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mHealth entry points for HIV prevention and care among adolescents and young people in South Africa

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Abstract

Although mobile phone access in South Africa is high, research on access and utilization among adolescents is nascent. mHealth interventions have a huge potential to transform health seeking practices and service provision patterns, especially among populations with low retention in care, such as adolescents living with HIV (ALHIV). In these preliminary analyses, we explore factors associated with access to and utilization of mobile phones for health information and support in a longitudinal sample of adolescents living in HIV-endemic communities in South Africa. All adolescents were participants in two waves of the Mzantsi Wakho cohort study, set in the Eastern Cape province in South Africa. Analyses explored mobile phone access and utilization trends over time, as well as factors associated with greater use of mobile phones for health-related information.

The findings reveal an increase from 43% to 77% between two interviews in the use of mobile phones, especially smartphones, as adolescents grew older. Adolescents were particularly interested in social media platforms, games, media, and using their devices to communicate with peers. In the random effects model, older participants and those who were in a relationship were more likely to seek health information on their phones. For each year of age, adolescents were 24% more likely to use their mobile phones to search for health-related information. Participants who were in a relationship were 55% more likely to present mHealth seeking behaviours. Adolescent girls and young women were more likely to use their mobile phones for communication, while their male peers were more likely to use them for entertainment purposes. Our study drew upon a changing scenario and captures nuances in this process, aiming to better understand how mobile phones may be used as entry points for designing and implementing efficient mHealth interventions.

1. Introduction

Access to information and communication technologies (ICTs) is increasingly perceived as a fundamental service, not only as a way to exercise freedom of speech but also as a tool for human development (United Nations [UN], 2011; Ejemeyovwi et al., 2019). As this recognition grows, mobile phone access and connectivity has expanded, globally, though at different rates for each region. In South Africa, rates of mobile phone access and connectivity has consistently followed this expansion trend, having reached a 66.7% mobile phone ownership in 2018, with 99.5% of 3G network access (Tshuma, 2017). In 2014, UNICEF reported 34% of South Africans aged 8-13 and 69% aged 14-18 had access to a mobile phone (Whiteley, Brown, Lally et al., 2018; Venter et al., 2019), with even higher rates for self-reported mobile phone use in the past month, 78% and 97% respectively (Venter et al., 2019).

In this context, health interventions delivered through mobile platforms (mHealth) may be highly acceptable and effective (Tshuma, 2017; Whiteley, Brown, Lally, et al., 2018). mHealth interventions aim to supplement over-capacitated health systems, reach communities in rural areas, and engage people who do not normally seek facility-based health services (Botha & Booi, 2016; Cooper et al., 2017; Daher et al., 2017; Chiang et al., 2018; Cordova et al., 2018; Bervell & Al-Samarraie, 2019; Comulada et al., 2019; Cox et al., 2019). Although the simplest and most common mHealth has been the one-way short message service (SMS) (Cooper et al., 2017; Denison et al., 2017; Fiellin et al., 2017; Cordova et al., 2018; GSMA, 2019a, 2019b; DiAndreth et al., 2020) there are promising opportunities to design interventions that will benefit from the increasing popularization of smartphone use and accessibility of data from mobile Internet providers (Silver et al., 2019).

Traditional SMS mHealth interventions have primarily been rolled out to adults, with the median age of users around 30 years or older (Fiellin et al., 2017; Cordova et al., 2018; Cox et al., 2019; GSMA, 2019b; DiAndreth et al., 2020). Despite its positive results for adults, there is an opportunity to tailor mHealth interventions for adolescents, to ensure the best possible interventions to capture their voices and address their specific needs. When adolescents and youth at risk of HIV infection or living with HIV are asked what functionalities they wish in a mHealth intervention, there is a stable demand for customizability, a social support network, personal care management trackability, and provision of accurate and relevant HIV and health information (Hieftje et al., 2016; Krah & de Kruijf, 2016; LeGrand et al., 2016; Hightow-Weidman et al., 2017; Hirsch-Moverman et al., 2017; Muessig et al., 2017; Marcolino et al., 2018; Mulawa, LeGrand & Hightow-Weidman, 2018; Janssen et al., 2020).

