

Proposal for Senior Honors Thesis

**HONS 497 Senior Honors Thesis**      Credits 2 (2 minimum required)

Directions: Please return signed proposal to the Honors Office **at least one week prior to your scheduled meeting with the Honors Council**. This proposal must be accepted by Honors Council the semester before presentation.

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Thesis Title: The relationship between socioeconomic and behavioral indices and the prevalence of HIV/AIDS

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Expected date of Graduation: 7 May 2017

I. Provide goals and brief description of your project or research.

Human immunodeficiency virus (HIV) and acquired immune deficiency syndrome (AIDS) affect millions of individuals worldwide. In 2014, The World Health Organization estimated that 36.9 million people, including 2.6 million children, were living with HIV or AIDS and 2 million individuals were newly infected with HIV. During the year 2014, 1.2 million died from AIDS-related illnesses, and by the beginning of 2015, 41% of infected persons were accessing antiretroviral therapy (World Health Organization 2014).

Scientists classify HIV as a retrovirus due to its transmission process. HIV virions bind to CD4+ T-helper cells and inject their RNA into the host cell. The RNA is inserted into the cell nucleus, and the cell produces and assembles new virus cells. HIV infection may develop into AIDS if left untreated (Michael et al. 1997). Many individuals do not have symptoms until HIV begins to progress towards AIDS. Symptoms include aches, fevers, and a sore throat, and the progression to AIDS can be characterized by rapid weight loss and extreme fatigue. Antiretroviral therapy inhibits HIV replication by targeting various stages of the replication cycle (Simon et al. 2006).

In numerous demographic studies, researchers have identified a plethora of factors that impact the spread of HIV across the world. The list includes socio-economic factors such as corruption, internal conflict, and poverty levels (Drimie and Casale 2009), as well as cultural and behavioral factors such as the status of women (Richardson et al. 2014), religious beliefs (Tan et al. 2015), hygiene practices (Nkenfou et al. 2013), and polygamy (Nyindo 2005).

Many researchers consider poverty levels a particularly important factor in the spread of HIV/AIDS, specifically in sub-Saharan Africa. For example, Cohen (2000) emphasized the cyclic nature of the HIV/AIDS epidemic, pointing out that poverty levels affect the spread of HIV, and, in turn, that families of HIV-infected individuals fall further into impoverishment. Cohen also discusses the multi-faceted factors that interact with poverty.



In this study I will investigate the relationships between HIV infection and measures of poverty, gender inequality, globalization, and literacy. In particular, I will analyze the prevalence of HIV as a function of four factors: per capita national gross domestic product (GDP), the Gender Inequality index, the Globalization index, and literacy rates.

In a pilot study I analyzed HIV infection as a function of per capita national gross domestic product (GDP). GDP is a numerical measure of the poverty level of each country. It measures the overall income of a country and is equal to the value of all goods and services produced during a year by its citizens. Unlike the gross national product (GNP), the GDP does not include any income from foreign investments.

II. Outline your methodology. **Please be specific.** How does this achieve your goals and how reliable is it?

Data for this study will be obtained for the year 2009 from the Global Health Observatory data repository, the United States Census Bureau, The World Bank, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics, and the Swiss Federal Institute of Technology Zurich. Within these data sets, I will identify the countries for which I can obtain all of the following numbers: 1) estimated numbers of individuals living with HIV/AIDS, 2) total population size, 3) per capita GDP, 4) gender inequality index value, 5) globalization index value, and 6) literacy rate. Table 1 lists the 115 countries for which these data are available. Fig. 1 shows, as an example, a scatterplot of the fraction of population infected with HIV in each country as a function of per capita GDP.

For each country, I will assume a binary outcome for each resident: the resident either was infected with HIV (outcome = 1) or was not (outcome = 0). I will use the standard technique of logistic regression (Hosmer and Lemeshow 2000) in MATLAB (Statistics and Machine Learning Toolbox, MATLAB 8.5.0) to analyze the relationship between HIV infection and the four factors.

In the pilot study I analyzed the relationship between HIV and the single factor per capita GDP. In particular, I regressed the log-odds of being infected with HIV against per capita GDP using the logistic regression model

$$\log \frac{P}{1-P} = \beta_0 + \beta_1 \text{GDP}, \quad (1)$$

where  $P$  is the probability of infection,  $\beta_0$  and  $\beta_1$  are parameters estimated from the data, and GDP is per capita gross domestic product.

