Impacts of Wealth on HIV Testing in Malawi: Empirical Analysis

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Abstract:

This paper explores the relationship between wealth and HIV testing in the nation of Malawi, building off of previous work that tried to isolate the relationship between income and a given health outcome. Due to a variety of issues such as inaccurate self-reporting and difficulty in combining various sources of income accurately, this paper replaces income in an existing Malawi health-income model with wealth, measured by the number and kinds of possessions they owned and then scored using principal component analysis. The model used is a logit model with HIV testing as the dependent variable and wealth as the independent variable of interest, with the controlling variables selected by LASSO. Malawi is an underdeveloped nation with a very low GDP per capita ($275), and national health issues such as high child mortality and an AIDS epidemic. The dependent variable was a binary HIV test variable, and the independent variable of interest was wealth, with control variables such as education and knowledge of health-related topics also considered. Results show a prediction accuracy ranging from 65.8% to 71.6%, and the post-lasso logistic regression coefficients show that neither wealth nor stigma-related variables were significant. Education and personal characteristics, such as circumcision and religion, were significant and positively correlated with HIV testing rates, suggesting that education and information access are the keys to further increasing the rate of testing.

JEL Classification: I15, D31, O12
Keywords: Development, Health, Malawi, Logit Model, HIV, LASSO

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1.0 INTRODUCTION

This study aims to explore the relationship between the wealth of Malawian men and their likelihood of getting tested for HIV. From a national and international governmental perspective, the relationship of wealth and HIV is important because it will allow policymakers to determine whether financial or economic hardships prevent men from getting tested, or if it is because of stigma. This is relevant because, often, it is believed that economic growth and rising wealth/income levels will fix health-related issues for a country (Chin 2010; Bloomberg 2002). There is no fundamental rule that wealth leads to better health in all circumstances. As such, this study examines the relationship between wealth and a given health outcome, with this health outcome being testing for HIV, building upon the work of Chin (2010).

Malawi, despite recent progress, still struggles with an HIV epidemic, and has one of the highest HIV populations in the world, with 9.2% of the population suffering from the virus (Avert 2020). Malawi is not unique in this, as many sub-Saharan African nations suffer from HIV/AIDS epidemics. There are three primary issues that worsen Malawi's status: the transmission is largely among young people, with one third of new cases being people aged 15-24 (meaning the virus continues to get new hosts that are unmarried and as such more prone to spreading it further); many in Malawi are unaware of how the virus is spread, with around 60% of the nation unaware of how HIV transmits from person to person; and many with HIV in Malawi are unaware of their own status, as 67% of young men in Malawi were unaware they had it (Avert 2020).

Aside from the humanitarian and health concerns associated with HIV, economists are concerned with HIV and other diseases in a national population because of the effects these diseases have on productivity, as well as the costs associated with the healthcare required to treat an epidemic-afflicted population. While the common saying is that "wealth is health" (Bloomberg

2002), there very well could be reverse causality, such that health is wealth. The productivity hours lost by managing the disease, preventing its spread, workers unable to perform their jobs, and would-be workers dying from the disease are immense. The money spent on healthcare and prevention could go to subsidizing industries, building infrastructure, and other methods of promoting economic growth. Malawi ranks low in GDP per capita, according to the World Bank (2018), with a GDP per capita of $516. Malawi is considered to be among the Least Developed Countries (UN 2014). This is not entirely because of HIV, but the issues caused by HIV play a significant role in the severity of the nation's poverty.

