective logistics plan. This report translates the results of these models into a practical roadmap for strategic decision-making.

Section 1: Finding the Optimal Health Camp Strategy

1.1 The Challenge: Juggling Priorities and Constraints

SNEHA's core mission involves running two types of medical camps: broad General Health Camps (GHCs) and more specialized NCD Screening Camps (NSCs) for diseases like diabetes and hypertension. Choosing how many of each to run is a complex puzzle. A GHC serves more people, but an NSC addresses a critical, growing health issue. Each camp type uses different amounts of money, staff time, and supplies.

A simple "rule-of-thumb" approach, like running as many camps as the budget allows, is bound to fail. It ignores other crucial limits, like the number of available doctors or logistical capacity. This could lead to wasted resources and a lower overall impact. A Linear Programming Problem (LPP) provides a better way forward, as it considers all these competing factors simultaneously to find the single best solution.

1.2 The Mathematical Model

We translated SNEHA's challenge into a clear mathematical model. The goal is to maximize a "Health Impact Score," a metric that reflects the strategic value of each camp type, rather than just the number of patients seen.

- **Decision Variables:**

  X_G: Number of General Health Camps (GHCs) to run per month.

  X_N: Number of NCD Screening Camps (NSCs) to run per month.
- **Objective Function:** Maximize Total Health Impact (Z)

  Maximize $Z = 150\, X_G + 170\, X_N$
- **Constraints:** The plan must operate within SNEHA's real-world limits:

1. **Budget:** $30{,}000\, X_G + 50{,}000\, X_N \leq 490{,}000$
2. **Doctor Hours:** $8\, X_G + 12\, X_N \leq 130$
3. **Nurse/Paramedic Hours:** $20\, X_G + 25\, X_N \leq 320$
4. **NCD Kits:** $100\, X_N \leq 250$
5. **Logistical Limit:** $X_G + X_N \leq 15$
6. **Non-Negativity:** $X_G, X_N \geq 0$
7. **Integer Constraint:** X_G, X_N must be whole numbers.

The complete model parameters and their operational justifications are summarized in Table 1. This table provides a transparent foundation for the subsequent analysis.

Table 1: LPP Model Parameters and Justifications

Component	Parameter	Value	Justification / Source
Decision Variables	X_G	-	Number of General Health Camps (GHC) per month.
	X_N	-	Number of NCD Screening Camps (NSC) per month.

Objective Function	GHC Impact Coefficient	150	(150 patients/camp) × (1.0 impact/patient).
	NSC Impact Coefficient	170	(100 patients/camp) × (1.7 impact/patient).
Constraints			
1. Budget	GHC Unit Cost	₹30,000	Operational cost per General Health Camp.
	NSC Unit Cost	₹50,000	Operational cost per NCD Screening Camp.
	Total Budget (RHS)	₹490,000	Total available monthly budget for camp activities.
2. Doctor-Hours	GHC Doctor-Hours	8	Doctor-hours consumed per GHC.
	NSC Doctor-Hours	12	Doctor-hours consumed per NSC.
	Total Doctor Hours (RHS)	130	Total available doctor-hours per month.
3. Nurse/Paramedic-Hours	GHC Nurse-Hours	20	Nurse/Paramedic-hours consumed per GHC.
	NSC Nurse-Hours	25	Nurse/Paramedic-hours consumed per NSC.
	Total Nurse-Hours (RHS)	320	Total available nurse/paramedic hours per month.

4. NCD Kits	NSC Kit Usage	100	Specialized kits consumed per NSC.
	Total Kits (RHS)	250	Total available NCD kits per month.
5. Logistical Limit	Total Camps (RHS)	15	Maximum operational capacity for camps per month.

1.3 Why a Structured Approach is Better

Without a formal model, a manager might rely on intuition or simple rules. For example, one might decide to run as many GHCs as possible because they are cheaper. This "heuristic" approach is flawed because it ignores the bigger picture. A plan focused only on cost might quickly run out of available nurse-hours, leaving a significant portion of the budget and doctor time unused. This would lead to a suboptimal result, failing to achieve the maximum possible health impact.

Linear Programming (LPP) provides a structured advantage by avoiding these pitfalls:

- **Holistic Optimization:** LPP looks at all the constraints - budget, staff, supplies, and logistics - at the same time. It finds a solution that works within all limits, not just one.
- **Guaranteed Best Solution:** Unlike a heuristic that might provide a "good" solution, LPP is mathematically guaranteed to find the single best possible outcome.
- **Data-Driven Decisions:** It transforms a complex decision into a clear, mathematical framework. This provides a defensible, evidence-based reason for the final strategic plan.

