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Research Article

Unpacking the black box of latent class analysis using qualitative life history interviews: A data-linked explanatory approach examining sexual behavior in rural South Africa

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Abstract

BACKGROUND
Sexual behaviors are determined by present-day factors and past/future considerations. Previous work utilizing latent class analysis on a population-based cross-sectional survey of rural South Africans aged 15-plus showed how sexual behaviors cluster in distinct population subgroups (Class 1: Single with consistent protective behaviors; Class 2: Risky behaviors; Class 3: In union with lack of protective behaviors) and their associations with age, sex, and HIV status.

OBJECTIVE
Expanding upon this work, we advance a novel mixed methods approach – data-linked explanatory analysis – to demonstrate how nested qualitative life history interviews (LHIs) with survey participants can be used to account for population patterns in studies utilizing person-centered techniques to classify health behaviors.

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METHODS
We predict the most likely latent class for a subsample of men and women aged 40-plus living with and without HIV from the survey (n = 45) and then analyze LHIs within each class by gender and HIV status. We highlight the different routes participants take to end up in the same predicted latent class in mid/later life, and we explore additional factors that may account for predicted class membership and HIV-related outcomes within the broader context of participants' lives.

FINDINGS
In the LHI sample (n = 45), 22% fell into Class 1, 7% into Class 2, and 71% into Class 3. Factors that may account for predicted latent class membership include: Class 1 – living with HIV or fears of contracting HIV; Class 3 – life events and lifestyle changes (for men without HIV), including illness (for men with HIV). In Class 3, married women's relative influence over their husbands' behaviors, as well as their husbands' own HIV-related awareness, actions, and concerns, also inform HIV-related outcomes.

CONTRIBUTION
Data-linked explanatory analysis is a novel and valuable approach to understanding the complexity underlying population subgroups identified by latent class analysis, enabling triangulation at the individual level and showing how survey-nested qualitative interviews can help uncover factors contributing to aggregate population-level patterns.

1. Introduction

With the HIV pandemic in sub-Saharan Africa well into its fourth decade, understanding sexual behavior has been an enduring concern for researchers across disciplines (Wellings et al. 2006). In surveys, sexual behaviors are often examined through retrospective self-reports with fixed response options, which are used to assess patterns of behavior and their associations with various outcomes. In qualitative interviews, participants are often asked to describe their relationships, offering greater depth and insight into the meanings they attach to their sexual practices. Bringing patterns from both types of data together is key to understanding sexual health and HIV-related outcomes in context (Pluye and Hong 2014).

Sexual health behaviors are complex phenomena (Fenton et al. 2001). While they are determined by factors at the moment they occur, they are also informed by events in the past and even considerations of the future. Health behaviors are also often interrelated and vary throughout the life course (Cockerham 2005; Umberson, Crosnoe, and Reczek 2010). In prior work, we aimed to address some of the limitations of sexual behavior survey studies conducted in African settings with a high HIV burden. Such studies often

focus on individual risk and protective behaviors as well as on younger adults. Utilizing a population-based cross-sectional sexual behavior survey of individuals aged 15 to 85-plus in a rural South African setting, we used latent class analysis to understand how sexual behaviors cluster in distinct population subgroups across a wide age range (Houle et al. 2020). While such an approach showed the patterning of multiple sexual behaviors across individuals, latent class techniques are nonetheless sensitive to which behavioral measures and responses are available in the data (Akers et al. 2016; Carter et al. 2019; Jonzon and Lindblad 2006). It is also unclear how respondents make sense of and internalize the interrelationships among their health practices.

This paper builds and expands upon prior work by integrating and analyzing qualitative life history interviews (LHIs) with a subset of survey participants. We aim to show how innovative use of this nested mixed methods dataset can help account for patterns of sexual behavior across population subgroups. We accomplish this with what we call data-linked explanatory analysis, one example of the many uses of data collection efforts involving sampling respondents for qualitative interviews from survey or census lists (Schatz 2003, 2012). Through this data-linked approach, we observe different routes participants take to end up in the same predicted latent class by mid/later life as well as additional factors that may account for predicted class membership and HIV-related outcomes within the broader context of participants' lives. These LHI data have been analyzed previously, including to advance a conceptual framework of HIV risk and protection across the later life course (Mojola et al. 2015). Analysis of these LHI data has also uncovered age, period, and cohort dimensions in middle-aged and older Africans' adaptation of their sexual practices in response to the HIV epidemic in South Africa (Mojola et al. 2021). The present analysis departs from previous analyses in its innovative use of nested LHIs to unpack the black box of a survey-based latent class analysis that identified patterns of sexual behaviors across population subgroups and their associations with age, sex, and HIV status (Houle et al. 2020). While other mixed methods sexual behavior studies have combined latent class techniques with qualitative interviews (e.g., Magno et al. 2018; Rodriguez-Hart et al. 2018), our work is unique in its intention to demonstrate how linked data sources can be strategically leveraged to account for population patterns in studies utilizing person-centered techniques to classify health behaviors.

2. Setting and nested mixed methods data sources

Below we describe the rural South African setting in which both the HIV sexual behavior survey and the qualitative life history interviews were collected. We then describe the linked data sources.

2.1 Study setting

Our study is based in the Agincourt Health and Socio-Demographic Surveillance System (AHDSS), run by the MRC/Wits Agincourt Research Unit of the University of the Witwatersrand. The AHDSS is located in the Bushbuckridge subdistrict of Ehlanseni District, Mpumalanga Province, in the rural northeast region of South Africa, about 500 kilometers from Johannesburg and close to the border with Mozambique (Kahn et al. 2012). The area is a former apartheid-era homeland, one of the underdeveloped areas of the country to which Black South Africans were forcibly resettled, and faced hardships including poor education, limited employment, and inadequate health services (Coovadia et al. 2009). The primary ethnic group is the Xitsonga/Shangaan-speaking amaShangaan. The kinship system is patrilineal; women marry into their husband's family through a payment of lobola (bride wealth) (Sennott, Madhavan, and Nam 2021). Marriage rates in South Africa are low relative to other African countries (Garenne 2016) and have continued to fall (Hosegood, McGrath, and Moultrie 2009; Posel, Rudwick, and Casale 2011). As a result, long-term informal unions and cohabitation are common forms of partnering (Sennott, Madhavan, and Nam 2021).