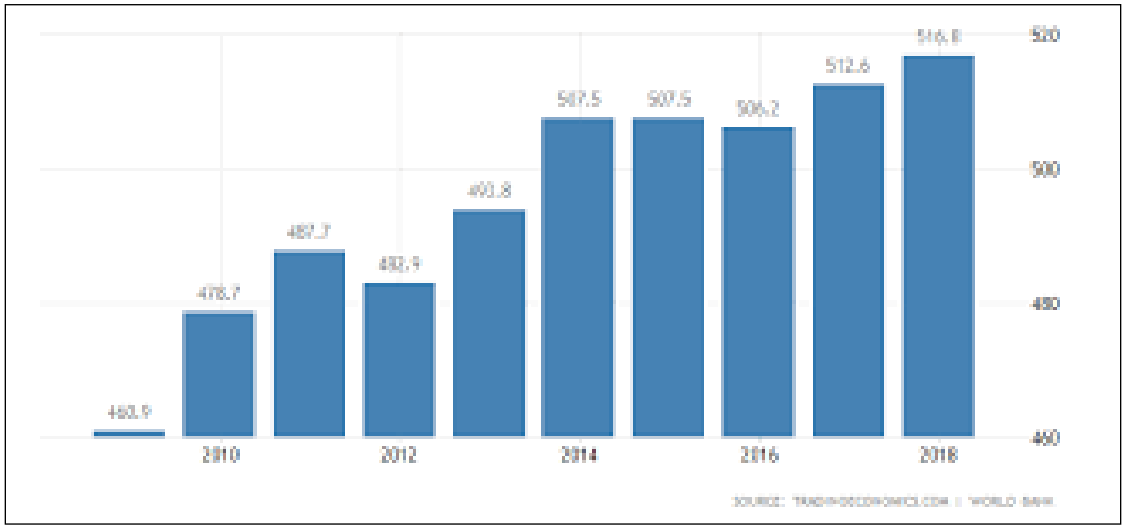
This paper was guided by three research objectives that differ from the study upon which it is based: First, it focuses on specifically HIV testing, rather than a more general measure of health; Second, it uses a logit model with controlling variables selected by LASSO (least absolute shrinkage and selection operator, a machine learning method), as opposed to other methods, as the dependent variable is binary; Last, it replaces income with wealth, as income can be a poor measure of overall economic well-being at an individual level. While there has been some research in the area of wealth and HIV testing, there is no conclusive consensus. This paper intends to help fill this void.

The rest of the paper is organized as follows: Section 2 covers the overall trend in Malawi's HIV+ population and the rates of testing. Section 3 gives a brief review of the relevant literature on the subject. Section 4 outlines the empirical model used in this study. Data and estimation methodology are discussed in section 5. Section 6 presents and discusses the empirical results of the regressions. This is followed by a conclusion in section 7.

2.0 TRENDS IN HIV INFECTION AND WEALTH IN MALAWI

Malawi is consistently one of the weakest countries in terms of GDP per capita, though it has improved over the years. The GDP per capita has grown 12% between 2009 and 2018 (shown in Figure 1), albeit inconsistently. This implies that the average person is getting richer.

