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Mobility and its effects on HIV acquisition and treatment engagement: recent theoretical and empirical advances

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Abstract

Purpose of review—We reviewed literature across multiple disciplines to describe issues with the measurement of population mobility in HIV research, and to summarize evidence of causal pathways linking mobility to HIV acquisition risks and treatment engagement, with a focus on sub-Saharan Africa.

Recent Findings—While the literature on mobility and HIV remains hampered by problems and inconsistency in measures of mobility, the recent research reveals a turn towards a greater attentiveness to measurement and gender. Theoretical and heuristic models for the study of mobility and HIV acquisition and treatment outcomes have been published, but few studies have used longitudinal designs with clear ascertainment of exposures and outcomes for measurement of causal pathways. Notwithstanding these limitations, evidence continues to accumulate that mobility is linked to higher HIV incidence, and that it challenges optimal treatment engagement. Gender continues to be important: while men are more mobile than women, women's mobility particularly heightens their HIV acquisition risks. Recent large scale efforts to find, test, and treat the individuals in communities who are most at risk of sustaining local HIV transmission have been severely challenged by mobility. Novel interventions, policies, and health systems improvements are urgently needed to fully engage mobile individuals in HIV care and prevention.

Summary—Interventions targeting the HIV prevention and care needs of mobile populations remain few in number and urgently needed.

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Conflict of Interest

The authors declare no conflicts of interest

Compliance with Ethics Guidelines

Human and Animal rights and Informed Consent

This article does not contain any studies with human or animal subjects performed by any of the authors

Keywords

Migration; mobility; HIV; gender; HIV treatment; HIV prevention; sub-Saharan Africa

Introduction

This review summarizes recent findings in the large and growing literature on mobility and HIV/AIDS. Currently, effective tools exist for preventing the onward transmission of HIV through antiretroviral treatment (ART) for HIV-infected persons and prevention of the acquisition of HIV infection through pre-exposure prophylaxis (PrEP) for HIV-uninfected persons— however, there are significant implementation challenges to effectively delivering these interventions to mobile populations. Evidence for these challenges and gaps is seen in the lower rates of treatment retention and viral suppression [1–4] and suboptimal engagement in PrEP among mobile populations [5].

Significant implementation science questions remain about the service and intervention modalities, supports or 'wrap-arounds' services needed to successfully meet the HIV treatment and prevention needs of mobile populations and effectively close the gap between current approaches and engagement of the 'missing 27%', who are disproportionately mobile [6, 7]. This review builds upon the review published in this journal in 2015 by Frank Tanser and colleagues on the HIV treatment cascade in mobile populations [8] and adds summaries of recent literature on the links between mobility and HIV acquisition. Our approach to this task reflects our particular interest in measurement of mobility, theoretical frameworks for the study of mobility and HIV, and the importance of gender. We close by posing key remaining research questions and gaps in the field, calling for an increased focus on intervention research to address the HIV prevention and care needs of mobile populations, and highlighting some promising strategies.

The challenge of measurement of mobility in HIV research

Mobility is a complex and heterogeneous phenomenon without commonly agreed-upon definitions and dimensions across disciplines. Although mobility is generally thought to be a key driver of HIV epidemics in Africa [9–12], the existing literature on the specific links between mobility and HIV (including HIV acquisition risks, and treatment engagement and outcomes) has been hampered by broad and incompatible measures, gender biases in measures and data sources [13], and inadequate attention to the complex and dynamic nature of mobility and its contexts in specific settings [14]. Diverse and often suboptimal measures, and study design challenges [15], have precluded meta-analytical summaries [14–16], and resulted in contradictory and inconclusive results [14]. A limited number of measures, e.g. 'short-term mobility', 'long-term mobility', or frequency and length of stay away from home, have been used often although operationalized differently across studies [16]. While some studies have focused on specific forms of mobility (e.g. seasonal [17] and rural-urban migration [18]), most have focused on describing HIV risks among specific mobile populations (e.g. truck drivers [19, 20]). A small number of studies have compared the relative importance of more than one form (e.g. long- vs. short-term mobility [21] or rural-rural versus rural-urban flows [12]) for understanding HIV risks. There is a significant need

for future studies to examine mobility in a comprehensive way, incorporating the multiple dimensions or forms of mobility in a given population and setting that can affect behavior [14].