While there has been steady socioeconomic improvement in the area (Kabudula et al. 2017), challenges stemming from poverty and limited employment opportunities contribute to enduring patterns of circular labor migration (Collinson 2010; Kahn et al. 2012). This has affected family life and intimate relationships through prolonged periods of spousal separation, which have strained gender relations and altered norms of sexual partnering (Hosegood, McGrath, and Moultrie 2009; Hunter 2005). Such norms differ for women and men: While women gain respectability through fidelity or "behaving well" (Sennott and Mojola 2017), norms of masculinity support men's multiple sexual partnerships both within marriage (polygamy) and outside of marriage (Hunter 2005; Mojola et al. 2021). Circular labor migration has also been a key driver of the South African HIV epidemic (Coffee, Lurie, and Garnett 2007). Elevated AIDS-related mortality in the area reached a peak in the first decade of the 2000s, contributing to declines in life expectancy that have rebounded with the wide-scale availability of anti-retroviral treatment (ART) (Houle et al. 2024).

2.2 HIV Prevalence and Sexual Behavior Survey (HIV Survey)

Since 1992, the AHDSS has conducted an annual census of the population. It also hosts numerous quantitative and qualitative studies that use the census as a sampling frame. Our data sources – an HIV prevalence and sexual behavior survey (HIV Survey) drawn from the AHDSS, and qualitative LHIs conducted with HIV Survey respondents – are two such examples. At the time of data collection for these studies, the area included approximately 90,000 people across 27 villages (Kahn et al. 2012).

The HIV Survey is a cross-sectional population-based HIV prevalence and sexual behavior survey conducted in 2010–2011 on an age-sex stratified random sample of men and women ages 15 to 85-plus and resident in the AHDSS in 2009. The study collected data on a range of self-reported sexual behavior measures – number of lifetime sexual partners, HIV testing history, diagnoses of sexually transmitted infections (STIs), and sexual relationships over the past 24 months – and included the collection of biomarker data for HIV (see Gómez-Olivé et al. 2013 and Houle et al. 2018 for additional details on the survey and biomarker data). It also included union status based on the 2009 Agincourt census round. Of the 7,662 randomly sampled participants, 4,362 consented to the interview and the HIV biomarker test. Analysis of the biomarker data revealed high HIV prevalence well into older ages – with more than 15% of men and 10% of women up to age 70 living with HIV (Gómez-Olivé et al. 2013).

2.3 Qualitative Life History Interviews

Following the HIV Survey, in 2013 we conducted qualitative LHIs with 60 middle-aged and older Africans who had participated in the survey to understand the life course factors shaping HIV vulnerability among this population (Mojola et al. 2015). The LHI sample was stratified by gender (male, female), HIV status (with HIV, without HIV), and age group (40s, 50s, 60-plus). HIV Survey respondents within these subgroups were selected at random for study participation. This sampling strategy avoided convenience sampling of the most accessible respondents in the AHDSS and ensured sufficient representation by gender, HIV status, and age.[5] However, the LHI sample is not representative of the Agincourt population.

[5] To create our sample list, we randomly drew 240 participants from the HIV Survey, stratified by gender (male, female), HIV status (with HIV, without HIV), and age group (40s, 50s, 60-plus). The 20 sampled individuals from each gender, age group, and HIV status category were assigned a random sequence number. We visited the top five listed individuals in each subgroup (e.g., men with HIV in their 40s; women without HIV in their 50s) and replaced individuals in sequence until we obtained five interviews in each subgroup (Mojola et al. 2021).

The LHIs focused on respondents' sexual, romantic, and marital histories leading up to and including their current or last relationship; family lives growing up; livelihood strategies; and educational and residential histories. The interviews also focused on how respondents and their partners managed exposure to HIV; general health, including other illnesses and use of allopathic or traditional medication; HIV testing experiences; and, for those who disclosed in the interview that they were living with HIV,[6] ART knowledge and uptake. A follow-up interview was conducted with 10 respondents living with HIV to address at greater length issues and topics discussed in the first interview. The LHIs were conducted in a private location of the respondent's choosing (usually their home), lasted between one and two hours, and were audio-recorded, translated from Xitsonga/Shangaan to English, and transcribed by a team of five interviewers from the study site.

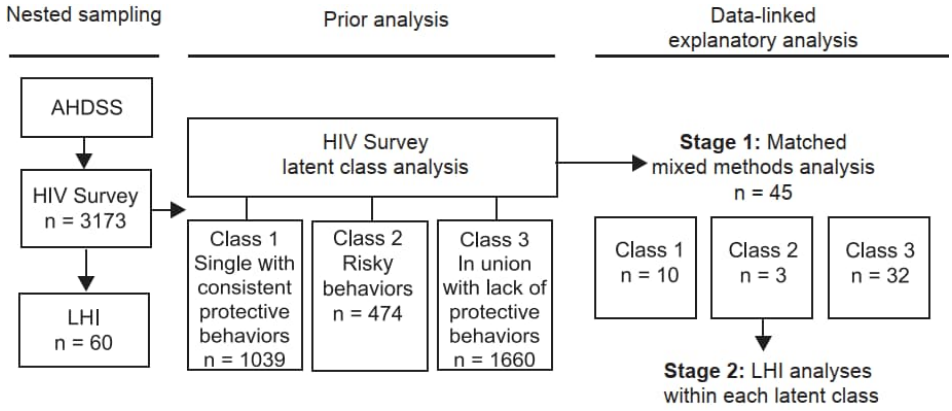
All study participants provided informed consent. The studies were approved by the authors' institutional review boards; the University of the Witwatersrand Human Research Ethics Committee, which oversees the Agincourt research site; and the Mpumalanga Province Research and Ethics Committee in South Africa.

3. Data-linked explanatory analysis

We begin this section by briefly describing the results from previous work to familiarize readers with how sexual behaviors cluster in the Agincourt population and their associations with age, sex, and HIV status. Next we proceed to the focus of this article by detailing our data-linked approach of assigning LHI respondents who participated in the HIV Survey to a latent class group and analyzing the LHIs within each class. We then present cases from the life history interviews that elucidate patterns for the classes identified in the latent class analysis and themes that emerged in the analysis of the LHIs. Figure 1 shows the nested mixed methods study design and stages of data-linked analysis.