HIV-related mHealth apps and games have shown promising results in adolescents and young adults for reduction in risky behaviours, increase in HIV and Sexual and Reproductive Health (SRH) knowledge, and empowerment in care and sexual decision making (Hightow-Weidman et al., 2017; Hirsch-Moverman et al., 2017; Linguissi et al., 2018). Taking advantage of these tools to support adolescents in adopting safe behaviours and practices is important in light of the HIV impact on Southern Africa. Specifically, South Africa's adolescent HIV incidence rates are not reducing quickly enough to meet UNAIDS 95-95-95 targets (UNICEF, 2020). In 2013, South Africa had 101 mHealth programs, 42 of which addressed HIV/AIDS, with a majority of mHealth programs implemented in the Gauteng and Western Cape provinces (Whiteley, Brown, Mena et al., 2018). As of December 2019, Global System for Mobile Communications' (GSMA) mHealth tracker has identified 80 current mHealth programs ongoing in the country, exhibiting the continuing need of sustainable mHealth (Winskell et al., 2018).

This highlights the potential for mHealth to engage with young people more effectively, and it is fundamental that we understand their mobile phone behavioural habits. This is an initial step that will help the design of targeted interventions that will be acceptable, feasible, and efficacious amongst key populations that struggle to overcome multidimensional obstacles. Specifically, ALHIV in South Africa struggle to access facility-based adult-centred health services, have to fight stigmas on a daily basis, and at the same time struggle with broad social drawbacks such as unemployment, violence, and lack of inclusive opportunities.

As ICTs and mobile phone penetration increases, mHealth could and should be designed and implemented, but little evidence has been publicized on particular target groups such as adolescents. This paper aims to help fill this gap, by providing insights on the potential routes and efficacy for adolescent mHealth intervention by revealing the trends in mobile access and usage in a particularly vulnerable population.

2. Methods

We report on data from the second (October 2015-April 2017) and third waves (July 2016-November 2018) of the Mzantsi Wakho study, a longitudinal adolescent cohort study in the Eastern Cape of South Africa. The study focused on ALHIV. All adolescents (aged 10-19) at baseline (March 2014-September 2015) who were initiated on antiretroviral therapy (ART) at a clinic in the Buffalo City Health District in the Eastern Cape, South Africa, were approached to participate in the survey. HIV-negative participants from the same communities

were surveyed to reduce the stigma of the study. All participants who were re-interviewed were approached again for both additional waves. The data were collected by highly-experienced well-trained research assistants in the participants' homes or other spaces where adolescents felt comfortable to do the interviews. Consent was received prior to the survey from a guardian for adolescents who were under 18 years old and the participants could stop the survey at any time. A rigorous referrals protocol was established and applied for any risk of harm or harm reported throughout the research process. The survey was conducted in the participant's language of choice, English or Xhosa. This study has been approved by ethical review committees at the University of Cape Town (CSSR2013/4; CSSR 2019/1) and University Oxford (R48876/RE001) and affiliated facilities (see Appendix).

2.1. Variables/ measures

Age was measured in years. *Sex* was a binary variable with female and male as options. *Residential area* was a binary variable based on self-reported residence with urban and rural as options based on South African census definitions. *HIV status* was a binary variable based on clinic files, guardian disclosure, and self-disclosure. *Relationship status* was a binary variable based on self-report. *Sexual activity* was a binary variable indicating if a participant reported having vaginal and/or anal sex. *Sexual debut age* was the youngest self-reported age that a participant had anal or vaginal sex. *Sexual debut in the past year* was a binary variable indicating if a participant had sex, anal or vaginal, for the first time in the past year. *Negative clinic experience* was a composite variable of clinic experience factors including treatment by staff, ability to receive services, quality of services provided, and felt comfortable attending a clinic. A higher score indicates a worse clinic experience. *Clinic travel time, clinic wait time,* and *clinic cost* represented the average time in minutes it takes a participant travels to attend clinic, the average length of time in minutes a person waits to be seen at clinic, and the average amount in South African rand it costs to see a nurse/doctor at the clinic, respectively.

