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Exploring the syndemic interaction between social, environmental and structural contexts of HIV infection in peri-mining areas in South Africa: a qualitative study

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ABSTRACT

Objective To explore the syndemic interaction between social, environmental, and structural contexts and HIV infection in peri-mining areas in South Africa.

Design Mixed qualitative methods consisting of in-depth interviews (IDIs) and focus group discussions (FGDs) exploring the interaction between HIV infection and the social, environmental and structural factors affecting people living in the peri-mining areas of South Africa. Themes were analysed following the syndemic theoretical framework.

Setting Participants were recruited from three mining companies and locations in the peri-mining communities surrounding the mining companies in Limpopo, Mpumalanga, and Northern Cape provinces.

Participants Inclusion criteria included mineworkers, healthcare workers, female sex workers (FSWs), injection drug users (IDUs), and other community members, ≥18 years, living in the peri-mining area at the time of participation. Three FGDs were conducted (n=30): 13 men and 17 women aged 18–55 years. IDIs were conducted with 45 participants: mineworkers (n=10), healthcare workers (n=11), FSWs (n=15), truck drivers (n=4) and IDUs (n=5).

Results The findings from this study indicate that a syndemic of four socio-behavioural factors is associated with HIV acquisition in peri-mining areas. These are migrancy, accessibility to alcohol and substance use, commercial and transactional sex, and uptake of HIV prevention services.

Conclusions Our findings have implications for HIV prevention programmes in mining companies, which rely on male condom usage promotion. More emphasis on better education about HIV prevalence, transmission and up-to-date prevention alternatives, such as pre-exposure prophylaxis for mineworkers is recommended. Furthermore, collaboration with community-based organisations is recommended to wholly address the syndemic factors influencing HIV transmission in peri-mining communities.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Our study applied a qualitative research design that allowed for in-depth observation through in-depth interviews and narrative engagement via focus group discussions with the community that allowed triangulating of research findings.
⇒ The study was conducted at three mines in South Africa but the findings provide insight into diverse mining settings including large versus small mining operations, and populations: all age ranges, men, and women, and in settings with high and low HIV burden.
⇒ The limited number of participants especially (truck drivers and people who inject drugs) in specific contexts (peri-mining settings) limit the generalisability of findings and indicate the need for further research.
⇒ We did not include the perspectives of relevant stakeholders such as partners of mineworkers or policymakers.

INTRODUCTION

Historically, the mine housing situation in South Africa was split along racial lines, with white mineworkers enjoying the benefit of company houses in towns or extensive housing allowances while their black counterparts were mainly housed in high-density, single-sex compounds and subject to institutionalised migrant labour and influx control.[1 2] Consequently, a direct and indirect role for the massive growth of informal settlements in peri-mining areas is a result of mining companies. Directly, through an influx of people living in informal settlements as a result of a mine employment and contract work. Indirectly, through the migration of people to informal settlements with the expectation of finding work in the mining companies. Mining companies in South Africa are dependent on migrant labour as part of its workforce. Migrants from within and outside South Africa are largely sexually

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active men separated from their families for extended periods of time.[3–5] Migrants are disproportionately affected by HIV infection and frequently have characteristics associated with poor HIV clinical outcomes. HIV epidemiology among migrants is influenced by changes in migration patterns and variations in transmission risk behaviours. Migration patterns related to working away from one's primary residence have contributed the spread of HIV/AIDS at a population level in South Africa.[3] HIV prevalence in mining communities reported in 2016 was 240/100 000.[6] Peri-mining areas in South Africa provide an interface between mineworkers and other key populations surrounding a mining company.

Evidence has shown that mineworkers, live in crowded quarters and informal settlements after they leave behind families and community support structures as they migrate from site to site, both within the borders of one country and across countries in search of employment.[5 7–9] The circular migratory nature of the mining industry means that hazards such as HIV are spread to labour-sending communities.[7] Circular migration or the location of mines in impoverished remote communities also allows mining companies to pass the burden of healthcare back onto these poor rural areas.[8] The informal peri-mining communities that have sprawled around the mines provide easy access to alcohol, drugs and the sex industry, contributing to the spread of sexually transmitted diseases, including HIV.[10–12] The social issues around migrancy and masculinity and living conditions of mineworkers have contributed to a rapid transmission of HIV/AIDS and sexually transmitted infections.[13] Also, the social has contributed to the spread of HIV in mineworkers.[14] Mineworkers isolated from their families lack a supportive social environment and are deprived of assertion of masculine identities such as casual relationships and participation in family leadership. Research in Asia found a correlation between the level of social support and adoption of safe sexual practices.[15] In conditions where there was loneliness and isolation, men were likely to engage in unprotected sex or have multiple sexual partnerships to symbolise some form of emotional intimacy.[15] Mineworkers are accessible to female commercial sex workers, alcohol establishments and generally report low uptake of HIV prevention services such as condoms and pre-exposure prophylaxis (PrEP) and postexposure prophylaxis (PEP). This interaction may determine the contribution of HIV to the larger epidemic. Masculinity manifests as low self-efficacy where the risk of acquiring HIV/AIDS is perceived to be lower than the risk of underground accidents and sometimes fatalities. As a result, unprotected sexual intercourse is seen as providing much needed comfort in a highly stressful environment. This relationship stems from a syndemic theory which involves the interactions between social and disease conditions.[16]

