**Diffusion theory in Sub-Saharan Africa:**
**Economic development, family planning knowledge, and contraceptive use at the subnational level**

Jaclyn Butler[1]
[1]The Pennsylvania State University

## Background and Motivation

In their seminal paper, "Social Interactions and Contemporary Fertility Transitions" (1996), John Bongaarts and Susan Cotts Watkins examined the relationship between levels of development and the onset and pacing of fertility decline in countries across the globe. Bongaarts and Cotts Watkins found that once multiple countries within a region experienced the onset of fertility decline below 10 percent below peak fertility, subsequent countries within that region experienced the fertility decline at lower levels of development, as measured by the Human Development Index (HDI). Although over time levels of development mattered less for the onset of fertility decline, levels of development continued to matter in the pacing of fertility decline, with more developed countries experiencing a more rapid decline than countries with lower levels of development. Bongaarts and Cotts Watkins proposed that these trends were explained by a cultural model of diffusion, whereby national-level trends in fertility are driven by the diffusion of knowledge, attitudes, and patterns of behavior (KAP) as localities are integrated into larger national, regional, and global social and economic contexts. In addition to representing increased integration into larger contexts, media exposure could also serve to facilitate the diffusion of knowledge and attitudes toward contraceptive use and in turn influence patterns of behavior.

This paper represents an empirical application of diffusion theory to two fertility indicators, family planning knowledge and contraceptive use, within micro-regions across Sub-Saharan Africa. Analyzing more than 600,000 women in 114 micro-regions in 13 African countries,[1] this paper examines the relationship between subnational-HDI and these fertility indicators from the early 1990s through the 2010s. As an integration of data from three sources (U.N. World Population Prospects, the Global Data Lab, and the Demographic Health Survey), this paper is an extension of an analysis I have conducted on micro-regions within Cameroon (see *Preliminary Results*). The diffusion of knowledge and behaviors over space and time is a question of central interest to this paper, particularly as it applies to regions within countries (micro-regions) that have varying levels of development, as measured by subnational HDI. How do patterns of diffusion vary between knowledge and behaviors over time, particularly among micro-regions with different levels and trajectories of development? Are there persistent gaps between family planning knowledge and contraceptive usage between more and less developed micro-regions? Alternatively, have gaps between micro-regions converged, or grown, over time?

While examining fertility patterns at the national and macro-regional level is necessary for understanding global trends, micro-level analyses provide a better sense of what regions within countries drive trends at the national level. Moreover, since development occurs unevenly within countries (Harttgen & Klasen, 2012), micro-level analyses are important because macro-level trends mask unevenness in fertility practices and outcomes among countries' sub-regions and sub-populations. Individuals and groups have differential access to social and economic networks, markets, and resources within countries based on their geographic, demographic, and socioeconomic characteristics. Much of these differences are place-based, with rural, less developed areas experiencing higher levels of isolation from urbanized nodes which are more

[1] The 13 sample countries are Benin, Cameroon, Ethiopia, Ghana, Kenya, Malawi, Mali, Namibia, Niger, Nigeria, Tanzania, Uganda, and Zimbabwe. These countries were selected based on availability of DHS data at the subnational level for four time intervals in the early 1990s through the 2010s.

integrated into regional, national, and global economies. Sub-Saharan Africa is a critical region of interest in fertility studies since the region's share of the global population is projected to increase to approximately 40% of the total global population by year 2100 (Gerland et al., 2014). While there is variation in fertility rates and outcomes between countries in Africa, overall fertility rates in Sub-Saharan Africa remain high compared to other regions in the world and there is evidence of substantial stalls in fertility declines in many African countries (Bongaarts, 2008). Understanding regional differentials within countries is key to understanding national-level trends as well as macro-level trends with Africa as a global region.

