Mobile Device Usage by Gender Among High-Risk HIV Individuals in a Rural, Resource-Limited Setting

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Abstract

Background: *Mobile health (mHealth) is a promising tool to deliver healthcare interventions to underserved populations. We characterized the use of mobile devices in rural KwaZulu-Natal, South Africa to tailor mHealth interventions for people living with HIV and at risk for acquiring HIV in the middle-income country.*
Methods: *We surveyed participants in community settings and offered free HIV counseling and testing. Participants self-reported their gender, age, relationship, and employment status, receipt of monthly grant, condomless sex frequency, and circumcision status (if male). Outcomes included cell phone and smartphone ownership, private data access, health information seeking, and willingness to receive healthcare messages. We performed multivariable logistic regression to assess the relationship between demographic factors and outcomes.*
Results: *Although only 10% of the 788 individuals surveyed used the phone to seek health information, 93% of cell phone owners were willing to receive healthcare messages. Being young, female, employed, and in a relationship were associated with cell phone ownership. Smartphone owners were more likely to be young, female, and employed. Participants reporting condomless sex or lack of circumcision were significantly less likely to have private data access or to purchase data.*
Conclusions: *mHealth interventions should be feasible in rural KwaZulu-Natal, though differ by gender. As women are more likely to own smartphones, smartphone-based mHealth interventions specifically geared to prevent the acquisition of or to support the care of HIV in young women in KwaZulu-Natal may be feasible. mHealth interventions encouraging condom use and medical male circumcision should consider the use of nonsmartphone short message service and be attuned to mobile data limitations—especially when targeting men.*

Keywords: *telemedicine, mHealth, smart phones, global health, infectious disease*

Introduction

Mobile health (mHealth) creates the opportunity to deliver healthcare interventions to patients on their mobile devices. The growing global penetration of mobile phones[1] enables the realization of mHealth in both high-income countries and low- and middle-income countries (LMIC). mHealth interventions take many forms, but at present are primarily realized in the form of short message service (SMS), text and application (app) interventions. Many mobile devices are capable of SMS, but app interventions require smartphones. High-income countries with pervasive smartphone ownership have adopted both SMS- and app-based mHealth with promising outcomes.[2]

The practicality and utility of mHealth and other digital health interventions must be approached differently in LMIC, where smartphone penetration reaches only 42%.[1] Poor network accessibility, prohibitive data costs, and outdated mobile phone technology limit the deployment and scaling of effective mHealth interventions in LMIC.[3] Other challenges (such as sharing of mobile devices among families and lack of adequate data security measures) endanger privacy and confidentiality,[3] limiting healthcare interventions. Rural areas, often more impoverished, have limited broadband and energy service coverage.[4,5] Even in densely populated urban areas, access can pose difficulties. For example, an mHealth app to improve linkage to care for people living with HIV (PLWH) evaluated in Johannesburg, South Africa, was unable to enroll even 10% of 4,537 screened patients due to lack of mobile phone ownership or SIM card, nonapp compatible operating system, or insufficient RAM or data.[6] Additionally, there exists a gender gap in mobile phone and smartphone ownership in LMIC, where men are at least 10% more likely than women to own smartphones.[1]

Challenges aside, mHealth is being implemented and studied in LMIC.[7] LMIC mHealth interventions primarily utilize

DOI: 10.1089/tmj.2020.0218

SMS (with mixed outcomes)[7] and have been used to empower community health workers,[8] provide pregnant women with health education,[9] increase uptake of maternal services among pregnant women,[10] encourage medical male circumcision (MMC) to decrease HIV transmission,[11] and improve medication adherence in chronic disease.[12] SMS-only interventions in LMIC are known to increase health communication,[13] health-seeking behavior,[14] and patient engagement in care.[13]

HIV prevalence among South African adults 15–49 years of age is 20%,[15] with hotspots in KwaZulu Natal province demonstrating up to 40% HIV prevalence.[16] Concerning HIV risk behaviors in South Africa, the rate of condom use at last sex reached 55.6% among individuals 15–64 years of age with two or more sexual partners in the prior year.[17] Although MMC can decrease the risk of contracting and transmitting HIV during penile–vaginal sex by 60%,[18] only an estimated 31.8% of South African males 15–64 years of age were circumcised as of 2018—and only 18.6% of the population was medically circumcised.[17]

mHealth interventions across South Africa demonstrate feasibility and usability.[7] South African mobile phone ownership reaches 91% with smartphones comprising 51% of mobile devices.[1] Current (2018) data indicate that younger South Africans (ages 18–29) are more likely to own mobile phones.[19] Although South African men are more likely to own smartphones, this difference disappears among non-smartphone mobile phone owners.[19] Nationally, 38% of South Africans use their cell phone to seek health information, and this number increases to 44% among smartphone owners, although little data exist from rural settings.[19] With these trends in mind, we sought to characterize the usage of mobile technology among individuals undergoing community-based HIV testing while living in rural KwaZulu-Natal, South Africa to tailor mHealth interventions to engage PLWH and those at risk for acquiring HIV in rural KwaZulu-Natal.