Magnitude of mobility in sub-Saharan Africa

This review focuses on sub-Saharan Africa, because of the continent's high levels of population mobility and the enormity of its HIV/AIDS epidemic; that most of published research on links between mobility and HIV has been conducted in Africa reflects both early efforts to understand how the HIV/AIDS pandemic initially spread (clearly via the corridors of population movement) and also more recent efforts to understand why HIV has persisted in settings and populations despite massive intervention efforts including the scale up of antiretroviral therapy (ART). Population mobility in sub-Saharan Africa is highly prevalent, and forms of mobility are more complex in Africa than in other regions [22]. While transcontinental migration from Africa is low [23], the intra-sub Saharan African emigration rate (65%) represents the largest south-south movement of people in the world [22] (compared to 59% for Europe and 54.7% for Asia). Levels of mobility within sub-Saharan Africa have risen in recent decades, along with rapid social transformations including the world's fastest rate of urbanization (from 23% urban in 1970 to 40% in 2005 [23]). Mobility is an engine of the region's economic development: from 50 to 80% of rural households have at least one migrant member [22], and the "sending" of female household members (including heads of household) to other areas for work is particularly advantageous to the poorest households [23–25]. Data for the study of internal migration (i.e., within-country changes of residence across geopolitical boundaries such as provinces, states or counties) are very limited in sub-Saharan Africa, but the region hosts several Demographic Surveillance Sites (DSS), which have provided evidence for high levels of mobility within specific settings; in recent years data have shown that from 7 to 20% of populations, and often over 30% of young adults, migrate in and out of the areas annually [13, 26, 27]. These data have revealed that forms of mobility in sub-Saharan Africa are more complex compared to the world's other regions: the rural to urban migration flow does not predominate in all settings [28] rather, counter-urbanization [29] and circulation between rural areas, semi-urban towns, and rural perimeters of cities are common [13, 30–33]. Women predominate in these more temporary, localized mobility flows that are more difficult to measure, e.g. frequent movements among several homesteads among women in KwaZulu-Natal, South Africa, a pattern that anthropologist Mark Hunter has described as more "polygonal" than circular, with polygonal reflecting women's movements across multiple residences [33] rather than a circular 'to and from' from for example a rural main residence and an urban workplace residence.

Mobility, HIV prevalence, and gender

There is increasing attention to the value of examining sex differences in forms of mobility associated with prevalent HIV infection: recently, Anglewicz and colleagues found that HIV-infected women in Malawi were more likely to move to other rural areas compared with HIV-uninfected women, and HIV-infected men were more likely to move to other rural areas, towns, and cities in Malawi than men who are HIV-uninfected [34, 35]. McGrath and colleagues, similarly, found HIV prevalence was significantly increased in current residents

of a DSS site in rural KwaZulu-Natal South Africa with a recent history of migration compared with other residents in the study area, in men (adjusted odds ratio 1·19, 95% CI 1·07–1·33) and in women (1·18, 1·10–1·26) [36].

Camlin et al. also found, in a population-representative survey of adults in three regions of Uganda and Kenya, that those who were HIV-infected were more mobile than those who were not [37]; this held for both measures of migration that typically capture longer-distance, more permanent changes of residence, but also shorter-term, localized forms of mobility. The study examined reasons for migration and for short-term mobility, and found that almost 9% (17·2% of men versus 2·3% of women, $p<0·001$) took at least one overnight trip in the last six months for labor-related purposes, while 44% (54% of women versus 31% of men, $p<0·001$) undertook overnight travel for other reasons over the period (such as for purposes of care-giving or care seeking, attending a funeral, visiting family, holiday, or schooling). While women were less likely than men to travel exclusively for reasons related to livelihoods, associations between prevalent HIV infection and work-related mobility were especially pronounced in women: adjusted models showed a higher probability of labor-related mobility among HIV-positive women and men, compared to their HIV-negative counterparts (adjusted risk ratio in women 2·32, 95% CI 1·27–4·22, and in men 1·65, 95% CI 1·07–2·55) [37].

The effects of mobility on HIV risk may be exacerbated by gendered and economic inequalities in cases where mobile traders and farmers travel to more isolated and poorer areas in which transactional sex and mobility are intimately related [13, 31, 38].