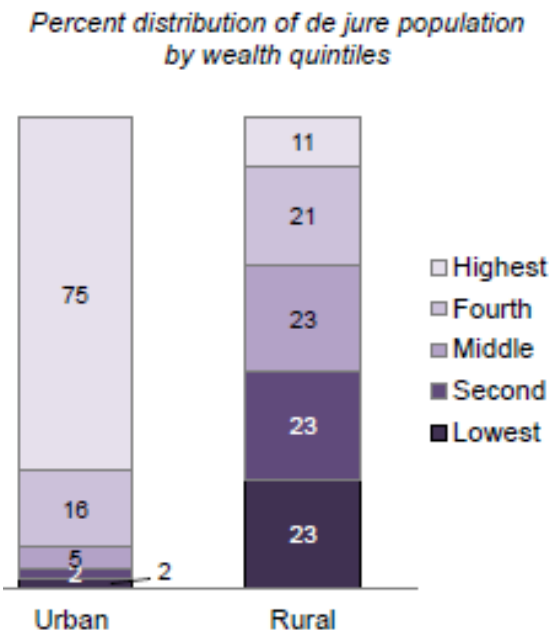
Figure 1: GDP per Capita of Malawi



Source: World Bank

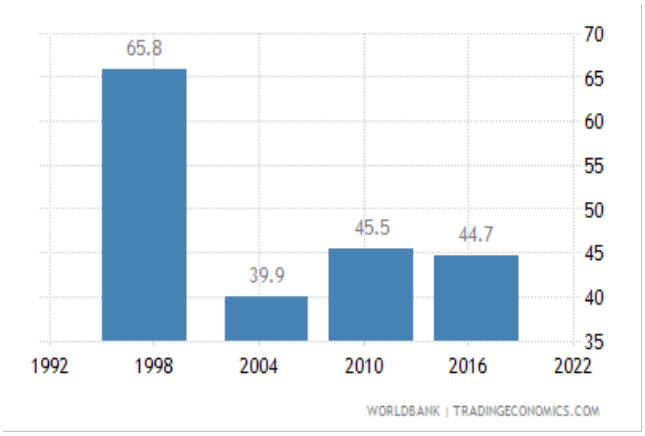
There is reason to believe, however, that this gain in wealth is not evenly distributed. Figures 2 and 3 demonstrate this inequality through the urban/rural divide in wealth as well as the Gini coefficient, respectively. If HIV testing rates increase with income, this concentration of wealth would not bode well for testing rates. There is a slight downward trend on the Gini coefficient estimate, but also heavy fluctuation over the past 20 years.

Figure 2: Household Wealth by Residence



Source: DHS Malawi

Figure 3: Gini Coefficient Estimate

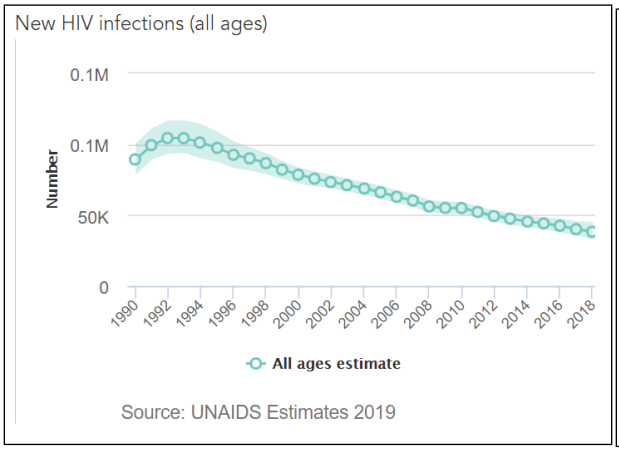


Source: World Bank

HIV infections in Malawi have made substantial decreases in the past 25 years, as shown in Figure 4. Cited reasons are increases in education and in testing, though considering Figure 4 only shows new cases, it is entirely possible that since people most at risk of getting it would already have it, and that deaths related to AIDS are decreasing, the virus is simply running out of new people to which to spread. We do see that the disease is becoming more and more survivable,

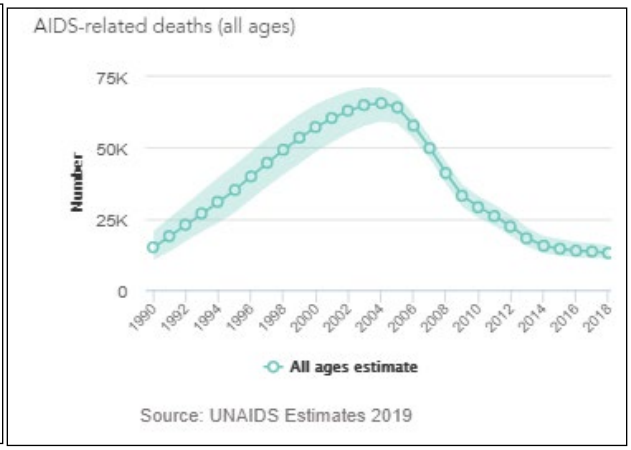
though, which is a positive as it means those who are infected are not facing death sentences anymore.