[6] Interviewers were blinded to the HIV status of participants at the time of recruitment.

Figure 1: Nested mixed methods study design and data-linked analysis

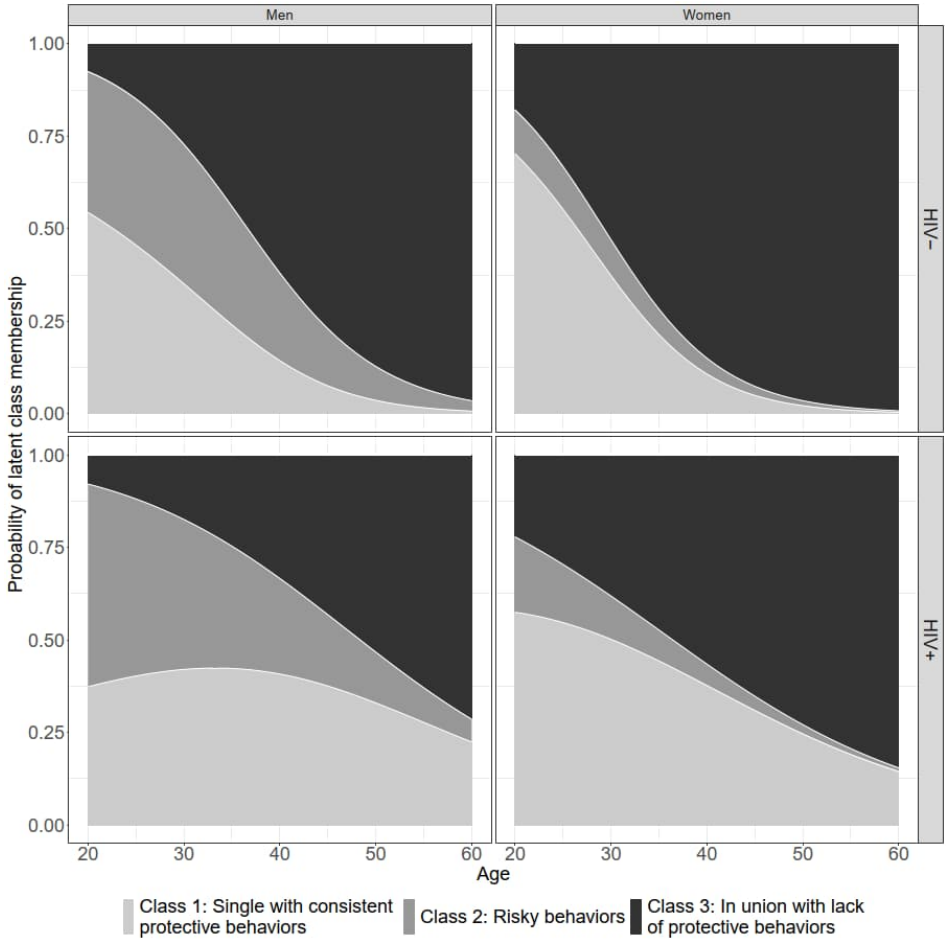


Notes: The 3,173 individuals in the HIV Survey are those who reported at least one sexual partner in the past 24 months and provided complete information on all covariates. In the matched mixed methods analysis, 45 out of the 60 LHI respondents reported a sexual partner in the past two years and provided complete information on all covariates.

3.1 Prior Latent Class Analysis

In the prior latent class analysis (LCA) (Houle et al. 2020), the sexual behavior indicators included whether the respondent was in a formal/informal union; whether they reported ever having been diagnosed with an STI (excluding HIV); and, for the last two years, the total number of sexual partners, the proportion of partners with whom they reported using a condom mostly or always, whether any of their partners were casual/anonymous, and the proportion of partners whose HIV status they knew the first time they had sex. We fit a series of models (including two to six classes) with these indicators to identify the number of latent classes. In this population, our LCA identified three subgroups that had different sexual behavior patterns. Figure 2 provides the summed predicted probabilities of latent class membership by age, sex, and HIV status. The probability for each class is added to the other classes, so that the cumulative area for successive curves represents the probability of membership in these classes. While the figure draws on cross-sectional data, it shows variation in clusters of sexual behaviors at different ages. Below we discuss each class in turn.

Figure 2: Summed predicted probability of latent class membership by sex, age, and HIV status



Notes: All other covariates are held at their mean values. Indicators included whether the respondent was in a formal/informal union; whether they reported ever having been diagnosed with an STI (excluding HIV); and, for the last two years, the total number of sexual partners, the proportion of partners with whom they used a condom mostly or always, whether any of their partners were casual/anonymous, and the proportion of partners whose HIV status they knew the first time they had sex. Covariates included sex, age, education level, household socioeconomic status, nationality (South African or Mozambican/other),[7] HIV status, self-reported ever having an HIV test, and alcohol consumption in the past month.

[7] About 30% of the Agincourt population includes former refugees of the Mozambican civil war and their descendants.

Class 1 – single with consistent protective behaviors. Individuals in this class typically were not in a union, reported one regular sexual partner, and, compared to the other classes, had the highest probability of reporting mostly/always using a condom and knowing their partner's HIV status before having sex for the first time. For this class, there were no gender differences in the sexual behavior indicators. Membership in this class was lower at older ages – though women and men with HIV had a higher probability of membership in this class at older ages than did their counterparts without HIV, who had the highest probability of being in this class up until young adulthood (early 20s for women, late 20s for men).

Class 2 – risky behaviors. Individuals in this class almost always reported multiple sexual partners, had a high prevalence of STIs, often reported a casual/anonymous partner, and had inconsistent patterns of mostly/always using a condom and knowing their partner's HIV status. Compared to women, men had a higher probability of being in a union and reporting two or more sexual partners in the past two years. Men with HIV had the highest probability of being in this class in younger adulthood (until their late 20s), while men without HIV had the second highest probability of being in this class at all ages. Women with HIV had a relatively higher probability of being in this class until younger adulthood (mid/late 20s) compared to women without HIV, who had a low probability of being in this class across all ages.