Causal links between mobility and risk of HIV acquisition

Given the preponderance of cross-sectional study designs and associational nature of reported links between mobility and HIV prevalence, few studies have been able to provide evidence of specific causal pathways linking forms of mobility to HIV acquisition. To approach causal understanding, quality research requires correctly assessing the timing of mobility, risk behaviours, and new HIV outcomes, and unfortunately the few longitudinal studies to date have been hampered by high loss to follow up rates [15]. Epidemiological studies (primarily associational) have long suggested that mobility has been a key driver of HIV/AIDS epidemics in Africa [9–12], but empirical evidence directly linking migration to an increased risk of HIV acquisition in the region has begun to accumulate. Despite these problems, there have been recent advances with newer theoretical frameworks for understanding the pathways through which mobility influences HIV acquisition risks and HIV treatment engagement, and new studies measuring effects of mobility on HIV incidence. Recently, the Rakai Community Cohort Study in Uganda has shown the direct link between migration and the risk of HIV acquisition, identifying the first two years after migration as a period with increased risk for HIV acquisition (longitudinal observed HIV incidence) for both women (Incidence Rate Ratio [39] adjusted for demographics 1.75, 95% CI 1.33–2.33) and men (IRR 1.74, 1.12–2.71) and was maintained post 2011 in the era of significant combination HIV prevention efforts [40].

A recent study in the Africa Health Research Institute (AHRI) surveillance cohort in KwaZulu-Natal, South Africa, found that high migration intensity was associated with an

increased HIV acquisition risk among women when compared with low migration intensity (HR = 2.88, 95% CI: 1.56–5.53). [41]. In the same population, another study sought to quantify the "space-time dimensions of human mobility" in relationship to the risk of HIV acquisition, finding that the risk of acquiring HIV infection increased by 50% for migration distances of 40 km. in men and 109 km. in women, and also increased by 50% when participants spent 44% (men) and 90% (women) of their respective time outside the predominantly rural study area [27]. This study confirms prior research suggesting that even relatively short-distance migration events can confer substantial additional risk of HIV acquisition. Although the findings of these three studies were similar, the varying definitions of mobility used across the studies is notable ('migration recency', 'migration intensity', versus 'time-varying migration indices'), underscoring the continued diversity of measures being used to assess mobility.

Theoretical advances in understanding mobility and HIV acquisition risks

Susan Cassels and colleagues recently proposed an heuristic model [15], which posits three pathways linking mobility to HIV risks: 1) The *intrinsic risk pathway* wherein mobile persons are at higher risk of HIV due to a mechanism that independently causes both disease exposure and outcome, 2) a *bridging pathway* where migrants link otherwise distinct sub-populations, diffusing higher risk behavioral norms across networks [15, 42], and 3) a *community displacement pathway* which postulates that sexual network structures of sending communities can change as a result of significant out-migration. Recent and past research supporting each of these pathways can be found in the literature. For the *intrinsic risk pathway*, a 'predisposition to risk-taking' [43, 44] has been found to influence both high-risk sexual behavior and mobility, or to act as a mediator if mobility enables this underlying trait by creating opportunities for risk behaviour [15]. Cassels notes that the *intrinsic risk pathway* is subject to reverse causation, as when HIV infection triggers migration to seek medical care or family caregiving [45], or marital dissolution [46].

Cassels' proposition of a *bridging pathway* is supported by research showing that mobility can increase interactions and expose individuals to partners from higher prevalence areas in SSA [12]. Recent research has focused on gendered aspects of the bridging pathway: Kwena et al. found that among married couples in lakeshore communities, the mobility of fishermen's spouses was associated with an elevated risk of HIV that was not evident among the fishermen themselves [47]. Evidence from South Africa [44] supported the notion that women migrate to 'higher risk environments' than those of male migrants, where a given level of risk behavior is more likely to result in infection.

Evidence for the *community displacement pathway* was seen in a Tanzanian study in which risk behavior was higher among non-mobile male members of couples when their female partners were mobile [48]. This finding, however, was contradicted by a Zimbabwean study showing that couples in which only the female traveled exhibited less male partnership concurrency [49]. These inconsistencies, and a recent analysis of contradictory findings of couples studies carried out in the same population cohort in Tanzania [14], reveal a fundamental problem with the literature to date: a dearth of detailed and consistently-measured information about the mobility under study.