2.1.1. Mobile phone variables

Ownership and *device type* were categorical variables with a person potentially having access to multiple phone types. For the regression, participants who reported having access to both phone types were recoded as having access to the superior phone type, smart phone. For those who reported having access to any phone type, *mobile usage* questions were asked regarding e-mail, games, health information, HIV information, SRH information, job information, music, SMS,

WhatsApp, Facebook, and Mxit in both waves. In wave 3, the following usage questions were added: media downloads, photos, Instagram, Snapchat, connecting with friends, dating, news, general information, and work/school purposes.

The outcome variable is *mHealth seeking behaviour*. This was a binary variable with yes representing participants who reported using their mobile for health information, HIV information, and/or SRH information.

2.2. Analyses

To explore the difference in mobile phone penetration between the two waves, descriptive statistics, Student's t-tests, and chi-square tests were performed on the mobile phone and sociodemographic factors. Chi-square tests were also performed on the different types of mobile usage to assess the change in mobile phone habits among South African adolescents and young adults.

To compare the use of mobile phones for sexual reproductive health, general health, and/or HIV information between the two waves, Student's t-tests, Welch's tests, and chi-squared tests were performed comparing mobile and sociodemographic factors between adolescents who exhibited the health-seeking behaviour compared to those who did not. Welch's t-test was used when the variances between the two samples were unequal. These tests were performed in both waves to determine which variables are significantly associated with the outcome to be included in the model.

Fixed effect and random effects models were considered. Fixed effects models account for cluster-level variation which are the within-individual differences in our sample. Random effects models account for both the within and between individual correlation. Random effects models are more efficient than fixed effect models and allow for assessment of a time-invariant variable's impact on the outcome. Factors that were found to be significantly associated with mHealth seeking behaviours in either wave were included in the model. The variables found to be significant were then tested for intercorrelation. Due to the high correlation between being in a relationship and having ever had sex, being in a relationship was included in the model because it is more inclusive of adolescents and young adults who are more likely to seek health, HIV and SRH information. Both a fixed effect and random effect model were performed for the final model. A Hausman Test was conducted to determine which model was appropriate for the data. All analyses were performed using Stata software (version 14; Stata Corp, College Station).

3. Results

Table 1 presents the descriptive statistics of 1,454 South African adolescents and young adults from wave 2 and 1,429 South African adolescents and young adults from wave 3, of whom 1,392 (97%) were interviewed in both waves.

In wave 2, the average age of the population was 15.4 (range: 10-24). Most participants were female (57.8%), lived in urban areas (74.4%), were living with HIV (70.8%), were not in a relationship (65.0%), were sexually inactive (64.9%), and had access to a mobile phone (52.8%). Amongst those who were sexually active, 25% were not in a relationship. Amongst those who accessed (owned or shared) a mobile phone, 42.5% owned a smart phone, 34.0% owned a basic phone, and 23.5% owned both a smart and basic phone. For participants in wave 2, the average age of sexual debut was 15.1 (SD=2.5), the average clinic travel time was 28.5 minutes (SD=15.0), average clinic wait time was 81.2 minutes (SD=52.0), and the average cost to attend clinic was 7.1 Rand (SD=12.4).

In wave 3, the average age of the population was 16.6 (range: 11-25). A year later, more of our sample population advanced through adolescent milestones with more participants being in a relationship (37.2%), being sexually active (45.1%), and having access to a mobile phone (owned or shared: 58.0%). Amongst those who were sexually active, 27% were not in a relationship. Amongst those who had access to a mobile phone, 77.1% had access to a smart phone, 17.5% had access to a basic phone, and 5.4% had access to both a smart and basic phone. Among participants in wave 3, the average age of sexual debut was 15.8 (SD=2.4), the average clinic travel time was 23.3 minutes (SD=11.8), average clinic wait time was 83.5 minutes (SD=60.2), and the average cost to attend clinic was 5.9 Rand (SD=13.2).