Class 3 – in union with lack of protective behaviors. Individuals in this class were most likely to be in a union (≥ 75% probability) and report just one sexual partner. Unlike Class 1, they had low levels of mostly/always using a condom and knowing their partner's HIV status. Compared to women, men had a higher probability of reporting two sexual partners in the past two years. Membership in this class was higher at older ages – for men aged 40-plus, it was more common to be in this class than in Class 2; for women aged 40-plus, it was more common to be in this class than in Class 1. Women and men without HIV had the highest probability of being in this class in younger adulthood (mid/late 20s for women, early/mid-30s for men), while their counterparts with HIV had the highest probability of membership in this class in midlife (early/mid-40s).

3.2 Stage 1: Matched mixed methods analysis

To assign LHI respondents to a latent class from the HIV Survey, we predicted their posterior probabilities for being in each class and assigned them to the class with the highest probability.[8] Table 1 provides descriptive statistics on the most likely predicted

[8] While these latent class assignments are expository in nature, examining the average posterior probabilities of individuals assigned to each class indicated low classification uncertainty. (Class 1 = 0.81 [0.53–0.99]; Class 2 = 1.0; Class 3 = 0.97 [0.76–1.0].)

class membership for LHI sample respondents by gender and HIV status. Of the 45 (out of 60) LHI respondents for whom class membership could be estimated, 22% fell into Class 1, 7% into Class 2, and 71% into Class 3. (Fifteen of the LHI respondents could not be assigned to a latent class because they did not report having had a sexual partner in the past two years [n = 12] or did not provide complete information on all covariates used in the LCA model [n = 3].)[9] In Class 1, there were only three women (all living with HIV) versus seven men (three with HIV, four without HIV). There were three men but no women in Class 2 and a balanced gender mix in Class 3, with 15 men (eight with HIV, seven without HIV) and 17 women (eight with HIV, nine without HIV). That the majority of the LHI sample fell into Class 3 is consistent with observed patterns of age in relation to class membership (see Figure 2).[10]

Table 1: Predicted latent class membership among LHI sample respondents, by gender and HIV status

	Men		
	With HIV	Without HIV	**TOTAL**
Class 1 – Single/protective behaviors	3	4	7
Class 2 – Risky behaviors	1	2	3
Class 3 – Union/lack protective behaviors	8	7	15
TOTAL	12	13	25

	Women		
	With HIV	Without HIV	**TOTAL**
Class 1 – Single/protective behaviors	3	0	3
Class 2 – Risky behaviors	0	0	0
Class 3 – Union/lack protective behaviors	8	9	17
TOTAL	11	9	20

3.3 Stage 2: Analysis of LHIs within each latent class

The LHIs were analyzed in a series of iterative steps. First, the LHI transcripts were read carefully and summarized into narrative form following major themes in the interview guide: family life, work/livelihood, relationships, general health, HIV knowledge/risk, and (if relevant) ART. This helped anchor the data into the main areas of focus of the life

[9] Of the fifteen excluded LHI respondents, ten were women (four with HIV, six without HIV) and five were men (three with HIV, two without HIV). They were primarily an older (13 out of 15 were aged 60-plus) and widowed (10 out of 15) group.

[10] As previously noted, the qualitative LHI sample was stratified by gender, age group, and HIV status and is not representative of the population aged 40-plus in the Agincourt study site.

history interviews and helped familiarize us with major themes of the life histories across respondent categories of gender, age group, and HIV status (Deterding and Waters 2021). Next, we leveraged the nested nature of the data by assigning LHI respondents to their most likely predicted class (1, 2 or 3). Within each latent class group, the cases were sorted into subgroups of gender, age, and HIV status (e.g., men, 40s, with HIV; women, 50s, without HIV) to show the distribution of these characteristics within each class (see Table 1). This approach aligned with the prior LCA analysis that identified important variation by these dimensions (Houle et al. 2020). We then analyzed two sections of the summarized narratives for each individual by subgroup – relationships and HIV knowledge/risk – with attention to themes that elucidated subgroup similarities (e.g., men without HIV in Class 3) and differences (vs. men with HIV in Class 3). In the final stage of analysis, we analyzed the entire life history transcript within each latent class group again to situate findings in the broader context of participants' lives (Rosenthal 1993). During this process, we also leveraged patterns identified in the LCA to make sense of patterns identified in the LHIs.

4. Life history cases

We present life history narratives of six individuals (three men and three women). We focus on individuals in Class 1 (n = 10; single with consistent protective behaviors) and Class 3 (n = 32; in union with lack of protective behaviors) because, as consistent with aggregate patterns by age, few LHI participants (all men) fell into Class 2 (those with risky behaviors; n = 3). We aim to accomplish two tasks. First, we aim to render visible life events and experiences over time that help explain someone's most likely predicted class in mid/later life. Second, we aim to highlight additional factors, such as beliefs, decisions, and rationalizations about sexual health practices, and how they connect to HIV-related outcomes and concerns. In so doing, our analysis augments latent class analysis from a high-HIV-prevalence setting, focused on identifying clusters of sexual behavior by sex and across a wide age range, by examining sexual practices throughout the life course and in the context of people's lives.[11]

[11] Except for age, gender, and HIV status (the sampling criteria for the life history interviews), all information presented is based on respondents' accounts.

4.1 Class 1: Single with consistent protective behaviors

4.1.1 Women

In our LHI sample, Class 1 was comprised of only three women, consistent with the LCA that showed the low probability of older women's predicted membership in this class. Consistent with aggregate patterns (women with HIV had a higher likelihood of being in Class 1 at older ages than their counterparts without HIV; see Figure 2), the LHI respondents in this class were also all living with HIV. One was a recent widow; the other two were unmarried (one divorced, one never married) and discussed having sexual partners they saw infrequently, with whom they used condoms. In their LHIs, both unmarried women also discussed prior relationships with men that ended in unfortunate ways, including sexual affairs and abandonment. The life events leading up to and following their HIV diagnoses help explain the protective behavioral strategies they now practice. The case of Ayanda, presented below, also helps explain how formerly married women not engaging in protective sexual practices earlier in life (which aligns with Class 3) would later in life be single and practicing safer sex (which aligns with Class 1, her current predicted class).