Materials and Methods

Community members were recruited voluntarily by approaching individuals in community settings in Msinga subdistrict, KwaZulu Natal province. Msinga is among the poorest subdistricts in the country, characterized by high unemployment ($\sim$85%), poor access to piped water (11%), and high HIV antenatal prevalence (30%).[20] A team of trained community health workers provided health education, counseling, and offered voluntary and confidential private HIV testing in community-based settings.[21] No monetary incentives were given for participation. The survey was administered verbally by trained male interviewers in isiZulu, and responses were recorded electronically on handheld tablets.

We calculated frequency data for each survey item. We performed univariate and multivariate analyses to compare demographic characteristics with mobile usage outcomes. Demographic characteristics included self-reported gender, age, relationship and employment status, receipt of monthly grant, condomless sex frequency, and circumcision status (if male). As unemployment in Msinga is high, assessing sociodemographic and income status was challenging. For this study, we utilized employment and receipt of a government grant as surrogates for income, acknowledging that South Africa provides a variety of government grants with differing criteria. Mobile usage outcomes included cell phone and smartphone ownership, phone plan type, communication application usage, ability to charge phone daily, data purchasing behavior, private data access with adequate cellular signal, internet access, health information seeking, and willingness to receive healthcare messages. For univariate analyses, chi-square analysis (or Fisher's exact, if indicated) was performed. Multivariate logistic regression estimated associations of patient characteristics with cell phone ownership and other mobile device usage data. We computed profile likelihood confidence intervals. The multivariate models included demographic characteristics of age, gender, relationship and employment status, and receipt of monthly grant. Statistical analyses were performed using RStudio 1.1.456 running R 3.5.2 (The R Foundation for Statistical Computing 2018).

The protocol was approved by the Yale University Human Investigations committee and the South African Medical Association Research Ethics Committee.

Results

Among 788 individuals surveyed, the median age was 28 (IQR 22–40) years, 75% were male, and three-quarters reported being in a relationship (*Table 1* and *Supplementary Tables S1* and *S2*). Approximately a quarter (26%) of participants were employed and 21% received a monthly grant. The number of participants reporting condomless sex (whether "rarely," "sometimes," "often," or "always") surpassed the number reporting never having condomless sex (59% vs. 38%). Among the 587 men surveyed, 59% were circumcised.

Most participants (86%) owned personal cell phones, of which 43% were smartphones, a lower proportion than the 51% seen across South Africa as a whole.[1] The vast majority of cell phone owners reported the use of "pay-as-you-go" phone plans (97%), ability to charge the phone daily (97%), and use of SMS for communication (91%). Only 44% of cell phone owners had internet access on the phone, and only 10% used the phone to seek health information. However, 93% of cell phone owners were willing to receive healthcare messages through phone.

Table 1. Demographic and Mobile Phone Usage Characteristics of Participants

DEMOGRAPHIC CHARACTERISTICS		MOBILE PHONE USAGE CHARACTERISTICS	
$N = 788$	TOTAL (%)	$N = 681$	TOTAL (%)
Gender[a]		Phone plan type	
Male	587 (74.5)	Pay as you go	663 (97.4)
Female	198 (25.1)	Contract	18 (2.6)
Age[a] (median with IQR)	28 (22–40)	Communication application type	
14–17	53 (6.7)	SMS	620 (91.0)
18–24	239 (30.3)	WhatsApp	241 (35.4)
25–34	221 (28.0)	Both SMS and WhatsApp	197 (28.9)
35–44	104 (13.2)	Neither SMS or WhatsApp	17 (2.5)
45–54	65 (8.2)	Facebook	104 (15.3)
>55	93 (11.8)	Skype	5 (0.7)
In relationship[a]		Able to charge phone daily	
Yes	587 (74.5)	Yes	662 (97.2)
No	193 (24.5)	No	19 (2.8)
Employed		Data purchasing behavior[a]	
Yes	208 (26.4)	Purchase data	379 (55.7)
No	580 (73.6)	Median spent on data per month, in South African Rand (with range)	46.5 (0–10001)[b]
Receiving monthly grant status		Private data access with adequate cellular signal[a]	
Yes	169 (21.4)	Yes	265 (38.9)
No	619 (78.6)	No	415 (60.9)
Reporting condomless sex[a]		Internet access on phone[a]	
Yes	468 (59.4)	Yes	296 (43.5)
No	309 (39.2)	No	384 (56.4)
Circumcised (males only, $N = 587$)[a]		Use phone to seek health information[a]	
Yes	344 (58.6)	Yes	69 (10.1)
No	222 (37.8)	No	608 (89.3)
Own personal cell phone	681 (86.4)	Willing to receive healthcare messages on phone[a]	
Cell phone identified as smartphone (of those with cell phones)	293 (43.0)	Yes	634 (93.1)
		No	44 (6.5)