**Research questions**

This paper represents both a traditional application of diffusion theory and an extension of diffusion theory. This paper is traditional in that it examines macro-level patterns of the timing of the onset and pacing of fertility decline across countries. However, this paper is an extension of diffusion theory in two respects: (1) its examination of the relationship between subnational HDI and the diffusion of ideas and behaviors through two specific fertility indicators, family planning knowledge and contraceptive use, and (2) its examination of how these patterns vary between micro-regions within countries at different levels of development. In RQ1, I examine the relationship between national levels of development in 28 countries in Sub-Saharan Africa (including the 13 sample countries) and the onset and pacing of the fertility decline at the national level in those countries. Over time, do these 28 countries experience the onset of the fertility decline at lower levels of development than preceding countries in the greater African region and developing countries across the world, and is the pace of the fertility decline slower in the countries with lower levels of development? In RQ2, I address how the diffusion of family planning knowledge and contraceptive usage varies across the 114 micro-regions with low, medium, and high levels of development (subnational HDI). How does this relationship vary across the four time points from the early 1990s to early 2010s? In RQ3, I address whether the relationships in RQ2 remain robust when accounting for women-level characteristics and level of media exposure within micro-regions. I also incorporate an interaction term for subnational HDI and time to determine whether and how the relationship between the two fertility indicators and subnational HDI varies at the four time intervals from the 1990s through the 2010s. When controlling for women-level characteristics and level of media exposure within micro-regions, does living in micro-regions with low, medium, or high levels of development impact the diffusion of family planning knowledge and contraceptive use, and does this relationship change over time? Moreover, how are socioeconomic characteristics and media exposure variables related to the two fertility indicators?

**Data and Research Methods**

This paper defines level of development using the U.N. Development Programme's Human Development Index (HDI), a commonly used measure of overall wellbeing in a country and level of economic development. HDI is a composite measure of three dimensions of wellbeing: health, education, and standard of living. Health is operationalized as life expectancy at birth, education is operationalized as average years of schooling for individuals aged 25 or more, and standard of living is operationalized as gross national income per capita (U.N. Development Programme, 2019). HDI is an integral measure in diffusion theory because "[c]ountries that are more developed have a greater proliferation of personal and institutional channels that connect them to countries outside their borders, for example through trade, labor migration, tourism, and international media" (Bongaarts & Cotts Watkins, 1996, p. 664). With regards to cultural factors, "[HDI] is also important in accounting for variation in networks. Development is accompanied by social differentiation (e.g., increased diversity in occupations

and educational levels), thus influencing the potential for network heterogeneity that is thought to be conducive to innovation" (Bongaarts & Cotts Watkins, 1996, p. 662). Thus the economic and social components of development are essential in diffusion theory, with HDI representing the degree to which regions and countries are socially and economically integrated into larger national, regional, and international contexts. Both national and subnational measures of HDI were retrieved from the Global Data Lab. To calculate subnational HDI, the Global Data Lab applied the U.N. Development Programme's estimation procedure to survey and census datasets sourced from the Global Data Lab and from statistical offices (see Global Data Lab (2019)). Since financial, health, and educational outcomes vary for women based on access to resources, HDI is an important region-level indicator in this paper.

The variables for family planning knowledge and contraceptive use, women-level socioeconomic characteristics, and media exposure were retrieved from IPUMS Demographic Health Survey. Family planning knowledge was selected as an outcome in this analysis because it represents a core process in diffusion theory – that is, the dissemination of knowledge along channels of interaction. Contraceptive use was selected because it represents a distinctive behavioral shift and application of knowledge. Family planning knowledge and contraceptive usage were coded as binary variables to indicate whether a woman has knowledge of modern methods or not and whether a woman is currently using or has ever used contraceptives. Where available, the variables of age, ethnicity, religion, education, household wealth, and urban/rural status will also be extracted from IPUMS DHS to account for compositional differences among women within micro-regions at varying levels of development. With regards to diffusion theory, these socioeconomic variables also represent measures of spatial and social "proximity" in the diffusion process, that is, "the grooves on a social map through which information and ideas, evaluation, and social influence flow." Bongaarts and Cotts Watkins note: "The social map consists of groups defined by spatial proximity (villages, regions) and/or social proximity (ethnicity, education, occupation). The term communities applies to both geographic and social groups representing community in a spatial and social sense" (1996, p. 661). This analysis will also use media exposure variables to represent communication nodes and exposure to fertility KAP in national, regional, and international contexts.

Since RQ1 is descriptive in nature, the relationship between national HDI and the onset and pacing of fertility decline over time will be visualized in basic line graphs and scatterplots for the 28 African countries. For RQ2, I will classify the 114 micro-regions as having low/medium/high levels of development based on the minimum and maximum levels of development in African countries (UNHDR, 2018). A subnational HDI of .649 or more represents high levels of development, a subnational HDI below .400 represents low levels, and the values in between represent medium levels. Since this paper is limited to African countries, setting the classification to the relative high/medium/low levels of development in Africa rather than global levels is both more relevant and also allows for more variation in the independent variable – levels of development within African micro-regions. Additionally, sensitivity tests will be used to analyze alternative thresholds, such as standard deviation thresholds from the mean level of development in Africa as a global region, to see if results remain consistent across different low/medium/high development classifications.