Ayanda: From married to in a "relationship" with "my job". Ayanda is a 41-year-old mother of five children.[12] As a young girl she hoped to marry so that she would have a "better life" than the one she experienced growing up, as her father did not have stable employment. Her first relationship was with a schoolmate who came from a well-off family. Because he was physically abusive, Ayanda eventually left him. Her next relationship was with the man she ultimately married, a tradesman whom Ayanda loved for being quiet and non-aggressive. As she explains, "Most of my life, I have spent it married." Their relationship of "many years" ended when Ayanda caught her husband cheating with a neighbor, a woman Ayanda knows has HIV. Throughout their marriage, Ayanda sometimes used contraception (injectables) but not condoms.

Ayanda left her husband following knowledge of his affair, moving with her children into her own home. She then dated an unmarried man from a nearby village, whom she met while working in that village as a caregiver. They did not use condoms, and Ayanda is not sure if he had HIV, but he did have other STIs, for which he sought treatment. He ultimately fell sick and died. Ayanda first tested for HIV during a testing campaign in the village where she was working. She tested positive for HIV and was given a clinic referral letter, but she never went because she worried about having to miss work. She was motivated to test again over a year later because she was experiencing severe constipation. At that point, given her low CD4 count, Ayanda immediately started ART.

[12] All names are pseudonyms. Ages are the respondent's age when the LHI data were collected.

Ayanda maintains a more casual relationship with a man who lives far away and whom she sees every few months. When having sex, they use condoms because she does not want more children and does not want to "add [to] the [HIV] virus in my body." She notes, however, that her "appetite for sex" has declined with age. At this stage in her life, Ayanda says that her foremost priority is work and to earn enough money to support her children until they are grown. In her words, "I don't have a concrete relationship [now]; the relationship that I have, it's [with] my job."

Earlier in her life, Ayanda was married to a man with whom she did not use condoms and who was having an extramarital relationship, which aligns with Class 3. In midlife (40s), Ayanda is no longer married, is living with HIV, and uses condoms with a sexual partner she sees infrequently, which helps explain her predicted membership in Class 1. Ayanda's LHI helps us see how, as a single mother of five children, she rationalizes using condoms with a more casual distant partner. Her LHI also highlights the importance Ayanda places on protecting her health and staying employed – factors otherwise obscured by looking only at her current predicted class (Class 1).

4.1.2 Men

Compared to women, there was more variation in the LHI sample among men in Class 1. Of the seven men in this class, three had HIV and four did not have HIV. Most of the men in this class were not in a union: two were single, one was separated, one was living with a girlfriend, and one was recently widowed.[13] Moreover, more than 70% (five out of seven) of the men in this group were in their 40s. Of these, several mentioned being tested for HIV, talking about HIV with their sexual partners, and/or the importance of using condoms (either for HIV prevention or following an HIV diagnosis). Half (two out of four) of the men who did not have HIV discussed using condoms due to fear of HIV, as Bongani's case illustrates.

Bongani: "I told myself that condoms are number one". Bongani is 43 years old and lives in a multigenerational household. His parents separated when Bongani was a child, and he grew up with his mother and siblings. His late father had another wife and, according to Bongani, "liked women" and died of AIDS a long time ago. His mother left to work on the farms, and Bongani dropped out of school to help care for his younger siblings. When he is able to find work, Bongani helps his mother buy food for the household.

[13] Due to the time lag in the collection of the two data sources – HIV Survey data were collected in 2010–2011 while the LHIs were collected in 2013 – relationship status could have changed in that two- to three-year time frame.

Bongani describes several romantic relationships, most of which ended in similar ways. He had relationships while working at farms, where farmworkers are provided housing, making it easier for partners to visit. Bongani describes women at the farms as "not good" and says he was "wronged" by one girlfriend, who was having sex with other men. Another girlfriend subsequently left the farms to work elsewhere; Bongani visited her at her new workplace, but she eventually got another boyfriend. Bongani then met another woman – his most recent relationship, which lasted two years – who offered him a place to live and said she would find a job for him in a nearby town. He describes her in unflattering ways – as someone who drank, lied, and had affairs with other men. Bongani recently left her, and his mother discourages him from visiting her. They did not use condoms, and her behavior contributes to Bongani's uncertainty about whether he is "okay or not" (HIV infected or not).

Bongani is now single. He says he uses condoms with women he does not trust, and notes – "I told myself that condoms are number one." He discusses a recent encounter with a woman he met at a bar. She went back to his house with him, and Bongani feigned not feeling well to avoid having sex with her because he did not have any condoms. While it has been "a long time" since he last tested for HIV, Bongani says his health is otherwise fine and that he will go for testing as soon as he gets paid from a construction job he just completed. He notes that he is scared of HIV, recalling the pain of watching relatives die undignified deaths from AIDS.

In midlife, Bongani is no longer in a relationship. His difficulties in securing stable employment are closely tied to his struggles in finding a suitable partner. Bongani's sense of having been "wronged" by women, his decision to use condoms with women he does not trust, and the loss of many loved ones to AIDS all reflect how he rationalizes his concern about HIV risk, helping to explain his increased caution at this stage in his life. As with Ayanda, Bongani's LHI illuminates additional factors that may help explain Class 1 membership.

4.2 Class 3: In union with lack of protective sexual behaviors

4.2.1 Men

Class 3 is the largest predicted class in the LHI sample, which reflects aggregate patterns for this age group, as shown in the LCA (see Figure 2). Of the fifteen men in this class, eight had HIV and seven did not have HIV. Nearly all were in a union, and two men (both living with HIV) reported having a second partner; one was in a polygamous marriage and the other had both a wife and a girlfriend. Most men without HIV in this group talked about no longer engaging in the types of sexual relationships and behaviors they had

previously engaged in, often before the peak of the AIDS epidemic in their communities. These men also described events that precipitated changes in their sexual lives, including injuries, which sometimes forced an early retirement; giving up drinking and smoking; adopting a religious life; and/or leaving partners whose behavior they disliked. Most men with HIV in this group also discussed changes in their sexual lives, such as fidelity to current partners, condom use, and/or declining sexual health – however, those changes often occurred in conjunction with an HIV diagnosis. These men also discussed prior relationships with partners who had sexual affairs, left them, and/or died. These life events elucidate the different routes men take to end up in the same predicted latent class (Class 3) in mid/later life, as illustrated in the cases of Vuyo (who did not have HIV) and Nhelo (who was living with HIV). We first present both cases and then discuss what we learned from them.

