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 phases they are most likely to be lost
- **Objectives:** 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**.
- State space models (SSM): parameterized by probability of transitioning from one state to another
  \[ S_t = \text{state at time } t \]
  \[ p_{ij} = p_r(S_t = k | S_{t-1} = i) \]
- Example: \( S = \{1,2,3,4,5\} = \{\text{HIV diagnosis, engagement in care, disengagement from care, ART initiation, viral suppression}\} \)
- \( p_{ij} \): probability of transition from engaged to engaged (retention)
- \( p_{io} \): probability of re-entry into care after disengagement
- Effect of covariates on \( p_{ij} \) can be assessed by multinomial logistic regression:
  \[ \logit(p_{ij}(X)) = \beta_k'(I(S_{t-1}=i)) X_i \]

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 (LTU)
- **State=5:** deceased

**Step 2. Data preparation**
Patient monitoring plan: Expected return dates by AMPATH protocol is
- **Three month if on ART**, + two weeks = at least one visit at every 197 days to be defined as engaged. Otherwise, disengaged unless transferred-out or died.
- **LTU:** no clinical visit in a year after disengagement.

**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 bw Jan. 2008 - Sep 2012). Sixty seven% female, median age of 35, and median CD4 count at baseline of 239 cells/mℓ.

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

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

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 failing out of care at each stage of the cascade.

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