

THE DEVELOPMENT AND ASSESSMENT OF CONTRACEPTIVE IDEATIONAL
PROFILES AMONG URBAN SENEGALESE WOMEN: IMPLICATIONS FOR HEALTH
COMMUNICATION

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ABSTRACT

Emily Rose Mangone: The Development and Assessment of Contraceptive Ideational Profiles
Among Urban Senegalese Women: Implications for Health Communication
(Under the direction of Kristen Hassmiller Lich)

In Senegal, 24 percent of in-union women who want to avoid pregnancy are not using modern contraceptive methods. Social, cultural, and cognitive factors are probable deterrents to contraceptive use. A better understanding of women's ideational profiles as they relate to contraceptive readiness and health information consumption could help family planning (FP) programs reach and empower women.

The objective of this dissertation was to identify and interpret meaningful contraceptive ideational profiles (CIPs) among in-union women of reproductive age in urban Senegal and examine how and why CIP structure and membership changed between survey waves in 2011 and 2015. We applied latent variable methods to identify and describe prototypical profiles of women based on their contraceptive awareness, misconceptions, self-efficacy, partner FP acceptance, partner communication, and perceived community support. In Aim 1, we identified three cross-sectional CIPs at baseline and two at endline. CIPs with higher ideational scores had larger membership at baseline and endline. Women reported similar sources of health information across CIPs, but women in CIPs with higher ideational scores reported more sources on average.

In Aim 2, we extended this analysis to identify four longitudinal CIPs that represented ideational patterns at both baseline and endline. These profiles were labeled "CIP 1: Lowest efficacy and FP awareness, highest misconceptions, unsupported," "CIP 2: Low efficacy and FP

awareness, rejects misconceptions, unsupported,” “CIP 3: Moderate efficacy, high FP awareness, high misconceptions, moderate support,” and “CIP 4: Highest efficacy and FP awareness, fewest misconceptions, most supported.” Exposures to FP communication via TV, radio, religious leaders, and conversations with health workers were associated with lower odds of membership in less empowered CIPs, as was exposure to messages about the legitimacy of FP and birth spacing. In Aim 3, we examined contraceptive use and intention to use as a function of current and previous CIP membership. Consistent with our hypotheses, membership in CIP 4 and transition to CIP 4 were strong predictors of FP use and intention.

This study demonstrated the potential of latent CIP methodologies to complement and enhance current social and behavior change approaches by identifying and responding to unique ideational needs and skills.

For my mother, with immeasurable love and gratitude.

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LIST OF ABBREVIATIONS

| | |
|------|---|
| ABIC | Adjusted Bayesian information criteria |
| AIC | Akaike information criteria |
| BCH | Bolck, Croon, and Hagnaars method |
| BIC | Bayesian information criteria |
| CHW | Community health workers |
| CIP | Contraceptive ideational profile |
| FP | Family planning |
| ISSU | <i>Initiative Sénégalaise de Santé Urbaine</i> |
| IUD | Intrauterine device |
| LAM | Lactational amenorrhea |
| LCA | Latent class analysis |
| LMR | Lo-Mendell-Rubin adjusted likelihood ratio test |
| LPA | Latent profile analysis |
| LTA | Latent transition analysis |
| LTB | Lanza, Tan, Bray method |
| MCP | Modern contraceptive prevalence |
| MLE | Measurement, Learning & Evaluation project |
| OR | Odds ratio |
| SBC | Social and behavior change |
| SDM | Standard Days method |
| SE | Standard error |
| URHI | Urban Reproductive Health Initiative |

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CHAPTER 1. INTRODUCTION

The use of contraception for spacing and preventing pregnancies is foundational to the health and well-being of women and families globally.¹ The advancement of family planning (FP) and modern contraceptive methods as a public health priority gives women and their partners greater agency to realize their reproductive intentions, that is, whether to have children, how many children to have, and when. Access to safe, voluntary family planning is essential to women's reproductive health, human rights, education, and social and economic participation globally.² It is also central to the health and well-being of children, families, and communities. Despite the increasing recognition of the social, economic, and health benefits of family planning at the global level, an estimated 218 million women of reproductive age (15–49) in low- and middle-income countries were not using a modern method in 2019 despite their reported intention to avoid pregnancy.³ Meeting this need with modern contraceptive methods would decrease unintended pregnancies by 68 percent, reduce unsafe abortions by 72 percent, and contribute to reducing maternal deaths by 62 percent.³ For these reasons, identifying and implementing strategies to expand and improve family planning programs has become a top priority for many governments in the last decade.

Family Planning in Senegal

As a founding member of the Ouagadougou Partnership in 2011 and an early (2012) commitment maker to the Family Planning 2020 (FP2020) initiative, Senegal has demonstrated high-level commitment to increasing access to and use of family planning as a public health priority.^{4,5} As part of the FP2020 initiative, the government of Senegal set an ambitious goal of

reaching 45 percent modern contraceptive prevalence (MCP) and reducing unmet need^a to 10 percent by 2020.⁴ Although Senegal made important progress toward this goal, it ultimately fell short of meeting this milestone with an estimated MCP of 27.7 percent among married women and 19.8 percent among all women and an unmet need of 22.4 percent among married women.⁶ Further, among women of reproductive age who are married or in union, nearly 49 percent would like to use a contraceptive method to space or prevent childbirth but only half (52%) have their demand for FP satisfied by a modern contraceptive method.⁷ As a result of persistently low contraceptive use and a high fertility rate of 4.8 births per woman, the maternal mortality rate remains high at 315 deaths per 100,000 live births.⁸

There are many well-known barriers to modern contraceptive use including lack of knowledge, misconceptions, health concerns, low cultural acceptance, lack of social support, limited female empowerment, lack of autonomy, low self-efficacy, poor geographical access, and limited financial resources for FP. When FP is accessible, there can also be poor quality of FP services, provider bias, and limited method choices.^{1,9–11} Although Senegal has made important supply chain improvements to expand access to modern methods in the past decade, fears and misconceptions persist and knowledge and social support remain low.^{12–17} These findings suggest that cognitive and social factors are probable deterrents to contraceptive use and continuation. Particularly in urban settings, where access to contraceptive products and services is typically higher than in harder-to-reach rural settings, key remaining challenges to informed, rights-based family planning appear to be cognitive (knowledge, misconceptions) and socio-

^a Unmet need is an indicator that describes women who are fecund and sexually active but are not using any method of contraception and report not wanting any more children or reporting wanting to delay the next child.⁷⁹

cultural (acceptability, efficacy).⁷ It is therefore of significance to study urban women's contraceptive ideation as well as socio-cultural barriers to developing supportive interventions.

Ideation

Ideation is a concept that refers to the perceptions and ideas that individuals hold that reflect various social, environmental, and personal influences.^{18,19} An ideation model posits that shifts in “ways of thinking,” defined and measured by a set of relevant psychosocial variables that together form an “ideational profile,” can influence behavioral change.^{20–23} In lay terms, ideation represents a person's readiness to act.²⁴ Ideation comprises three primary domains of psychosocial variables: cognitive (knowledge, attitudes, values, perceived risk, subjective norms), emotional (preferences and self-efficacy), and social (interpersonal communication, social support, and social influence).^{21,23,25} A contraceptive ideational profile (CIP) manifests through ideational constructs that represent contraceptive readiness and influence contraceptive intention and behavior. In 2015, the Camber Collective published a report on segmentation and contraceptive decision-making among women in Niger that compared the stated vs. the statistically derived importance of factors influencing contraceptive ideation and decision making.²⁶ Ideational factors that were identified as both high stated importance and high derived importance included having enough information on contraceptive methods, belief that contraception would not impact future fertility, and spousal support. An additional factor that was not of stated importance but was of derived importance was social support from friends, family, and religious leaders. In 2017, Babalola used psycho-social constructs including efficacy beliefs, misconceptions, spousal communication, contraceptive knowledge, and perceived social support for contraceptive use/perceived contraceptive use among peers to identify prototypical groups of urban Nigerian women of reproductive age based on shared latent ideational patterns.²⁷

Babalola identified four distinct classes including women who were 1) Disempowered (inefficacious, unsupported, misinformed), 2) Unsupported (efficacious, unsupported, misinformed), 3) Skeptics (efficacious, supported, misinformed), and 4) Empowered (efficacious, informed, and supported). Membership in these classes had strong predictive relationships with contraceptive intention and use. This study concluded that ideational segmentation should be routinely applied as part of the overall process of the development of health communication programming so that information can be more appropriately tailored to key audience segments. Further, Babalola concluded that understanding the information channel preferences, access, and consumption habits of the women in each segment would help identify outreach modalities for each class.²⁷