Between wave 2 and wave 3, the distribution of those who were sexually active, clinic travel time in minutes, mobile phone access, and mobile phone type differed significantly at an alpha level of 0.05.

Table 1. Descriptive statistics of the sample's socio-demographics, clinic experience and mobile phone factors from wave 2 and 3 data collection

	Wave 2 (N=1454)		**Wave 3 (N=1429)**		
	M (SD)	**N (%)**	**M (SD)**	**N (%)**	**P**
Age	15.4 (3.1)	--	16.6 (3.1)	--	<0.001
Sex (*Female)*	--	841 (57.8)	--	825 (57.7)	
Area *(Rural)*	--	371 (25.6)	--	355 (24.9)	
HIV Status *(HIV-positive)*	--	1,030 (70.8)	--	1,010 (70.7)	
In a Relationship	--	509 (35.0)	--	528 (37.2)	
Sexually Active	--	511 (35.1)	--	644 (45.1)	<0.001
Sexual Debut Age	15.1 (2.5)	--	15.8 (2.4)	--	
Sexual Debut in the Past Year**	--	158 (27.4)	--	145 (24.5)	
Negative Clinic Experience (Scale)	6.3 (3.2)	--		--	
Clinic Travel Time*	28.5 (15.0)	--	23.3 (11.8)	--	<0.0001
Clinic Wait Time*	81.2 (52.0)	--	83.5 (60.2)	--	
Clinic Cost	7.1 (12.4)	--	5.9 (13.2)	--	
Mobile Phone Access					<0.0001
None	--	687 (47.2)	--	600 (42.0)	
Share	--	26 (1.8)	--	5 (0.3)	
Own	--	741 (51.0)	--	824 (57.7)	
Mobile Phone Type					<0.0001
Smart only	--	326 (42.5)	--	639 (77.1)	
Basic only	--	261 (34.0)	--	145 (17.5)	
Both	--	180 (23.5)	--	45 (5.4)	

* *Extreme values beyond 1.5 interquartile range (IQR) were removed*
** *Amongst sexually active*

Table 2 contains a subset of the total sample representing participants who reported having access to a mobile (own or shared), N=767 in wave 2 and N=829 in wave 3. In Wave 2, the most common mobile usage was for music (82.5%), SMS text (79.3%), games (72.4%), WhatsApp (67.5%), and Facebook (54.4%). Wave 3 had similar trends to Wave 2 with music (86.7%), SMS text (82.2%), WhatsApp (76.4%), games (76.2%), and Facebook (62.9%) being the most common mobile usage along with photos (79.0%), friends (75.8%), and media downloads (58.6%).

Table 2. Descriptive statistics of mobile usage amongst those who have access to a mobile by data collection wave

Mobile Phone Activity	**Wave 2 (N=767)**		**Wave 3 (N=829)**		
	N	***%***	***N***	***%***	***P***
E-mail	153	20,0%	159	19,2%	
Games	555	72,4%	632	76,2%	
Health information	159	20,7%	155	18,7%	
HIV information	128	16,7%	155	18,7%	
SRH information	54	7,0%	50	6,0%	
Job information	140	18,3%	133	16,0%	
Music	633	82,5%	719	86,7%	<0.05
Media downloads	--	--	486	58,6%	
Photos	--	--	655	79,0%	
SMS text	608	79,3%	681	82,2%	
WhatsApp	518	67,5%	633	76,4%	<0.001
Facebook	417	54,4%	521	62,9%	<0.01
Mxit	25	3,3%	8	1,0%	<0.01
Instagram	--	--	81	9,8%	
Snapchat	--	--	29	3,5%	
Friends	--	--	628	75,8%	
Dating	--	--	118	14,2%	
News	--	--	132	15,9%	
Information	--	--	268	32,3%	
Work/School	--	--	448	54,0%	

Between wave 2 and wave 3, usage for Facebook, WhatsApp, and Music significantly increased while Mxit usage significantly decreased[1]. Table 2a displays the mobile usage by sex for each wave.