I calculated the odds ratio (OR) to determine how the odds of infection changes with an increase in GDP. If  $P_1$  and  $P_2$  are the probabilities of infection before and after an increase of  $c$  dollars in per capita GDP, respectively, then by the properties of logarithms the change in log-odds is

$$\Delta \log \text{odds} = \left[ \log \frac{P_2}{1-P_2} \right] - \left[ \log \frac{P_1}{1-P_1} \right] = \log \frac{\frac{P_2}{1-P_2}}{\frac{P_1}{1-P_1}}. \quad (2)$$

By equation (1), the change in log-odds can also be written

$$\Delta \log \text{odds} = \left[ \beta_0 + \beta_1 (\text{GDP} + c) \right] - \left[ \beta_0 + \beta_1 \text{GDP} \right] = \beta_1 c$$



(3)

Equating the right hand sides of equations (2) and (3) and exponentiating both sides leads to the standard formula for the odds ratio OR (Hosmer and Lemeshow 2000):

$$\text{OR} = \frac{\frac{P_2}{1-P_2}}{\frac{P_1}{1-P_1}} = e^{\beta_1 c}. \quad (4)$$

In the preliminary study I calculated the odds ratio for an increase of  $c = \text{US}\$10,000$ . The results of my pilot study appear in Section V of this proposal.

In the continuation of the project, I will analyze HIV as a function of the full suite of factors. The odds ratio for each factor will evaluate the effect of some change  $c$  for that factor while all other factors are held constant. For the four factors I am analyzing, the full logistic regression model is

$$\log \frac{P}{1-P} = \beta_0 + \beta_1 \text{GDP} + \beta_2 \text{GEN} + \beta_3 \text{GLO} + \beta_4 \text{LIT}, \quad (5)$$

where *GEN* is the gender inequality index, *GLO* is the globalization index, and *LIT* is the literacy rate.

- III. Explain in what sense your project is original, unique, or beyond normal senior expectations. How does it relate to current knowledge in the discipline?

I conducted a literature search to see what research had been done in this particular area. I found a range of studies; however, none analyzed the prevalence of HIV in the way that I am proposing to do. My project combines characteristics of small-scale quantitative studies with large-scale data in order to better understand the global trend of HIV prevalence and the four associated factors: GDP per capita, gender inequality index, globalization index, and literacy rates.

- IV. Include a substantive annotated bibliography of similar or related work.

Cohen, Desmond. 2000. *Poverty and HIV/AIDS in Sub-Saharan Africa*. New York: Social Development & Poverty Elimination Division, Bureau for Development Policy, United Nations Development Programme.

The author discusses the complex relationship between poverty and HIV/AIDS, denoting that the variables surrounding and involved with poverty are multifaceted. Focusing on Sub-Saharan Africa, his study highlights the array of socioeconomic factors that contribute to poverty and emphasizes the need for human development in such regions to form an effective response to the HIV/AIDS epidemic. This paper was valuable for informing me about role poverty has with both other factors and the HIV/AIDS epidemic.



Drimie, Scott, and Marisa Casale. 2009. "Multiple stressors in Southern Africa: the link between HIV/AIDS, food insecurity, poverty and children's vulnerability now and in the future." *AIDS Care* 21:28-33. doi: 10.1080/09540120902942931.

This paper also highlights the complicated nature of the HIV/AIDS epidemic. The authors emphasize that the coping strategies employed by families under economic stress are erosive, disabling successive generations from effectively coping with crises. The HIV/AIDS epidemic aggravates other stressors by reducing family income and the ability to cope during crises. This paper guided my understanding of the interaction between poverty and HIV prevalence.

Global Health Observatory data repository. "Number of people (all ages) living with HIV: Estimates by country." *World Health Organization*. Accessed October 13, 2015. <http://apps.who.int/gho/data/node.main.620>.

This repository contains estimated numbers of individuals of all ages living with HIV/AIDS by country, and the entire set spans a set of years. The data for my project comes from the year 2009 and utilizes data from 115 countries in the analysis. This data set and the total population by country data are used to calculate an estimated percentage of the population living with HIV/AIDS.

Hayward, James L., Lynelle M. Weldon, Shandelle M. Henson, Libby C. Megna, Brianna G. Payne, and Andre E. Moncrieff. 2014. "Egg cannibalism in a gull colony increases with sea surface temperature." *The Condor* 116 (1):62-73. doi: 10.1650/condor-13-016-r1.1.