[a]Number of participants with missing information for the following variables: gender (3), age (13), in relationship (8), reporting condomless sex (11), circumcised (21), data purchasing behavior (72), private data access with adequate cellular signal (1), internet access on phone (1), use of phone to seek health information (4), willing to receive healthcare messages on phone (3).

[b]Outlier of 40,000 Rand/month removed.

IQR, interquartile range; SMS, short message service.

Table 2. Univariate Analysis Between Select Demographic Factors and Mobile Usage Outcomes

VARIABLE	OWN PERSONAL CELL PHONE, $N=788$		OWN PERSONAL SMARTPHONE, $N=681$[a]		USE SMS FOR COMMUNICATION, $N=681$		HAVE ADEQUATE CELLULAR SIGNAL FOR PRIVATE DATA ACCESS, $N=681$[b]		HAVE INTERNET ACCESS ON PHONE, $N=681$[b]	
	NO, $N=107$ (%)	YES, $N=681$ (%)	NO, $N=388$ (%)	YES, $N=293$ (%)	NO, $N=61$ (%)	YES, $N=620$ (%)	NO, $N=415$ (%)	YES, $N=265$ (%)	NO, $N=384$ (%)	YES, $N=296$ (%)
Age[b]	$p=<0.0001$		$p=<0.0001$		$p=0.0005$[c]		$p=0.0008$		$p=<0.0001$	
14–17	4 (3.7)	49 (7.2)	26 (6.7)	23 (7.8)	9 (14.8)	40 (6.5)	21 (5.1)	28 (10.6)	25 (6.5)	24 (8.1)
18–24	20 (18.7)	219 (32.2)	96 (24.7)	123 (42.0)	31 (50.8)	188 (30.3)	121 (29.2)	98 (37.0)	94 (24.5)	124 (41.9)
25–34	21 (19.6)	200 (29.4)	106 (27.3)	94 (32.1)	17 (27.9)	183 (29.5)	131 (31.6)	69 (26.0)	104 (27.1)	96 (32.4)
35–44	18 (16.8)	86 (12.6)	52 (13.4)	34 (11.6)	1 (1.6)	85 (13.7)	48 (11.6)	37 (14.0)	54 (14.1)	32 (10.8)
45–54	11 (10.3)	54 (7.9)	44 (11.3)	10 (3.4)	2 (3.3)	52 (8.4)	42 (10.1)	12 (4.5)	43 (11.2)	11 (3.7)
>55	29 (27.1)	64 (9.4)	57 (14.7)	7 (2.4)	1 (1.6)	63 (10.2)	45 (10.8)	19 (7.2)	57 (14.8)	7 (2.4)
Gender[b]	$p=0.07$		$p=0.07$		$p=1.00$		$p=0.41$		$p=0.09$	
Male	88 (82.2)	499 (73.3)	294 (75.8)	205 (70.0)	45 (73.8)	454 (73.2)	298 (71.8)	200 (75.5)	291 (75.8)	208 (70.3)
Female	19 (17.8)	179 (26.3)	91 (23.5)	88 (30.0)	16 (26.2)	163 (26.3)	114 (27.5)	65 (24.5)	90 (23.4)	88 (29.7)
In Relationship[b]	$p=<0.0001$		$p=0.34$		$p=1.00$		$p=0.17$		$p=0.32$	
In Relationship	59 (55.1)	528 (77.5)	304 (78.4)	224 (76.5)	48 (78.7)	480 (77.4)	328 (79.0)	199 (75.1)	301 (78.4)	226 (76.4)
Not in Relationship	47 (43.9)	146 (21.4)	77 (19.8)	69 (23.5)	13 (21.3)	133 (21.5)	81 (19.5)	65 (24.5)	76 (19.8)	70 (23.6)
Employed	$p=0.003$		$p=0.002$		$p=0.81$		$p=0.09$		$p=0.0008$	
Yes	15 (14.0)	193 (28.3)	91 (23.5)	102 (34.8)	16 (26.2)	177 (28.5)	107 (25.8)	85 (32.1)	89 (23.2)	104 (35.1)
No	92 (86.0)	488 (71.7)	297 (76.5)	191 (65.2)	45 (73.8)	443 (71.5)	308 (74.2)	180 (67.9)	295 (76.8)	192 (64.9)
Reporting condomless sex[b]	$p=0.53$		$p=0.004$		$p=0.007$		$p=0.005$		$p=0.02$	
Yes	63 (58.9)	405 (59.5)	212 (54.6)	193 (65.9)	26 (42.6)	379 (61.1)	265 (63.9)	140 (52.8)	213 (55.5)	192 (64.9)
No	36 (33.6)	273 (40.1)	174 (44.8)	99 (33.8)	35 (57.4)	238 (38.4)	148 (35.7)	124 (46.8)	169 (40.0)	103 (34.8)
MALES ONLY	OWN PERSONAL CELL PHONE, $N=587$		OWN PERSONAL SMARTPHONE, $N=499$[a]		USE SMS FOR COMMUNICATION, $N=499$		HAVE ADEQUATE CELLULAR SIGNAL FOR PRIVATE DATA ACCESS, $N=499$[d]		HAVE INTERNET ACCESS, $N=499$	
	NO, $N=88$ (%)	YES, $N=499$ (%)	NO, $N=294$ (%)	YES, $N=205$ (%)	NO, $N=45$ (%)	YES, $N=454$ (%)	NO, $N=298$ (%)	YES, $N=200$ (%)	NO, $N=291$ (%)	YES, $N=208$ (%)
Circumcised[d]	$p=0.006$		$p=0.10$		$p=0.18$		$p=0.005$		$p=0.08$	
Yes	36 (40.9)	308 (61.7)	172 (58.5)	136 (66.3)	33 (73.3)	275 (60.6)	167 (56.0)	141 (70.5)	169 (58.1)	139 (66.8)
No	42 (47.7)	180 (36.1)	115 (39.1)	65 (31.7)	12 (26.7)	168 (37.0)	121 (40.6)	58 (29.0)	114 (39.2)	66 (31.7)