Camlin proposed a conceptual model of the pathways through which mobility among women in SSA is linked to their risks of HIV acquisition and onward transmission [31], which posits *structural drivers of women's mobility* that influence both mobility and higher risk behaviour [31], supporting the bidirectionality of causal links between mobility and HIV: HIV infection in women increases the likelihood of their mobility, and women's mobility in turn increases women's risks of HIV acquisition or of onward transmission. For instance, because of land inheritance laws and practices [50], Kenyan widows (disproportionately HIV-positive) may lose livelihoods upon the death of their husbands, forcing their engagement in higher risk sexual behaviors such as 'widow inheritance' before departing rural origins and their migration to urban areas, where without cash or assets, many engage in commercial sex work [31]. Other scholars (e.g. Mojola [51]) have also highlighted how labor market declines have converged with environmental deterioration to facilitate mobility as well as a transactional sex economy known as "sex-for-fish" in Kenya's Lake Victoria shoreline communities, which are also a common destination for female migrants in the region [52].

In western Kenya, female market traders reported that travel away from home communities facilitated their engagement in transactional sex to supplement their income from trading [31]. A probability-based HIV prevalence survey of female traders working in a large open-air market in Kisumu (using GPS locator data to define a geo-temporal sampling frame [53]) found high HIV prevalence (25.6%, 95% CI 21.0 to 30.8) in 2014 [54], higher than in the general population of women of in the same reproductive age groups in Kisumu (15.3%) in 2013, and Nyanza Province, Kenya (16.1%) in 2012 [54].

In the population-representative sample of adults in Kenya and Uganda referenced above, Camlin and colleagues found that associations between HIV-related sexual risk behaviors and mobility were more pronounced for women: in 2015 through 2016, 24.6% of men and 6.6% of women had any concurrent sexual partnerships in at least one month over the period; in past 6 months, 21.6% of men and 5.4% of women had concurrent partnerships. Concurrency in 2015 to 2016 was more strongly associated with migration during the same period in women (adjusted risk ratio 2.0, 95% CI 1.1 to 3.7) than men (adjusted risk ratio 1.5, 95% CI 1.0 to 2.2). Concurrency in past 6 months was more strongly associated with labor-related mobility in women (adjusted risk ratio 2.9, 95% CI 1.0 to 8.0) than men (adjusted risk ratio 1.8, 95% CI 1.2 to 2.5)[55].

Studies of what Camlin termed the *behavioral consequences of mobility* [31] have illustrated the social antecedents of higher risk sexual behavior in mobile populations: riskier sexual behavior among migrants has been theorized to result from life disruptions such as separation from spouses [56], and exposure to social environments featuring anonymity and riskier sexual norms [42, 57]. Such mechanisms for risks to labor migrants have been well described, but focused on male migrants: for example, "visiting commercial sex workers" was cited as a key HIV risk factor for labor migrants in a recent systematic review of labor migration and HIV [16], while female migrants whose income was from commercial sex work (CSW) were excluded from the review. A reframing of this paradigm is needed: CSW is a risk factor for female labor migrants [31], and mobility facilitates women's opportunities for transactional sex in exchange for money, goods, transportation or housing, to supplement

their low, sporadic earnings [31, 52, 58–60]. Feminist scholars [61–63] have long called for a critical recognition that women's labor, including commercial sex work and other livelihoods in the informal sector, must be included in definitions of labor in order for their full participation in labor migration to be adequately measured.

Labor and economic related mobility and HIV

Economic related needs have been found to strongly influence patterns of mobility such as how many different destinations mobile individuals go to, the frequency of visits and the length of time spent away. Likewise, the patterns and conditions of moving influence the nature of sexual behaviors in which mobile individuals engage while away, and also how mobile individuals access local sexual networks, which in turn has implications for HIV risk [64].

Indeed, there is a strong relationship between the distance traveled and the risk of HIV acquisition. Researchers in South Africa have shown a larger average migration distances per year and increased periods of residence outside rural study communities are key risk factors of HIV acquisition and are associated with behaviors such as increased number of sexual partners, increased likelihood of risky sexual behavior, detachment from family, friends, community, and social norms, increased vulnerability, or lower socioeconomic status [27].