In this study, Hayward et al. surveyed the rates of cannibalism and hatching success in a colony of Glaucous-winged gulls and Glaucous-winged × Western Gull hybrids on Protection Island, Washington, USA. They compared the trends they observed in cannibalism and hatching success to sea surface temperature (SST) during a breeding period using the method of logistic regression, hypothesizing that higher SSTs would result in increased rates in cannibalism and decreased rates in hatching success. While noting that there are other factors that affect gull behaviors, they concluded that higher SST could result in climate change, and thus affect gull population levels. This study served as an example of the uses of logistic regression and enhanced my understanding of this particular method of analysis.

Hosmer, David W., and Stanley Lemeshow. 2000. *Applied logistic regression*. New York: Wiley.

This book provided a background on the method of logistic regression, which I used to analyze my data.

Joint United Nations Programme on HIV/AIDS. 2014. "MDG 6: 15 Years, 15 Lessons of Hope from the AIDS Response Fact Sheet." *UNAIDS*.

This provides global statistics regarding the HIV/AIDS epidemic from 2000-2015. I utilized statistics from 2014 and 2015 for my proposal.





Michael, Nelson L., George Chang, Leslie G. Loum, John R. Mascola, Dale Dondero, Deborah L. Birx, and Haynes W. Sheppard. 1997. "The role of viral phenotype and CCR-5 gene defects in HIV-1 transmission and disease progression." *Nature Medicine* 3 (3):338-340.

This paper explains the transmission process of HIV-1 and analyzes the effect of CCR-5 gene defects on the risk of HIV infection in subjects from the San Francisco Men's Health Study. The study found that the defect was protective against HIV-1 infection and slowed progression of the disease in non-syncytium-inducing macrophage-tropic viruses. This provides a background for transmission of the HIV virus and an understanding of antiretroviral therapy.

Nkenfou, Celine Nguefeu, Christelle Tafou Nana, and Vincent Khan Payne. 2013. "Intestinal parasitic infections in HIV infected and non-infected patients in a low HIV prevalence region, West-Cameroon." *PloS one* 8 (2): e57914.

This study analyzed the association between water quality, HIV status, and intestinal parasites by examining blood and stool samples from HIV-positive individuals and a control group. Through sample examination, seven types of parasites were identified. Of the HIV-positive group, 59.5% were found to be infected with intestinal parasites. The authors concluded that HIV status and quality of water were major factors in intestinal parasitosis. This paper provided more background of HIV infection and how it affects and is affected by other infections.

Nyindo, M. 2005. "Complementary factors contributing to the rapid spread of HIV-I in sub-Saharan Africa: a review." *East African Medical Journal* 82 (1):40-6.

This review gives a survey of previous literature on factors affecting the spread of HIV-1 in sub-Saharan Africa and determines prominent factors. The author found that poverty, famine, gender inequality, internal conflict, corruption, and resistance to change in sexual behavior are among the most common factors influencing the spread of HIV-1. This paper was useful in providing an overview of the literature on poverty and HIV/AIDS, as well as directing me to other relevant literary sources.

Obel, Josephine, Markus Larsson, and Morten Sodemann. 2014. "Sexual and reproductive health and HIV in border districts affected by migration and poverty in Tanzania." *European Journal of Contraception & Reproductive Health Care* 19 (6):420-431. doi: 10.3109/13625187.2014.944639.

This study focuses on sexual practices and reproductive health as it relates to HIV prevalence in districts near the borders of Tanzania. Data was collected using questionnaires, group discussions, and interviews. The authors found that engagement in transactional sex, average number of sexual partners, and frequency of simultaneous partners was significantly higher in the border districts, while access to sexual and reproductive health services was insufficient. This study supplied useful information on factors affecting the spread of HIV, giving a larger perspective on the complexity of poverty.



Richardson, Eugene T., Sean E. Collins, Tiffany Kung, James H. Jones, Khai Hoan Tram, Victoria L. Boggiano, Linda-Gail Bekker, and Andrew R. Zolopa. 2014. "Gender inequality and HIV transmission: a global analysis." *Journal of the International AIDS Society* 17 (1).

