State-space models for engagement, retention, and re-entry in the HIV care cascade

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Abstract # 1042

BACKGROUND

Recently the HIV care cascade which describes essential steps in the whole HIV care continuum has become a central assessment metric to monitor progress and identify gaps in HIV care needs in the US and worldwide.

- **Main use**: Targeting some key questions related to HIV care efforts
  1. *When* patients are most likely to fall out of care
  2. *Where* along the phase they are most likely to be lost
  3. *Who* is most likely to disengage at each phase.
- **Limitations**:
  1. The lack of representing various types of longitudinal patient experiences
  2. Analytical approaches in addressing the questions surrounding the cascade.
- **Objective:** We propose a state space representation of the HIV care cascade and corresponding statistical framework that can describe the longitudinal dynamics along the phases in the cascade.

METHODS

- Each phase in the HIV care cascade is viewed as a ***state***.

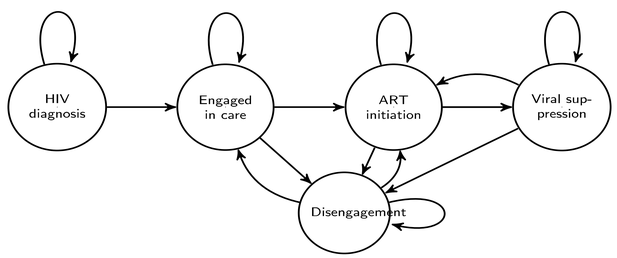


Figure 1. State space based representations of the conventional HIV care cascade.

- State space models (SSM): parameterized by probability of transitioning from one state to another

$$S_t = \text{state at time } t$$

$$pr_{jkt} = pr\{S_t = k \mid S_{t-1} = j\}$$

- Example: **S**={1,2,3,4,5} = {HIV diagnosis, engagement in care, disengagement from care, ART initiation, viral suppression}
- p_{22t} : probability of transition from engaged to engaged (***retention***)
- p_{32t} : probability of ***re-entry*** into care after disengagement
- Effect of covariates on $\mathbf{pr}_{jkt}$ can be assessed by multinomial logistic regression:

$$\mathbf{logit}\{pr_{jkt}(X_t) / pr_{jJt}(X_t)\} = \beta_{jk}^{T} I\{S_{t-1}=j\}\, X_t$$

X_t = a collection of covariates
J = reference state
β_{jk} = a log relative rate ratio

APPLICATION

Application of the framework on existing data requires three main processes:

1. **Operationalization of the care cascade:** best reflect and capture dynamics in a cohort
2. **data preparation:** appropriately incorporates patient monitoring plan
3. **implementation of SSM:** use SSM tailored to step 1.

We illustrate application of the framework using AMPATH (Kenya) data.

Step 1. Operationalization of the care cascade

AMPATH data on HIV testing and viral load is limited (cost and resource constraints). Due to the limitations, we represented the current operation by

- State=1: engaged in care
- State=2: disengaged from care
- State=3: transfer-out
- State=4: lost-to-follow-up (LTFU)
- State= 5: deceased,

focusing on ***retention aspect of care***.

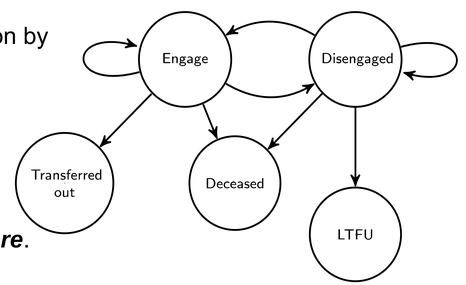


Figure 2. State space representation of the HIV care cascade using the AMPATH data

Step 2. Data preparation

Patient monitoring plan: Expected return dates by AMPATH protocol is

- Three month if on ART
- Six month if not on ART

+ two weeks = at least one visit at every 197 days to be defined as engaged. Otherwise disengaged unless transferred-out or died.

- LTFU: no clinical visit in a year after disengagement.