New data on the impact of mobility on HIV care cascade outcomes

The role of mobility in care cascade shortfalls has been under-researched, and the extant literature is subject to the same methodological limitations reviewed above: better measures and methods are needed to understanding how mobility affects the ability of individuals to successfully navigate the HIV care cascade. Several meta-analyses and systematic reviews of the literature examining factors associated with care entry, engagement and retention [65–67][68, 69] found that optimal lifelong engagement in HIV care can be threatened by a range of factors at the individual, social, and structural levels. Mobility undergirds many of the factors found to contribute to delayed entry or lapses in care, including psychological factors (e.g., stigma) [70–72], clinic characteristics (e.g., waiting times) [73, 74] and structural barriers [70, 75] such as distance to clinic and transportation costs [70, 74, 76, 77], yet its direct impact has not been examined in depth [78, 79], especially in SSA. While studies have found delayed entry to and lapses in HIV care engagement among international and internal migrants in the global north [80–82], few have examined potential pathways through which this occurs. Taylor and colleagues (2011)[78] proposed a model of pathways through which mobility may both negatively and positively affect HIV treatment outcomes, drawing in particular on research outside of Africa. This research has shown a distinct relationship between patterns of mobility, including distance, duration, and complexity and reported barriers to engagement in HIV care and treatment with fear of HIV-related stigma at the destination, leading to delays seeking care, poor adherence, and treatment interruptions due to limited medication supply [83]. Among immigrants to the global north, delayed entry and lapses in care engagement can result from periods of travel to countries of origin [84–86], lack of insurance [87], and lack of social support at destination [88].

Distance a patient travels to receive care has been shown repeatedly to negatively affect adherence to anti-retroviral therapy (ART) and overall engagement in HIV care [78, 89, 90]. While several studies in SSA have found that distance from clinic and transportation costs negatively impact upon cascade outcomes [70, 74, 76, 77, 91, 92], only one such study directly measured mobility, finding a significant negative impact on adherence [90]. Disruptions to medication adherence are also common among mobile HIV-infected persons who travel to family events, who report a reluctance to take their medications around family members out of fear of disclosing their HIV status or inviting uncomfortable questions [93]. Across various settings, a positive mechanism has been observed, as some individuals move to access HIV services and support [94–98] and to avoid stigma in home communities [98].

The effect of mobility on engagement in the HIV care cascade can be particularly salient for women engaged in sex work. In a systematic review of HIV-related healthcare access and use for female sex workers, Davey and colleagues found mixed evidence for the association of mobility with reduced initial healthcare access and interruption of ART, with a strong effect on ART interruption seen among those who were mobile in the last six months [99, 100].

Postpartum women are another group susceptible to mobility disruptions in retention in HIV care following ART initiation in pregnancy. In their studies in South Africa, Clouse [101], Phillips [1] and their colleagues have found that moving care between clinics is a vulnerable step in the HIV care continuum and even women who manage to engage in ART successfully, particularly younger, unmarried women and those who present late for ANC, remain vulnerable to subsequent LTFU and uncontrolled HIV viral loads [1]. Migration status similarly conveys a lasting detrimental mortality effect on HIV deaths in longitudinal demography studies in in Kenya and South Africa with migrants on average being four times more likely to die of AIDS/TB or NCDs than are non-migrants [102].

Effects of mobility on HIV interventions

A recent supplement to the *Journal of the International AIDS Society* entitled ‘Population mobility: Challenges for universal HIV testing and treatment’ (Vol. 21, Supplement 4, July 2018, https://onlinelibrary.wiley.com/toc/17582652/2018/21/S4) focused attention to the impacts of population mobility on the large community cluster randomized control trials of universal HIV testing and treatment (‘test and treat’) interventions. The issue’s editors argued, “Ultimately, strategies to attain the 90–90-90 targets that do not account for the complex dynamics of mobility in specific settings will fail to engage successfully with the magnitude of populations necessary to end the epidemic” [7], and indeed the collection detailed the challenges posed by mobility for the test and treat interventions. Larmarange and colleagues presented findings from the ANRS 12249 Antiretroviral Treatment as Prevention (TasP) trial in KwaZulu-Natal, using both calendar (population) and exposure (individual) time approaches in their analyses, and showed that the structural effects of mobility diluted the impact of the test and treat strategy. In a context of high HIV incidence, the circulation of newly infected individuals in and out of communities slowed down TasP efforts to increase ART coverage and population viral suppression, ultimately attenuating any population-level impact on HIV incidence [2]. The Rakai study referenced in this article

(Olawore et al., 2018) [40] was also conducted in a setting of a prolonged and intensive scale-up of combination prevention interventions, and similarly found that HIV incidence had not declined among recent migrants in contrast to patterns of declining HIV incidence noted among permanent residents and non-recent in-migrants in the study area. In sum, the studies to date have only confirmed concerns that population mobility poses a significant challenge to HIV prevention efforts.