[a]Among cellphone owners.

[b]Number of participants with missing information for the following variables: age (13), gender (3), in relationship (8), reporting condomless sex (11), have adequate cellular signal for private data access (1), have internet access on phone (1).

[c]Fisher's exact used (all others calculated with chi-square).

[d]Number of participants with missing information for the following variables: circumcised (21), have adequate cellular signal for private data access (1).

Table 3. Multivariable Analysis Between Select Demographic Factors and Mobile Usage Outcomes

VARIABLE	OWN PERSONAL CELL PHONE, $N=788$	OWN PERSONAL SMARTPHONE, $N=681$[a]	HAVE ADEQUATE CELLULAR SIGNAL FOR PRIVATE DATA ACCESS, $N=681$[b]	HAVE INTERNET ACCESS, $N=681$[b]
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Age[b]				
14–17	6.38 (2.24–23.17)**	8.55 (3.30–24.59)***	3.01 (1.37–6.76)*	9.24 (3.58–26.54)***
18–24	5.30 (2.64–10.87)***	8.98 (4.05–22.87)***	2.27 (1.21–4.38)*	9.39 (4.23–23.94)***
25–34	4.37 (2.17–8.94)***	5.90 (2.65–15.05)***	1.36 (0.72–2.64)	6.20 (2.79–15.82)***
35–44	2.06 (0.99–4.35)	4.33 (1.81–11.61)**	1.94 (0.95–4.04)	3.91 (1.63–10.51)**
45–54	1.72 (0.75–4.11)	1.34 (0.46–4.05)	0.69 (0.59–1.63)	1.51 (0.53–4.52)
>55	Reference	Reference	Reference	Reference
Gender[b]				
Male	Reference	Reference	Reference	Reference
Female	1.97 (1.11–3.68)*	1.88 (1.25–2.83)**	0.70 (0.47–1.04)	1.81 (1.21–2.74)**
In relationship[b]				
Yes	2.99 (1.89–4.74)***	0.83 (0.56–1.23)	0.72 (0.49–1.06)	0.82 (0.55–1.22)
No	Reference	Reference	Reference	Reference
Employed				
Yes	1.92 (1.07–3.64)*	1.97 (1.36–2.88)***	1.74 (1.20–2.52)**	2.07 (1.42–3.04)***
No	Reference	Reference	Reference	Reference
Receiving monthly grant				
Yes	0.94 (0.51–1.75)	0.62 (0.37–1.02)	1.92 (1.20–3.11)*	0.66 (0.39–1.09)
No	Reference	Reference	Reference	Reference

[a]Among cellphone owners.

[b]Number of participants with missing information for the following variables: age (13), gender (3), in relationship (8), have adequate cellular signal for private data access (1), have internet access (1).

*$p=<0.05$, **$p=<0.005$, ***$p=<0.0005$.

aOR, adjusted odds ratio; CI, confidence interval.

