Improving Health Information Access in the World's Largest Maternal Mobile Health Program via Bandit Algorithms

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Introduction

Boosting cohort engagement in mHealth programs

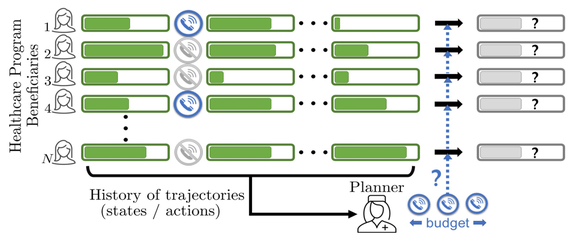
Key Challenges:

1. Scheduling limited intervention resources in sequential planning problem
2. Inferring preferred time slot for automated voice messages

CHAHAK: Campaign for Health-resource Allocation using Historical data in AI based system for Kilkari

- **Model Multi-Action Time Series Bandit**
- **First work optimising time slot section**

Human behavior is likely to contain **temporal dependencies**



Kilkari: India's Ministry of Health & Family Welfare mHealth program

World's largest maternam mHealth program

Maternal Health | Immunization

Child health | Family Planning

automated voice messages sent for **72 weeks** → **3 million** active subscribers

armman

Mission: Reduce maternal, neonatal and child mortality and morbidity in underprivileged communities

Method

Problem Domain: Intervention Planning Under Limited Resources

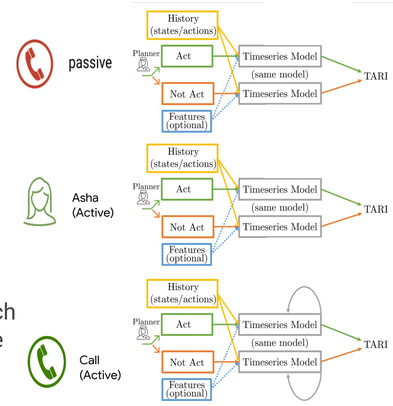
Scheduling limited multiple interventions to maximize engagement in a mobile health program

Model & Objective 1: Beneficiary as arms of bandit model[1], maximize # of beneficiaries in engaging state.
Solution: Time Series Bandits (TSBs) and Multi Action TAR [2] approach using Greedy and LP selection strategies
Model & Objective 2: Time slots as arms of bandit model, infer preferred time slot of every beneficiary for receiving automated voice messages.
Solution: Run a Upper Confidence Bound (UCB) model for each each beneficiary. The timeslot (a_τ at timestep τ) is chosen based on the following UCB equation:

$$a_\tau = \arg\max_j \mu_j + \sqrt{2(\log \tau)/\nu_j}$$

Actions

Multi Action - Time-series Arm Ranking Index (MA-TARI)



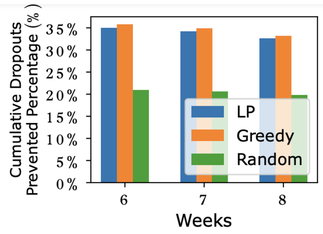
Results

Experiment Setup - Intervention Planning

We consider the following methods:

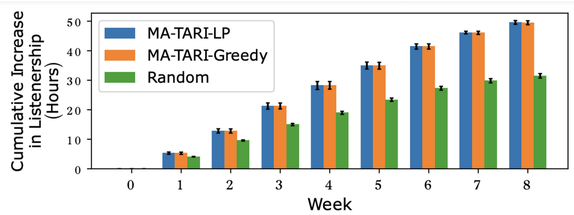
1. MA-TARI Integer Linear Programming
2. MA-TARI Greedy
3. Random - randomly allocate interventions
4. Control - No interventions

Simulated experiment: Consider 4000 beneficiaries in simulation and allow 1% ASHA interventions and 1% CALL interventions every week

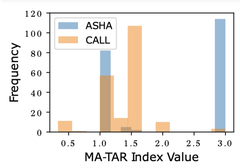


MA-TARI cumulatively **prevents 33% more dropouts** by 8th week as compared to Random

Results - Intervention Planning

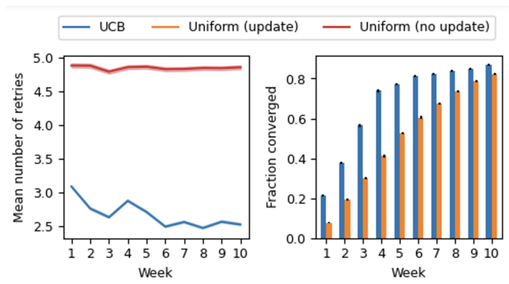


Real world significance: 49.6h and 49.47h of additional content listened by the beneficiaries by the 8th week (for the LP and Greedy variants, respectively). **57% increase in exposure** compared to Random



Potentially delay the poor listenership state by 3x weeks

Results - Time Slot Planning



[LEFT] *Uniform (no update))* requires an average of **4.86 calls per week**, while *UCB* requires **2.5 calls per week** by week 6

[RIGHT] *UCB* achieves a pickup rate difference of **less than 0.15**, compared to the true pickup rate **within 4 weeks**, for 75% of the population, compared to **8 weeks** by *Uniform (update)*

Conclusion

1. Proposed Multi-Action Time-series Arm Ranking Index (MA-TARI): (i) act on beneficiaries which will benefit the most from an intervention (ii) use greedy selection strategy for multiple actions - practical and scalable (iii) 49hrs more content listened (iv) 57% increase in engagement and 33% more dropouts prevented compared to Random
2. Propose Upper Confidence Bound based strategy for Call Time Slot optimization: 47% reduction in call attempts rate by week 6

Path to Deployment

1. *Nationwide deployment of CHAHAK through collaboration with our NGO partner ARMMAN*
2. *Planned cohort study to validate CHAHAK's benefits on ground*
3. *Draw from experience of deploying SAHELI to tackle the challenges that come up*

References

1. *Field Study in Deploying Restless Multi-Armed Bandits: Assisting Non-profits in Improving Maternal and Child Health.* Mate et al., AAAI 2022
2. *Limited Resource Allocation in a Non-Markovian World: The Case of Maternal and Child Healthcare.* Danassis et al., IJCAI 2023