Section 2: The Solution and What It Means for Management

2.1 The Optimal Plan: 13 GHCs and 2 NSCs

Solving the model gives a clear and definitive answer. To achieve the maximum possible **Health Impact Score of 2,290**, SNEHA should conduct **13 General Health Camps** and **2 NCD Screening Camps** each month. Any other combination would either be impossible under the current constraints or would result in a lower impact score.

2.2 Where are the Real Bottlenecks?

The analysis reveals a crucial insight about SNEHA's resources. It's not a lack of medical staff or supplies that limits the organization's impact. Instead, the operation is constrained by two factors simultaneously. Table 2 details the utilization of each resource.

Table 2: Resource Utilization and Constraint Status

Resource	Used	Available	Status	Slack
Budget (₹)	490,000	490,000	Binding	0
Logistical Limit (Camps)	15	15	Binding	0
Doctor-Hours	128	130	Not Binding	2
Nurse/Paramedic-Hours	310	320	Not Binding	10
NCD Kits	200	250	Not Binding	50

Insight: The two **Binding** constraints tell a story of incredible efficiency but also of a hard ceiling. SNEHA is running a perfectly tuned engine, using every drop of fuel (budget) and running at its maximum RPM (logistical limit). This is good news, as it means no resources are being wasted. However, it's also a warning. The organization has hit a growth wall. The fact that there are still doctors, nurses, and NCD kits on the shelf at the end of the month proves that the problem isn't a lack of medical resources. The real challenge is the administrative capacity to get those resources out into the community. This insight should fundamentally shift the focus of strategic planning from "How do we get more medical supplies?" to "How do we get better at deploying what we already have?"

2.3 Stress-Testing the Strategy: How Stable is Our Plan?

Our optimal plan of 13 GHCs and 2 NSCs is the perfect solution for the world as we've defined it. But in the real world, numbers are rarely static. Budgets shift, priorities evolve, and operational efficiencies change. The crucial question for any manager is: how fragile is this "perfect" plan? Will a small change cause our entire strategy to collapse, or is it robust enough to handle minor fluctuations?

This is where sensitivity analysis becomes an invaluable tool. It allows us to stress-test our solution by asking targeted "what-if" questions. We can pinpoint exactly how much a key number can change before it forces us to find a completely new optimal plan. Below, we test two realistic scenarios to understand the tipping points of our strategy.

Table 3: Strategic Stability Analysis

Scenario	**Parameter Change**	**Is the Change Within the Allowable Range?**	**Impact on the Optimal Plan of (13 GHC, 2 NSC)**	**Managerial Takeaway**
1. The Efficiency Gain	We find a way to increase our logistical capacity by one camp, from 15 to 16.	**No.** (The allowable increase is only 0.8 camps).	The change is significant enough to **break the current optimal mix**.	This is a game-changing improvement. The plan must be completely resolved to find a new, better strategy that takes advantage of the new capacity.
2. The Impact Boost	A new training program makes our GHCs 10% more effective, increasing their impact score from 150 to 165.	**Yes.** (The allowable increase is 20 points).	The change is not enough to alter the strategy. The plan **remains the optimal choice**.	This is a welcome improvement. We can implement it with confidence, knowing our core strategy holds firm. The total impact score will simply increase.

Interpretation: This analysis provides a powerful narrative for decision-making. Imagine a manager with two proposals on their desk. One is for a new training program to make GHCs more effective. The other is a pitch to hire a part-time logistics coordinator. Our model proves that hiring the coordinator is the game-changing move. The training is a welcome, incremental improvement that our current strategy can easily absorb. But the coordinator is the key that unlocks a higher level of impact, fundamentally changing what's possible and requiring a whole new strategic plan. This data gives SNEHA the evidence needed to justify investments in administrative capacity - a traditionally difficult area to fund - by directly linking it to a measurable increase in community health outcomes.

2.4 From Static Report to Dynamic Tool: The Excel Scenario Planner

The sensitivity analysis in Table 4 is excellent for understanding the *stability* of our current plan. However, a written report is static. To make this analysis truly actionable for SNEHA's management, an interactive **"What-If" Scenario Planner** was built directly into the accompanying Excel workbook.