For RQ3, a series of logistic regression models will be conducted with family planning knowledge and contraceptive usage regressed on subnational HDI, with some iterations treating subnational HDI as a categorical variable (low/medium/high) and some iterations treating subnational HDI as a continuous variable. The first model will include women-level socioeconomic characteristics, the second model will incorporate media exposure variables, and the third model will incorporate interaction terms for subnational HDI and year to determine whether and how the relationship between subnational HDI and the two indicators of family planning and contraceptive use varies over time.

## Preliminary results for Cameroon and expected findings

(RQ1) Consistent with diffusion theory, although Cameroon experienced the onset of the fertility decline at a lower level of development (national HDI) compared to other countries in Africa and other developing countries in other global regions, fertility declines have occurred at a slower pace in Cameroon. It is anticipated that the results of the extended analysis will be consistent with the Cameroon analysis. Although countries in Sub-Saharan Africa will experience the onset of the fertility decline – and at lower levels of development compared to countries that experienced the onset earlier in time – fertility declines will occur at a slower pace in countries with lower levels of development compared to countries with higher levels of development.

(RQ2) Levels in family planning knowledge increased and experienced a near-complete convergence across the regions of Cameroon over time, even among Cameroon's least developed regions. Although an increase in subnational HDI was not immediately correlated with an increase – or decrease – contraceptive usage in the subsequent time period, broadly speaking, levels of contraceptive use remain low in the least developed regions of Cameroon. For the extended analysis, it is anticipated that although micro-regions with low, medium, and high levels of development within the 13 sample countries will experience a convergence in family planning knowledge over time, the level of development will continue to matter for contraceptive use, with less developed micro-regions continuing to have lower levels of contraceptive use than more developed micro-regions.

(RQ3) The small sample size and consequent lack of variation in the outcome variables was a limitation for logistic regression models in the Cameroon analysis. However, this limitation will be rectified with the larger sample size of 13 countries. It is anticipated that when accounting for the socioeconomic characteristics of women within micro-regions with low, medium, and high levels of development, subnational HDI will not be statistically significant for family planning knowledge but will continue to remain statistically significant for contraceptive use. The anticipated relationship between the outcomes and media exposure variables is less clear. Although it is expected that higher levels of media exposure would represent exposure to more heterogeneous networks of knowledge, attitudes, and patterns of behavior (KAP) and increased integration into national, regional, and global networks, it is also possible that media exposure variables are highly correlated with the socioeconomic controls and explain little of the variation in the outcomes. In the model that incorporates interaction terms for year and subnational HDI, it is anticipated that the relationship between subnational HDI and family planning knowledge will be stronger in the earlier time intervals than the later time intervals. The relationship between subnational HDI and contraceptive use is expected to remain significant in the four time intervals from the 1990s through the 2010s.

## Conclusions & Extensions

As an empirical application of diffusion theory at the subnational level, this paper not only addresses the differential diffusion processes for fertility knowledge and behavior, but also how this relationship varies over time and between micro-regions with varying levels of development. Although not elaborated upon in this abstract, a critical component of Bongaarts and Cotts Watkins's argument is that diffusion is a social process whereby heterogeneous or homogeneous networks promote or inhibit the diffusion of KAP. This paper will elaborate on this when discussing how women's socioeconomic characteristics and level of media exposure represent social channels of interaction. This will not only provide insight and nuance into the relationships between family planning knowledge and contraceptive use at varying levels of development, but also what characteristics promote or inhibit the diffusion of fertility KAP.

**Works cited**

Bongaarts, J. (2008). Fertility Transitions in Developing Countries: Progress or Stagnation? *Studies in Family Planning*, 39: 105-110.

Bongaarts, J., & Cotts Watkins, S. (1996). Social Interactions and Contemporary Fertility Transitions. *Population and Development Review*, 22(4), 639–682. https://doi.org/10.1007/s11483-013-9324-1

Gerland, P., Raftery, A., Sevcikova, H., Li, N., Gu, D., Spoorenberg, T., Alkema, L., Fosdick, B., Chunn, J., Lalic, N., Bay, G., Buettner, T., Heilig, G., and Wilmoth, J. (2014). World Population Stabilization Unlikely This Century, *Science* 346: 234-337.

Global Data Lab. (2019). Subnational Human Development Index. Retrieved from https://globaldatalab.org/shdi/about/.

Harttgen, K., & Klasen, T. (2012). A Household-Based Human Development Index. *World Development*, 40(5): 878-899.

U.N. Development Programme. (2018). Human Development Indices and Indicators. Retrieved from http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf.