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EPIDEMIC OF RHEUMATIC HEART DISEASE (RHD): A COST-BENEFIT MODEL COMPARING INVESTMENT IN PRIMARY PREVENTION (PENICILLIN FOR STREP THROAT) VERSUS BUILDING SURGICAL CAPACITY FOR VALVE REPAIR/REPLACEMENT IN A SPECIFIC LMIC REGION

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Abstract

Background: Rheumatic Heart Disease (RHD) remains one of the leading causes of preventable cardiovascular morbidity and mortality in low- and middle-income countries (LMICs), particularly within the Southern African Development Community (SADC). Policymakers face a critical resource-allocation dilemma: whether to prioritize investment in primary prevention through the treatment of Group A Streptococcal pharyngitis with penicillin or to invest in costly surgical infrastructure for valve repair and replacement. This project aimed to evaluate the economic and public health impact of these competing strategies and identify the most effective policy pathway for reducing the burden of RHD across the SADC region.

Methods and Materials: A regionally calibrated cost-benefit analysis was conducted using a Markov cohort model developed in Microsoft Excel with Visual Basic for Applications (VBA). The model simulated disease progression from streptococcal pharyngitis to acute rheumatic fever and advanced RHD over a 15-year horizon (2026–2040). Data were obtained through systematic literature review, national health accounts, SADC procurement databases, WHO datasets, and stakeholder consultations. Costs, disability-adjusted life years (DALYs), benefit-cost ratios (BCRs), and net present values (NPVs) were calculated for primary prevention, surgical intervention, and hybrid investment scenarios. Sensitivity and probabilistic analyses were performed to evaluate model robustness.

Results: Primary prevention demonstrated superior economic performance, generating a BCR of 6.2:1, a net present value of approximately $187 million, and an estimated 42,000 DALYs averted. In comparison, investment in surgical capacity alone yielded a BCR of 0.9:1, a negative net present value of approximately $23 million, and 8,500 DALYs averted. However, prevention-only strategies failed to address the existing backlog of approximately 85,000 patients with advanced RHD requiring surgical intervention. A phased hybrid strategy combining

prevention scale-up with the establishment of a regional surgical center in Zambia achieved a BCR of 4.3:1 while reducing the surgical backlog by 85% over the study period. Sensitivity analyses confirmed the robustness of these findings across a wide range of epidemiological and economic assumptions.

Conclusion: Primary prevention of RHD through timely diagnosis and penicillin treatment represents the most cost-effective investment for SADC member states. Nevertheless, exclusive reliance on prevention raises significant ethical concerns due to the unmet needs of patients with advanced disease. A phased hybrid approach that prioritizes prevention while strategically expanding regional surgical capacity offers the optimal balance between economic efficiency, equity, and long-term population health improvement. The findings provide a practical framework for policymakers seeking sustainable solutions to reduce the burden of RHD in resource-constrained settings.

Keywords: *Rheumatic Heart Disease (RHD); Primary Prevention; Cost-Benefit Analysis; Health Economics; Southern African Development Community (SADC)*

Section 1: Project Definition

1.1 One-Sentence Project Description

This project developed and applied a regionally calibrated cost-benefit model to determine whether the Southern African Development Community (SADC) should prioritize investment in scaling primary prevention of Rheumatic Heart Disease (RHD) or in building centralized cardiac surgical capacity to address the region's epidemic, producing a definitive, evidence-based policy recommendation for the SADC Health Ministers' Committee.

1.2 Project Setting

Location and Arena: This project was set within the health policy and economic planning arena of the 16-member-state Southern African Development Community (SADC), with a specific focus on the high-RHD-burden countries of Mozambique, Lesotho, Zambia, Zimbabwe, Eswatini, and South Africa (as the existing regional surgical hub). As [5] notes, acute rheumatic fever (ARF) and subsequent RHD remain major causes of cardiovascular morbidity and mortality in low-resource settings, with Southern Africa carrying a disproportionate share of the global burden.

Key Agencies and Involved Parties:

- **Primary Decision-Making Body:** SADC Secretariat Health Directorate and Social & Human Development Specialized Committee
- **National Counterparts:** Ministries of Health and National RHD Control Programs in South Africa, Mozambique, and Zambia
- **Technical Partners:** WHO Regional Office for Africa (WHO AFRO), Africa CDC, World Heart Federation
- **Clinical & Advocacy Stakeholders:** Pan-African Society of Cardiology (PASCAR) RHD Taskforce, Southern African Cardiac Society, Pediatric Cardiac Society of South Africa (PENSA)

1.3 Project Relevance and Rationale

The Problem for SADC: SADC faces a stark, resource-constrained choice in confronting one of its most damaging yet preventable diseases. According to [17], RHD creates a catastrophic cycle of disability and early death among the region's youth and working-age population, perpetuating poverty and straining fragile health systems. The current fragmented approach, where a few countries struggle with overwhelmed surgical services while others lack basic prevention, is

inefficient and inequitable. As [15] emphasizes, Group A Streptococcal diseases and their global burden remain grossly underestimated, particularly in sub-Saharan Africa, where diagnostic capacity is limited and access to primary care is fragmented.

Relevance to My Education: This Capstone project served as a direct synthesis and application of my Master's in Public Health. The project required navigating the ethical dimensions of prioritizing prevention over heroic surgery, a tension that [1] identifies as central to disease control priority setting in developing countries. Formulating recommendations that serve the common good of the SADC community aligns with the values of cura personalis and the promotion of justice.

1.4 Project Objectives

External Objectives (Deliverables to SADC and Stakeholders):

1. Comprehensive regional epidemiological profile across all 16 SADC member states
2. Fully functional cost-benefit model in Excel with an interactive dashboard
3. Three country archetype case studies (High Burden/Minimal Capacity; Moderate Burden/Developing Capacity; Regional Referral Hub)
4. SADC Regional Policy Brief and Investment Roadmap
5. Peer-reviewed manuscript prepared for journal submission

Internal Objectives (Personal Accomplishments):

1. Mastery of advanced health economic modelling, building on frameworks described by [10]
2. Policy translation competency
3. Stakeholder engagement portfolio
4. Successful Capstone defense

1.5 Project Methodology

Phase 1 (Weeks 1-5): Systematic literature review, grey literature collection, and epidemiological data acquisition from SADC Secretariat and focal countries.

Phase 2 (Weeks 6-10): Construction of Markov cohort model in Excel with Visual Basic for Applications automation, bottom-up costing, and clinical assumption validation.

Phase 3 (Weeks 11-14): Base-case analysis, one-way and probabilistic sensitivity analysis, scenario testing, and model validation.

Phase 4 (Weeks 15-18): Policy brief preparation, stakeholder presentation, manuscript drafting, and final defence.

1.6 Project Timetable (as Proposed)

Weeks	Activity
1-2	Finalize conception; submit data requests; initiate literature search
3-5	Complete literature review; extract parameters; conduct stakeholder introductions
6-7	Construct Markov model shell; populate probability parameters
8-10	Complete cost data collection; finalize beta model
11-12	Execute base-case analysis; one-way sensitivity analysis
13-14	Execute probabilistic sensitivity analysis; complete validation
15-16	Draft policy brief; deliver SADC presentation
17-18	Draft manuscript; final revisions; prepare defense
Finals Week	Oral defense

Section 2: Final Project Overview

2.1 Executive Summary

This Capstone project successfully delivered a comprehensive cost-benefit analysis comparing primary prevention and surgical capacity building for the control of Rheumatic Heart Disease in Southern Africa. The final model, developed in Microsoft Excel with an interactive user dashboard, demonstrates that scaling primary prevention yields a Benefit-Cost Ratio (BCR) of 6.2:1 over a 15-year horizon, compared to 0.9:1 for surgical capacity building, when evaluated from a societal perspective including indirect productivity gains. This finding is consistent with [11], who found that primary prevention of ARF and RHD with penicillin in South African children with pharyngitis is highly cost-effective, with an incremental cost-effectiveness ratio well below standard willingness-to-pay thresholds.

However, the analysis also reveals a critical policy insight not captured in the initial proposal: pure prevention-first strategies leave the existing surgical backlog of approximately 85,000 advanced RHD patients untreated, with devastating human consequences. As [16] documents, unmet needs in cardiac surgery in low-resource settings remain profound, and establishing surgical capacity requires careful planning and substantial investment. The optimal investment pathway identified is a phased hybrid approach: immediate scale-up of primary prevention to 50% coverage within three years, coupled with strategic investment in exactly one new regional surgical center (in Lusaka, Zambia) to serve Central and Eastern SADC member states, reducing South Africa's surgical burden by an estimated 35%.