Figure 4: New HIV Infections



Source: UNAIDS Estimate

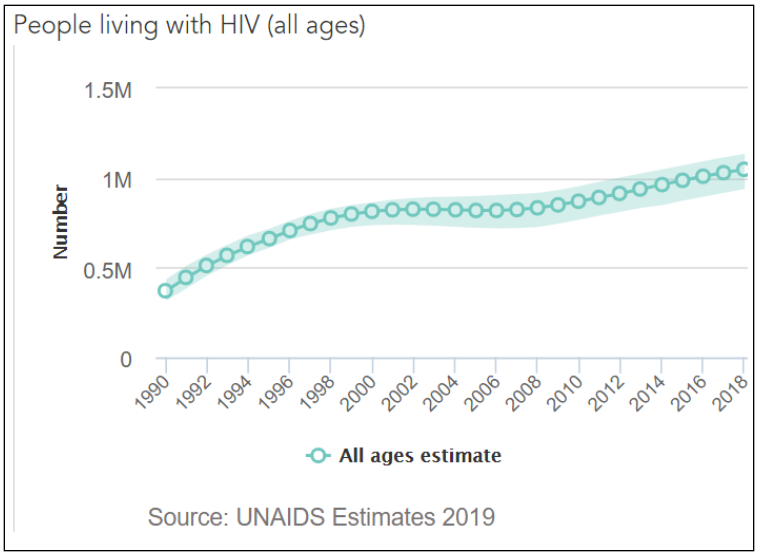
Figure 5: Deaths Related to AIDS



Source: UNAIDS Estimates

We do see that the amount of people who have the virus is continually rising, as shown in Figure 5, but interestingly this can be seen as a measure of success in treatment. Fewer people dying of the disease, combined with infection rates not being zero and there being no way to completely cure the disease, means that the number of people in the population who are infected will continue to rise. So long as they are treated and their viral loads are suppressed, this is a good thing, and will correct itself over time as generations pass and treatment becomes more and more widespread.

Figure 6: Amount of People Living with HIV



3.0 LITERATURE REVIEW

The literature regarding the subject of HIV and its determinants has been explored fairly well, but there is less on the subject of HIV testing and its determinants. Kim et al. (2016) is one such study in the subject, examining the effect of inequality on HIV testing. They found that HIV testing was more concentrated among the rich in 2004 and 2010, but the degree of the concentration fell in 2010, meaning that HIV testing had become more equal, and more people were tested in 2010 among all groups (urban and rural, rich and poor, men and women) compared to 2004 (Kim et al., 2016). This implies that wealth should still be a principal component of predicting whether someone gets an HIV test or not in 2016, but other studies, such as Rajaraman & Heymann (2007) and Berendes & Rimal (2011) explored stigma and other social factors as the focuses of whether or not someone gets tested for HIV. The former finds that education, people who became parents after the initialization of the Prevention of Mother to Child Transmission Programme, and people who have provided care for others who were HIV positive are all positively correlated with HIV testing, as well as an acknowledgement of the gender gap and socio-economic gap in HIV testing (Rajaraman & Heymann, 2007), though this study focused on

Botswana and not Malawi. The latter finds strong correlations between behavioral change programs as well as lower stigma with higher HIV testing rates. The authors conclude that predicting HIV testing requires incorporating certain psychosocial variables to better improve accuracy (Berendes & Rimal, 2011).

Other studies have attempted to construct risk profiles of HIV-infected citizens of Sub-Saharan African countries most afflicted by the disease. One such study by Asiedu, Asiedu, & Owusu (2012) constructed a risk profile of citizens of Lesotho, Malawi, Swaziland, and Zimbabwe, using survey data. The authors found that women are more at risk than men, urban residents are more at risk than rural residents, and there is a parabolic relationship between age and HIV infection in all four countries. They also found that marital status, wealth, and education are inconsistent in sign and significance across countries. For Malawi, education is negatively correlated with HIV infections, as it is with testing as determined by Rajaraman & Heymann (2007) in the previously discussed literature. Marital status is insignificant to HIV status. Wealth, surprisingly, is positively correlated with HIV infection.

Some studies have examined solutions to the role of stigma in HIV testing, as many people are hesitant to get tested for HIV when the person conducting the test is known to them (Choko et al., 2011). Choko et al. (2011) explored this area by offering participants of the study an option to conduct self-testing kits. The authors found that the kits were accurate, and the vast majority of participants found them easy to use, and greatly preferred them to having a test be done in person. This lends credence to the argument that wealth is not the principle focus in HIV testing rates, but rather stigma and social standing (Choko et al., 2011).