Social and Behavior Change Communication

In the context of family planning, social and behavior change (SBC) communication is the use of mass and social media, community-level activities, and interpersonal communication, to influence individual and group knowledge, attitudes, and behaviors around contraceptive use.²⁸ SBC can instigate shifts in contraceptive ideation, intention, and behavior.^{20,21,23,27,29,30} Evidence suggests that exposure to FP SBC can increase knowledge, modify attitudes and social norms, and ultimately create informed, voluntary demand for family planning.²⁹⁻³¹

SBC communication can be transmitted through mass media (TV, radio, newspaper, billboards, other print), social media (Facebook, WhatsApp, TikTok, Instagram, Messenger, WeChat), digital media (interactive voice response, text messages, USSD), community-level activities (non-governmental organizations, associations, community meetings, religious leaders/talks), and interpersonal communication (door-to-door visits, community health workers [CHWs], and word-of-mouth between family, friends, and neighbors). There are often tradeoffs

between the reach of a channel and its impact on desired behavioral outcomes. Community- and individual-level SBC communication have shown promising results in terms of knowledge, attitudes, and some sexual health behaviors.^{31–33} Community- and individual-level SBC communication require more resources and effort but can be an effective way of connecting with individuals and communities through tailored communication. The appeal of mass media is that it can reach larger audiences, potentially at the national level, and it is often combined with approaches that are intended to both educate and entertain (“edutainment”). Recent longitudinal impact evaluations among urban women of reproductive age in Nigeria, Senegal, Kenya, and India have found significant relationships between exposure to various sources of FP information and modern FP use.^{34–37} For example, in Senegal, an evaluation found that exposure to messages about FP via community activities resulted in a five percentage point increase in modern method use (eight percentage points when the sample was restricted to women in the two poorest wealth quintiles).³⁴ It also found that exposure to FP via radio was associated with a four percentage point increase in modern method use for poor women. In Nigeria, exposures to FP messages via TV, radio, and community events were all associated with two percentage point increases in modern method use.³⁷ Integrated, multi-channel programs can achieve a larger impact than those that use a single channel and the breadth and intensity of exposure to mass media campaigns can result in a dose-response effect.^{20,27,38} Understanding the impact of various modalities and messaging strategies of SBC programs on contraceptive ideation, use, and intention to use can shed light on the most effective strategies to enable informed voluntary decision making and can ultimately be used prospectively to segment audiences and tailor communication. The conceptual model in Figure 1 builds on the Ideation Model of Strategic Communication and Behavior

Change developed by Kincaid in 2000 and adapted by Babalola in 2015.^{23,39} This conceptual model brings together SBC, ideation, intention, and behavior.

A Person-Centered Approach to Audience Segmentation

Historically, the most common approach to explaining relationships between variables of interest in the social sciences has been through variable-centered methodologies such as regression and factor analysis. Variable-centered approaches describe associations among variables and address the relative importance of independent variables in contributing to variance in dependent variables.^{40,41} In contrast, person-centered approaches assume a heterogeneous population and seek groups of individuals that exhibit similar characteristics or patterns. The two approaches can be complementary, but increasingly, person-centered approaches are being recognized for their ability to surface associations between underlying factors in behavioral and ideational models.^{42–44}

Latent class analyses (LCA), latent profile analysis (LPA), and latent transition analysis (LTA) are person-centered forms of finite mixture modeling that can be used to identify unobservable, or latent, prototypical profiles within a large heterogeneous population based on observed response patterns.⁴¹ Latent modeling techniques are common methods to better identify and understand homogenous or prototypical subgroups in heterogeneous populations in health policy and services research.^{45–47} LCA, LPA, and LTA have also been used recently to better understand contraceptive ideation and reproductive decision making.^{27,48–50} LPA and LTA have important implications in identifying subgroups of women with discrete, internally consistent profiles of contraceptive ideation and FP use and intention and examining how those profiles change over time.

Data Source and Context

The Urban Reproductive Health Initiative (URHI) was a four-country initiative funded by the Bill & Melinda Gates Foundation that sought to improve the reproductive health of the urban poor in Senegal, Nigeria, Kenya, and the state of Uttar Pradesh in India through various advocacy, demand, and supply-side interventions implemented through country consortia between 2010 and 2015.³⁴ In Senegal, Intrahealth International led the local implementation of the *Initiative Sénégalaise de Santé Urbaine* (ISSU). ISSU was launched in 2011 in four urban sites—Dakar, Guédiawaye, Pikine, and Mbao—and expanded to two additional urban sites in 2013, Mbour and Kaolack. The ISSU project used both supply-side and demand generation activities to increase the use of modern contraception in targeted urban sites (Table 1).

To monitor and evaluate the impact of the URHI on contraceptive use, the Carolina Population Center at the University of North Carolina at Chapel Hill led the Measurement, Learning & Evaluation (MLE) project as the evaluation component of this initiative. Evaluation components in Senegal included longitudinal data collection in six cities (Dakar, Guédiawaye, Pikine, Mbao, Mbour, and Kaolack) for women of reproductive age (15–49) in 2011 (baseline) and 2015 (endline) and in three cities (Guédiawaye, Pikine, Mbao) at midline (2013).⁵¹ This dissertation uses the longitudinal data for urban women of reproductive age that were in union at baseline and had matched endline data.

Specific Aims

The overall objective of this research was to identify and describe CIPs among urban in-union women of reproductive age in Senegal and to examine whether, how, and why these CIPs change over time given exposure to various FP SBC interventions. This objective was split into three measurable aims, as follows.

Aim 1

The objective of Aim 1 was to use a person-centered approach to identify and interpret meaningful contraceptive ideational profiles among urban, partnered Senegalese women of reproductive age using evidence-based indicators from social, emotional, and cognitive domains related to contraceptive ideation. We hypothesized that there are multiple discrete latent profiles of in-union urban Senegalese women who share prototypical patterns of key ideational factors that influence contraceptive decision making. Using data from a longitudinal sample of women of reproductive age in six Senegalese cities in 2011 and 2015, we conducted latent profile analyses to identify CIPs at baseline and endline using constructs related to FP awareness, beliefs, efficacy, partner acceptance, partner communication, and social support. We then examined the structure, membership, and interpretation of these CIPs in 2011 and 2015 to understand and describe differences across CIPs in terms of group demographics, psychosocial factors, information consumption preferences, and contraceptive use and intention to use among non-users.

Aim 2

The objective of Aim 2 was to identify and describe CIPs using longitudinal data such that the structure and interpretation of the CIPs were informed by women's ideational patterns across time. Creating longitudinal CIPs allowed us to assess transitions between CIPs over time and examine the exposures that increase the probabilities of these transitions. Specifically, we examined whether exposures to different FP message content and exposures to different channels/modalities were predictive of women's transitions from less empowered/supported CIPs at baseline to more empowered/supported CIPs at endline. The examination of relationships

between different FP communication intervention approaches and transitions between CIPs over time can inform future FP policies and programming.

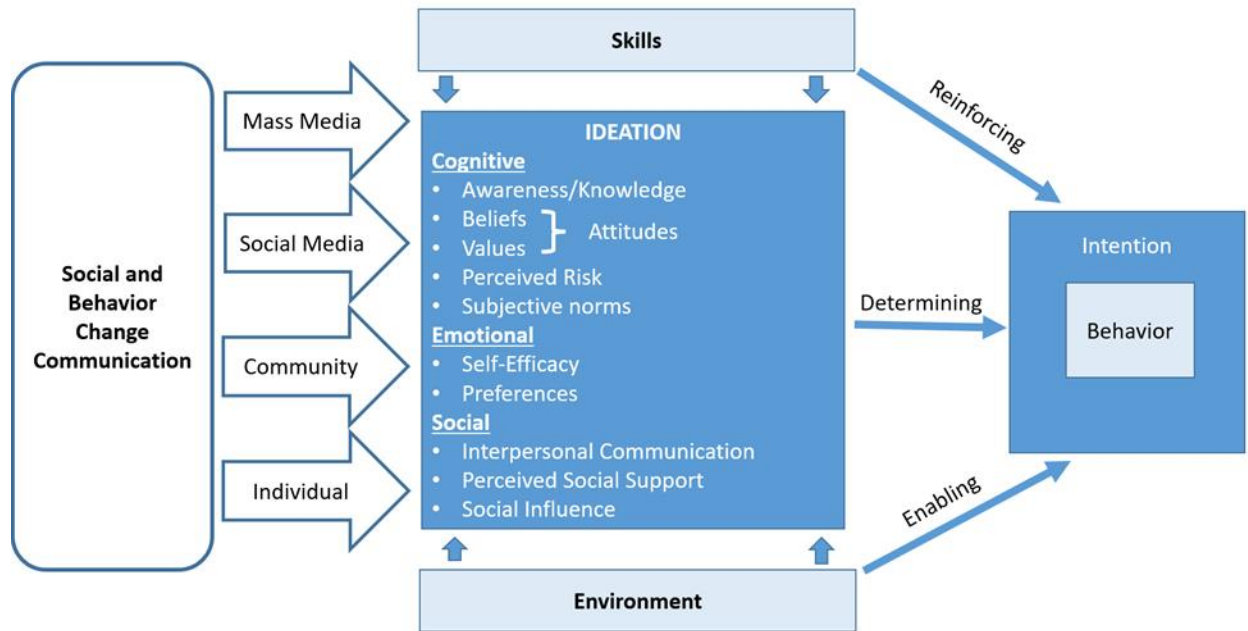
Aim 3

The objective of Aim 3 was to test whether membership in different CIPs was associated with modern contraceptive use and intention to use among non-users. We hypothesized that women in more empowered CIPs have higher predicted probabilities of modern FP use and intention to use compared with women in less empowered CIPs, even when controlling for covariates. This aim was consistent with the hypothesis that CIPs can be interpreted in terms of contraceptive readiness and empowerment.