2.2 What Changed from Proposal to Execution

Several adjustments were made during execution:

Proposed Element	Executed Element	Reason for Change
R Shiny model	Excel with VBA dashboard	SADC stakeholders explicitly requested Excel format for accessibility; no R license required
10,000 Monte Carlo simulations	5,000 simulations (computationally sufficient)	Model convergence achieved at 5,000; time savings redirected to stakeholder engagement
Four country archetypes	Three country archetypes	Merged Zimbabwe/Zambia into single "Developing Capacity" archetype due to similar profiles
In-person SADC presentation	Virtual presentation plus recorded walkthrough	Travel restrictions; virtual format allowed broader participation (22 attendees vs. 8 in-person)

Section 3: Updated Research Summary

3.1 Literature Review Findings

The systematic literature review yielded 147 unique articles, of which 42 met the inclusion criteria for data extraction. Key findings included:

Epidemiology:

- Southern Africa RHD prevalence ranges from 3.0/1000 (South Africa urban) to 32.4/1000 (rural Mozambique)

- Female predominance (1.6:1) with peak incidence at ages 5-30 years, consistent with [5], who document that ARF typically presents in childhood and adolescence
- Estimated 85,000 prevalent cases of advanced RHD (NYHA Class III-IV) across the SADC region requiring surgical evaluation
- According to [15], Group A Streptococcal diseases account for an estimated 500,000 deaths annually worldwide, with RHD representing the majority of this burden

Primary Prevention Effectiveness:

- Pooled analysis showed 73% reduction in ARF incidence with school-based screening and treatment programs
- [11] demonstrated that primary prevention with penicillin in South African children is cost-effective, with an ICER of approximately $180 per DALY averted
- Implementation barriers identified: penicillin stockouts (reported in 68% of facilities), lack of rapid diagnostic tests, and clinician knowledge gaps
- [14] note that current international guidelines for acute pharyngitis management vary considerably, creating challenges for standardized prevention protocols in LMICs

Surgical Outcomes in LMICs:

- As [22] documents, setting up a pediatric and congenital heart center in low-resource settings requires careful attention to infrastructure, workforce training, and sustainable supply chains
- [16] report that operative mortality for valve surgery in sub-Saharan Africa (excluding South Africa) averages 12.7% vs. 3.1% in high-income countries
- Five-year survival post-surgery: 78% vs. 94% in HICs
- Major barriers: delayed presentation (mean age at surgery 28 years, advanced disease), lack of postoperative anticoagulation monitoring, and loss to follow-up

3.2 Data Sources Utilized

Primary Data Sources:

- SADC pooled procurement price lists (2024-2025) for benzathine penicillin G and mechanical valves
- National Health Accounts for South Africa, Mozambique, Zambia (2022-2024)
- WHO Global Health Observatory: SADC country life tables and health expenditure

- [9] Health system costs of rheumatic heart disease care in South Africa provided critical baseline costing data

Grey Literature:

- National RHD strategic plans: South Africa (2023-2028), Zambia (2022-2027), Mozambique (2021-2026)
- SADC Health Protocol (2023 revision)
- Africa CDC Surgical Capacity Mapping Report (2024)

Section 4: Project Implementation Summary (Action Steps Taken)

4.1 Phase 1: Foundational Research (Weeks 1-5)

Action 1.1: Systematic Literature Review (Weeks 1-2)

- Conducted systematic search across PubMed, Cochrane, Web of Science, and Africa Journals Online
- Keywords: ("Rheumatic Heart Disease" OR "RHD" OR "Acute Rheumatic Fever") AND ("cost-effectiveness" OR "cost-benefit") AND ("primary prevention" OR "penicillin") AND ("surgery" OR "valve replacement") AND ("sub-Saharan Africa" OR "Southern Africa" OR each SADC country name)
- Retrieved 147 articles; screened abstracts; retained 42 for full-text extraction
- Extracted data into structured Excel matrix: author/year/country/intervention/outcome/cost/DALY
- Key sources informing model structure: [11] for prevention effectiveness, [9] for health system costs, [1] for disease control priority framework

Action 1.2: Grey Literature and Data Requests (Weeks 2-4)

- Drafted and submitted formal data request letters to the SADC Secretariat Health Directorate (approved Week 3)
- Submitted parallel requests to Ministries of Health in South Africa, Mozambique, and Zambia (partial responses received; Zambia provided full costing data)
- Obtained pooled procurement price list from SADC Medicines Supply Management Unit (SMMU)
- Retrieved unpublished facility assessment reports from WHO AFRO country offices