This paper looks specifically at gender inequality and HIV prevalence, aiming at determining whether or not inequality plays a particular role in HIV transmission. Using international data for gender inequality, rates of transmission, modes of transmission, Muslim or non-Muslim status, and Democracy index, the authors found that gender inequality contributed significantly to the HIV epidemic in each country. This paper provided information on social and behavioral factors associated with HIV prevalence and aided my understanding of the complexity of disease transmission.

Shisana, Olive, Kathleen Rice, Nompumelelo Zungu, and Khangelani Zuma. 2010. "Gender and Poverty in South Africa in the Era of HIV/AIDS: A Quantitative Study." *Journal of Women's Health (15409996)* 19 (1):39-46. doi: 10.1089/jwh.2008.1200.

This study provides a quantitative analysis of poverty, gender, and HIV/AIDS in South Africa. 6,338 men and 10,057 women were interviewed, and the data used to determine the nature of HIV/AIDS epidemic and poverty in relationship to gender. The authors found that gender inequality contributed to the epidemic. Women were more likely to live in poverty and more likely to be HIV infected; however, no directionality for a causative relationship between poverty and HIV was established. This study provides useful information in understanding poverty and the HIV/AIDS epidemic and a background for future work.

Simon, Viviana, David D. Ho, and Quarraisha Abdool Karim. "HIV/AIDS epidemiology, pathogenesis, prevention, and treatment." *The Lancet* 368 (9534):489-504. doi: [http://dx.doi.org/10.1016/S0140-6736\(06\)69157-5](http://dx.doi.org/10.1016/S0140-6736(06)69157-5).

This paper gives a broad overview of HIV/AIDS, including statistics, the transmission process, and methods for prevention and treatment of the disease. This provides a better understanding of the disease and how the transmission process is related to factors that may affect HIV/AIDS prevalence.

Tan, Judy Y., Valerie A. Earnshaw, Felicia Pratto, Lisa Rosenthal, and Seth Kalichman. 2015. "Social-structural indices and between-nation differences in HIV prevalence." *International Journal of STD & AIDS* 26 (1): 48-54.

This study examines the role of social-structural indices; such as freedom of religion, education expenditures, homicide rates, unemployment rates, and women's social rights; in the prevalence of HIV. The authors performed logistic regression analysis on international data to determine which factors had the greatest influence and concluded that religious freedom, homicide rate, and educational expenditures were the most significant in predicting national HIV rates. This paper combined analysis of social and economic factors associated with HIV prevalence, aiding a broader understanding of HIV transmission.



The World Bank. 2009. "GDP per capita (current US\$)." *The World Bank*. Accessed October 13, 2015.

<http://data.worldbank.org/indicator/NY.GDP.PCAP.CD/countries/1W?page=1&display=default>.

This data set contains estimated gross domestic product (GDP) per capita in current US dollars by country and organized by year. Per capita specifies that the GDP for each year has been averaged for the estimated population of each year. The data used in my study comes from the year 2009. This is the first independent variable analyzed in my study; the logistic regression analysis shows whether or not there is a relationship between GDP per capita and the percent population living with HIV/AIDS.

Tsai, Alexander C., David R. Bangsberg, and Sheri D. Weiser. 2013. "Harnessing Poverty Alleviation to Reduce the Stigma of HIV in Sub-Saharan Africa." *PLOS Medicine* 10 (11):1-6. doi: 10.1371/journal.pmed.1001557.

This study analyzes the social stigma surrounding HIV in sub-Saharan Africa. Social stigma associated with HIV resulted in decreased food and livelihood security and solid networks for HIV-infected individuals, thus undercutting adherence to HIV treatment. The authors suggest methods of poverty alleviation that improve familial and community economic stability to both reduce social stigma regarding HIV and improve adherence to HIV treatment regimens.

Udoh, Isidore A., Joanne E. Mantell, Theo Sandfort, and Myron A. Eighmy. 2009. "Potential pathways to HIV/AIDS transmission in the Niger Delta of Nigeria: poverty, migration and commercial sex." *AIDS Care* 21 (5):567-574. doi: 10.1080/09540120802301840.

This study examines poverty, migration, and commercial sex and their relationship to HIV/AIDS transmission. Using data from a Delphi survey, the study found that these variables contributed to HIV transmission and concluded that efforts to address poverty, sex work, and multiple concurrent partners and to provide information on protection from HIV were needed.

United States Census Bureau. 2009. "Midyear population and density." *United States Census Bureau*. Accessed October 16, 2015.