This dissertation contributed evidence on whether and how latent profile and latent transition methodologies can offer meaningful insight into contraceptive ideation and decision making by taking a person-centered approach to identifying profiles of women with shared psycho-social characteristics related to contraceptive use and intention. This research can inform the development of FP policies on health communication, intervention programming, data collection, and research priorities that can more effectively support consideration and uptake of contraception among women, their partners, and their communities.

Figures

Figure 1. Conceptual Model of Ideation & Social and Behavior Change Communication



Tables

Table 1. Intervention Components of the ISSU³⁴

| Type | Approach/Channel | Description |
|--------|---|---|
| Demand | Engagement of religious leaders as FP champions | ISSU trained Muslim religious leaders to promote FP messages in religious settings, in small group discussions, and to participate in debates about FP on the radio and television. |
| Demand | Radio | ISSU sponsored FP messages in radio shows including health programs, religious programs, music programs, and debate programs |
| Demand | TV | ISSU aired FP messages and advertisements on television using stations that are popular in the study cities. |
| Demand | Print | ISSU implemented a small number of print media activities including promoting FP through newspapers and magazines. |
| Demand | SMS | ISSU sent information messages about FP via SMS |
| Demand | Internet | ISSU posted FP messages on social media and the internet |
| Demand | Community and in-person | ISSU trained community-health volunteers (“Badiénou Gokh”) to share information about FP through one-on-one discussions with women and other members of the household or small group discussions with multiple women in the home. Badiénou Gokh also led educational discussions or awareness-raising sessions. |
| Supply | Informed Push Model | ISSU implemented a new stocking and commodity tracking system to push commodities to facilities at risk of depleting their stock. |
| Supply | Quality improvement measures | ISSU trained providers in FP counseling and service delivery strengthened the referral system through the use of a systematic screening tool to identify clients’ FP needs, deployed midwives into facilities with gaps in services, supported access to private through pharmacy training. |

REFERENCES

1. World Health Organization. Family planning/Contraception. Published 2018. Accessed June 29, 2018. <http://www.who.int/news-room/fact-sheets/detail/family-planning-contraception>
2. Lee M, Finlay J. *The Effect of Reproductive Health Improvements on Women's Economic Empowerment: A Review Through the Population and Poverty (PopPov) Lens.*; 2017. Accessed March 3, 2020. https://www.prb.org/wp-content/uploads/2017/09/17-246-POPPOV_Women_Empower.pdf
3. Sully E, Biddlecom A, Darroch JE, et al. *Adding It Up: Investing in Sexual and Reproductive Health 2019.*; 2020. doi:10.1363/2020.31637
4. Senegal | Family Planning 2020. Accessed November 13, 2021. <https://www.familyplanning2020.org/senegal>
5. Senegal - Ouagadougou Partnership. Accessed November 13, 2021. <https://partenariatouaga.org/en/country/senegal/#>
6. Track20. FP2020 Data Dashboard | Family Planning 2020. Published 2019. Accessed January 19, 2021. <http://www.familyplanning2020.org/data-dashboard>
7. ANSD/Sénégal AN de la S et de la D and I, ICF. Senegal Enquête Démographique et de Santé Continue (EDS-Continue) 2017. Published online 2018. Accessed August 31, 2018. <https://dhsprogram.com/publications/publication-FR331-DHS-Final-Reports.cfm>
8. The World Bank. Maternal mortality ratio (modeled estimate, per 100,000 live births) | Data. Published 2015. Accessed July 13, 2018. <https://data.worldbank.org/indicator/SH.STA.MMRT?locations=SN>
9. Haider TL, Sharma M. Barriers to Family Planning and Contraception Uptake in Sub-Saharan Africa: A Systematic Review. *International Quarterly of Community Health Education*. 2013;33(4):403-413. doi:10.2190/IQ.33.4.g
10. Sedgh G, Hussain R. Reasons for Contraceptive Nonuse among Women Having Unmet Need for Contraception in Developing Countries. *Studies in Family Planning*. 2014;45(2):151-169. doi:10.1111/j.1728-4465.2014.00382.x
11. Zegeye B, Ahinkorah BO, Idriss-Wheeler D, Olorunsaiye CZ, Adjei NK, Yaya S. Modern contraceptive utilization and its associated factors among married women in Senegal: a multilevel analysis. *BMC Public Health*. 2021;21(1):1-13. doi:10.1186/S12889-021-10252-7/TABLES/2
12. Aichatou B, Seck C, Anne TSB, Deguenovo GC, Ntabona A, Simmons R. Strengthening government leadership in family planning programming in Senegal: From proof of concept to proof of implementation in 2 districts. *Global Health Science and Practice*. 2016;4(4):568-581. doi:10.9745/GHSP-D-16-00250

13. Daff BM, Seck C, Belkhatat H, Sutton P. Informed push distribution of contraceptives in Senegal reduces stockouts and improves quality of family planning services. *Global health, science and practice*. 2014;2(2):245-252. doi:10.9745/GHSP-D-13-00171
14. Gueye B, Jacobs J, Ndiaye A, Sutton P. Senegal has practically eliminated contraceptive shortages. Here's how. World Economic Forum. Published 2017. Accessed July 13, 2018. <https://www.weforum.org/agenda/2017/11/senegal-has-practically-eliminated-contraceptive-shortages-here-s-how/>
15. Hasselback L, Gueye B, Ndao O, Ndour SK, Cissé C. Incentivizing access to family planning in Senegal via the informed push model. *Journal of Pharmaceutical Policy and Practice*. 2014;7(1):O12. doi:10.1186/2052-3211-7-S1-O12
16. Krug C, Cavallaro FL, Wong KLM, Gasparrini A, Faye A, Lynch CA. Evaluation of Senegal supply chain intervention on contraceptive stockouts using routine stock data. Hodges MH, ed. *PLOS ONE*. 2020;15(8):e0236659. doi:10.1371/journal.pone.0236659
17. Winston J, Calhoun LM, Corroon M, Guilkey D, Speizer I. Impact of the Urban Reproductive Health Initiative on family planning uptake at facilities in Kenya, Nigeria, and Senegal. *BMC women's health*. 2018;18(1):9. doi:10.1186/s12905-017-0504-x
18. Cleland J, Wilson C. Demand Theories of the Fertility Transition: An Iconoclastic View. *Population Studies*. 1987;41(1):5-30. doi:10.1080/0032472031000142516
19. van de Kaa DJ. Anchored Narratives: The Story and Findings of Half a Century of Research into the Determinants of Fertility. *Population Studies*. 1996;50(3):389-432. doi:10.1080/0032472031000149546
20. Babalola S, Vonrasek C. Communication, ideation and contraceptive use in Burkina Faso: an application of the propensity score matching method. *The journal of family planning and reproductive health care*. 2005;31(3):207-212. doi:10.1783/1471189054484022
21. Kincaid DL. Social networks, ideation, and contraceptive behavior in Bangladesh: a longitudinal analysis. *Social science & medicine*. 2000;50(2):215-231. Accessed July 13, 2018. <http://www.ncbi.nlm.nih.gov/pubmed/10619691>
22. Mason KO. Explaining fertility transitions. *Demography*. 1997;34(4):443-454. Accessed September 19, 2018. <http://www.ncbi.nlm.nih.gov/pubmed/9545624>
23. Kincaid DL. Mass Media, Ideation, and Behavior. *Communication Research*. 2000;27(6):723-763. doi:10.1177/009365000027006003
24. Babalola S, Kusemiju B, Calhoun L, Corroon M, Ajao B. Factors associated with contraceptive ideation among urban men in Nigeria. *International Journal of Gynecology & Obstetrics*. 2015;130:E42-E46. doi:10.1016/j.ijgo.2015.05.006