Previous research in the HIV field applying the syndemic theory has typically investigated interrelationships between social and behavioural factors and HIV-associated outcomes. This does not negate the application of syndemic theory to investigations of the cumulative impacts of social, environmental or structural conditions on HIV acquisition and disease progression.[17] Importantly, there is also a paucity of research on syndemic factors that specifically impact HIV acquisition among mineworkers and people living in peri-mining communities. This research gap exists even though some studies have shown strong links between different social and behavioural factors and HIV-related outcomes, including those indicative of broader social disadvantage and marginalisation.[18 19] To address the highlighted gaps, we conducted a study to understand social and behavioural factors that continue driving new HIV infections among mineworkers in order to tailor interventions focusing on the identified risks. This paper applies the syndemic theory to explore the interaction between social, environmental and structural context of HIV infection in peri-mining settings.

METHODS

Theoretical framework

Guided by a syndemic theory by Singer *et al*,[20] a qualitative study was conducted to explore HIV risk among mineworkers in three peri-mining communities in South Africa. The syndemic theory postulates that co-occurring health problems are a result of social, economic and political inequities that work synergistically to increase the negative health consequences of one another.[20] This study applies a syndemic framework which emphasises the identification of underlying social, economic and environmental factors that elucidate the HIV risk of mineworkers in peri-mining communities. Syndemic theory has been applied in previous HIV research with heterosexual male populations to explain ways social determinants have contributed to HIV risk in South Africa.[16 17 20 21]

Study design

This exploratory qualitative study adopted a cross-sectional design where participants were invited to participate in in-depth interviews (IDIs) or focus group discussions (FGDs) at one-time point.

Study setting

The study was conducted in three mines belonging to a major mining company in South Africa located in three provinces of South Africa—a platinum mine in Limpopo, a coal mine in Mpumalanga and an iron ore mine in Northern Cape and their surrounding peri-mining communities. HIV prevalence according to the 2017 South African National HIV Prevalence, Incidence, Behaviour and Communication Survey, 2017 was highest in Limpopo (10.9%) and Mpumalanga (17.3%) and lowest in Northern Cape (8.3%) provinces.[22]

Patient and public involvement

We attended several meetings with the staff from the mining companies to introduce the study and facilitate

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meetings with mineworkers. During these meetings, we approached mineworkers for recruitment into the study. Furthermore, study staff conducted meetings with mining officials including community engagement officers who introduced us to the different available gate keepers in the respective communities. The gate keepers included public administration officials and employees of community-based organisations. Through these gatekeepers, two coauthors (NS and KM) approached and distributed study-approved flyers to the people living and working in the peri-mining communities and working in the mining companies to introduce the study and obtain their help in reaching out to community members including the key populations including female sex workers (FSWs), people injecting drugs and truck drivers. Participants were involved in the design and dissemination of this study.

Sampling

For the IDIs, mineworkers were conveniently sampled from the mining companies. Truck drivers, FSWs and injection drug user (IDUs) were conveniently sampled from the communities through peers. Healthcare workers participating in IDIs were purposively sampled based on their role for providing HIV care to mineworkers. FGD participants were purposely sampled to represent a wide range of community members and explore their perceptions of the mine in the communities. To reach saturation of themes, a minimum of 15 IDIs interviews and 8 FGD members are required. Table 1 outlines the selection of participants by site and demographics.

Data collection

We invited interested participants in peri-mining communities to participate in our study from August 2021 to December 2021. Four female and three male trained research assistants (RAs) administered written consent to those willing to participate in the study. Thereafter, KM and PN collected demographic information (age, gender, HIV status, occupation and participant category) from consenting participants using a questionnaire. RAs subsequently conducted IDIs with mineworkers, healthcare workers, members of identified key populations including FSWs, truck drivers and people who inject drugs (PWIDs). In addition, FGDs were conducted with selected community members in the dominant language. IDIs were conducted in private spaces including rooms or open spaces in the community whereas FGDs were conducted in community or church halls large enough to accommodate 8–12 people.

All participants were either working in the mining companies or had been living in the peri-mining communities for at least 6 months, ≥18 years and willing to consent to audio recording of the interview. Consenting participants were assigned a unique study number for confidentiality. The final of 75 conveniently sampled participants included male and female participants. The diversity of this ultimate sample enabled obtaining a fairly comprehensive picture about experiences and perceptions related to HIV risk in the peri-mining communities.

Through semi-structured guides RAs conducted IDIs (online supplemental file 1 (mineworkers), online supplemental file 2 (key populations), online supplemental file 3 (healthcare workers) and FGDs (online supplemental file 4 (community members)) lasting 30–45 and at least 90 min, respectively. A team of researchers developed the guides in English and the topics covered included the role of social networks that place mineworkers at risk for HIV infection, mineworkers' individual susceptibility to HIV and experiences while accessing HIV prevention and testing services. Piloting of the guides was not done prior to data collection. Interviews were conducted in quiet locations, mostly an open space or empty offices or community halls. Discussions were primarily conducted in English, but participants were free to express themselves in vernacular (IsiZulu, IsiXhosa, Setswana, Afrikaans, Sepedi and English) whenever they felt it better articulated their lived experiences of HIV risk. RAs were trained to listen carefully and probe during interviews. Field notes were also made during the interviews. The investigator (LC) reviewed the first five participant interviews and provided feedback to teams to enhance the questioning and probing. After the interviews, RAs thanked participants and presented a reimbursement of ZAR150~US$10 for their time. Saturation of themes during data collection was achieved through regular debriefing discussions with the RAs on probing techniques. Interviews were stopped when no new issues emerged.