Age was a primary driver of significant univariate findings (*Table 2*). Young people 18–34 years of age were more likely to own cell phones ($p=<0.0001$), own smartphones ($p=<0.0001$), use SMS for communication ($p=<0.0005$), have a place for private data access with adequate cellular signal ($p=0.0008$), and have internet access on the phone ($p=<0.0001$). Being in a relationship was associated with cell phone ownership ($p=<0.0001$) but not smartphone ownership ($p=0.34$). Even unemployed participants were likely to own cell phones ($p=0.003$). Individuals reporting condomless sex were likely to have internet access ($p=0.02$) but uncircumcised males were not ($p=0.005$).

Table 3 and *Supplementary Table S3* presents the multivariate logistic regression for select demographic factors and outcomes, where *Table 4* and *Supplementary Tables S4* and *S5* focuses on condomless sex and male circumcision status (controlling for age, relationship and employment status, receipt of monthly grant, and—in the case of condomless sex—gender). We identified that being young, female, in a relationship, and employed best correlated with cell phone ownership (*Fig. 1*).[1] With regard

[1]Cell phone ownership. For female gender: adjusted odds ratio (aOR) = 1.97 with 95% confidence interval (CI): 1.11–3.68. For relationship status: aOR = 2.99 with 95% CI: 1.89–4.74. For employment: aOR = 1.92 with 95% CI: 1.07–3.64.

Table 4. Selected Multivariate Logistic Regression for Condomless Sex and Male Circumcision Status

ALL PARTICIPANTS	USE SMS FOR COMMUNICATION, $N=681$ AOR (95% CI)	HAVE ADEQUATE CELLULAR SIGNAL FOR PRIVATE DATA ACCESS, $N=681$[a] AOR (95% CI)
Condomless sex[a]		
No	Reference	Reference
Yes	3.27 (1.83–5.93)***	0.49 (0.34–0.69)***
MALES ONLY	**USE SMS FOR COMMUNICATION, $N=499$[b] AOR (95% CI)**	**HAVE ADEQUATE CELLULAR SIGNAL FOR PRIVATE DATA ACCESS, $N=499$[b] AOR (95% CI)**
Circumcised[b]		
No	1.29 (0.64–2.72)	0.61 (0.41–0.91)*
Yes	Reference	Reference

[a]Number of participants with missing information for the following variables: condomless sex (11), have adequate cellular signal for private data access (1); [b]Number of participants with missing information for the following variables: circumcised (21), use SMS for communication (1), have adequate cellular signal for private data access (1).

*$p=<0.05$, ***$p=<0.0005$.

aOR, odds ratio, adjusted for age, gender, relationship status, employment status, and receipt of monthly grant.

to age, the greatest effect was seen among the youngest age groups: Ages 14–17 and ages 18–24 were most likely to own a cell phone (aOR = 6.38 with 95% CI: 2.24–23.17 and aOR = 5.30 with 95% CI: 2.64–10.87, respectively). Similarly, smartphone ownership and internet access were best associated with age, gender, and employment, again in favor of employed young women (*Fig. 2*).[2,3]

Individuals 14–17 years of age were most likely to have a place for private data access with adequate cellular signal (aOR = 3.01 with 95% CI: 1.37–6.76), followed closely by individuals 18–24 years of age (aOR = 2.27 with 95% CI: 1.21–4.38). Individuals reporting condomless sex were less likely to have a place for private data access with adequate cellular signal (aOR = 0.49 with 95% CI: 034–0.69) (*Fig. 3*), as were uncircumcised males (aOR = 0.61 with 95% CI: 0.41–0.91) (*Fig. 4*). However, individuals reporting condomless sex were likely to use SMS (aOR = 3.27 with 95% CI: 1.83–5.93). Uncircumcised males also tended to use SMS, although this trend was not statistically significant (aOR = 1.29 with 95% CI 0.64–2.72).

Discussion

In this study, we evaluated mobile device usage among community members in rural KwaZulu-Natal, South Africa. Data from this study can be used to tailor mHealth interventions relating to HIV treatment and prevention in this population. We found that the percentage of individuals in KwaZulu-Natal seeking health information on their mobile device (10%) is much lower than that seen across South Africa as a whole (38%).[19] However, the vast majority of surveyed individuals were willing to receive healthcare messages through phone, increasing optimism for the uptake of mHealth interventions in this rural population.