25. Babalola S, Kincaid DL. New Methods for Estimating the Impact of Health Communication Programs. *Communication Methods and Measures*. 2009;3(1-2):61-83. doi:10.1080/19312450902809706
26. Camber Collective. *Increasing Contraceptive Use in Niger.*; 2015. Accessed April 9, 2020. https://static1.squarespace.com/static/55723b6be4b05ed81f077108/t/58c8862a1b10e3a1c3bca058/1489536809131/Niger_Final+FP+Report.pdf
27. Babalola S. Changes in Ideational Profiles of Women of Reproductive Age in Urban Nigeria: The Role of Health Communication. *Health Education and Behavior*. Published online 2017. doi:10.1177/1090198117699510
28. High-Impact Practices in Family Planning (HIP). *Health Communication: Enabling Voluntary and Informed Decision-Making.*; 2012. <https://www.fphighimpactpractices.org/wp-content/uploads/2017/06/HealthCommunication.pdf>
29. Krenn S, Cobb L, Babalola S, Odeku M, Kusemiju B. Using behavior change communication to lead a comprehensive family planning program: the Nigerian Urban Reproductive Health Initiative. *Global health, science and practice*. 2014;2(4):427-443. doi:10.9745/GHSP-D-14-00009
30. Babalola S, Figueroa ME, Krenn S. Association of Mass Media Communication with Contraceptive Use in Sub-Saharan Africa: A Meta-Analysis of Demographic and Health Surveys. *Journal of Health Communication*. 2017;22(11):885-895. doi:10.1080/10810730.2017.1373874
31. Mwaikambo L, Speizer IS, Schurmann A, Morgan G, Fikree F. What works in family planning interventions: a systematic review. *Studies in family planning*. 2011;42(2):67-82. Accessed September 18, 2018. <http://www.ncbi.nlm.nih.gov/pubmed/21834409>
32. Ross DA, Chagalucha J, Obasi AIN, et al. Biological and behavioural impact of an adolescent sexual health intervention in Tanzania: A community-randomized trial. *AIDS*. 2007;21(14):1943-1955. doi:10.1097/QAD.0b013e3282ed3cf5
33. Lou CH, Wang B, Shen Y, Gao ES. Effects of a community-based sex education and reproductive health service program on contraceptive use of unmarried youths in Shanghai. *Journal of Adolescent Health*. 2004;34(5):433-440. doi:10.1016/j.jadohealth.2003.07.020
34. Benson A, Calhoun L, Corroon M, et al. The Senegal urban reproductive health initiative: a longitudinal program impact evaluation. *Contraception*. 2018;97(5):439-444. doi:10.1016/j.contraception.2018.01.003
35. MLE. Measurement Learning and Evaluation of the Urban Reproductive Health Initiative: Senegal 2015 Endline Survey executive summary. Published online 2016. Accessed September 22, 2018. <https://www.popline.org/node/652195>

36. Speizer IS, Corroon M, Calhoun L, et al. Demand generation activities and modern contraceptive use in urban areas of four countries: A longitudinal evaluation. *Global Health Science and Practice*. 2014;2(4):410-426. doi:10.9745/GHSP-D-14-00109
37. Calhoun L, Mcguire C, Beisser M, Hopkins J. End of Project Report: The Measurement, Learning and Evaluation (MLE) Project for the Urban Reproductive Health Initiative. Published online 2017.
38. High-Impact Practices in Family Planning (HIPs). Social and Behavior Change: A Critical Part of Effective Family Planning Programs. Washington, DC: USAID. Published April 2018. Accessed September 12, 2021. <https://www.fphighimpactpractices.org/briefs/sbc-overview/>
39. Babalola S, John N, Ajao B, Speizer IS. Ideation and intention to use contraceptives in Kenya and Nigeria. *Demographic Research*. Published online 2015. doi:10.4054/DemRes.2015.33.8
40. Laursen B, Hoff E. Person-centered and variable-centered approaches to longitudinal data. *Merrill-Palmer Quarterly*. 2006;52(3):377-389. doi:10.1353/MPQ.2006.0029
41. Collins L, Lanza S. *Latent Class and Latent Transition Analysis*. Wiley; 2010. Accessed September 1, 2018. <https://www.wiley.com/en-us/Latent+Class+and+Latent+Transition+Analysis%3A+With+Applications+in+the+Soci+al%2C+Behavioral%2C+and+Health+Sciences-p-9780470228395>
42. Bámaca-Colbert MY, Gayles JG. Variable-Centered and Person-Centered Approaches to Studying Mexican-Origin Mother-Daughter Cultural Orientation Dissonance. *Journal of youth and adolescence*. 2010;39(11):1274. doi:10.1007/S10964-009-9447-3
43. Meeusen C, Meuleman B, Abts K, Bergh R. Comparing a Variable-Centered and a Person-Centered Approach to the Structure of Prejudice: <https://doi.org/10.1177/1948550617720273>. 2017;9(6):645-655. doi:10.1177/1948550617720273
44. Weaver SR, Kim SY. A Person-centered Approach to Studying the Linkages among Parent-Child Differences in Cultural Orientation, Supportive Parenting, and Adolescent Depressive Symptoms in Chinese American Families. *Journal of youth and adolescence*. 2008;37(1):36-49. doi:10.1007/S10964-007-9221-3
45. Petersen KJ, Qualter P, Humphrey N. The application of latent class analysis for investigating population child mental health: A systematic review. *Frontiers in Psychology*. 2019;10(MAY). doi:10.3389/fpsyg.2019.01214
46. Miranda VPN, dos Santos Amorim PR, Bastos RR, et al. Evaluation of lifestyle of female adolescents through latent class analysis approach. *BMC Public Health*. 2019;19(1):184. doi:10.1186/s12889-019-6488-8

47. Ingledew DK, Hardy L, Cooper CL. Latent class analysis applied to health behaviours. *Personality and Individual Differences*. 1995;19(1):13-20. doi:10.1016/0191-8869(95)00045-8
48. Opollo D, Pillai VK. Latent class analysis of reproductive decision making in Zambia. *African and Asian Studies*. 2012;11(3):371-383. doi:10.1163/15692108-12341238
49. Dalglish SL, Vandermark J, Rossier C, Kemou A, Neighbor H. Using Marketing Science to Understand Contraceptive Demand in High-Fertility Niger. *Studies in Family Planning*. 2018;49(4):367-383. doi:10.1111/sifp.12078
50. Harris ML, Egan N, Forder PM, Coombe J, Loxton D. Contraceptive use among women through their later reproductive years: Findings from an Australian prospective cohort study. *PloS one*. 2021;16(8). doi:10.1371/JOURNAL.PONE.0255913
51. Measurement Learning & Evaluation Project for the Urban Reproductive Health Initiative. MLE Senegal Study Design.docx - MLE Senegal Dataverse. Published 2017. Accessed August 31, 2018. <https://dataverse.unc.edu/file.xhtml?fileId=7491126&version=RELEASED&version=.0>

CHAPTER 2. THE DEVELOPMENT OF CONTRACEPTIVE IDEATIONAL PROFILES AMONG URBAN IN-UNION WOMEN IN SENEGAL: A LATENT PROFILE ANALYSIS

Background

Family planning (FP) is one of the most significant public health advances of the 20th century because it has given women greater agency to realize their reproductive intentions, that is, whether to have children, how many children to have, and when. This has advanced women's reproductive health, education, and social and economic participation globally.^{1,2} However, many countries have struggled to increase FP use and realize those health, social, and economic dividends. Despite Senegal's early (2012) commitment to the Family Planning 2020 (FP2020) global partnership and membership in the Ouagadougou Partnership, Senegal fell short of its goals of reaching a 45 percent modern contraceptive prevalence (MCP) and reducing unmet need^b to 10 percent by 2020.³ In 2020, the estimated MCP was 27.7 percent among married women and 19.8 percent among all women and unmet need was 22.4 percent among married women.³ These statistics put Senegal's MCP in the bottom third of the 69 FP2020 priority countries.⁴

Increasing MCP requires dual investments in improving the supply of contraceptive products and services and expanding demand for these products and services. Senegal has made significant supply-side improvements in the past decade, particularly through the implementation of an informed push model of contraceptive distribution and resource mobilization.⁵⁻⁹ However,

^b Unmet need is an indicator that describes women who are fecund and sexually active but are not using any method of contraception and report not wanting any more children or reporting wanting to delay the next child.⁷⁹

demand generation activities appear to have had less success in developing a culture supportive of FP use and combatting misinformation. Data from the Measurement, Learning & Evaluation (MLE) project in Senegal indicate persistent high levels of misinformation about contraception in urban areas.^{10,11} Data from a 2011 baseline survey of urban women and men found that more than half of women and approximately half of men believed that “people who use contraceptives end up with health problems” and that “contraceptives are dangerous to women’s health.”¹¹ Additionally, more than one-third of women and nearly one-third of men believed that “use of a contraceptive injection can make a woman permanently infertile.” A summary of findings from the 2015 endline survey noted that more than 40 percent of urban women interviewed still believed that contraception was dangerous for one’s health.¹⁰

Among Senegalese women who said that they wanted to avoid pregnancy and were not using a modern family planning method in 2013, opposition to use was the most commonly cited reason for not using (26%), followed by postpartum reasons (25%), infrequent sex (18%), and fear of side effects and health concerns (14%).¹² In 2017, the primary reason for contraceptive discontinuation among Senegalese women using contraception was the desire to have a child (33%), followed by side effects or health concerns (29%), infrequent sex or separation (20%), and husband’s disapproval (6%).¹³ In a 2020 publication, 45 percent of Senegalese women surveyed reported that their husbands were the major source of pressure to have more children and 62 percent reported that women should not use contraceptives without their husband’s permission.¹⁴ Another 2020 study indicated that autonomous decision-making was significantly ($p < 0.05$) associated with a 14 percent reduction in the rate of unmet need but that Senegalese women’s autonomy in health decision making was very low (6%).¹⁵ The same study also suggested that educating male partners could potentially increase women’s health decision-

making autonomy. These data indicate that cognitive and social factors are probable deterrents to modern contraceptive uptake and continuation in Senegal, particularly in urban areas where supply chain barriers to access are less pronounced.

Ideation

Although many studies have examined these factors in isolation, a better understanding of ideational profiles of women could improve program and policy makers' understanding of contraceptive decision making and how programs might better reach and tailor family planning interventions to women, male partners, and communities. The concept of ideation refers to the perceptions and ideas that individuals hold that reflect various social, environmental, and personal influences.^{16,17} Ideation was first examined by demographers in the context of contraceptive decision making in the 1980s as an alternative explanation to economic demand theory to explain societal fertility decline.^{16,18,19} An ideation model posits that shifts in ways of thinking, defined and measured by a set of relevant psychosocial variables, which together form an ideational profile, can influence behavior change.^{19–22} Ideation comprises three primary domains of psychosocial variables: cognitive (knowledge, attitudes, values, perceived risk, subjective norms), emotional (preferences and self-efficacy), and social (interpersonal communication, social support, and social influence).^{21–23}

A 2017 study of urban women of reproductive age in Nigeria identified distinct contraceptive ideational profiles that had strong predictive relationships with contraceptive intention and use.²⁴ The author concluded that ideational profiling could be routinely applied as part of the overall process of the development of health communication programming so that information can be more appropriately tailored to key audience segments. In this paper, we extended the application of these methods to urban women of reproductive age (15–49) in

Senegal between 2011 and 2015. The objective of this study was to identify and interpret latent prototypical profiles of women based on theory-driven and evidence-based cognitive, emotional, and social factors. A priori, we did not have specific hypotheses about how many distinct profiles might best fit the characteristics of this population or how these profiles may change over time. However, given that there were significant investments in social and behavior change communication during this time, we expected to see more empowered ideation reflected in the structure or membership of the profiles at endline.²⁵

To our knowledge, this was the first study to apply person-centered latent variable modeling to contraceptive ideation in Senegal, a country that may benefit from an improved understanding of how complex cognitive, emotional, and social factors shape contraceptive ideation, intention, and use. The identification, interpretation, and application of these profiles can inform policies and other actions to improve audience segmentation and strengthen FP programming, to shape contraceptive demand in line with the public health objectives of the Government of Senegal.

Methods

Data

The Initiative Sénégalaise de Santé Urbaine (ISSU) was an initiative implemented between 2011 and 2015 that sought to improve the reproductive health of the urban poor in Senegal through various advocacy, demand, and supply-side interventions in six urban sites: Dakar, Guédiawaye, Pikine, Mboi, Mbour, and Kaolack. To monitor and evaluate the impact of the ISSU on contraceptive use, the MLE project collected longitudinal data in 2011 and 2015 in all six cities from urban women of reproductive age (15–49).²⁶ A two-stage sampling design was used. In the first stage, the 2002 Population and Housing Census's districts were used as the

primary sampling units (PSU) and a random sample of 268 districts was selected across all cities based on probability proportional to their populations. PSU were stratified by poor and non-poor so that 50 percent of PSU were selected from the poor strata, thereby increasing the inclusion of poor women.^{10,25} In each PSU, 21 households were randomly selected for interview with equal probability to create a sample of 5,628 households. All women of reproductive age in included households were eligible for participation in the baseline survey. At baseline, 9,614 women were interviewed. At endline, 6,927 women were re-interviewed for a follow-up rate of 73.5 percent.^{10,25} Women were re-weighted at endline to account for attrition.

We restricted our dataset to women who were in-union (married or living with a partner) at baseline and who had matched endline responses (n=4,047). Premarital sex is taboo in Senegal and several important survey questions were only asked of women who were in union. In-union women are of interest programmatically because many are at risk for unintended pregnancy and short birth intervals. We restricted our sample to women who had both baseline and endline data to ensure a balanced dataset and delineate changes in profile membership and interpretation that were not due to attrition. To ensure that there were no meaningful differences in ideational profiles between the full sample of in-union women at baseline (n=5,351) and the longitudinal sample of in-union women who had matched baseline and endline data (n=4,047), we conducted a sensitivity analysis at baseline with the full sample of in-union women. We examined differences in the number and quality of profiles produced by the inclusion of women without endline data to determine whether there were meaningful differences in the structure or interpretation of the profiles. For all analyses, we accounted for clustering at the district level and applied probability weights for the six cities at baseline and endline.

Analytical Plan

We conducted latent profile analyses (LPA) to identify and interpret prototypical subgroups of women with shared contraceptive ideation at baseline and endline. An LPA is a form of finite mixture modeling often used in health policy and health services research to identify unobservable, or latent, prototypical profiles within a large heterogeneous population based on observed response patterns.^{27–30} LPA assumes that there is a mixture of discrete distributions that comprise the population heterogeneity and identifies the most likely model by defining a finite number of profiles.³¹ LPA assumes an underlying latent categorical variable that gives rise to the observed variables and returns the probability of membership in each profile based on patterns of item-response probabilities. The equation for the LPA represents the probability of the occurrence of a specific set of responses as a function of the probabilities of membership in each latent profile and the probabilities of the occurrence of each response conditional on latent profile membership (Equation 1).³⁰

Equation 1. Latent Profile Analysis

$$P(Y = y) = \sum_{c=1}^C \gamma_c \prod_{j=1}^J \prod_{r_j=1}^{R_j} \frac{I(y_j = r_j)}{\rho_j, r_j | c}$$

In this equation, $\rho_{j,r_j|c}$ represents the item-response probability of a response r_j to observed indicator j , conditional on latent profile c membership. $I(y_j=r_j)$ is the indicator function that equals 1 when indicator variable $j=r_j$ (equals 0 otherwise).³⁰ $\prod_{j=1}^J \prod_{r_j=1}^{R_j} \frac{I(y_j = r_j)}{\rho_j, r_j | c}$ represents the probability of a particular observed response pattern y conditional on membership in latent profile c . The first term $\sum_{c=1}^C \gamma_c$ represents the summation of profile 1 to profile C of the

prevalence of latent profile c , which, because latent profiles are mutually exclusive and exhaustive, sum to 1.

LPA is a person-oriented approach in that the objective is to look for groups of individuals that exhibit similar characteristics or patterns. This contrasts with other latent variable models such as factor analysis, which is a variable-centered approach that seeks to quantify the individual contributions of specific variables in the study.³⁰ Because we hypothesize that women have distinct profiles that drive their response patterns to key indicators, LPA was selected as the most appropriate approach for this study. LPA and latent class analysis (LCA) have been used in similar low-resource contexts to better understand reproductive decision making, including a recent study that defined contraceptive ideational profiles using a parallel dataset for urban women of reproductive age in Nigeria.^{24,32,33}

Conceptual Model and Indicator Selection

Figure 2 presents the analytical model that assumes an underlying latent categorical variable that gives rise to observable cognitive, emotional, and social indicators. Hypothesizing categorical contraceptive ideational profiles makes theoretical sense because they incorporate various facets of internal and external contraceptive decision-making, which is unlikely to be a linear continuous phenomenon. We selected ideational indicators (constructs) of the latent CIP variable based on 1) Kincaid's theoretic framework of contraceptive ideation, 2) evidence from the literature, 3) previous research on contraceptive ideational profiles in low resource settings, and 4) a review of the shape and variance of available variables in the dataset.^{20,24,34} Wurpts and Geiser (2014) suggest that using at least five indicators with strong relationships to the latent profile variable in LPA contributes to greater certainty in defining the classes.³⁵ After considering tradeoffs between including more indicator variables and increasing the risk of data

sparseness and including a subset of indicator variables that risk not adequately specifying the model, we ultimately selected six indicators.