Vuyo: From "playboy" to "churchgoer". Vuyo is 74 years old, retired, and lives with his wife, with whom he has eight children. After several years working on farms and then as a gardener in the city, Vuyo ultimately landed a job near a game reserve, where he worked for 15 years, until he reached retirement age. During this time, Vuyo was involved in an accident while dancing and drinking at a social gathering, resulting in serious bodily injury.

Vuyo has been married four times and has never used any form of contraception, including condoms. He met his first wife, of four years, at a shebeen (informal drinking establishment) in the city; together they had two children. Despite what Vuyo describes as a "very nice relationship", he says he "did her wrong" when he returned to his rural home and took too long to go back to the city. He ultimately lost his job, and it was difficult for him to find another one. That ended the marriage. Vuyo had two more marriages that also ended. His second marriage lasted 10 years and produced two children. Vuyo describes most of those married years as good, until he discovered that his wife was a "drunkard" who would spend money intended to support the household on beer instead. Vuyo's relationship with his third wife, of three years, ended similarly.

Vuyo describes his fourth and current wife as a churchgoer. They both belonged to the same church at first, but a vivid dream led Vuyo to join a different denomination. Vuyo now describes himself as a churchgoer and someone who has abandoned his old ways. He is "old now," he says, and "[has] children and grandchildren." Regarding sex, he notes, "I only have sex with my wife, unlike before. I was a playboy when I was still young." Vuyo admits that he will still tell a woman if he is attracted to her, but it is "just for playing," and he will not "follow up." While he had STIs in the past, which he treated with traditional medicine, he does not think of himself as at risk for HIV because he does "not want women anymore" and says he can only get HIV if his wife "plays around with other men." Vuyo shares a story of a friend who lives nearby, with whom he spent a lot of time. His friend started coughing and is now critically ill (presumably with AIDS).

Vuyo explains that his friend stopped going to church, started drinking alcohol, and started "womanizing." Vuyo shares that in his view, people get infected with HIV when they have sex with people they "meet in taverns when they are drunk; that is why they get sick." Reflecting on his own life, he says, "I thank God, for he has helped me [to] stop drinking liquor. . . . I was also smoking, and I have stopped everything."

Nhelo: "In the past, I didn't think about it [HIV]". Nhelo is 51 years old and lives with his wife, with whom he has four children. Like Vuyo, Nhelo describes having several jobs throughout his life, including in mines and in service industries. His work contracts were often variable, ranging from a few months to a few years. Like many men his age, he thus endured a highly itinerant and inconsistent work life.

Nhelo describes many sexual relationships throughout his life – serious relationships on their way toward marriage, girlfriends of varying duration, and relationships at work that were "just playing" and ended when he got another job. Nhelo's first significant relationship lasted five years. Though they did not marry, Nhelo and his girlfriend had a child together. He paid partial lobola to marry her, but given his job at the time, which placed him at a substantial physical distance, their relationship began to deteriorate and Nhelo learned that she was with another man. A year later, Nhelo married his current wife, whom he met near his home village. He liked that she took "good care of herself," and he describes their relationship as one where they care for one another and "discuss things." Nonetheless, Nhelo says he had "lots of affairs" during his marriage. In one relationship, which lasted several years, the girlfriend traveled to the city to sell fruit for extra money when she was off duty from work. When she started to get weak and developed rashes on her body, a telltale sign of AIDS, she consulted doctors, but to no avail for her health. Nhelo later learned that the girlfriend had died. Nhelo suspects that she was having an affair in the city. It was Nhelo's wife – who knew about the relationship and had met the girlfriend – who told Nhelo that she suspected the girlfriend had HIV. Nhelo also says he rarely used condoms in his relationships because "it was not understood how serious it [HIV] was."

Nhelo stopped working in 2001 following a problem with his leg and returned home, where he now stays "full-time." Six years later, after he became increasingly ill, his wife took him to the hospital, where he was diagnosed with tuberculosis and later HIV. Nhelo surmises that he contracted HIV from the girlfriend who died. Following his diagnosis, his wife also tested positive for HIV. They are both now on ART and support one another. Nhelo notes that he and his wife still have sex and that the only change is to "condomize." Reflecting on his life, Nhelo says, "In the past, I didn't think about it [HIV]. I saw it in the time I was already HIV positive."

Nhelo's life history interview shows an itinerant past during which he had many sexual relationships, which aligns with Class 2. Vuyo's life history similarly shows a migratory work life, and he characterizes himself as a "playboy" in the past, though how

quickly he settled into a life of fidelity in marriage is unclear. In the LCA, membership in Class 2 is more common for a longer period of time for men with HIV than for men without HIV, for whom the probability of membership in Class 3 increases more rapidly (see Figure 2). While the number and meaning of classes in the past may not be well represented in the cross-sectional LCA, the LHIs help us see pivotal moments in people's lives. For Vuyo, behavioral changes were seemingly triggered by an injury and religious calling; for Nhelo, change came from illness followed by an HIV diagnosis. Vuyo is also about 20 years older than Nhelo. He may have avoided the risk of HIV given that the height of his sexual activity likely occurred before the peak of the AIDS epidemic in South Africa (Mojola et al. 2021) – a pattern also observed among other men without HIV in Class 3.

4.2.2 Women

Of the seventeen women in Class 3, eight had HIV and nine did not have HIV. Consistent with aggregate patterns, most (11 out of 17) were in a union; the others were divorced or recently widowed. Most of the women in this class reported (or suspected) that their husbands had extramarital relationships – either girlfriends or other wives. Their reactions and responses varied, as did the extent to which concerns specific to HIV featured into them. Responses included talking with their husbands, confronting extramarital partners, and/or leaving partners whose behavior they found unacceptable. Some insisted on condoms or HIV testing, while others also placed their trust in God's hands. Their efforts and relative influence in addressing any precarity, concern, or distress stemming from their husbands' extramarital relationships, as well as their husbands' own HIV-related awareness, actions, and concerns, are noteworthy in explaining differences in HIV-related experiences and outcomes, as illustrated in the cases of Lindiwe (who did not have HIV) and Stella (who was living with HIV). As with the men's cases, we present both women's cases first and then discuss what we learn from them.

Lindiwe: "We talked, and he understood". Lindiwe is 56 years old and lives with one of her daughters and four grandchildren. Her only relationship has been with her husband, whom she married at age 19 after becoming pregnant.

Lindiwe's husband is a government employee and works in the city, at a steady job that affords them a regular household income. However, because of the job, he is able to come home only once a month at most. While Lindiwe has supplemented the household income by taking on short-term jobs, she says her husband has otherwise been able to support them. Nonetheless, Lindiwe says that "men sometimes are difficult" and speaks of knowledge of her husband's extramarital affairs. She laments that it makes "your heart … painful" and heightens fears of HIV. She notes, however, that her husband came to

that reckoning too, and "our Lord has helped him to be a good husband again." Lindiwe explains that her husband was educated about HIV at his workplace and that he had two friends from work die of AIDS – "He saw that HIV kills."

Lindiwe and her husband have used condoms in times of uncertainty in their relationship. At Lindiwe's urging, they have also both been tested for HIV. "We talked, and he understood," she says. Since they both tested negative for HIV, they have resumed sex without condoms. While Lindiwe admits she cannot know for certain that her husband is no longer having extramarital relationships, she says he knows a lot about HIV and is fearful of it, and she trusts that he will use condoms: "If he is not faithful, he has HIV knowledge. He will use condoms. . . . I trust him on that." She continues, "It's like when you tell a person to do something and that person is not ready, he/she won't do it. But if that person is ready, he will use them [condoms] even if you didn't say anything."

Stella: "I'm behaving well". Stella is 50 years old and has four children. She describes two relationships – the first was with a boyfriend she met in secondary school, and the second was with the man she ultimately married. Stella went to live with her husband's family after he agreed to pay lobola, which was the year after their first child was born.

Throughout their marriage, Stella's husband was often away for work. His support for the family during his absence was variable. While at times he would bring home food and other household items, there were also stretches when he would provide nothing at all. Despite Stella's inquiries into his absence, at one point her husband was away for nearly four years. Stella speaks at length about her husband's extramarital relationships. A few years ago, Stella learned from a relative that her husband had a girlfriend at his workplace. Stella confronted her husband and the girlfriend; she asked her if she knew Stella was his wife and asked her husband how he expected her and the children to survive when he was not sending money home. Stella admonished the girlfriend to leave and never come back. Despite her efforts, Stella later learned that her husband had another girlfriend. When Stella traveled to confront the second woman, a fight broke out. Nonetheless, the relationship continued, and the girlfriend became pregnant. Stella also learned that her husband had another wife, for whom lobola was paid, as well as a child from that marriage, but Stella refused to let the wife live with them. Her husband remains married to that woman.

During her last pregnancy, Stella tested positive for HIV. She was in disbelief because she was, in her words, "behaving well." It was only when Stella went into labor and was given nevirapine (the drug used to prevent in utero HIV transmission) that she realized her test results were accurate. Stella suspects she contracted HIV from her husband, as one of his girlfriends was rumored to have HIV and gave birth to twins who died. Stella was prescribed ART, is otherwise healthy, and says she still has sex with her

husband, though less frequently than in the past. She suggests that using male condoms with her husband is a nonstarter, though she mentions using female ones. Meanwhile, her husband refuses to believe that Stella has HIV and says he will only go for testing "when he is sick."

For Lindiwe and Stella, experiences within their marriages, particularly in a context of prolonged periods of living apart from their husbands, are noteworthy. Their HIV-related experiences and outcomes also implicate the behavior of their husbands, which was not always in their control. For example, while Lindiwe had some success negotiating HIV testing with her husband, Stella had none, even following her own diagnosis. Lindiwe and Stella's LHIs also point to a range of alternative strategies that married women employ to navigate concerns about infidelity and/or HIV, such as open communication with their husbands (Lindiwe) and confronting extramarital partners (Stella). The success of those strategies in influencing the husband's behavior, however, is largely dependent on him. Consequently, in Lindiwe's case, her HIV risk remains uncertain. Assuming continued fidelity on her part, if her husband contracts HIV through condomless sex with an extramarital partner, she too is at risk. If Lindiwe's instincts are accurate and her husband's knowledge of HIV and witnessing AIDS-related deaths of his peers motivate him to use condoms outside of their marriage, then Lindiwe might be protected. As the LCA shows, men's extramarital relationships are consistent with patterns predicted for men in Class 3. (Men in Class 3 have a 6% probability of having more than one partner [Houle et al. 2020].)

5. Discussion

In this article, we present a novel mixed methods approach – data-linked explanatory analysis – to show how qualitative life history interviews can be used to account for population-level patterns in studies utilizing person-centered techniques to classify health behaviors. Here we highlight three key ways. First, while latent class analysis in previously published work showed how sexual behaviors cluster at the population level and their associations with age, sex, and HIV status (Houle et al. 2020), nested qualitative life history interviews show how the HIV epidemic in South Africa interplayed with individual life histories to affect predicted membership in different latent classes in mid/later life. The interviews also highlight how people make sense of and internalize the interrelationships among their health practices. For example, LHIs provide the details underlying how a former "playboy" like Vuyo would later become a "churchgoer" and faithful husband (which aligns with Class 3, his current predicted class). Vuyo also emphasizes the importance he places on giving up alcohol, seeing the often reckless behavior in bars and taverns as contributing to the spread of HIV in his community. His

lifestyle changes are also consistent with age-based norms emphasizing respectability in older age (Angotti et al. 2018; Sennott and Angotti 2016). The LHIs also provide details underlying how a formerly married woman like Ayanda, who was once having condomless sex with her husband, would later be single and using condoms with a partner she sees infrequently (which aligns with Class 1, her current predicted class). Condoms are not always easy for women to negotiate with male partners and are thought to undermine trust and intimacy (Chimbiri 2007; Mojola 2014). As a mother of five children who is living with HIV, Ayanda notes that she uses condoms to avoid increasing her HIV viral load and jeopardizing the efficacy of her HIV treatment – a commonly articulated concern among older women on ART and often emphasized in counseling messages in South African health facilities (Angotti et al. 2023; Mabuto et al. 2021). In these ways, the LHIs reveal the critical moments, even turning points (Crosnoe and Elder 2002) – such as threats from spouses, spiritual signs, or a serious health diagnosis like HIV – that prompt people to reflect and even reshape their lives and futures in ways that impact their health. As well, the LHIs show the meaning and purpose people attach to their actions. Overall, while we cannot say with certainty how people might have been classified earlier in their lives (the LCA is based on cross-sectional data), the LHIs nonetheless elucidate shifts that help explain why and how class membership may change over the course of people's lives.