Our analyses confirmed that younger individuals were more likely to own mobile devices, whether cell phones or smartphones (*Figs. 1 and 2*). Individuals 18–24 years of age were most likely to own a smartphone, likely reflecting global connectivity trends,[1] as well as increased purchasing power when compared with younger teenagers. The remainder of the represented ages (45–70) are unlikely to own a smartphone and would therefore currently be unable to participate in evidence-based mHealth application (app) interventions. Importantly, then, our study demonstrates that equitable access to mHealth app-based interventions among older adults in rural KwaZulu-Natal may require provision of smartphones and internet access to avoid perpetuating health disparities.[22]

Distinct from national South African statistics, women in our rural setting were more likely than men to own cell phones and smartphones. This was surprising and perhaps hints at changing societal and cultural norms for the surveyed female population. Given that smartphone owners are primarily female, mHealth app interventions targeting improved linkage to and engagement in care for women living with HIV and at risk for acquiring HIV in KwaZulu-Natal would be feasible.

Those in relationships were more likely to own cell phones, but not smartphones. Therefore, SMS-based mHealth interventions may be more appropriate than app-based interventions when targeting individuals who are sexually active and at higher HIV acquisition and transmission risk. Attention must be paid to data security and privacy in the event that the device is purchased or owned by someone else.

By evaluating employment and monthly grant receipt, we attempted to construct an income measure, as can be seen in *Figure 2*. Individuals receiving a South African monthly grant in part qualify based on low income.[23] As such, the group of

[2]Smartphone ownership. For age 18–24: aOR = 8.98 with 95% CI: 4.05–22.87. For female gender: aOR = 1.88 with 95% CI: 1.25–2.83. For employment: aOR = 1.97 with 95% CI: 1.36–2.88.

[3]Internet access. For age 18–24: aOR = 9.39 with 95% CI: 4.23–23.94. For female gender: aOR 1.81 with 95% CI: 1.21–2.74. For employment: aOR = 2.07 with 95% CI: 1.42–3.04.

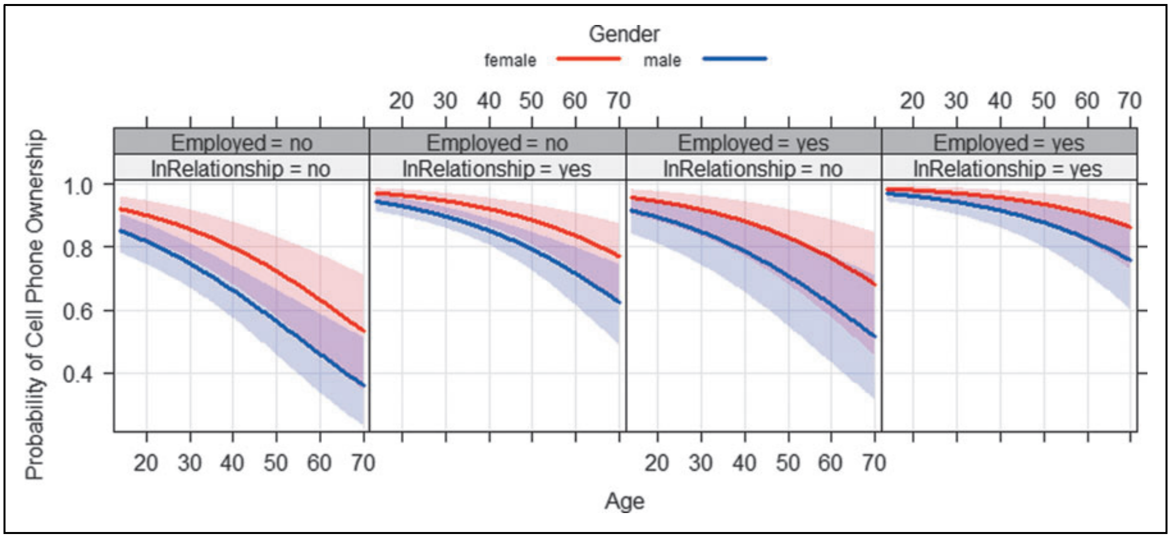

Fig. 1. Effect of age, gender, relationship status, and employment on cell phone ownership.

unemployed individuals receiving a monthly grant (the far left of the figure) represents the lowest socioeconomic status surveyed. Conversely, the employed individuals on the far right of the figure (employed but not receiving grant) constitute the highest socioeconomic status surveyed. Thus, then as income increases across the graph, so does the likelihood of smartphone ownership. Our study therefore demonstrates that equitable access to evidence-based mHealth app interventions among low-income individuals in rural KwaZulu-Natal may require the provision of smartphones.