Data analysis

All interviews were transcribed verbatim. Audio recordings with renderings of local languages were directly transcribed and translated into English by RAs. KM and PN, fluent in the study languages, checked the accuracy of the transcripts against digital recordings. Multiple reading of transcripts was done by LC and PN to capture context, followed by manual coding and categorisation of recurring themes.

Table 1 Selection of participants in FGDs and IDIs by site and demographics

Site	FGDs*	IDIs
Platinum	9	Mineworkers (n=4) Healthcare workers (n=6) Female sex workers (n=5) Injection drug users (n=2)
Iron ore	11	Mineworkers (n=3) Healthcare workers (n=2) Female sex workers (n=5) Truck drivers (n=4)
Coal	10	Mineworkers (n=3) Healthcare workers (n=3) Female sex workers (n=5) Injection drug users (n=2)

*Distribution by demographics shown in table 1.
FGDs, focus group discussions; IDIs, in-depth interviews.

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Transcripts were imported into QSR International NVivo V.10 software to group the initial codes into themes and subsequently organise into key dimensions and identify patterns across groups.[23] Soft-copy transcripts were stored securely and safely on password-protected computers and audio-recordings were deleted from recorders. Transcripts were not returned to participants for comment. Reporting adheres to Consolidated criteria for Reporting Qualitative research criteria for qualitative research.[24]

Two members of the study team with PhD and Masters' degree qualifications (LC and PN) independently reviewed and coded the transcripts guided by the syndemic framework constructs to explore the social, environmental and structural interactions that heighten HIV risk in peri-mining communities. To analyse the qualitative data, we used thematic analysis after inductively and deductively developing codes using a study-developed codebook. The codes in the codebook were organised into three overarching domains of factors, namely social, environmental and structural. Four themes, aligned to these domains and partly adapted from the original syndemic framework and emerging from the data, were defined. Syndemic constructs were used as initial guides to coding, and the subsequent themes emerging during iterative and deductive coding were therefore closely aligned with the four constructs. Collaboratively, LC and PN reviewed and refined emerging key dimensions and themes The process of refining, reviewing key dimensions and emerging themes was repeatedly done until saturation was achieved when no additional themes or categories could be identified. The analysis process identified salient differences in the different populations. Participant demographic characteristics were summarised from a demographic questionnaire completed before the interviews began.

RESULTS

Participant characteristics and experiences are summarised quantitatively. Emergent themes are then presented with relevant quotes.

Participant characteristics

Three FGDs were conducted with 13 male and 17 female participants whose ages ranged from 15 to 55 years with an average of 37 years. Majority of the participants were healthcare workers in the community (n=8, 26.7%). A demographic summary of FGD participants is shown in table 2.

The 45 IDI participants included 17 males and 28 females of average age of 33 years, ranging from 20 to 59 years. Most self-reported HIV status was negative. IDIs were conducted with mostly FSWs in the community (n=15, 33.2%). The demographic summary of IDI participants is shown in table 3.

Emergent themes around the syndemic factors influencing HIV infection from FGDs and IDIs

Participants displayed an overall understanding of HIV/AIDS and were knowledgeable about high-risk behaviours such as non-condom use, multiple sexual partnerships and using injection drugs, that increase HIV transmission and acquisition. While there was a general understanding of HIV/AIDS, participants identified multiple interconnected syndemic factors in the peri-mining communities driving HIV infections. These factors were centred around the following emergent themes as illustrated in figure 1, namely: (1) migrancy due to work and living away from supportive structures, (2) accessibility to drugs and alcohol establishments, (3) accessibility to an active sex industry and (4) uptake of HIV prevention services.

Themes have been described in greater detail with minimally edited illustrative quotes.

Table 2 Demographic summary of focus group discussion participants (n=30)* in the peri-mining communities around the three study sites

Demographics	n	%†
Gender		
Male	13	43.3
Female	17	56.7
Age		
Average		37 years
Range		18–55 years
Occupation		
Healthcare workers	8	26.7
Tavern owners	2	6.7
Traditional leaders	3	10.0
Religious leaders	2	6.7
Community leaders	4	13.3
Street vendors	3	10.0
Female sex worker	1	3.3
Mineworker	1	3.3
Municipal workers	2	6.7
Unknown	4	13.3

*Not all participants reported their full demographic characteristics.
†Unless otherwise stated.

Theme 1. Social factors: migrancy due to work and living away from social support structures

Migrating from home either within or outside South Africa was one of the most salient themes that emerged from the IDIs and FGDs. Participants reported that because mineworkers were domiciled away from their primary residences and are separated from their regular partners for prolonged periods, they seek for sexual services from FSWs in the surrounding communities or fellow mineworkers. The use of available HIV prevention services such as condom use is infrequent which increases HIV risk. This healthcare worker explained pathways to HIV acquisition to mineworkers and their spouses.

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Table 3 Demographic summary of in-depth interview participants (n=45)* in the peri-mining communities around the three study sites

Demographics	n	%†
Gender		
Male	17	37.8
Female	28	62.2
Age		
Average		33 years
Range		20–59 years
HIV status (self-reported)		
Seronegative	18	40.0
Seropositive	14	31.1
Unknown	14	31.1
Category of participant		
Mineworkers	10	22.2
Female sex workers	15	33.2
People injecting with drugs	5	11.1
Truck drivers	4	8.9
Healthcare workers (mining companies)	11	24.4

*Not all participants reported their full demographic characteristics.
†Unless otherwise stated.

I would say uhm, you know mineworkers most of them are from different provinces. What they do is that they frequent sex workers, and they have many sexual partners in the workplace. Let us say I work in the mines, and my colleague is a mineworker as well. So, since my husband is far. I would rather be busy with this one while I know my husband is far away and he would not know anything. So, I would be busy and dating this one sometimes we use condoms and sometimes we do not. So that is the problem of mine workers. They have many partners sometimes they do not use condoms and sometimes they use condoms then they take the HIV home to their wives. That is the life here in [Name of area]. That is what I have seen since living and working here. (Healthcare worker, IDI, coal mine)

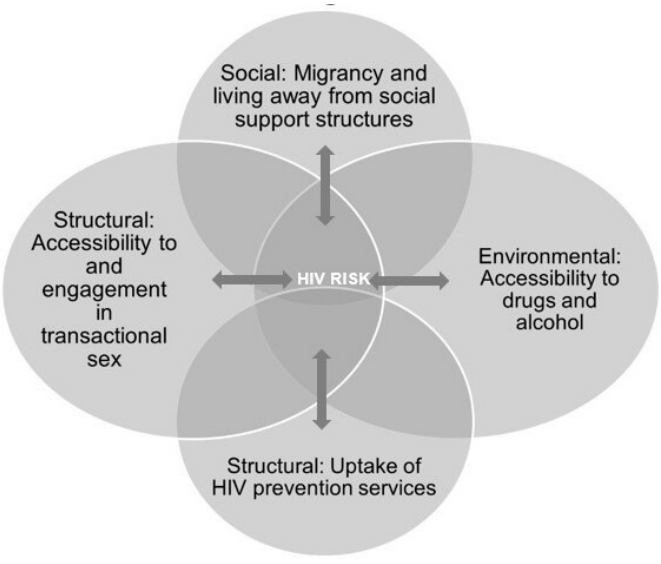


Figure 1 A visualisation of the syndemic factors influencing HIV infection among mineworkers in peri-mining communities in South Africa. Adapted from Singer *et al*.[20]

Most mineworkers migrate from outside and within South Africa, live away from their families and due to this disruption form casual relationships. For some, these casual relationships are with FSWs within reach in the local community. One participant described how a syndemic of migrancy, stress (due to workload), alcohol abuse and risky sex/sex work are associated with higher HIV incidence in mineworkers. A suggestion to provide accommodation for mineworkers and their families was seen as a way of preventing high-risk sexual behaviours as described in this narrative.

One, they cannot live with their families where they work and two, the workload is stressful. And you know when people are stressed, they want to drink beer, they want to …, it's in our nature to just try and look for something to relax and some people relax with prostitutes. And also, not those men, they get salaries, when people just can afford, you know there is that thing maybe that's why there is a lot of prostitution around the mines. Mines generally pay well. When there's a lot of money circulating, prostitutes are going to be there, to be rife there, it's a common thing in most mining areas. They should at least think about men who are married, they should at least build like ehh a family house, a mini family that is …, that a person can come with a wife, a family, be there, together. That sort of thing can prevent HIV, eish there are a lot of things. (Male mineworker contractor, IDI, platinum mine)

This participant described how a syndemic of migrancy, being away from the wife and his need for sex is associated with risky sex with sex workers and lack of knowledge of HIV prevention services and exposure to HIV infection in mineworkers.

I: Okay, so how does commercial sex work directly affect the health of the mine workers? How do you think that relates to their health? P: Okay like me, I am from [name of another province], right? So, when I come here, I don't have a wife here, I don't have a girlfriend and you know as men, we like sexual satisfaction, not every men but it's a need of a human being to be sexually satisfied. Then we end up meeting people that we don't know their status and protection is not always 100%. Even with condoms, it's not 100% and most people don't have knowledge of PrEP, they don't have much knowledge about PrEP and Post exposure prophylaxis or medications. Because if we

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have knowledge of that, maybe if a condom accidentally broke, then it means, I have to rush to the clinic and enquire and consult, so that I get help. So, most of the people don't know those services. So that's why they end up getting infected. (Mineworker, IDI, iron ore mine)

Migrancy due to work has also led to the mushrooming of informal settlements around the mine which have increased social ills around the communities such as substance abuse and illnesses such as HIV which are putting a lot of strain on the existing health services. The unintended consequences the mines bring to a certain area are reflected in this narrative from the FGDs.

I: We are talking about the informal settlements. Anyone else who can comment on the negative influence the mine has on the community? P: There is an increase in illnesses. where previously we didn't have much of the illnesses, right, but we know that they are so much. The other thing, the defaulters' rate. In most cases these people coming from their places or areas knowing their HIV status and having illnesses not basically on HIV but having illnesses, right, but when they arrive here in this area, most of them have diseases and the death rate as well. Do you understand? crime alcohol, drug abuse you name them, so it is crazy like nobody's business. Those are the negativity that the mines brought to our area. (Resident, FGD #5, iron ore mine)

By the nature of their occupation, truck drivers are highly mobile and spend a lot of time travelling without their spouses. In this study, truck drivers reported accessibility to FSWs as a pathway to HIV infection. One way to minimise the spread of HIV is for trucking companies to allow male truck drivers to travel with their female partners or spend more time with their families as reported by one participant:

My take is firstly, the trucking companies, must give drivers permission to travel with their wives, that's the first thing. Because they spend most of the time in the trucks. So, if there is a provision that a truck driver can go with his wife, it minimizes the chances of having extra marital affairs and secondly, the trucking companies must also give drivers enough time to be with their families. (Truck driver, IDI, iron ore mine)

Theme 2. Environmental factors: accessibility to drugs and alcohol establishments

In this study, we found that there was high accessibility to alcohol at taverns and shebeens in the local community and bars in the mine hostels. Mineworkers participating in IDIs and FGDs revealed that binge drinking often led to risky sexual behaviour which increased HIV risk.

When having sex with multiple partners, sometimes under the influence of alcohol, making wrong decisions because you don't think straight [not of a sober mind] because when we drink alcohol, you say hey today, I am not going to use a condom and that's how you contract HIV Or you don't think about what's happening, so there are two different things because you cannot remind yourself, you'll see it after [you will realise that afterwards]. (Male mine employee, IDI)

I: When you talk, the things you hear, please tell me, the things that they talk about, which ones can make HIV to continue spreading? P: Okay, what I have noticed when the conversations are taking place is, when they are drinking alcohol is, when they go there, they don't take condoms along and when a person is drunk, at a drinking place or a tavern or wherever they are. The one whom they meet, the girl that they meet, they will just take her and have sex with her, that's what I have noticed, if you are drunk, you are out of your senses and then anything can happen, anytime. Everything is okay when you are drunk. You do not see a wrong thing. Do you understand? So, you will say actually, even if you can use a condom, you will say no, on the first round it's with a condom, on the second round, you will say, actually, this one is okay. Guys (men) suffer as a result of that. (Mineworker, IDI, coal mine)

In the community, there is accessibility to injectable drugs and participants in the FGDs described how HIV transmission was likely to happen as a result of multiple people sharing one syringe as narrated by these FGD participants.

I: Okay and then what do you think are some of the behaviours that could put people at risk of HIV infection, just in general, the type of behaviours that can put people at risk of contracting HIV? I think that in most cases they abuse alcohol. Like for instance people are not having information and education about HIV and AIDS but in most cases after using or abusing alcohol. After using alcohol then these guys will always say, I was drunk that is why I had sex with this partner, tomorrow is the other partner, the next day is the other partner. Like I said earlier on, there will be a group of five people and we will use one needle to inject ourselves when we are on heroin or sometimes they will inject themselves with crystal meth also but the thing is they are using one needle do that is the dangerous thing. Also, blue toothing when it comes to drugs. **I: What is blue toothing?** P4: I am using the drug and you are drawing my blood and injecting it to yourself to get the high and that is very much dangerous. **I: Okay. So, you are saying that it is the five of us, I take the drugs like full dose of the drugs and then from there, the 4 are going to take my blood and inject it in themselves to get the high?** P4: Now we have too little money to buy a lot of drugs. But the two of us are using it, the drugs that we could afford. We will use it for instance me and you, we will use it

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and then she will draw my blood. Like you would do it to him. (Residents, FGD #4&5, iron ore mine)

Theme 3. Structural factors: accessibility to an active sex industry and engagement in transactional sex

The combination of migrancy, contractual work and stressful working conditions was cited as one of the reasons for indulging the services of FSWs among male mineworkers. FSWs reported engaging in commercial sex for their sustenance due to unemployment. Many of the FSWs migrated from other provinces or neighbouring countries due to poverty. Many of their casual sex partners include truck drivers and mineworkers. Mineworkers in this study reported working in stressful conditions, without family support. One way to destress was to engage in binge drinking and high-risk sexual behaviour. Mineworkers reported inconsistent condom use, inebriated unprotected sexual acts with multiple female partners. Many noted that this was the most probable way of acquiring HIV infection. Participants highlighted the syndemic relationship between these three factors as narrated below:

> **I: Okay, so just generally, what type of risky behaviours do mine workers engage in that place them at risk of getting infected with HIV?** P: Ja, I would say the top of the list is prostitution, and there are other things like maybe drug abuse. Definitely because like I said, I …, there's a lot of contractors here and a lot of Anglo employees also who maybe stay in Rustenburg and work here. So, some maybe here the whole week then just go back home maybe weekends or once in a while. So being away from your …, from their partners, can sort of like maybe encouraged by someone to engage in multiple partners sex and things like that, Two, at times the schedule can be quite stressful, some people maybe just want to let off some steam, they end up engaging in sexual activities simply because they have had a very stressing working condition, also maybe like you are saying, they stay in a facility which doesn't allow them to stay with their family. And their family stay somewhere in the village or in another town and you know, when you are alone, it's just easy for …, it's tempting to just do something because no one can really reprimand you or see you, it's people you really care about whom when you are around them, you wouldn't do such things, are just away and you are more or less free to do what you want. (Male mineworker, IDI, platinum mine)