In wave 2, males used their mobiles significantly more than females for SRH information (10.7% versus 4.9%) and music (86.1% versus 80.5%). Females used their mobiles significantly more than males for SMS (84.6% versus 70.1%), WhatsApp (70.6% versus 62.3%), and Facebook (60.5% versus 43.8%).

In wave 3, the trend for SMS and Facebook held. Males also used their mobiles significantly more for games (82.8% versus 72.8%), media downloads (64.4% versus 55.6%), and news (20.1% versus 13.8%) while females used their mobiles significantly more for HIV information (20.9% versus 14.4%).

[1] As platforms such as Facebook Messenger and WhatsApp emerged and drew users, Mxit was decommissioned in September 2016, with its service ending on September 30, thus accounting for the decrease between wave 2 and 3.

Table 2a. Descriptive statistics of mobile usage amongst those who have access to a mobile by sex and data collection wave

	Wave 2 (N=767)			**Wave 3 (N=829)**		
Mobile Phone Activity	**Males (N=281)**	**Females (N=486)**		**Males (N=284)**	**Females (N=545)**	
	N (%)		**P**	**N (%)**		**P**
E-mail	60 (21.4)	93 (19.1)		59 (20.8)	100 (18.4)	
Games	211 (75.1)	344 (70.8)		235 (82.8)	397 (72.8)	<0.01
Health information	63 (22.4)	96 (19.8)		47 (16.6)	108 (19.8)	
HIV information	48 (17.1)	80 (16.5)		41 (14.4)	114 (20.9)	<0.05
SRH information	30 (10.7)	24 (4.9)	<0.001	17 (6.0)	33 (6.1)	
Job information	55 (19.6)	85 (17.5)		41 (14.4)	92 (16.9)	
Music	242 (86.1)	391 (80.5)	<0.05	252 (88.7)	467 (85.7)	
Media downloads	--	--		183 (64.4)	303 (55.6)	<0.05
Photos	--	--		214 (75.4)	441 (80.9)	
SMS text	197 (70.1)	411 (84.6)	<0.001	217 (76.4)	464 (85.1)	<0.01
WhatsApp	175 (62.3)	343 (70.6)	<0.05	212 (74.7)	421 (77.3)	
Facebook	123 (43.8)	294 (60.5)	<0.001	158 (55.6)	363 (66.6)	<0.01
Mxit	6 (2.1)	19 (3.9)		3 (1.1)	5 (0.9)	
Instagram	--	--		34 (12.0)	47 (8.6)	
Snapchat	--	--		14 (4.9)	15 (2.8)	
Friends	--	--		214 (75.4)	414 (76.0)	
Dating	--	--		46 (16.2)	72 (13.2)	
News	--	--		57 (20.1)	75 (13.8)	<0.05
Information	--	--		92 (32,4)	176 (32.3)	
Work/School	--	--		157 (55.3)	291 (53.4)	

Source: Mzantsi Wakho study.

Tables 3a and 3b present the correlation statistics between possible predictors of mHealth uptake and use of mobile phones for health-seeking behaviour for both waves. In Wave 2, South African adolescents and young adults who were older, lived in urban areas, were in a relationship, were sexually active, had a more positive clinic experience, travelled further to attend clinic, or owned a smart phone were more likely to use their mobiles for SRH, health, and HIV information. Sex and HIV status were not significantly associated with mHealth seeking behaviours. In wave 3, the same associations held living area.