After controlling for demographic factors, both condomless sex and lack of circumcision among men inversely correlated with having a place for private data access with adequate cellular signal. We believe that people who have a place for private data access with adequate cellular signal will be more likely to use a sexual health app. Therefore, even if data plans were provided to target individuals with low uptake of MMC or condom use, it is possible that these individuals may not utilize a mHealth app given their lack of private data access. At present, it would appear that mHealth app interventions targeting increased condom use or increased MMC in KwaZulu-Natal are not ideal at this time. Instead, given the likelihood of these groups to utilize SMS, SMS-only mHealth interventions to increase MMC and (especially) condom use do

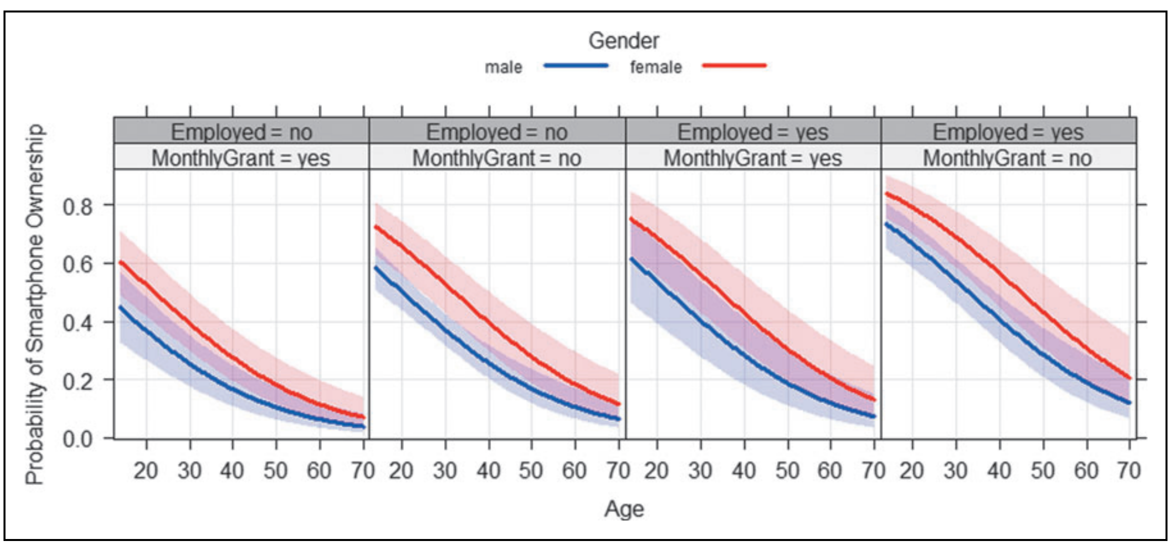

Fig. 2. Effect of age, gender, relationship status, and monthly grant on smartphone ownership.

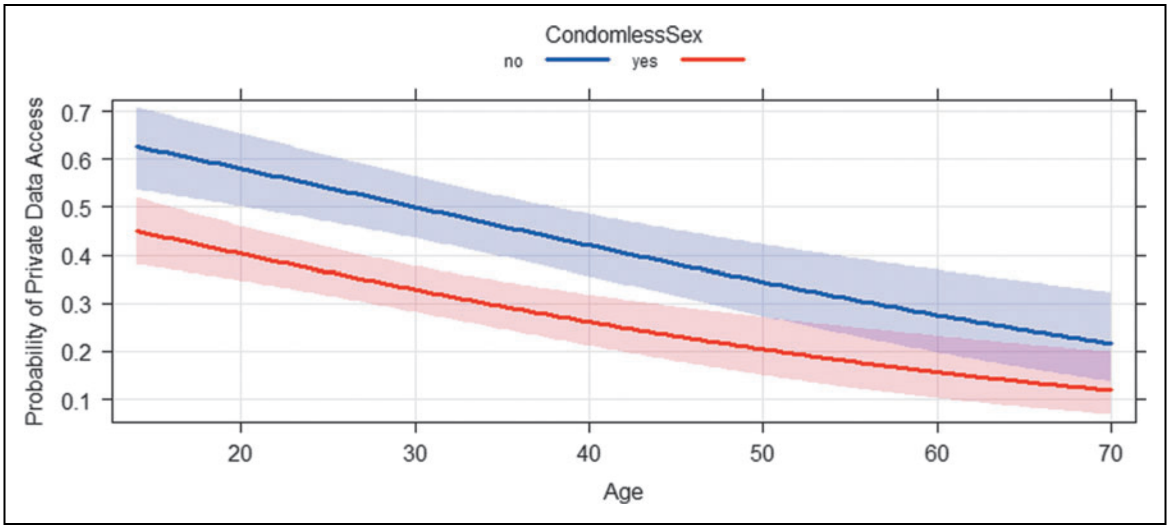

Fig. 3. Relationship between condom use and private data access.

appear currently feasible. Trends showing increased smartphone ownership and internet access among the subset of the population reporting condomless sex were not significant, but perhaps may become so in the future as distribution of technology and penetration of data networks continue to develop.