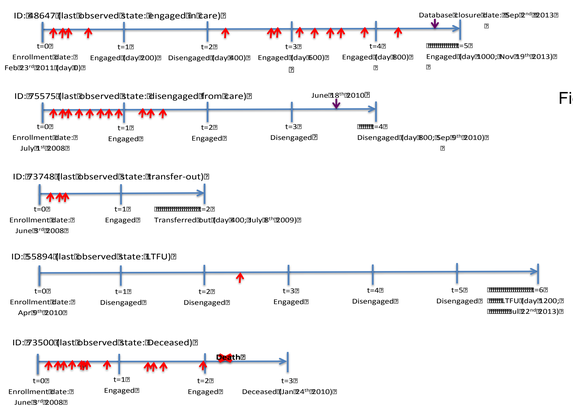


Figure 3. Sample data from AMPATH to ascertain state membership at each time grid that reflects the AMPATH patient monitoring plan

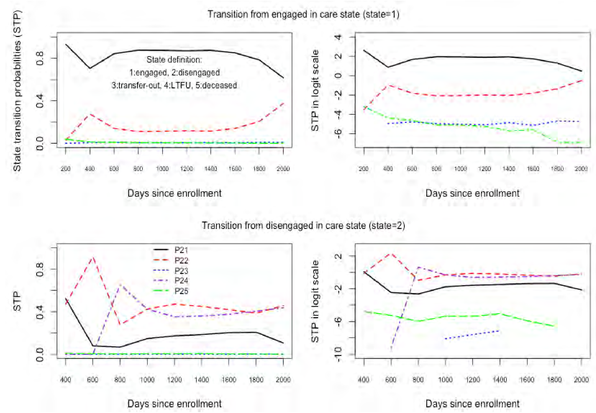
Step 3. Implementation of SSM

Accordingly, 5 state SSMs were considered using engaged in care (state=1) as a reference state.

RESULTS

Participants: 57,596 patients ≥13 years of age (enrolled btw Jan. 2008 - Sep 2012). Sixty seven% female, median age of 35, and median CD4 count at baseline of 239 cells/ml[3].

1. Unadjusted SSM: Temporal trends – ***when*** and ***where*** questions



2. Adjusted SSM: Effect of covariates & identify groups at high risk – ***when, where,*** and ***who*** questions

Table. Overall state transition rates (STR) and relative risk ratio (RRR) for effects of covariates on the STR

State at t-1		Engaged				Disengaged			
State at t		Engaged	Disengaged	Transfer-out	Death	Engaged	Disengaged	LTFU	Death
Overall STR		0.84	0.14	0.01	0.01	0.12	0.54	0.34	0.004
RRR (95% CI)	Age>=35	-	0.7 (.68, .72)	0.6 (.54,.67)	1.02 (.95,1.09)	-	0.91 (.86, .97)	0.96 (.90,1.03)	1.23 (.91,1.66)
	Male	-	1.17 (1.14, 1.20)	0.88 (.78, .99)	1.77 (1.66, 1.89)	-	0.97 (.91, 1.03)	0.93 (.87, .99)	1.05 (.78, 1.41)
	CD4<350, ARV+	-	0.2 (.19, 0.21)	0.46 (.38, .55)	0.42 (.38, .46)	-	0.43 (.40, .48)	0.36 (.33, .40)	0.7 (.49, 1.01)
	CD4>=350, ARV-	-	0.38 (.36, .39)	0.3 (.24, .37)	0.1 (.08, .12)	-	0.84 (.76, .93)	0.76 (.68, .84)	0.36 (.22, .61)
	CD4>=350, ARV+	-	0.14 (.13, .15)	0.27 (.22, .33)	0.09 (.08, .10)	-	0.38 (.34, .42)	0.29 (.26, .32)	0.13 (.06,.29)
	CD4 unknown, ARV-	-	1.97 (1.85, 2.09)	1.04 (.72, 1.51)	1.03 (.89, 1.19)	-	2.27 (1.90, 2.72)	2.14 (1.78, 2.57)	1.75 (1.03, 3.00)
	CD4 unknown, ARV+	-	1.4 (1.31, 1.49)	1.25 (.92, 1.71)	0.91 (.78, 1.05)	-	0.43 (.39, .48)	0.19 (.17, .21)	0.17 (.09,0.34)

CONCLUSIONS

The proposed approach is the first attempt to capture all possible transition dynamics using longitudinal data and to find determinants of the transitions to seek answers to the when, where, and who questions. Findings from SSM-based analysis of the care cascade based on a clinical cohort will inform the development of guidelines that are tailored to patient characteristics in that cohort, customized to sub-populations at highest risk of falling out of care at each stage of the cascade.

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