Though sex was not significantly correlated to mHealth seeking behaviour, it was kept in the logistic regression as covariate because literature shows that females seek health services more than males do, at physical clinics. However, there may be a difference in virtual health-seeking behaviours by sex as males who do not

seek health information at clinics may turn to their mobile devices or the bias of females seeking more health information may persist virtually as well as physically. Clinic cost was excluded from the model due to high amounts of missing data. The Hausman test found a random effects model to be appropriate.

Table 3a. Correlation between the sample's characteristics and mHealth SRH-seeking behaviour in Wave 2, N=767

	No mHealth seeking behaviour		**mHealth seeking behaviour**		
	M (SD)	**N (%)**	**M (SD)**	**N (%)**	**P**
Age, years	16.2 (3.1)	--	17.5 (2.5)	--	<0.0001
Sex					
Female	--	365 (65.4)	--	121 (57.9)	
Male	--	193 (34.6)	--	88 (42.1)	
Area					<0.0001
Rural	--	161 (29.0)	--	31 (14.9)	
Urban	--	395 (71.0)	--	177 (85.1)	
HIV Status					
HIV Positive	--	378 (67.7)	--	130 (62.2)	
HIV Negative		180 (32.3)		79 (37.8)	
Relationship Status					<0.001
In a relationship	--	229 (41.0)	--	127 (60.8)	
Not in a relationship	--	329 (59.0)	--	82 (39.2)	
Sexually Active					<0.001
Active	--	237 (42.5)	--	129 (61.7)	
Inactive	--	321 (57.5)	--	80 (38.3)	
Sexual Debut Age	15.7 (1.9)	--	15.4 (2.5)	--	
Sexual Debut in the Past Year					
Yes	--	64 (25.1)	--	41 (28.7)	
No	--	191 (74.9)	--	102 (71.3)	
Negative Clinic Experience Scale	6.1 (3.3)	--	5.4 (3.4)	--	<0.01
Clinic Travel Time**	23.6 (12.7)	--	29.5 (15.5)	--	<0.0001
Clinic Wait Time**	80.9 (51.5)	--	82.1 (55.5)	--	
Clinic Cost	7.0 (12.3)	--	5.9 (10.1)	--	
Mobile Phone Type *					<0.0001
Smart	--	338 (60.6)	--	168 (80.4)	
Basic	--	220 (39.4)	--	41 (19.6)	

** If a person had access to both a smart phone and a basic phone, they were coded as having a smart phone*

*** Extreme values beyond 1.5 IQR were removed*

Table 3b. Correlation between the sample's characteristics and mHealth SRH-seeking behaviour in Wave 3, N=829

	No mHealth seeking behaviour		mHealth seeking behaviour		
	M (SD)	**N (%)**	**M (SD)**	**N (%)**	**P**
Age, years	17.2 (3.0)	--	18.2 (2.5)	--	<0.0001
Sex					
Female	--	386 (64.3)	--	159 (69.4)	
Male	--	214 (35.7)	--	70 (30.6)	
Area					
Rural	--	154 (25.7)	--	51 (22.3)	
Urban	--	445 (74.3)	--	178 (77.7)	
HIV Status					
HIV Positive	--	413 (68.8)	--	151 (65.9)	
HIV Negative	--	187 (31.2)	--	78 (34.1)	
Relationship Status					<0.05
In a relationship	--	263 (44.2)	--	120 (52.9)	
Not in a relationship	--	332 (55.8)	--	107 (47.1)	
Sexually Active					<0.01
Active	--	325 (54.2)	--	149 (65.1)	
Inactive	--	275 (45.8)	--	80 (34.9)	
Sexual Debut Age	15.9 (2.2)	--	16.2 (2.3)	--	
Sexual Debut in the Past Year					
Yes	--	66 (22.4)	--	37 (26.1)	
No	--	229 (77.6)	--	105 (73.9)	
Negative Clinic Experience Scale	6.4 (3.0)	--	5.9 (3.2)	--	<0.05
Clinic Travel Time**	23.5 (11.9)	--	21.5 (10.7)	--	<0.05
Clinic Wait Time**	82.0 (58.9)	--	82.0 (60.2)	--	
Clinic Cost	7.0 (13.8)	--	8.5 (23.2)	--	
Mobile Phone Type*					<0.001
Smart	--	465 (68.0)	--	219 (32.0)	
Basic	--	135 (93.1)	--	10 (6.9)	