Finally, De Paula, Shapira, and Todd (2013) explored the relationship between knowledge of HIV and one's own status on behaviors that heighten the risk of acquiring HIV. They

constructed a belief-risky behavioral model and find that belief in oneself not having HIV leads to riskier behavior, such as having extramarital sex or sex with multiple partners (De Paula, Shapira, & Todd, 2013). This underscores the need to have more accessibility to testing and for more people to be tested so that they do not engage in these behaviors and increase their chances of contracting HIV.

4.0 DATA AND EMPIRICAL METHODOLOGY

4.1 DATA

This study uses data from the Demographic and Health Survey (DHS) conducted in Malawi between October 2015 and February 2016. It is a cross-sectional data set where the unit of observation is individual males. Summary statistics for the variables selected by LASSO are shown in Table 1.

Table 1: Summary Statistics

Variable	Observations	Mean	Std. Dev	Min	Max
iftestedhiv	7466	0.7071	0.4551	0	1
wealth	7466	18007.16	107578.1	-117217	392359
numpartners	7466	0.6232	0.5781	0	5
translator	7466	0.0362	0.1867	0	1
interviewlength	7466	36.2269	27.7962	3	97
education	7466	7.2348	3.7278	0	20
householdsize	7466	5.2941	2.2875	1	17
cellphone	7466	0.5308	0.4991	0	1
bankaccount	7466	0.1838	0.3873	0	1
childrenever	7466	2.4464	3.0015	0	26
numinjections	7466	0.427	2.9411	0	90
healthins	7466	0.023	0.15	0	1
circumcised	7466	0.2574	0.4372	0	1
age1stsex	7466	14.9776	7.0824	0	42
working	7466	0.8036	0.3973	0	1
healthylookinghavehiv	7397	0.9676	0.5649	0	1
usedcondomlastsex	5736	0.2861	0.452	0	1
hadanysti12months	7466	0.0439	0.455	0	1
christianity	7466	0.8752	0.3267	0	1
north	7466	0.2103	0.4075	0	1

central	7466	0.3565	0.479	0	1
south	7466	0.4332	0.4955	0	1

4.2 EMPIRICAL METHODOLOGY

Following Chin (2010), this study uses a model where a given health outcome is a function of an independent wealth variable. In this model, HIV testing is the given health outcome, and a propensity score matching-created wealth variable is the principal independent variable of interest. We have adapted this model by making it into a logistic regression model since the dependent variable is binary and are using LASSO to select controlling variables rather than relying on the conflicted literature. This is fundamentally a prediction problem with the prediction being whether or not somebody has been tested in their life for HIV. Machine learning excels at prediction. For this reason, we run a lassologit regression selecting from over fifty variables, found in the appendix. LASSO is a regularization method designed to reduce overfitting in a model by selecting variables with significance and shrinking the coefficients of the rest to zero.

The model could be written as follows:

$$\text{Logit}(p_{iftestedhiv}) = \log(p_{iftestedhiv}/1\text{-}p_{iftestedhiv}) = \beta_0 + \beta_1 X_1(\text{wealth}) + \beta_2 X_2(\text{numpartners}) + \beta_3 X_3(\text{translator}) + \beta_4 X_4(\text{interviewlength}) + \beta_5 X_5(\text{education}) + \beta_6 X_6(\text{householdsize}) + \beta_7 X_7(\text{cellphone}) + \beta_8 X_8(\text{bankaccount}) + \beta_9 X_9(\text{childrenever}) + \beta_{10} X_{10}(\text{numinjections}) + \beta_{11} X_{11}(\text{healthins}) + \beta_{12} X_{12}(\text{circumcised}) + \beta_{13} X_{13}(\text{age1stsex}) + \beta_{14} X_{14}(\text{working}) + \beta_{15} X_{15}(\text{healthylookinghavehiv}) + \beta_{16} X_{16}(\text{usedcondomlastsex}) + \beta_{17} X_{17}(\text{hadanystilast12months}) + \beta_{18} X_{18}(\text{Christianity}) + \beta_{19} X_{19}(\text{north}) + \beta_{20} X_{20}(\text{central}) + \beta_{20} X_{20}\ (\text{south}) + u$$

The independent control variables selected by LASSO all come from the same DHS survey as the dependent and primary independent variable of interest. The 19 control variables are numpartners, measured by the number of lifetime sexual partners of each respondent; translator,

which is a binary variable where 1 = usage of a translator in the interview and 0 is otherwise; interviewlength, the length of the interview in minutes; education, measured in years of schooling; householdsize, measured in household members; cellphone, measured as 1 = ownership of a cellphone and 0 otherwise; bankaccount, measured as 1 = having a bank account and 0 otherwise; childrenever, measured as the number of children alive or dead that the respondent fathered; numinjections, measured as the number of injections the respondent had received in the last 12 months; healthins, measured as 1 = having health insurance and 0 otherwise; circumcised, measured as 1 = having been circumcised and 0 otherwise; age1stsex, measured in years; working, measured as 1 = current employment and 0 otherwise; healthylookinghavehiv, measured as 1 = the respondent saying yes to the question, "Can a healthy-looking person have HIV?" and 0 otherwise; usedcondomlastsex, measured as 1 = the respondent used a condom in their last sexual encounter and 0 is otherwise; hadanystilast12months, measured as 1 = having had any sexually transmitted infections in the last 12 months and 0 otherwise; Christianity, measured as 1 = belonging to some sect of Christianity and 0 otherwise; and North, Central, and South, each binary variables corresponding with the three different regions of Malawi.

5.0: EMPIRICAL RESULTS

Results of the lassologit model's accuracy, sensitivity, and specificity can be found in Table 2, and results of the logit model using LASSO-selected variables can be found in Table 3. At alpha = .5, the model correctly predicts whether or not a man in Malawi will get tested for HIV 71.5% of the time. This is fairly strong, as it will predict correctly the majority of men's HIV testing status more often than not. The issue with the model is its specificity. The model is incredibly sensitive, with a sensitivity of 98.68%, but its specificity is a meagre 6%. The model has too many false positives. This indicates an issue where the alpha value may be too low. For this reason, we also

check at alpha = .6 and alpha = .75. When the alpha is set to .6, we see significant improvements. The specificity of the model more than doubles to 13.35%, with a minor sacrifice in sensitivity, which declines to 95.68%. The accuracy of the model becomes 71.6%, a negligible improvement over alpha = .5. This is a more balanced model, which makes it superior to the previous one, but the specificity is still low. At alpha = .75, we see a sharp decline in sensitivity, down to 81.51%, but significant improvements in specificity, up to 27.8%. The overall accuracy of this model is 65.8%, a noticeable decrease compared to the other two, but the model is significantly more balanced.

Table 2: Prediction Accuracy per Alpha

Alpha	Accuracy	Sensitivity	Specificity
0.5	71.50%	98.68%	6%
0.6	71.60%	95.68%	13.35%
0.75	65.80%	81.51%	27.80%

Looking at the results of the post-LASSO logistic regression, we see primarily that wealth is insignificant and negatively affects whether or not someone is tested for HIV. The variables that are significant in affecting whether or not a Malawian man is tested for HIV are the number of sexual partners (+), the length of the interview (+), education (+), household size (-), cell phone access (+), the amount of children they ever had (+), the number of recent injections (+), circumcision (+), the age at which they had sex for the first time (+), whether or not they used a condom during their last sexual encounter (+), Christianity (+), and if they are from the northern region of Malawi (+). Some of these are expected. One would intuitively think that men who have sex with more partners, are more educated, have cell phones (and therefore more information), had more injections (taking care of health), and use condoms would have a higher propensity to test themselves for HIV to ensure they do not have it. Others do not make intuitive sense, such as why

the length of the interview, the number of children they ever had, being Christian, or a higher age of lost virginity would cause higher rates of HIV testing. Interestingly, having more children seems to increase the amount of HIV testing, but larger households have a negative relationship with HIV testing.