There are limitations with our study. We did not collect data on the level of educational attainment, which may significantly influence cell phone and smartphone adoption in KwaZulu-Natal. We did not inquire as to how individuals came by their mobile devices (i.e., if they were self-purchased; gifted by a friend, family member, sexual partner), nor did we collect data on the operating system, functioning, or age of the device. It is possible that even those participants with smartphones possess outdated technology. As most individuals in KwaZulu-Natal are not formally employed, assessing sociodemographic status and income was challenging. For this study, we utilized employment and receipt of a government grant as surrogates for income, acknowledging that South Africa provides a variety of government grants with differing criteria. Additionally, although we inquired regarding circumcision status, we did not differentiate between the medically circumcised and the traditionally circumcised, and as a result may have underestimated the amount of males who would qualify for MMC. However, we note that traditional

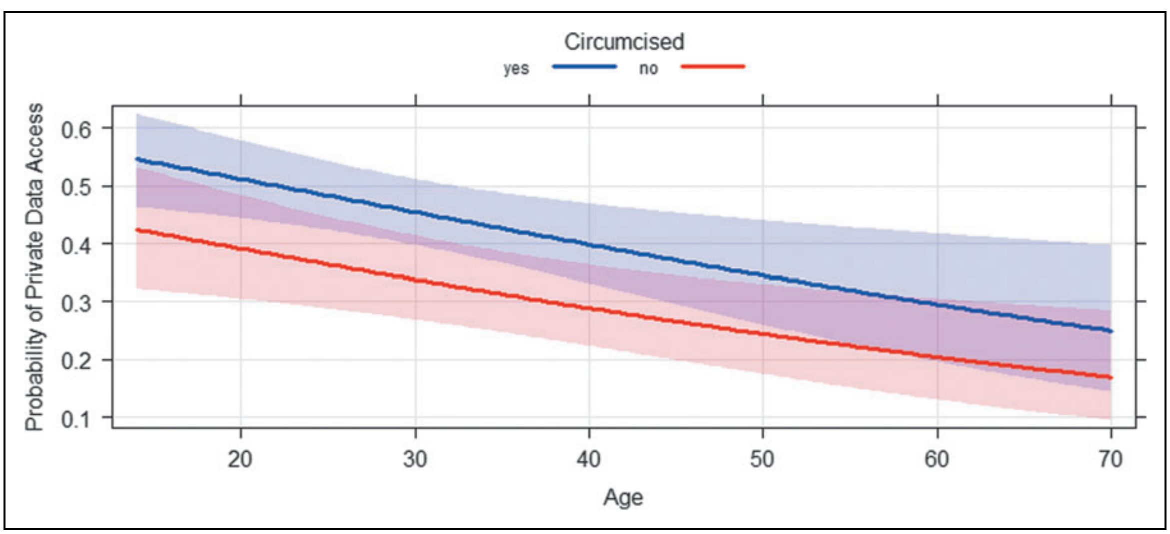

Fig. 4. Relationship between circumcision status and private data access.

circumcision is not common in KwaZulu-Natal.[24] We did not measure relative rurality and are therefore unable to comment on how mobile device usage may change as individuals live farther from the city center or cell tower in the area.

Conclusions

Most participants were willing to receive healthcare messages through phone, indicating that mHealth interventions may be feasible in rural KwaZulu-Natal, although differ by gender. As women are more likely to own smartphones, smartphone-based mHealth interventions specifically geared to prevent the acquisition of or to support the care of HIV in young women in KwaZulu-Natal may be feasible. mHealth interventions encouraging condom use and MMC should consider the use of nonsmartphone SMS and be attuned to mobile data limitations—especially when targeting men.

Acknowledgments

The authors are grateful to their isiZulu-speaking interviewers: Bulelani N. Khoza, Celumusa Ngubane, Dumisani Ntshangase, and Melusi Sithole.

Disclosure Statement

R.D. is a consultant for Warm Health Technology. The spouse of S.V.S. was a part-time contractor for ProUnlimited LLL, through which he provided services to Amgen Pharmaceuticals from October 2015 to October 2018. There is no conflict with regard to this article, but it is included in the interest of full disclosure. The remaining authors have no commercial associations.

Funding Information

This study was supported by a STOP TB (UN) grant provided to Philanjalo NGO. B.R.C. is supported by NIH grant 2T32AI055432-16. K.C. is supported by Doris Duke Clinical Research Fellowship no. 2016178. M.G.N. is supported by NIH grant 5T32A1007046-40. S.V.S. is supported by Doris Duke Foundation no. 2015216.

Supplementary Material

Supplementary Table S1
Supplementary Table S2
Supplementary Table S3
Supplementary Table S4
Supplementary Table S5

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Received: June 9, 2020
Accepted: June 11, 2020
Online Publication Date: August 24, 2020