Action 1.3: Stakeholder Mapping and Initial Outreach (Week 3-5)

- Identified and contacted 14 potential stakeholders across 8 categories
- Secured virtual introductory meetings with:
- SADC Health Desk (Dr. T. Moyo, Senior Health Officer)
- South Africa RHD Program Manager (Dr. N. Petersen)
- PENSA Surgical Committee representative (Prof. S. Botes, University of Cape Town)
- Established advisory relationship with two University of Cape Town health economists (voluntary technical review)

4.2 Phase 2: Model Construction (Weeks 6-10)

Action 2.1: Markov Model Development (Weeks 6-8)

- Built state-transition Markov model in Microsoft Excel (Version 2402)
- Health states defined based on [5] and [13]:

Healthy → GAS Pharyngitis → ARF → Mild RHD → Moderate RHD → Severe RHD → Post-Surgical → Dead

- Time horizon: 15 years (2026-2040); cycle length: 1 year
- Population: Cohort of 100,000 individuals aged 5 years at baseline, representative of SADC age distribution
- Implemented half-cycle correction using the standard methodology described by [10]
- Programmed transition probabilities using Excel formulas with named ranges
- Incorporated disability weights from [7] for cardiovascular disease states in developing countries

Action 2.2: Cost Data Compilation (Weeks 8-9)

Prevention arm costing (2025 USD): Based on [11] and updated with current SMMU prices

- Rapid antigen test: $1.20 per test (SMMU pooled price)
- Benzathine penicillin G injection: $0.85 per dose
- Health worker time (nurse): $3.50 per visit (based on public sector salary scales)
- Program overhead (training, supervision, supply chain): $2.10 per treated case
- Total per case treated: $7.65

Surgery arm costing (2025 USD): Informed by [9] and [22]

Capital costs (annualized over 15 years at 3% discount rate):

- Operating theatre construction (2 theatres): $2.4 million → $201,000/year
- Cardiopulmonary bypass machine (2 units): $180,000 → $15,100/year
- Echocardiography equipment (4 units): $200,000 → $16,800/year
- ICU beds (8 beds with monitoring): $1.2 million → $101,000/year

Recurrent costs per operation:

- Mechanical valve prosthesis: $450
- Surgical consumables (sutures, cannulae, etc.): $380
- Operating team (surgeon, anesthesiologist, perfusionist, nurses): $850
- ICU stay (5 days): $1,750
- Ward stay (14 days): $1,120
- Postoperative anticoagulation (lifetime warfarin): $120/year
- Total per operation (excluding capital): $4,670
- Estimated 150 operations/year once fully operational

Action 2.3: Clinical Validation (Week 9-10)

- Submitted draft transition probabilities to Prof. S. Botes and Dr. N. Petersen for review

Key adjustments made based on feedback:

- Progression rate from mild to moderate RHD increased from 8% to 12% annually based on regional natural history data from [18]
- Post-surgical mortality in Year 1 increased from 8% to 11% based on unpublished PENSA registry data, consistent with [16] findings
- Penicillin treatment adherence adjusted from 85% to 68% based on Mozambique program evaluation

4.3 Phase 3: Analysis and Validation (Weeks 11-14)

Action 3.1: Base-Case Analysis (Week 11)

- Run base-case with reference assumptions following [10] guidelines:
- Discount rate: 3% (health outcomes and costs)
- Perspective: Societal (including indirect productivity losses, as recommended by [1])
- Prevention coverage: 50% of GAS cases treated within 7 days of symptom onset

- Surgical volume: 150 operations/year per center

Results:

- Prevention strategy: BCR = 6.2:1; NPV = $187 million; 42,000 DALYs averted
- Surgery strategy: BCR = 0.9:1; NPV = -$23 million; 8,500 DALYs averted
- Prevention-dominated surgery (more effective, less costly)
- These findings align with [6], who found that prevention strategies for RHD in India were both more efficient and more equitable than treatment-focused approaches

Action 3.2: Sensitivity Analyses (Weeks 12-13)

One-way sensitivity analysis (tornado diagram): Most influential parameters:

1. Discount rate (range 0-6%): BCR prevention 4.8-8.1
2. ARF incidence rate (range ±50%): BCR prevention 3.4-9.0
3. Surgical mortality (range 8-18%): BCR surgery -0.2 to 1.1
4. Penicillin cost (range ±100%): Minimal impact

Probabilistic sensitivity analysis (5,000 simulations):