<https://www.census.gov/population/international/data/idb/region.php?N=%20Results%20&T=6&A=separate&RT=0&Y=2009&R=1&C=>.

The midyear population and density data set provides the population by country for each year. I utilize the data from 2009 to calculate the estimated percent population living with HIV/AIDS by country. This data is used in the logistic regression analysis, serving as the dependent variable in this and future analyses.



Whiteside, Alan. 2002. "Poverty and HIV/AIDS in Africa." *Third World Quarterly* 23 (2):313-332. doi: 10.1080/01436590220126667.

Whiteside discusses the HIV/AIDS epidemic and its relationship with poverty, describing the connection as cyclic and pointing out methods of dealing with the epidemic that are ineffective. The study provides information on the socioeconomic impact of HIV/AIDS and emphasizes the need for a new way of understanding the epidemic and poverty in order to break the poverty/epidemic cycle. This was useful to my study by giving a qualitative background and pointing out the intricacy of the HIV/AIDS epidemic in Africa.

V. Provide a statement of progress to date and list the research methods coursework completed.

The results of my pilot study show that, for the countries listed in Table 1, the odds of HIV infection was inversely related to per capita GDP. In particular, a \$10,000 increase in per capita GDP was associated with a 26% decrease in the odds of HIV infection ( $p < 0.00001$ ;  $\beta_1 = 3.008 \times 10^{-5}$ ; OR = 0.74). I presented the pilot study at the 2016 Michigan Academy of Science, Arts and Letters, and I submitted a paper for publication in the *Michigan Academician*. Additionally, I submitted an abstract for review for a presentation at the 2017 Joint Mathematics Meetings in Atlanta.

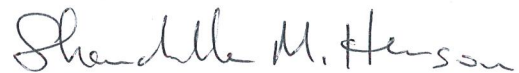
#### Department Chair Approval

- This student's performance in his/her major field is acceptable.
- He/she has completed the requisite research methods coursework for the research to be pursued.
- I understand that he/she plans to graduate with Honors.

  
Department Chair (signature)

#### Research Advisor Approval

I have read and support this proposal:

  
Primary Advisor (signature)

I have read and support this proposal:

\_\_\_\_\_  
Secondary Advisor (signature)

If human subjects or if live vertebrate animals are involved, evidence of approval from the Institutional Review Board or an Animal Use Committee is needed through the campus scholarly research offices (Ext. 6361).





Table 1. The 115 countries on which the pilot study is based.

Afghanistan	Cyprus	Kenya	Senegal
Albania	Czech Republic	Kyrgyzstan	Serbia
Algeria	Democratic Republic of the Congo	Lao People's Democratic Republic	Sierra Leone
Angola	Denmark	Lesotho	South Africa
Armenia	Djibouti	Liberia	South Sudan
Australia	Dominican Republic	Madagascar	Spain
Azerbaijan	Ecuador	Malawi	Sri Lanka
Bahamas	Egypt	Malaysia	Sudan
Bangladesh	El Salvador	Maldives	Suriname
Barbados	Eritrea	Mali	Swaziland
Belarus	Estonia	Mauritius	Switzerland
Belize	Ethiopia	Mexico	Tajikistan
Benin	Fiji	Mongolia	Thailand
Bhutan	Gabon	Morocco	The former Yugoslav republic of Macedonia
Bolivia (Plurinational State of)	Gambia	Mozambique	Togo
Botswana	Georgia	Namibia	Trinidad and Tobago
Burkina Faso	Germany	Nepal	Tunisia
Burundi	Ghana	Nicaragua	Uganda
Cabo Verde	Guatemala	Niger	Ukraine
Cambodia	Guinea	Nigeria	United Kingdom of Great Britain and Northern Ireland
Cameroon	Guinea-Bissau	Pakistan	United Republic of Tanzania
Central African Republic	Guyana	Panama	Uruguay
Chad	Haiti	Papua New Guinea	Uzbekistan
Chile	Honduras	Paraguay	Venezuela (Bolivarian Republic of)
Colombia	India	Peru	Viet Nam
Congo	Indonesia	Republic of Moldova	Yemen
Costa Rica	Iran (Islamic Republic of)	Romania	Zambia
Côte d'Ivoire	Italy	Rwanda	Zimbabwe
Cuba	Jamaica	Sao Tome and Principe	



Figure Caption

Figure 1. Fraction of population living with HIV/AIDS graphed against per capita gross domestic product (GDP) in US\$.