Table 3: Regression Results

Variable	Coefficient	Std. Err.
wealth	-0.00000004	0.00000004
numpartners	0.8656***	0.102
translator	-0.0655	0.1877
interviewlength	0.0028**	0.0013
education	0.0985***	0.0116
householdsize	-0.0839***	0.0165
cellphone	0.2457***	0.0786
bankaccount	0.0429	0.1165
childrenever	0.0725***	0.017
numinjections	0.0902***	0.0333
healthins	0.3108	0.3085
circumcised	0.4365***	0.0952
age1stsex	0.0198*	0.0103
working	0.0615	0.101
healthylookinghavehiv	0.0136	0.0684
usedcondomlastsex	0.1533*	0.0932
christianity	0.2151*	0.1171
north	0.3716***	0.1047
central	0.0743	0.0797
constant	-0.8198***	0.2657
observations	5707	
pseudo r2	0.0963	
LR chi-square	554.23	

The regression results suggest that HIV testing is not determined by wealth, and the variables associated with stigma were not selected by LASSO, meaning that their coefficient estimates were weak and did not contribute strongly to the model. This suggests that neither wealth nor stigma contributed to men's HIV testing rate in 2014-2015 in Malawi. The biggest contributors

seem to be education, information access, sexual promiscuity, and certain personal characteristics such as religion (specifically Christianity) and circumcision. This would suggest that previous models that focused on wealth/income effects or stigma effects on HIV testing may be outdated. This is beneficial to testing efforts, as it means that neither wealth nor stigma are barriers to HIV testing in Malawi anymore, meaning that programs targeted at making testing both accessible and socially acceptable have worked well. This is reinforced by education and information access being so pivotal in predicting HIV testing, as those who are informed are the ones getting tested.

5.1: POLICY IMPLICATIONS AND LIMITATIONS

Governments and medical facilities in Malawi should take this news of wealth and stigma not being a strong predictor of whether or not a man will get tested for HIV as a positive, as it suggests that efforts made in the areas of reducing the inequality in testing and the stigma faced by people getting tested have been incredibly successful. Policymakers should consider emphasizing the things that this study as well as others have shown have strong returns, these being education and access to mobile phones, which naturally allow people to be more connected to news and to each other and that allows proper information to spread in conjunction with education. The success of mobile phones in this model, while radio and television were not selected, suggests that leapfrogging has occurred in Malawi insofar as how the populace receives information, meaning policymakers do not have to focus as much on spreading information through these platforms (though they still should) regarding HIV and HIV testing.

Limitations to this study were a lack of available questions to better proxy for stigma. The questions available were sufficient, but better phrasing could allow for more firm conclusions to be drawn. Interview length being significant and being positive shows that there may have been some translation and understanding issues among survey respondents. If interview length is

positive, it may imply that shorter interviews just had people trying to rush and saying no, or that interviews that were longer allowed for participants to understand what was being asked. Then again, it could just be that interviews with participants that said yes just had more questions. Uncertainty over the accuracy of respondents' responses is something that can be improved upon in future studies.

6.0: CONCLUSION

This paper has examined the state of HIV testing in Malawi, as well as the determinants of testing for men. It found that HIV testing is not influenced by wealth or by stigma, as has been previously thought, but rather is strongly influenced by education and access to information via cell phones, consistent with previous literature. HIV testing rates have increased over time, and more men are being tested. The former barriers to being tested are being removed. These results suggest that more aggressive information and education campaigns should be conducted, as they have the leading effects on HIV testing rates. More people knowing their HIV status allows for more effective containment, and more effective containment allows for the eradication of the disease and an end to the economic toll it places on Malawi and other developing countries. Future studies can focus in further on different aspects of information access and types of education, likely with survey questions inaccessible in present data. Policymakers should consider further increasing information access and education, both in general and specifically about HIV.

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