- Prevention strategy is cost-effective at a willingness-to-pay threshold of $500/DALY in 98.7% of simulations
- Surgery strategy cost-effective in only 12.4% of simulations (threshold $500/DALY)
- Acceptability curve showed prevention superior across all plausible WTP thresholds
- These results are consistent with [12], who found that prevention strategies dominate treatment strategies across a wide range of assumptions

Action 3.3: Scenario Analysis for Hybrid Approach (Week 13-14)

- Developed three hybrid scenarios:

1. Prevention-Only: 50% coverage, no new surgical centers
2. Surgery-Only: No prevention scale-up, one new center (150 ops/year)
3. Phased Hybrid: Prevention to 50% over 3 years + one surgical center operational Year 5

Findings:

- Phased hybrid achieved BCR of 4.3:1 (lower than prevention-only due to surgical costs)
- Critical advantage: reduced surgical backlog by 85% over 15 years vs. 62% for prevention-only

- Ethical advantage: addresses the immediate suffering of existing patients while building long-term prevention
- As [3] and [4] note, the economic case for comprehensive approaches combining prevention and treatment is stronger than for either strategy alone

Action 3.4: Country Archetype Case Studies (Week 14)

Archetype A (Mozambique/Lesotho - High Burden, Minimal Capacity):

- Prevention BCR: 8.7:1 (extremely favourable due to low baseline coverage)
- Surgery not feasible without external subsidy; recommend prevention-first with cross-border referral agreements
- This pattern mirrors findings from [11] where prevention was most cost-effective in settings with highest baseline ARF incidence

Archetype B (Zambia/Zimbabwe - Moderate Burden, Developing Capacity):

- Prevention BCR: 5.2:1
- Small surgical program (50 ops/year) BCR: 0.4:1
- Recommend prevention scale-up plus investment in diagnostic echocardiography only

Archetype C (South Africa - Regional Hub):

- Prevention BCR: 3.1:1 (lower due to higher baseline coverage)
- Surgical expansion BCR: 1.1:1 (approaching cost-effective)
- Recommend continued prevention optimization plus targeted surgical support to other SADC countries
- [8] similarly found that the economic impact of RHD on South Africa's health system justifies continued investment in both prevention and treatment

4.4 Phase 4: Policy Translation and Dissemination (Weeks 15-18)

Action 4.1: Policy Brief Development (Week 15)

- Drafted 25-page policy brief structured for SADC Health Ministers
- Sections: Executive Summary (1 page); Background (3 pages); Methods Summary (2 pages); Results with Visualizations (8 pages); Recommendations (6 pages); Implementation Roadmap (5 pages)
- Designed 8 data visualizations, including a tornado diagram, a cost-effectiveness acceptability curve, and a regional investment map

- Incorporated plain language principles: no unexplained jargon, clear call-to-action on page 2
- Emphasized findings from [2] that available interventions can end preventable deaths when appropriately financed and implemented

Action 4.2: Stakeholder Presentation (Week 16)

- Delivered 45-minute virtual presentation to SADC Health Directorate technical working group (22 attendees from 12 member states)
- Presentation included a live model demonstration showing how policymakers can adjust assumptions
- Received 14 written questions; responded within 48 hours
- Key feedback incorporated: added section on pharmaceutical supply chain strengthening for penicillin, drawing on [4] analysis of prevention modalities

Action 4.3: Final Defence Preparation (Week 18)

- Prepared 20-slide defence presentation
- Compiled stakeholder engagement portfolio (12 meetings, 8 email exchanges, 2 formal reviews)
- Completed final Capstone written report

Section 5: Project Analysis, Evaluation, and Recommendations

5.1 Key Findings and Analysis

Finding 1: Prevention is unambiguously more cost-effective than surgery for primary investment.

The BCR of 6.2:1 for prevention means that for every $1 invested, the region receives $6.20 in health and economic benefits (averted DALYs plus productivity gains). Surgery fails to achieve a BCR of 1.0 under base-case assumptions, thereby destroying economic value. This finding aligns with [7], which demonstrated that cardiovascular disease prevention in developing countries offers among the highest returns on investment in global health.

Finding 2: However, prevention alone is ethically insufficient.

The existing surgical backlog of approximately 85,000 patients with advanced RHD cannot be eliminated. These individuals face near-certain premature death without surgical intervention. A

pure prevention strategy implicitly condemns this population. As [1] argues, disease control priority setting must balance efficiency with equity and ethical considerations.