This tool turns the model from a static answer into a live decision-making dashboard. It empowers any manager to ask critical "what-if" questions without needing to be an operations research expert.

- **How it works:** An administrator can simply input a new hypothetical value for the total budget or the logistical camp limit in the planner's input cells.
- **The result:** By re-running the Solver, they can instantly see how the optimal camp mix (the 13-2 plan) adapts in response to a potential new grant (a budget increase) or a process improvement (a logistical limit increase).

This practical extension bridges the gap between a theoretical answer and a real-world strategic tool, allowing SNEHA to adapt its plans as conditions on the ground change.

Section 3: Optimizing Medical Supply Logistics

3.1 The Challenge: Cost-Effective Distribution

Beyond strategic planning, SNEHA faces the daily logistical challenge of distributing medical supply kits from four storage units to four camp locations across Mumbai. To tackle this, we built a Transportation Problem model to find the cheapest possible shipping plan. The supply and demand parameters are detailed in Table 4.

Table 4: Transportation Problem Supply and Demand Parameters

Sources (Storage Units)	**Supply (Kits)**		**Destinations (Camp Locations)**	**Demand (Kits)**
S1: Andheri	300		D1: Dharavi	280
S2: Dadar	250		D2: Mankhurd	220
S3: Chembur	200		D3: Govandi	250
S4: Bandra	150		D4: Malad	150
Total Supply	**900**		**Total Demand**	**900**

A realistic cost for each route was calculated based on both distance and estimated travel time, reflecting the realities of Mumbai traffic.

Unit Cost = (Distance in km × ₹10) + (Travel Time in hr × ₹300)

3.2 The Optimal Distribution Plan

The model was solved to find the least-cost plan for shipping all 900 required kits. The optimal solution results in a **minimum total transportation cost of ₹220,650**. The specific shipping schedule is detailed in Table 5.

Table 5: Optimal Transportation Allocation Plan (Kits)

	D1: Dharavi	**D2: Mankhurd**	**D3: Govandi**	**D4: Malad**
S1: Andheri	0	100	50	150
S2: Dadar	130	120	0	0
S3: Chembur	0	0	200	0
S4: Bandra	150	0	0	0

Insight: This plan is a powerful argument against localized, "common sense" decision-making. A warehouse manager in Chembur, seeing a need in nearby Dharavi, would naturally want to ship supplies there. The model, however, forbids this. Why? Because it takes a CEO's perspective, not a warehouse manager's. It sees that the Chembur-to-Govandi route is exceptionally cheap (unit cost of ₹80). The most efficient use of Chembur's limited supply is to serve that route exclusively. This forces other, more flexible warehouses to handle the demand in Dharavi. While those individual routes might seem less efficient, the decision minimizes the cost for the *entire system*. This data provides a concrete defense against "silo thinking" and proves the value of centralized, data-driven logistics. In fact, the data shows that forcing even one kit to be sent from Chembur to Dharavi would increase the total system cost by ₹460 - a hidden penalty that only a holistic model can reveal.

Section 4: Conclusion

This analysis demonstrates that operations research is more than an academic exercise; it is a powerful tool for any non-profit, like SNEHA, that is serious about maximizing its impact. By applying these quantitative methods, we have moved from intuition to an evidence-based strategy that is both optimal and defensible.

The insights gained are not just numbers; they are a roadmap for the future:

- **A Clear Strategic Focus:** The ideal monthly plan of **13 General Health Camps and 2 NCD Screening Camps** provides a clear, data-driven operational target.
- **Identifying the True Growth Barrier:** The discovery that **budget and logistical capacity** are the real bottlenecks - not a lack of medical staff - is a transformative insight. It redirects the organization's energy from fundraising to improving internal processes and capacity.
- **Making Smarter Investments:** The analysis proves that investing in logistical improvements will yield a far greater return in health impact than simply adding more funds to the budget at this stage.
- **Driving Down Operational Costs:** The optimal logistics plan, with a minimum transportation cost of **₹220,650**, shows how a system-wide view can unlock significant savings that can be reinvested into the mission.

Ultimately, this report provides SNEHA with the tools to move from being a well-intentioned organization to a data-savvy, high-impact public health leader. It empowers management to make choices with confidence, ensuring that every limited resource is leveraged to its fullest potential to serve the health and well-being of Mumbai's most vulnerable communities.