Second, our analysis of nested LHIs also reveals a wider range of protective practices that individuals employ throughout their lives and in the context of their intimate relationships than are visible in the LCA. Sexual behaviors in the LCA – measured as condom use, number of sexual partners, and knowing a partner's HIV status – cannot fully explain, for example, how married women like Lindiwe handle concerns about contracting HIV from their husbands in a context where labor migration often separates spouses for long periods of time, or how communication influences partner behavior. In this way the LHIs help us see the role that others play in informing one's health practices, risks, and outcomes (Reczek 2012; Umberson 1992). They also point to ways to improve future survey instruments and analyses. Perhaps the classes would look different if a broader array of protective strategies were considered, such as separation or divorce (Reniers 2008; Watkins 2004) or having open conversations with spouses about HIV-related concerns (Schatz 2005); if dyads were included; or if protective strategies were measured by partner type (e.g., a spouse or more casual partner). Similarly, the integration of nested LHIs also points to additional covariates that might enhance understanding of latent class membership. For example, in Class 3, men's life history interviews suggest greater attention to factors such as religiosity, comorbidities, and partner death, while women's life history interviews point to alternative strategies for managing risks associated with marital infidelity.

Third, in future research, nested LHIs could also inform the selection of the number of latent classes as an additional source of information beyond factors such as model selection criteria. For instance, to adjudicate between including an additional class or not (e.g., a three- vs. four-class model), LHIs could help the analyst determine whether adding the additional class captures a substantively meaningful dimension that would otherwise be obscured by selecting a model with fewer classes. Nested LHIs, along with their predicted posterior probabilities for each latent class, could also be used to point to possible explanations for uncertainties in the modeling process and outputs.

Despite the value of data-linked explanatory analysis, we note important considerations in our use of it. First, our analysis involved the use of existing data sources. Notably, our LHI sample was not drawn with results from the latent class analysis in mind. Rather, we took advantage of the nested nature of existing data to show how class membership for each LHI participant can be predicted and then utilized to help account for patterns identified in the LCA. This meant that the distribution of our (middle-aged and older) LHI sample was, consistent with aggregate patterns, highly concentrated in Class 3 (see Figure 2). It also restricted the analytic qualitative sample sizes to what was already available in the original dataset. For researchers interested in identifying factors that can account for outcomes within each latent class in a population, or to explore a particular latent class in greater depth, another linked sampling approach would be to draw the qualitative samples after the latent class analysis (Creswell et al. 2011). Moreover, our data were not collected concurrently. The time lag in the collection of our data – with the qualitative LHIs carried out two to three years after the HIV Survey – means that in some instances, the data sources may be misaligned (e.g., with a change in relationship status or sexual behavior practices). The LHIs utilized in this analysis also did not systematically collect information on the timing and duration of sexual relationships, data that might better explain predicted class membership. Sexual behavior researchers interested in data-linked explanatory analysis might more systematically collect information on relationship histories (Luke, Clark, and Zulu 2011).

Second, our data are also subject to bias in at least two respects. While we utilized LHIs to address limitations arising from the cross-sectional treatment of the life course in the LCA, life history interviews are nonetheless sensitive to recall bias, as (older) individuals were asked to reflect on their lives across several decades. Retrospective accounts may also assign different meanings to actions than respondents might have originally attributed to them (Rosenthal 1993), which may be particularly relevant with respect to HIV (Mojola et al. 2021). Additionally, whether in surveys or qualitative interviews, researchers must remain attentive to how social desirability concerns (differentially) inform what men and women report, particularly with sensitive topics like sex (Houle et al. 2016; King 2022; Nnko et al. 2004). For example, in the women's LHIs, reports of concurrent sexual partnerships were rare; in the men's LHIs, many mentioned

previous partners whose involvement with other men led to the end of the relationship (Mojola et al. 2021). However, how people understand health concerns such as HIV-related risk – for example, from whom they believe they contracted HIV or the efficacy of their efforts to avert infection – is a critical insight in and of itself, as it elucidates the context in which understanding and actions arise (e.g., relationship precarity due to family separation; gender norms governing for whom marital infidelity is permissible) (Watkins-Hayes 2019). Relatedly, different modes of data collection facilitate distinct interactions and possibilities (Angotti and Kaler 2013; Poulin 2010). For instance, while the HIV Survey and the LHIs collected similar sexual behavior information, participants may have been more willing to discuss their use of condoms in the LHIs than in the HIV Survey, as discussion of one's HIV status was more likely to occur in the qualitative interviews. Researchers interested in data-linked explanatory analysis, particularly with sensitive topics, should remain attentive to these issues.

6. Conclusion: A data-linked explanatory approach

While this article focuses on sexual behavior in a rural South African population, a data-linked explanatory approach can be utilized and applied to understand a wide range of topics and contexts, and in conjunction with different methodological techniques. One example is with health lifestyles literature (Cockerham 2005), which frequently uses latent class techniques to observe how health behaviors cluster in a population (Landale et al. 2013; Mollborn and Lawrence 2018). Our approach offers both practical and empirical benefits. Practically, it can be cost-efficient. Given the expansive use of mixed methods approaches to population research (e.g., Ahissou et al. 2022; Martin et al. 2021; Semaan et al. 2022), survey data and qualitative interviews can be collected simultaneously. Empirically, it enables triangulation at the individual level and shows how survey-nested qualitative interviews can help uncover factors contributing to aggregate population-level patterns. It can elucidate the diverse paths participants take to arrive at the same latent class, identify a wider range of factors beyond LCA indicators for understanding latent class membership and in the broader context of people's lives, and offer valuable insight to inform important aspects of LCA – such as determining the appropriate number of latent classes. In sum, data-linked explanatory analysis is a novel and valuable mixed methods approach for understanding the complexity underlying population subgroups identified by latent class analysis.

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