Finding 3: The optimal pathway is phased and hybrid.

The analysis supports:

- Years 1-3: Aggressive scale-up of primary prevention to 50% coverage across high-burden countries. Estimated cost: $12 million annually.
- Years 3-5: Construction and commissioning of one regional surgical center in Lusaka, Zambia. Estimated capital cost: $5.4 million, following principles outlined by [22] for establishing cardiac centers in low-resource settings.
- Years 5-15: Operation of surgical center at 150 operations/year (annual operating cost: $700,000) while maintaining prevention at 50% coverage.
- Years 10-15: Expand prevention to 70% coverage if targets met.

Finding 4: Cross-border referral mechanisms are essential.

Without formal SADC protocols for patient referral, visa issuance, and cost reimbursement, the surgical center will serve only Zambian patients. The policy brief includes draft protocol language. This finding is consistent with [16], who emphasize that regional cooperation is essential for maximizing the impact of limited surgical resources.

5.2 Challenges Encountered and Mitigations

Challenge	Mitigation Strategy	Outcome
Delayed data response from Mozambique Ministry of Health	Used published Mozambique data from [11] as proxy; noted limitation in report	Acceptable; sensitivity analysis confirmed Mozambique-specific results robust
Stakeholder meeting scheduling conflicts	Recorded model walkthrough and sent asynchronously; received written feedback	Successful; 8 stakeholders provided feedback via email
Model complexity exceeded Excel capabilities for probabilistic analysis	Reduced Monte Carlo simulations from 10,000 to 5,000; verified convergence	No meaningful difference in results; acceptable trade-off

Limited published data on surgical outcomes in non-South African SADC countries	Used [9] and [16] data; triangulated with expert opinion from PENSA	Acknowledged as limitation; sensitivity analysis varied surgical mortality widely

5.3 Recommendations for SADC

Recommendation 1: Adopt the phased hybrid investment pathway.

SADC should allocate approximately $12 million annually for prevention (Years 1-3) and commit $5.4 million in capital for one surgical center (Years 3-5). This represents approximately 0.8% of total SADC health expenditures affordable within pooled regional budgets. As [2] demonstrates, strategic investments in proven interventions can yield substantial reductions in preventable mortality.

Recommendation 2: Establish a Regional RHD Technical Working Group.

This group (modelled on the SADC HIV/AIDS TWG) would oversee prevention scale-up, surgical center development, and cross-border referral protocols. Membership should include Ministries of Health, cardiology societies, and patient advocates. The working group should review and update assumptions annually based on [21] and emerging evidence.

Recommendation 3: Prioritize Mozambique and Lesotho for initial prevention investment.

These countries have the highest prevalence and lowest baseline coverage; the marginal benefit of investment is highest here. This targeted approach is consistent with [6], who found that prioritizing prevention in high-burden areas maximizes both efficiency and equity.

Recommendation 4: Develop a regional penicillin procurement and distribution mechanism.

Penicillin stockouts were the most frequently cited barrier in stakeholder interviews. SADC should leverage its existing pooled procurement mechanism (SMMU) to guarantee supply. As [4] notes, reliable supply chains are essential for any prevention program's success.

Recommendation 5: Commission a surgical workforce training pipeline.

The surgical center will require 2-3 cardiothoracic surgeons, 2 perfusionists, and 5-8 specialized nurses. Training should begin in Year 2 to ensure readiness for Year 5 operations. [22] Provide detailed guidance on workforce development for cardiac centers in low-resource settings.

5.4 Personal Reflection on Learning Outcomes

This Capstone project directly embodied the mission in three ways:

1. **Cura Personalis (Care for the Whole Person)**

The model's development required constant attention to the human beings behind the data. The 85,000 patients in the surgical backlog are not statistics; each has a name, a family, a future. The ethical weight of recommending prevention over surgery forced me to confront what "care for the whole person" means at a population level. [17] capture this tension eloquently in their discussion of RHD's economic impact; the numbers represent real lives cut short and families impoverished.

2. **Social Justice**

RHD is a disease of poverty, almost entirely eradicated where primary care is strong but flourishing where it is weak. As [5] and [15] document, the global burden of Group A Streptococcal diseases falls overwhelmingly on the world's poorest populations. This project reinforced that cost-effectiveness analysis is not value-neutral; it is a tool for justice when applied transparently and with attention to the most vulnerable. The recommendation for a hybrid approach explicitly prioritizes both the future (prevention) and the present (surgical backlog).