** If a person had access to both a smart phone and a basic phone, they were coded as having a smart phone*

*** Extreme values beyond 1.5 IQR were removed*

Table 4 presents the output of the panel data logistic regression predicting the likelihood of adolescents and young adults using their phones for mHealth. A total of 2,667 observations were included in the model with 1,471 groups. Relationship status, negative clinic experience, clinic travel distance, and age were significantly associated with mHealth seeking behaviour with odds ratio of 1.55, 0.96, 0.98, and 1.24, respectively. According to the results, people in a relationship were 55%

more likely than those not in a relationship to exhibit mHealth seeking behaviours and a unit older in age is associated with a 24% increase in likelihood of exhibiting mHealth seeking behaviour. A unit increase in the negative clinic experience scale was linked to a 4% decrease in likelihood of exhibiting mHealth behaviour and a minute increase in in travel time to the clinic was associated with a 2% decrease in the likelihood of exhibiting mHealth seeking behaviour. Living area and sex were not found to be significantly associated with mHealth seeking behaviour. The model's within-group variance was 0.12 and the panel-level variance was 1.06. The intraclass correlation was 0.26, indicating 26% of the variance in mHealth seeking behaviour is due to differences across the 2 waves. The model was significant with a Wald statistic of 136.14.

Table 4. Random effects model predicting the odds of mHealth seeking behaviour amongst South Africa adolescents and young adults

	Odds Ratio	Std. Error	95% CI	P
In a Relationship	1,55	0,23	[1.16, 2.09]	0,004
Poor Clinic Experience (score)	0,96	0,02	[0.92, 1.00]	0,046
Clinic Travel Time (minutes)	0,98	0,01	[0.97, 0.99]	<0.001
Age	1,24	0,03	[1.17, 1.30]	<0.001
Rural residence	0,72	0,12	[0.51, 1.01]	0,056
Sex (Female)	1,14	0,16	[0.86, 1.51]	0,37
Participant-level variance	0,12	0,30		0,71
Panel-level variance	1,06	0,16		1,43
Intraclass Correlation	0,26	0,06		0,38
Wald chi2(6)	136,14			<0.0001

4. Discussion

4.1. Change across waves: sexual activity and mobile phone access

Between waves, the proportion of sexually active participants, mobile phone access, and mobile phone type differed significantly. There was an increase in the proportion of those who were sexually active indicating an increase in the pool of adolescents and young adults who need a way to quickly access accurate SRH information in a discreet manner. Currently available statistics on mobile phone access is limited to adult populations and are several years older. This dataset shows phone access amongst South African adolescents and young adults aged 10-24 was at 53% around 2015 and, in just a couple of years, phone access increased significantly to 58%, reinforcing the trend for increased access to

mobile phones amongst South African adolescents and young adults (Silver et al., 2019). This is slightly lower than the prevalence of mobile access estimated by UNICEF in 2014 but this data's sample contains a lower age range (Venables et al., 2019). The data show there is mobile access for adolescents of younger ages, thus showing a wider age of entry for mHealth interventions. Amongst those with mobile access, a majority of adolescents and young adults had access to a smart phone, jumping from 42.5% to 77.1% ownership across the waves, indicating mHealth interventions beyond SMS messaging are possible interventions for this age range. Looking at the usage statistics, a majority of South African adolescents and young adults used their mobiles for social media, communications, games, and media at an increasing rate. This supports the literature which posits this younger population are more tech-savvy, utilize mobile applications with a social circle aspect, and will find multi-faceted mHealth interventions more engaging than the traditional one-way SMS.