Table 2 presents evidence of how selected ideational domains and indicators from Kincaid's framework of ideation relate to contraceptive readiness, intention, and use. In the cognitive domain, evidence suggests that limited knowledge or awareness of contraceptive methods is associated with lower contraceptive use and is a determinant of unmet need.^{14,36,37} Indeed, informed choice, or the principle that individuals must have access to information, including the benefits and health risks, on a wide variety of family planning methods, is a fundamental tenet of policies governing the provision of family planning counseling and services.^{38,39} Being fully informed also helps women make choices that are responsive to their reproductive intentions, lifestyles, and expectations around side effects, which influence discontinuation.⁴⁰ However, although knowledge of different methods is necessary, it is not sufficient. Women's negative beliefs and misconceptions around contraception are also associated with low uptake and discontinuation.^{11,12,40-42} Examples of common misconceptions in Senegal include the belief that modern methods will make a woman sterile, cause cancer, or cause other harmful health effects.¹¹

In the emotional domain, contraceptive self-efficacy is a woman's belief in her ability to take actions required for successful family planning.⁴³ Self-efficacy theories emphasize that an individual's belief in his/her ability to execute key health behaviors is critical to the successful completion of those behaviors, and the association between high contraceptive self-efficacy and contraceptive intention and use is well documented.⁴³⁻⁴⁷

In the social domain, there are three indicators including a male partner's approval/disapproval of FP use, communication with a partner about FP, and social support for

FP use. Male partners often hold more decision-making power in relationship dynamics and this has historically influenced women's participation in family planning.^{13,14,48–52} Particularly in countries like Senegal where there is high gender inequality and where intimate partner violence is a social norm, perceptions of partner disapproval of FP can deter women from contraceptive consideration, uptake, and continuation.⁵³ Relatedly, communication between partners about FP is strongly predictive of FP readiness, intention, and use.^{49,50,54,55}

Beyond male partners, a woman's belief that there is social and community support for her use of FP also creates an environment in which she is enabled and empowered to consider family planning.^{41,42,56–58} Finally, Table 2 also shows which indicators have been previously used to create contraceptive ideational profiles among urban women of reproductive age in Nigeria.²⁴

Once we selected theory- and evidence-based domains and indicators of our latent variable, we created constructs using the available variables in the MLE dataset. Table 3 presents an overview of how the six indicators were constructed. Three indicators were continuous constructs comprised of multiple survey questions. For FP awareness, women were asked to name any FP methods they knew. When they had listed all methods they knew, they were then prompted on whether they had heard of other methods that they had not spontaneously listed. For each method that a woman mentioned spontaneously, she received a score of 1 point. For each method that she had heard of when prompted, she received 0.5 points. Points were summed and the resulting construct had a range of 0 to 13. For misconceptions, women were asked whether they totally agreed, agreed, disagreed, or totally disagreed with seven statements about common negative misconceptions about FP. Responses received -2, -2, 2, and 2 points, respectively, such that high scores indicated a strong rejection of misconceptions and low scores represented a strong belief in misconceptions (range of -14 to 14). Perceived self-efficacy was scored in the

same way for eight questions about a woman's beliefs about her ability to act on her contraceptive intentions (range of -16 to 16). For constructs that were a composite of multiple variables, we examined Cronbach's alpha to test whether the variables reliably measured the same phenomenon and found satisfactory internal consistency. We also reviewed the shape and variance of the indicators and explored collapsing or bifurcating indicators.

To better understand how these indicators related to each other at baseline and endline, we also calculated a correlation matrix (Table 4). This matrix demonstrated that there was relatively low correlation (<0.40) across the indicators suggesting that the indicators represented related but distinct ideational concepts.

Once the indicators were defined, we used a modified three-step approach to LPA.^{59–63} In Step 1, we estimated the latent profile model using only the hypothesized indicators (no covariates) at baseline and endline using maximum likelihood and selected the most appropriate number of classes based on the model fit statistics using Mplus8 software.⁶⁴ Because there is sensitivity of the likelihood function to converge on a local, instead of a global, solution in mixture models, we used 500 random start values to establish a global maximum and avoid local solutions.⁶⁵ We accounted for the complex survey design methodology used in the original data collection by using sampling weights at the city level in the analysis and also accounting for the cluster design in the calculation of the standard errors.⁶⁶ Models with two to eight profiles were estimated. We estimated a maximum of eight profiles because at eight profiles, some of the profiles had very low membership, entropy was consistently low, and profiles were less meaningful in interpretation. We selected the optimal model by evaluating goodness-of-fit statistics that evaluate model fit and parsimony, balancing these indicators with interpretability and practicality for both baseline and endline data. These measures included the Akaike

information criteria (AIC), Bayesian information criteria (BIC), sample-size adjusted BIC, and the Lo-Mendell-Rubin (LMR) adjusted likelihood ratio test.^{30,31,67} AIC and BIC are both log likelihood-based statistics that compare competing models by identifying the best model fit for the smallest number of parameters.^{68–70} The AIC statistic tends to favor more complex models while the BIC and the adjusted BIC tend to represent the fewest number of profiles that should be selected. For AIC, BIC, and ABIC, the model with the smallest statistic indicates the best model fit. LMR is a log likelihood ratio test that compares the model with $k-1$ classes to one with k classes and tests for significance. All the goodness-of-fit statistics were considered together to select the best model. We also examined entropy as a standardized index of model-based classification accuracy, where higher values (>0.80) indicate a better separation between profiles and a more precise assignment of individuals to latent profiles.⁷¹

In Step 2, we assigned women to their most likely profile based on the latent profile posterior probabilities generated in Step 1. The posterior probability measures the certainty of an individual's profile membership based on their item-response patterns. Individuals who have a response pattern that fits closely with Profile X have a high probability of membership in Profile X and a low probability of membership in other profiles. We used these item-response probabilities to characterize and label each of our identified profiles. Also in Step 2, we used the posterior probabilities to calculate a special weighting variable that accounts for the uncertainty around the class assignment.^{59,61,72} The Bolck, Croon, and Hagnaars (BCH) method estimates class-specific probabilities and standard errors for binary and categorical outcomes by using a misclassification matrix D where row a and column b represent the estimated probability that a subject who is truly a member of Profile A would be labeled as a member of Profile B.^{61,73,74} Modified BCH weights are group-specific weights that are the inverse of a matrix of

classification probabilities for the most likely latent profile membership (column) by latent profile (row).⁶¹

In Step 3, we introduced four demographic covariates into the model to identify characteristics that predict membership in the latent profiles. These covariates included age (categorical; youth: 15–24, adult: 25–34, mature: 35–49), wealth quintile, education level (categorical; no education/Koranic only, primary education, secondary education or higher) and number of children born (“parity”; count; 0–16). This analysis helped us understand the demographic makeup of the profiles. We used a multinomial logistic regression with a bias-correction method to estimate the effect of each covariate for each latent profile in comparison to the reference latent profile.³⁰

Finally, we estimated the expected value of our binary distal FP and health communication outcomes of interest for each profile using the BCH method to account for the uncertainty in our profile assignments. For family planning, we examined current use of a modern FP method among all women and intention to use any FP method in the next twelve months among women not currently using a method. The World Health Organization defines modern methods as including male and female sterilization, daily oral pill, intra-uterine devices (IUDs), implants, injectables, male and female condoms, emergency contraception, Standard Days Method (SDM), and lactational amenorrhea (LAM).⁷⁵ For health communication, we examined differences in self-reported principal sources of health information across profiles. Women were asked to list their principal sources of health information and were prompted for media, medical, community, and interpersonal sources. We estimated the expected value of these distal outcomes within each latent profile by taking a weighted average of the observed values

for all participants. Last, we used a Wald chi-square test to compare the expected values between each pair of latent profiles, which tests the null hypothesis that the expected values are equal.

Results

Table 5 presents the weighted demographic characteristics of in-union women included in the balanced sample at both baseline and endline (n=4,047). At baseline, nearly 43 percent of women were aged 35–49 and 41 percent of women were 25–34. Most women were Muslim (94.0%) and had two or more children (73.7%). Most women were not currently using a modern method (74.0%) but had used some type of contraceptive method in their lives (62.1%). Between baseline and endline, the proportion of women who used a modern method increased from 26 percent to 35 percent.

Model Selection and Interpretation

Table 6 presents the model fit statistics for the latent CIPs at baseline and endline. AIC, BIC, and adjusted BIC statistics decreased marginally as the number of profiles increased at both baseline and endline, until the number of profiles became high and the proportional membership became very small for some profiles. The LMR test, which tests for significance of the k-1 profiles, indicated that the three-profile solution was preferable at a $p < 0.05$ threshold at baseline. Entropy (0.77) was only slightly below the 0.8 target for the three-profile solution at baseline, indicating that there was moderate separation between profiles. We selected a three-profile solution at baseline based on a balanced assessment of model fit statistics and interpretability of the profiles at baseline. At endline, we selected a two-profile solution. The LMR test indicated that a two-profile solution was preferable to a three-profile solution. Entropy for the two-profile solution at endline (0.77) was similar to the three-profile solution at baseline and larger than models with more profiles.

Labeling CIPs relies on qualitative interpretation of the item-response probabilities. Extreme item-response probabilities are more influential and help shape the interpretation of that profile. Table 7 presents the mean item-response probabilities for each indicator as well as the overall proportion of women included in each profile at baseline and endline. Baseline CIP 2 and endline CIP 1 were qualitatively similar, as were baseline CIP 3 and endline CIP 2. Table 7 juxtaposes the two-profile endline solution against the three-profile solution selected at baseline to clarify how the profiles differ. There was good separation (no overlap) between the item-response probabilities in endline CIPs 1 and 2. At endline, there was not a profile that was analogous to CIP 1 at baseline and that is represented by the greyed-out column.

To support the interpretation of the profiles at baseline and endline given different scales of the underlying indicators, we calculated and visualized z-scores to understand the relative strength and contribution of the indicators relative to the mean of the overall population (Figure 3). Table 7 and Figure 3 aided in the descriptive naming of the profiles.

Baseline CIP 1: Lowest FP ideation scores

For the baseline three-profile model, women in CIP 1 had relatively low contraceptive awareness, were more likely to believe myths and misconceptions around FP, and had very low perceived self-efficacy. Even when standardized to the mean of the population, the average score for perceived self-efficacy was the most extreme indicator for this group indicating that women in this profile reported very low ability to act on their FP decisions. Women in this group also were least likely to report that their partner would accept their use of FP, to have discussed FP with their partners in the past six months, and to believe that their communities would support their decisions to use FP. Baseline CIP 1 had the smallest proportional membership with only 6 percent of women being assigned to this profile.

Baseline CIP 2: Average-low FP ideation scores

In baseline CIP 2, women had moderate contraceptive awareness, fairly neutral agreement or disagreement with common misconceptions about FP, and neutral perceived self-efficacy. For these three indicators, women in CIP 2 had significantly higher scores than women in CIP 1. This was also true for FP communication, though only marginally. However, women in CIP 2 were just as unlikely to believe that their communities would support their decisions to use an FP method and to report that their partners would allow them to use FP compared to women in CIP 1. We also note from Figure 3 that women in CIP 2 still had, on average, lower scores than the general population. Twenty-seven percent of women were assigned to baseline CIP 2.

Baseline CIP 3: High FP ideation scores

In baseline CIP 3, women had the highest average scores for contraceptive awareness, perceived self-efficacy, partner acceptance of FP use, discussion of FP with their partners in the past six months, belief that their communities would support their decisions to use an FP method, and were the most likely to reject myths and misconceptions. Although there were some overlaps in indicator confidence intervals between CIP 1 and CIP 2, CIP 3 had no overlapping attributes with CIP 1 or CIP 2. On average, women in baseline CIP 3 had much higher scores than the overall population. Baseline CIP 3 had the largest proportional membership with 67 percent of women.

Endline CIP 1: Neutral-low FP ideation scores

Endline CIP 1 item response probabilities were not significantly different from those in baseline CIP 2 except for having slightly lower perceived self-efficacy. We do not find this to be a qualitatively meaningful difference, however, and therefore maintain the label of Neutral-low FP ideation scores. Twenty-one percent of women were assigned to endline CIP 1.

Endline CIP 2: High FP ideation scores

Endline CIP 2 had significantly higher scores for all indicators compared to Baseline CIP 1 and 2 and Endline CIP 1. Compared with women in baseline CIP 3, women in endline CIP 2 had significantly higher awareness and more strongly rejected misconceptions. However, compared to baseline CIP 3, endline CIP 2 had lower self-efficacy and less partner communication. Compared to baseline CIP 3, endline CIP 2 had statistically similar reported likelihood of a partner forbidding FP and perceived community support. Although there were nuanced differences between endline CIP 2 and baseline CIP 3, we retained the naming convention of “High FP ideation scores” for simplicity and because there were no extreme or meaningful differences between the underlying indicators. The majority of women (79%) were assigned to endline CIP 2.

To examine whether the inclusion of women lost to attrition resulted in different profile selection and/or interpretation, we ran an LPA model at baseline that included in-union women who did not respond at endline (n=5,353) and compared those model results with the LPA results of the restricted longitudinal sample at baseline (n=4,047). Both models suggested a three-profile solution and there were no statistically significant or meaningful differences between the item response probabilities for any indicator in either profile. That is, for every indicator’s item response probability there was no overlap of the unrestricted and restricted sample 95% confidence intervals. One difference we did note was that in the unrestricted model, there were slightly higher proportions of women in baseline CIPs 1 and 2, and a slightly smaller proportion of women in baseline CIP 3. This is not surprising, given that we might expect a higher loss-to-follow-up among less empowered women. However, the exclusion of those women did not change the interpretation of the profiles at baseline, so we moved forward with the assumption

that the same was true at endline. We therefore used the restricted longitudinal sample (n=4,047) in all further analyses.

Covariates

Table 8 presents the odds ratios for key demographic predictors for CIP membership. Including all five demographic covariates enable the assessment of the effects of each covariate while the effects of the other covariates are fixed.³⁰ Overall, age group was not significantly associated with changes in the odds of any profile membership and none of the demographic covariates were significant in predicting differences in the odds of membership between CIP 1 and CIP 2 at baseline. Only having a primary education, compared to no education, was significantly associated with higher odds of membership in CIP 3 compared to CIP 1 at baseline. The small proportional memberships of baseline CIPs 1 and 2 may have contributed to the limited number of effects detected for these profiles. Increased wealth (compared to the poorest wealth quintile), having a primary or secondary education, and higher parity were all associated with higher odds of membership in CIP 3 compared with CIP 2 at baseline. Residence in the city of Mbao compared with Dakar was associated with significantly lower odds of CIP 3 membership compared with CIP 2 at baseline. At endline, wealth was not significant in predicting CIP membership, but higher education and additional children were again associated with significantly higher odds of endline CIP 2 membership compared to CIP 1 membership. Residence in the cities of Mbao and Kaolack were associated with significantly lower odds of endline CIP 2 membership.

Distal Outcomes of Interest

Family Planning Use and Intention

Table 9 presents our estimation of the mean of the distal outcomes of interest for each latent profile using BCH weights. At baseline, the mean current modern method use (where use=1) in CIP 1, 2, and 3 was 0.022, 0.018, and 0.447, respectively. Baseline CIPs 1 and 2 did not have statistically significant ($p=0.87$) differences in expected modern FP use. However, the expected modern method use in baseline CIP 3 was significantly higher ($p=0.000$) than in CIPs 1 and 2. We also compared mean intention to use any method in the next 12 months among non-users, where no intention was coded as 0, unsure/don't know was coded as 1, and intention to use was coded as 2. We found that among non-users, members of CIP 1 had the lowest mean intention to use, members of CIP 2 had a medium mean intention to use, and members of CIP 3 had the highest mean intention to use. Wald chi-square tests confirmed that CIP 1 was significantly lower than CIP 2 and CIP 2 was significantly lower than CIP 3 ($p<0.000$). At baseline, the mean current modern method use among members of CIPs 1 and 2 was 0.048 and 0.466, respectively, and a Wald test confirmed that these were statistically different ($p<0.000$). Among non-users at baseline, members of CIP 1 had a mean intention to use of 0.185 which was statistically lower than the mean intention to use in CIP 2 ($p<0.000$).