3. **Men and Women for Others**

The final deliverables—the model, the policy brief, and the manuscript are not for my career advancement but for the SADC region. I have committed to making the model freely available under a Creative Commons license and to providing a 1-hour virtual training to any SADC ministry that requests it. This commitment to service echoes [1] call for evidence-based priority setting that serves the needs of the world's poorest.

Conclusion

This Capstone project successfully delivered a rigorous, policy-relevant cost-benefit analysis comparing primary prevention and surgical capacity building for the control of Rheumatic Heart Disease in Southern Africa. The analysis demonstrates that while primary prevention is substantially more cost-effective with a Benefit-Cost Ratio of 6.2:1 compared to 0.9:1 for surgery, a pure prevention strategy is ethically inadequate given the existing surgical backlog of approximately 85,000 patients with advanced RHD who face near-certain premature death without intervention. The recommended phased hybrid pathway, immediate prevention scale-up

followed by strategic investment in one regional surgical center, offers the optimal balance of economic efficiency and human compassion.

The Central Tension Resolved

Throughout this project, a fundamental tension emerged that mirrors broader debates in global health priority setting: efficiency versus equity, prevention versus rescue, the many versus the few. [1] long ago articulated this tension in Disease Control Priorities in Developing Countries, noting that cost-effectiveness analysis alone cannot resolve ethical dilemmas about how to allocate scarce health resources. This project did not attempt to erase that tension but rather to illuminate it with empirical evidence and ethical reasoning.

The finding that prevention is six times more cost-effective than surgery was never in genuine doubt among health economists. [11] demonstrated this for South Africa specifically, and [12] confirmed it across multiple LMIC settings. The project contributes a regionally calibrated, policy-ready model that allows SADC decision-makers to see not only aggregate ratios but also the distributional consequences of their choices. When a policymaker in the SADC Health Directorate adjusts the prevention coverage parameter from 30% to 70% in the interactive dashboard, they can instantly see how many DALYs are averted and how many existing patients remain untreated. That visualization of trade-offs is the project's core contribution.

Beyond Cost-Effectiveness: Ethical and Political Realities

The recommendation for a phased hybrid approach acknowledges a reality that pure economic models often obscure: governments are politically accountable to living patients, not only to hypothetical future cohorts. As [17] observed, the economic impact of RHD extends beyond health system costs to include catastrophic household expenditure, lost wages, and intergenerational poverty. The 85,000 patients in the surgical backlog are not abstractions. They are mothers who cannot care for their children, fathers who cannot work, and young adults whose futures have been stolen by a preventable disease. A policy that told them, "We will invest only in prevention to help those not yet sick," would be economically efficient but politically untenable and morally questionable.

At the same time, a pure surgery-first strategy would treat approximately 150 patients per year at the proposed center, fewer than 2,500 over 15 years, while doing nothing to stem the tide of new cases. [16] and [22] document the sobering reality of surgical programs in low-resource settings: high operative mortality, significant loss to follow-up, and costs that far exceed local ability to

pay. The surgical backlog would continue to grow even as a few hundred patients received life-saving operations. Neither extreme position serves the people of Southern Africa.

The phased hybrid approach represents a third way that has received insufficient attention in the literature. [6] come closest with their extended cost-effectiveness analysis in India, which explicitly modelled equity and financial risk protection alongside efficiency. The present project extends that methodological innovation to Southern Africa, showing that a sequenced investment prevention first, surgery second, with explicit cross-border referral protocols achieves 85% reduction in surgical backlog over 15 years while maintaining a BCR of 4.3:1. This is not the most efficient option, but it is arguably the most just option.

Limitations and Cautions

Several important limitations must be acknowledged. First, the model relies on epidemiological data that remain incomplete for several SADC countries, particularly Angola, DRC, and Madagascar. The sensitivity analysis demonstrates that results are robust to plausible variations, but the absence of high-quality country-specific data remains a constraint. Second, the surgical outcome data draw heavily from South African and a few other regional centers; outcomes at a new center in Lusaka might differ, likely toward higher mortality during the learning curve. Third, the model assumes that prevention scale-up can achieve 50% coverage within three years, an assumption that requires substantial health systems strengthening, including reliable supply chains for penicillin, trained primary care workers, and community engagement. [4] caution that the gap between efficacy and effectiveness for prevention programs in LMICs can be substantial. Fourth, and perhaps most significantly, the model does not fully capture the catastrophic health expenditure that RHD imposes on affected families. While indirect costs are included in the societal perspective, the model's DALY calculations cannot fully represent the lived experience of a family that sells its livestock, takes children out of school, or goes into debt to pay for a valve replacement that may or may not be available. [9] document these dynamics for South Africa; they are almost certainly worse in Mozambique, Lesotho, and other higher-burden, lower-capacity countries.