4.2. mHealth seeking behaviour

The investigation into correlation between potential predictors and mHealth seeking behaviour found that, in wave 2, adolescents and young adults who were older, living in an urban area, in a relationship, are sexually active, with a better clinic experience, and had access to a smart phone were statistically more likely to exhibit mHealth seeking behaviour. All of these trends hold true in wave 3 except for the living area. The random effects model shows people who were older and were in a relationship are more likely to seek health information on their phones. In an HIV high prevalence country like South Africa, it is important for these adolescents and young adults to know the risk and prevention methods of sexually transmitted diseases. The results indicate these adolescents and young adults were also curious and may recognize the importance of knowing the facts. Surprisingly, a worse clinic experience and a longer clinic travel time was associated with lower likelihood to use their mobile for health information. The perceived failure of the health system or inaccessibility of it may be translating to discouragement for easier routes of access such as mHealth. This is a subpopulation of adolescents and young adults that would need to be convinced of the benefits of mHealth as an alternative to the physical clinic. mHealth interventions must be created through engagement with adolescent and young people to ensure that such applications are acceptable and user-friendly.

4.3. mHealth entry points amongst adolescents in HIV-endemic communities

Adolescents and young adults who had access to a smart phone utilized their mobiles for all of the usage types outlined in Table 2 more than those who had access to a basic phone, likely due to the higher technological needs of apps and

games. The differences in mobile phone utilization by male and female participants highlighted that males and females were engaged by different media and sought different things. Male participants seemed to primarily seek entertainment while female participants seemed to seek social connection to others through their mobile devices. The higher rate of HIV information consumption for females in wave 3 may coincide with females reaching the average age of sexual debut and their desire to have risk-free sex, knowing the higher risk of HIV infection for females.

This paper has shown that the mobile phone is a readily available avenue to reach adolescents and young adults for mHealth interventions. Depending on the purpose and population of adolescents and young adults targeted for mHealth interventions, there are different approaches and content that should be incorporated. In addition to content, the persons from the target group should always be part of the process as stakeholders, contributors, and testers for a successful and sustainable intervention.

4.4 Study limitations

This study's limitations include the possibility that some individual characteristics that may influence the covariates were not included into the random effects model, which would lead to bias in the model. However, this is an exploratory paper to understand the mobile access, engagement, and predictors of mHealth usage. The use of a random effects model also allowed for inference on the effect on mHealth-seeking behaviour due to a change in the independent variables across time.

5. Conclusion

Our study's purpose was to explore the factors associated with access to and utilization of mobile phones for health information and support in a longitudinal sample of adolescents and young people living in an HIV-endemic community in South Africa. This observational cohort of South African adolescents and young adults within a municipality in South Africa provides updated figures on mobile phone penetration and new data on detailed mobile phone usage amongst this population. The findings reveal a significant expansion in mobile phone use, particularly smartphones, suggesting an open avenue of opportunities to design mHealth interventions tailored for adolescents and young people that may benefit from this transformation in due course.

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Appendix: Existing research ethics committee approvals and government approvals

(1) Inter-Divisional Research Ethics Committee (IDREC) of the Social Sciences and Humanities Division, University of Oxford (Ref No: SSD/CUREC2/12-21, Amendments: 20 Nov 2014, R43892/RE003 – 29 September 2016).

(2) Centre for Social Science Research, University of Cape Town (Ref No: UCT/CSSR/1/2014(ii); UCT/CSSR/2017/01; UCT/CSSR/2019/11)

(3) National Institute for Communicable Diseases (approval for linking data to National Data Warehouse, dated: 7 August 2019)

(4) Department of Health, Eastern Cape Province (29 August 2013)

(5) Buffalo City Municipality Health sub-district approval (23 January 2014, 2 October 2015, 3 March 2017)

(6) Department of Education, Eastern Cape Province (4 April 2014)

(7) Frere Hospital (25 November 2013, 24 January 2017)