Qualitative findings from this study showed that transactional sexual relationships were reported between older colleagues with higher income and younger colleagues who just joined the workforce. This participant describes how transactional sex work (between older and younger men) in the mine and the desire for upward mobility at work intersect as risk for HIV acquisition. The frequency of transactional sexual activities increase during the pay week as explained by this male participant.

> P: At the mine, we are all prostitutes, I am not gonna lie, we are all prostitutes. **I: Why do you say that? Can you explain to me**. P: The way things are done, things that we do, right, like you can see like daddy, I need quality time with you, they do that, some I know them but it doesn't …, they end up like having sex with that older man because his wife is in Eastern Cape. Like the older man is giving them R3,000 like that's how things are done. At the mine we are all prostitutes and we all cheat. You end up exchanging your body with someone for promotion [it's called upward mobility at work]. At the mine, you can date four people whereas they know. It's more like fish and oil trend especially for guys [this was not clear], it would be like, actually, that one is an easy target, go, I was there. Do you understand? It's something that I don't know, I don't understand how they think or is there another impact like going on, I don't know that company …, that people are so …, I don't know their mentality especially this week, especially this week. **I: What's happening this week?** P: Isn't it, we are getting paid! **I: Can you enlighten me a little bit about what happens when mine workers get paid? Just shed more light on that**. P: Hook me up with someone, I will pay you guys, don't worry. I don't know, money drives them somehow crazy and I don't know how but there's something happening, especially this weekend. (Male mineworker, IDI, platinum mine)

Theme 4. Structural factors: uptake of HIV prevention services

FSWs in the study mentioned structural support from community-based organisations (CBOs) through mobile outreach services where HIV prevention services such as condom distribution, PEP and PrEP. Many were aware of these services following educational campaigns provided by these CBOs. These services have been extended to PWIDs interviewed in the peri-mining areas by healthcare workers in communities. The quote below is confirmation from a healthcare worker in the community that FSWs consistently use HIV prevention services:

> **I: So, can you please tell me how do you think mine workers are increasing HIV in this community?** P: Well, I would say mine workers obviously they are labourers so they would work in here then the next month they will work somewhere else, then they would get retrenched and go to another province let us say Northwest. They start living there, then they frequent sex workers. But I am not saying sex workers are HIV positive. Others are and most men they do not want to use condoms but what I know is sex workers they protect themselves. They will be taking PrEP; they are taking PEP obviously they are taking ARV's some of them. So, mine workers they go around sleeping around then they take the HIV to

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their wives or wherever. So, it is a vicious cycle where they would sleep with me then sleep with you then take it to the wife then come back bring it back. So, it is just a vicious cycle and mind you they do not want to use condoms that is the dangerous thing condoms they do not want to use condoms.

I: So, what you are trying to say is that mineworkers they are drivers of HIV. P: Exactly. (Healthcare worker, IDI, coal mine)

Unlike FSWs and IDUs, there were divergent views among male and female mineworkers about availability of condoms and health services in the mines. Wellness programmes available in the mining companies provide a number of HIV prevention services including condom distribution. The accessibility of condoms is dependent on the type of employee in the mining company. Contractors reported inaccessibility of condoms whereas permanently employed staff had knowledge of where to find condoms. The male participant said condoms and health services in the mines were accessible to permanent employees and failure to use them was an individual choice:

Condoms are all over. When you go to the bathroom, you find them. When you pass the kitchen, you even see them, they are all over. I think the mine have gone uh far trying to curb the spread but it's a personal decision, to take or not to take and accessing the clinic is 24/7, those who are working shifts, they have access to clinic, they have access to any facility that can assist him. (Male mineworker, IDI, platinum mine)

The female participant said condoms were not available for contract workers in the mines and that workers were not informed about HIV and the use of condoms:

… (Because) since I arrived at the mine, I have never seen a condom. I am not saying that they should dispense condoms so that the people may use them while on duty but they must be made available maybe somewhere so that when a person passes, they can maybe pick up a condom. But something that they must always do, is to always teach people from the mine about the disease and how to behave well and to also condomize and that a person must always know their status. (Female mineworker, IDI, platinum mine)

In some instances, some participants reported that older mineworkers do not use the available biomedical HIV prevention services provided by the mining company. Rather, they use traditional drinks that are perceived to prevent one from HIV infection and also boost sexual performance.

Every weekend, they will leave the hostels and head to the brothels to do unnecessary things. They don't know how to protect themselves and you know especially the older people, some of them have that knowledge, some don't know, some think like ahh even though I have sex, I am going to drink this 2 litre muthi (traditional drink) and I will not get infected. It's just one of the things like they take something that is not real and they make it real and believe in that thing. Because they drink stuff that is in a two-litre container. I don't know what they call these things that they drink. It's muthi? They say it prevents diseases like HIV, gives you a sex boost [improves your sexual performance], it's something like sex booster [booster for sexual performance], HIV something but it contains a lot of things. And these people buy them, yoh! (Male mineworker, IDI, platinum mine)

Reports from mineworkers and healthcare workers revealed that PrEP is not offered in healthcare facilities in the mining company but is offered by primary healthcare facilities in the communities surrounding the mining companies. The uptake of HIV prevention services especially PrEP is affected by healthcare worker attitudes towards PrEP delivery. This healthcare worker alluded to the lack of PrEP in the mining companies, rather than in the government healthcare facilities in the communities. In addition, the preference of condoms over PrEP by healthcare workers was described in the following narrative:

We teach them here that if you get exposed, we have post exposure prophylaxis we don't have PrEP yet. PrEP, I think it is from the government. We don't condone that you know I don't see why we should give people PrEP because when you give people PrEP they won't condomize. PrEP, they will drink it because they know they have HIV positive partners but eventually they will be positive. You cannot drink PrEP; they say it's for a year. I was enquiring about that last week; they say we give it to you for a year it's preventative measure … but for how long? Health education you have this partner that is positive and I'm negative you can still make babies if this partner takes their treatment well if they suppressed, you go to your health care professional they will teach you but PrEP I don't think it works because eventually these people get become positive. You can't take PrEP forever then it's not PrEP anymore. So, we have PEP we have post exposure that you will only take within 72 hours of exposure to an HIV positive person. We don't want that we want you to use condoms with an exposed person but if it happens there's a condom burst yes you can come to us. We will cover you with post exposure prophylaxis treatment that is what we provide here we don't provide PrEP . PrEP I don't believe in it. (Healthcare worker, IDI, platinum mine)

Among healthcare workers interviewed, some displayed no knowledge of PrEP preventing its delivery. However, all the healthcare workers reported PEP delivery because of the accidental exposures to mineworkers that occur due to the occupational risks.

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We even have PEP available for maybe a rape case. We do have PEP available. I don't know anything about PrEP, I only know the PEP. PrEP is something that could be administered let's say to a commercial sex worker, if she's HIV negative but she's at high risk so she can take PrEP to try and prevent from contracting HIV, but it doesn't mean they have to be reckless, they still have to practise safe sex. Like with the PEP, I'm telling you that we do have PEP if the pharmacy paid for us, but with the PrEP I never, in this time …, I have never had experience with someone asking for PrEP. However, my reasoning is that, if someone came, there won't be a problem to get PrEP. (Healthcare worker, IDI, iron ore mine)

DISCUSSION

This study explored the syndemic relationship between social, environmental, and structural risk factors in the context of HIV in peri-mining communities. The findings from this study indicate the interrelationship of several factors that increase HIV risk in key populations of the peri-mining communities. The syndemic theory involves the interaction between social and disease conditions and was tested on the social and environmental factors that interact synergistically to contribute to excess burden of HIV among mineworkers. The syndemic lens was applied to distinguish between individuals who exhibit certain high-risk sexual behaviours such as reduced condom use, casual and multiple partners, commercial and transactional sex worker, and substance or alcohol use, and HIV acquisition. This study identified a syndemic of four socio-behavioural factors that are associated with HIV acquisition in peri-mining areas. These are migrancy, alcohol and substance use, accessibility to commercial and transactional sex, and access to and uptake of HIV prevention services. These align with findings from previous studies globally which have shown the multiple pathways HIV is transmitted or acquired in key populations.

Migrancy and mobility was identified as the most prominent factor for HIV acquisition in peri-mining settings. As a result of migration for work purposes, families are disrupted, and social support structures collapse. Subsequently, participants found themselves in situations where high-risk behaviour is normalised in addition to reduced access to healthcare services.[25] Physical distance from regular partners for prolonged durations, socialising with new people from different places, easy access to alcohol, FSWs and inconsistent condom use, facilitated an environment of casual and unprotected sex.[21] These findings are corroborated by numerous previous literature from studies conducted among mineworkers and truck drivers in Africa where migrant workers would often seek casual sexual partners to relieve their loneliness and to distract themselves from anxieties about home.[9 25 26]

There was an overwhelming consensus that risk-taking during sexual intercourse was influenced by prior substance use, mostly alcohol. Alcohol abuse limited the capacity of mineworkers to practice safer sex as observed in a study conducted among mineworkers in Mozambique.[11] Substance use was associated with risky sexual practices such as limited condom use with multiple sexual partners which increase HIV risk in these settings.[16 27] A study conducted in Nigeria exploring the syndemic relationship of substance use and sexual risk with HIV risk corroborated findings from our study and concluded that spontaneous inebriated sexual intercourse leaves no room for condom use and increases HIV risk among sexual partners.[18] Previous studies have shown a link between masculinity and engagement in high-risk behaviour.[13 14 18] The role of masculinity as a coping mechanism for a stressful and sometimes dangerous working environment where fatalities can occur is intertwined with their heightened risk of exposure to HIV.[13 14] Accessibility of mineworkers to FSWs is a well-documented phenomenon and previous studies have shown the symbiotic relationship between mineworkers and FSWs.[12] Masculinity manifests as low self-efficacy where the risk of acquiring HIV/AIDS is perceived to be lower than the risk of underground accidents and sometimes fatalities.[13] As a result, unprotected sexual intercourse is seen as providing much needed comfort in a highly stressful environment.[14] The syndemic relationship between underlying migrancy, accessibility to FSWs and the need to validate the masculinity by multiple sexual partnerships to curb insatiable sexuality is seen to increase HIV risk for mineworkers.[14]