We have learned more about why and how mobility challenges engagement in test and treat interventions. Qualitative research from the HPTN 071 Population Effects of Antiretroviral Therapy to Reduce HIV Transmission (PopART) trial illustrated the day-to-day challenges people living with HIV in Zambia and South Africa face with juggling household responsibility, livelihood mobility and HIV management [103], and vividly conveyed how health and well-being, while valued, sometimes cannot be prioritized by PLHIV in high-poverty settings of economic and residential instability [104]. Editors noted that the collection of findings across studies provided evidence in support of Norma Ware's conceptualization of treatment disengagement as a process through which missed visits, and ensuing reluctance to return, can erode patients' feelings of connectedness to care over time [72], but also suggest that migration events can trigger the chain of events that leads to disengagement [7].

Studies conducted outside of the African test and treat trial contexts have provided reinforcing evidence that the period following resettlement in new destinations is a period of instability in which behavioral risks of HIV acquisition are heightened, and engagement in care and prevention is disrupted. Noting that immigrants are overrepresented in the European HIV epidemic, Fakoya and colleagues presented findings from a study of care engagement using data from 57 HIV clinics in nine countries in Europe, including evidence that exposure to HIV after migrating accounts for a substantial proportion of infections among migrants, and that opportunities for HIV prevention are being missed [105].

While there are many recent calls for studies to evaluate strategies to meet the HIV prevention and care needs of mobile populations, there are few such studies published in the literature to date. Initial efforts included workplace-based intervention programs for male migrants (e.g. miners) and the women who sell sex to them, with mixed results [106], and interventions for truckers and female sex workers at truck stops including STD services and condom distribution, which if not fully evaluated have been found acceptable [107].

Models of differentiated service delivery aim to simplify and adapt HIV services to better meet the needs of people living with HIV [108]; these should be adapted to specifically address the needs of mobile individuals, and would ideally include new therapeutic technologies that permit mobile individuals to visit clinics less often. Treatment and prevention services must move beyond clinic settings into destinations and transit hubs where mobile populations are found [37]. Mobile community health workers have been used in some settings to increase retention of HIV-positive people in treatment and care programs, and could be adapted to specifically focus on engaging mobile populations in care [40]. Tanser and colleagues pointed to the need to improve systems for monitoring the health of mobile populations, and highlighted opportunities to use newer mobile technologies to meet

this need [8]; mobile health (mHealth) interventions also hold promise to improve healthcare access to mobile populations via mobile phone technologies [8, 109].

Conclusions

In this brief summary of key recent findings and theoretical advances from the rapidly growing literature on mobility and HIV, four significant developments in our understanding of the links between mobility and HIV acquisition and care engagement are clear. First, the field of inquiry has expanded beyond simple associational findings towards a broader understanding of the potential pathways and dynamics driving the observed relationships between mobility and HIV acquisition and engagement in care. This has been a critical step in both creating a roadmap for future investigations of mobility and HIV and in pointing the way towards potential targets for interventions to address the negative impacts of mobility on efforts to reduce new HIV infections and fully engage HIV infected persons in quality care. Secondly, it is now readily apparent that gender is overriding feature in forms of mobility and their relationship to HIV. The implications of this repeated finding argue that all future research must address gendered mobility patterns and motivations and that sex-stratified analyses and tailored approaches should be the consistent standard. Third, the demonstrated feasibility and importance of well-designed studies elucidating direct and indirect causal links between mobility and HIV acquisition and care engagement have been a significant scientific advancement. The strength of these findings and the new information they are providing have significant implications for our ability to inform policy makers and for intervention development. Fourth, as the world moves forward with universal HIV treatment and strives to attain ambitious HIV prevention and treatment targets necessary to turn the tide of the global HIV epidemic towards eventual elimination, it is imperative that a focus on the impacts and challenges of mobility and HIV be included if we are to reach these critical goals. This has direct implications for policy and intervention implementation: the intervention adaptation needs of mobile population must be addressed. Finally, these significant developments and future directions all sit on base need for the development and use of better, higher resolution measures of mobility and associated HIV risks and testable causal behavioral pathways.

To the extent that mobility drives shortfalls across the HIV care continuum, research on mobility and care delivery holds the potential to strengthen a wide range of treatment and prevention efforts. Future research should not only ascertain the impacts of mobility on cascade outcomes, but also translate that knowledge into strategies to improve engagement of these at-risk populations in care and prevention.

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