Implications for SADC and Beyond

Specifically for the SADC region, this project provides a roadmap for collective action. RHD is not a problem any single country can solve alone. South Africa cannot absorb the entire region's surgical caseload. Mozambique cannot build its own surgical center. But together, the 16

member states can pool procurement, share specialized workforce, establish cross-border referral protocols, and invest in prevention at scale. The SADC Health Protocol provides the legal framework; what has been missing is the economic evidence to justify the investment. This project supplies that evidence.

For the broader global health community, the project offers lessons for other neglected diseases that require both prevention and advanced treatment. The RHD dilemma is not unique. Similar tensions exist for HIV (prevention versus antiretroviral therapy), tuberculosis (case-finding versus drug-resistant treatment), and even some cancers (screening versus palliative surgery). In each case, the most cost-effective strategy is prevention, but the most just strategy includes treatment for those already affected. The phased hybrid model developed here invests in prevention immediately, builds treatment capacity strategically, and establishes explicit mechanisms for cross-subsidy and referral that may be applicable beyond RHD.

Personal and Formational Reflections

This Capstone project has transformed my understanding of what it means to do applied ethics in global health. Before this project, I believed that cost-effectiveness analysis was an important but technical exercise, important but separate from values. I now understand that every modelling decision embodies ethical choices: the choice of discount rate reflects how much we value present versus future lives; the choice of societal versus health system perspective reflects who counts in our analysis; the choice to include or exclude indirect costs reflects whether we see health as an end in itself or as a means to economic productivity.

The commitment to cura personalis care for the whole person has taken on new meaning. Caring for the whole person at the population level means caring for both the child who might develop RHD in ten years and the young adult whose damaged valves are failing today. It means caring for the family that will be impoverished by catastrophic health expenditure and the health system that must make impossible choices. It means caring with both the head (rigorous modelling) and the heart (ethical discernment).

The commitment to being men and women for others has also been clarified. This project was never solely an academic exercise. The deliverables, the model, the policy brief, and the manuscript were designed from the outset for use by SADC policymakers, not for storage in a university archive. I have made specific commitments to ensure ongoing access: the model is freely available under a Creative Commons license; I have offered virtual training to any SADC

ministry that requests it; I have deposited the model with WHO AFRO's knowledge repository. These commitments are modest but tangible expressions of service.

A Call to Action

The conclusion of this Capstone project is not an ending but a beginning. The model exists. The policy brief has been drafted. The stakeholders have been engaged. What remains is the implementation, the hardest part of any health policy endeavour.

I call on the SADC Health Directorate to take three specific actions within the next twelve months:

1. Establish the Regional RHD Technical Working Group proposed in Section 5.4, with an initial meeting scheduled before December 2026.
2. Commission a detailed implementation plan for the phased hybrid pathway, including firm cost estimates, site selection for the surgical center, and a workforce development timeline.
3. Submit a funding request to the SADC Secretariat and international donors (World Bank, Global Fund, Gates Foundation) for the initial three years of prevention scale-up, estimated at a total of $36 million.

This project does not end with submission; it ends with use. In [19] and [20] conclude their comprehensive review of acute rheumatic fever and rheumatic heart disease with a statement that has stayed with me throughout this project: "The tools to eliminate RHD as a public health problem exist. What is missing is the political will." This project provides the economic evidence to strengthen that political will. It demonstrates that elimination is not only medically possible but also economically sensible, provided that investments are made strategically and equitably, with attention to both prevention and treatment.

Rheumatic Heart Disease is a disease of poverty, but it is also a disease of policy neglect. It persists not because we lack effective interventions but because we have failed to prioritize them. Southern Africa has the opportunity to change that narrative. The region has the SADC framework for cooperation, the clinical expertise in its cardiology societies, and now the economic evidence from this project. What remains is the choice to act.

The 85,000 patients in the surgical backlog are waiting. The millions of children at risk are growing up. The question is no longer whether SADC can afford to act; it cannot afford not to. The cost of inaction is measured not only in dollars but in lives cut short, families impoverished,

and futures stolen by a preventable disease. This project has shown the way. Now comes the walking.

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