Transactional sexual relationships have been documented as drivers of HIV infection. In many cases, parties engaged in transactional sexual relationships exploit the immediate benefits that are derived from well-resourced partners as they seek to add value to their lives.[28] From our study, the value added was a promotion at work or monetary gain for their subsistence needs. Transactional sex is a pragmatic adaptation to modern life where the need for material expectations provides important incentives for multiple partnerships and unprotected sexual acts.[23] This in the long-term increases the HIV risk for both casual and regular sexual partners. Our study highlighted that as a result of power relations, transactional sex was observed between older men and younger partners (male or female) as has been evidenced by many studies examining age-disparate relationships and HIV acquisition.[29]

Injection drug use was reported at community-level and although this was not observed in mineworkers, the indirect HIV risks associated with injection drug use in mineworkers should not be ignored. A longitudinal study investigating drug use and HIV transmission among men who have sex with men (MSM) in the USA, reported an increased association with involvement in high-risk sexual transmission behaviour with the use of injectable illicit drugs such as cocaine and methamphetamines.[19] The link between drug use and HIV-associated outcomes in the high-risk populations as highlighted in previous research suggests that mineworkers in peri-mining

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communities are indirectly at great risk of contracting HIV.[30–32]

Our study showed low uptake of HIV prevention services. There was inconsistent or lack of condom use by mineworkers despite its availability in the mining companies. On the contrary, FSWs reported consistent use of condoms and other HIV prevention methods such as PrEP. Noteworthy, the presence of community-based organisations facilitated awareness of newer HIV prevention alternatives and many FSWs displayed knowledge of PrEP and how to use it. Due to the risky nature of their jobs, mineworkers possessed knowledge of PEP as a HIV prevention alternative in case of an accidental occupational exposure. PEP awareness has been facilitated by the healthcare workers in the mining companies. Of concern was the lack of willingness to educate mineworkers on PrEP as another effective way to reduce HIV risk. Misconceptions towards PrEP led to the perpetuation of social stigma associated with choosing to use PrEP over condoms by healthcare workers. A similar finding was reported in a study conducted in Ekurhuleni, South Africa where healthcare workers in primary healthcare facilities were reluctant to offer PrEP as an alternative HIV prevention method.[33] Furthermore, the suboptimal uptake of HIV prevention services was influenced by reliance on traditional medicine that was seen as not only a sexual booster but also having the ability to prevent or cure HIV infections. This underestimation of HIV risk after consumption of this drink makes mineworkers more susceptible to HIV infection and transmission.[12]

One of the strengths of this study was conducting both IDIs and FGDs which allowed for in-depth observation and narrative engagement with the community. Second, was the buy-in from all stakeholders following extensive consultations. The research team developed a good working relationship with mining employees, unions to reach out to different target groups. The study was conducted at only three mines in South Africa but the findings provide insight into diverse mining settings including large versus small mining operations, and populations: all age ranges, men, and women, and in settings with high and low HIV burden. Despite this, our study is not without limitations and interpretation of the findings should be done with caution. The limited number of participants especially (truck drivers and PWID) in specific contexts (peri-mining settings) indicate the need for further research. Social desirability bias where socially acceptable rather than true responses from the participants may occur was a possible limitation in this study. However, we mitigated this by ensuring that the interviewers were trained in techniques on introducing the study, establishing rapport and probing. Finally, we did not include the perspectives of other relevant stakeholders such as regular partners of mineworkers or policymakers.

CONCLUSIONS

The study confirms that social, environmental and structural factors play a crucial role in HIV transmission in peri-mining communities. These include peer influence on participants' sexual behaviours and IDU practices, and communities or areas that participants live and/or work in, where FSWs, and illicit drugs are often available and easily accessible. Mobility and migration to other places for work purposes are part of these drivers leading to HIV transmission. Our findings have implications for HIV prevention programmes, which heavily rely on promotion of male condom usage and HIV testing and disclosure. These programmes, especially in the mining companies may need to compensate for the reality that condom use is inconsistent and there is a need for better education about the prevalence of HIV and how it is transmitted, and accurate information about condoms, and PrEP especially for heterosexual males in high-risk settings (working away from home, for example). Future large-scale studies to understand men's perceptions on various HIV-prevention services are recommended. Mining companies represent important venues for addressing individual risk factors of HIV through targeted and comprehensive workplace HIV prevention interventions but also to mitigate social and structural risk factors for HIV/AIDS in peri-mining communities through community outreach and socioeconomic development interventions. These findings demonstrate the potential for successful HIV management programmes within the mining environment and in peri-mining communities. Mining companies provide an opportunity to extend care for other conditions, such drug treatment or harm reduction approaches to the peri-mining communities to prevent and reduce the associated unintended outcomes in their mineworkers.

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