Sources of Health Information

Table 10 presents the BCH-weighted mean self-reported principal sources of health information across profiles at baseline and endline. Women could report multiple sources. Across all CIPs at baseline and endline, TV was the most common source of health information. The top five sources within CIP 1 and CIP 2 at baseline were TV, friends/neighbors, midwives, radio, and doctors. Baseline CIP 3 was very similar except the order of midwives and friends/neighbors was reversed. A second overall trend was that women in higher profiles were

significantly more likely to cite a higher total number of sources, indicating that women with more empowered ideational profiles rely on or have access to more diverse sources of health information. Across CIPs at baseline and endline, there were no specific sources that were more likely to be cited by lower empowered profiles than higher empowered profiles, although overall women in endline CIP 1 were more likely to cite any interpersonal source than women in endline CIP 2.

To better understand how women and CIP membership changed over time, we examined how women were classified at both baseline and endline (Table 11). Women who were assigned to baseline CIP 1 split about evenly to assignment into endline CIP 1 and endline CIP 2. This represents improvement in contraceptive ideation for the entire group, though with more progress for women assigned to endline CIP 2. One-third of women who were assigned to baseline CIP 2 were assigned to the comparable CIP 1 at endline, indicating that there was not much change among these women. However, two-thirds of women demonstrated improved contraceptive ideation in their assignment to CIP 2 at endline. Most women (87%) who were assigned to CIP 3 at baseline were assigned to CIP 2 at endline indicating that the characteristics of this group did not change substantially. Thirteen percent of women assigned to baseline CIP 3 were assigned to endline CIP 1, indicating regressive contraceptive ideation.

Discussion

This study was the first to apply latent profile analysis as a person-centered approach to understand contraceptive ideation and decision-making in Senegal. We applied a theoretical framework that built on contraceptive profile research from other sub-Saharan African countries and hypothesized that there were empirically meaningful latent profiles of women who shared patterns of contraceptive ideation based on cognitive, social, and emotional factors. Using

longitudinal data for urban women of reproductive age, we identified discrete profiles of women with distinct characteristics and described how these profiles evolved over time. Contrary to our expectation that there might be larger number of profiles with one or two driving indicators, we found that cognitive, social, and emotional factors all moved together in the same direction, resulting in somewhat stepwise disempowered, neutral, and positive contraceptive ideation at baseline and neutral and positive contraceptive ideation at endline.

| <u>Baseline Contraceptive Ideation Profiles</u> | <u>Endline Contraceptive Ideational Profiles</u> |
|--|---|
| CIP 1: Lowest FP ideation scores (6%) | [No comparable CIP] |
| CIP 2: Neutral/low FP ideation scores (27%) | CIP 1: Neutral/low FP ideation scores (21%) |
| CIP 3: High FP ideation scores (67%) | CIP 2: High FP ideation scores (79%) |

At baseline and endline, women in CIP 1 were strongly characterized by their lack of perceived self-efficacy, though their average scores on all indicators were low. This finding suggests that women in CIP 1 may therefore benefit from specific motivational and empowering messaging and interventions in addition to interventions that provide more general knowledge, combat misconceptions, and strive to create a more enabling social environment. Although women in CIP 2 at baseline had much higher self-efficacy scores, higher knowledge, and fewer misconceptions on average compared to women in CIP 1 at baseline, they reported being just as unsupported by their partners and communities as women in CIP 1. This suggests that for both groups, programs should not just focus interventions on women themselves but also engage with those who influence and shape their decision making (religious and civic leaders, male partners, families). The fact that women in CIP 2 did not have statistically different FP use than women in

CIP 1 points to the importance of social and partner influences on FP use. However, the fact that a significantly greater proportion of non-users in CIP 2 intended to use FP compared to CIP 1 validates our theory that a narrow focus on behavioral outcomes misses more subtle but still important changes in contraceptive ideation that can be explored in the process of ideational profiling.

Although women in CIP3 at baseline and in CIP 2 at endline achieved relatively higher scores than their peers on all indicators, these proportionately largest groups of women should not be ignored by programs because of opportunities for increasing absolute scores. For example, although women in CIP 3 at baseline had the highest scores for all ideational factors, substantially higher scores could be achieved for most indicators. Scores for contraceptive awareness could increase by approximately 40 percent, rejection of misconceptions by 30 percent, perceived self-efficacy by 20 percent, FP partner communication by 40 percent, and social support by 30 percent. Overall, a general education and outreach campaign might be the best approach to increase scores across the board.

The finding that women in more empowered CIPs relied on a wider variety of health information sources than women in less empowered CIPs was not surprising but it was surprising that they also reported higher reliance on sources typically associated with traditional or last-mile access compared to women in less empowered CIPs. For example, we would have expected that women in CIP 1 at baseline might report significantly higher reliance on interpersonal sources, community sources, pharmacists, traditional healers, and community health workers (CHWs) than women in CIP 3 but this was not the case. Instead, what we found suggests that women across CIPs consume health information from different sources in proportionally similar ways but at a lower intensity for women in lower CIPs. The implications for health communication

decision makers are that they might need to use a wider variety of sources to reach women in lower CIPs but that in general the same channels can be used to reach all CIPs. Additionally, the insights about where women in different CIPs receive health information can inform the development of decision alternatives (interventions, policies, etc.) for improving contraceptive ideation, intention, and use in Senegal. Quantifying the potential reach of modalities across CIPs could also be used as a critical input to decision analysis assessing the relative cost-effectiveness of each alternative. The impact of identified decision alternatives would need to be further studied.

Finally, the finding that the “lowest FP ideation scores” profile (CIP 1) identified at baseline did not re-emerge at endline indicated overall ideational transition toward more empowered CIPs over time. All women in baseline CIPs1 and 2 moved into ideational states with higher indicator scores. Given changes in the number and structure of CIPs over time, it may not be immediately apparent which CIPs exist in a population at a given time and thus who to target for which intervention. To benefit from this approach, health programs and policy makers would need to ensure that ideational variables are collected periodically, potentially annually, from a representative sample to identify and respond to changing ideational patterns in the population.

Limitations

This study had several limitations. First, although the selection of indicators was driven by a theoretical framework, prior research, and scientific evidence of relationships between indicators and contraceptive ideation and use, there was still some subjectivity in the selection of indicators given the rich dataset, which offered multiple nuanced ways in which to define and measure the indicators. However, though the indicators were not psychometrically validated,

these indicators reflect important theory-driven and evidence-based factors of contraceptive decision making and were developed from available variables in MLE baseline and endline surveys. Further, some discarded indicators may have been theoretically relevant but had high correlation with other indicators or were internally inconsistent (for constructs). Our extensive examination and testing of various combinations and functional forms of potential indicators suggest that the relevant facets of contraceptive ideation were represented and provided meaningful insight into latent profiles of women. Relatedly, the use of secondary data meant that we could not capture all the variables that might have been theoretically relevant.

A second limitation was that the entropy scores at both baseline and endline were slightly lower than the desired 0.80 threshold. This indicates a greater degree of classification uncertainty and can bias the qualitative interpretation of profiles. A higher entropy score would have made a stronger argument for the cohesiveness and the utility of these latent profiles. However, we addressed much of the uncertainty through the three-step approach and use of BCH weights. We further emphasize that profile membership is an indicator of contraceptive ideation which, at a national level, will include some variance and nuances within groups.

A final limitation of this study was the finding that the majority of women at baseline and endline were already members of the most empowered CIPs. At face value, decision makers at policy and programmatic levels might interpret this finding as an indication that either this approach lacks nuance or that the population generally has positive ideation and requires limited intervention. One approach that can be taken in the future to address the former concern is to be more intentional about the selection of a larger number of CIPs using the justification that the actionability of the insights outweigh slight improvements in overall model fit. However, we believe that the more than 20 percent of women who were members of less empowered CIPs

constitutes a large enough population of interest for policy makers eager to see ideational and behavioral changes in these key populations. Furthermore, the identification of CIP characteristics can inform development of messaging specific to different women, potentially addressing unmet need.

Conclusion

This study applied a person-centered methodology to identify prototypical patterns of individual contraceptive ideation among in-union urban women of reproductive age in 2011 and 2015 in Senegal. The CIPs that this study identified indicate that contraceptive ideation and decision making are complex phenomena that rely on interrelated social, cognitive, and emotional factors. Although analyses such as the one presented here cannot capture every facet that contributes to contraceptive ideation, intention, and ultimate use, these types of analyses offer more insight and direction to FP communication programs than do traditional socio-demographic segmentation exercises. This study demonstrated the utility of the development of contraceptive ideational profiles and suggested real-world applications of communication programming based on these findings.

As the Department of Reproductive Health and Child Survival (DSRSE) in Senegal finalizes the next National Strategic Framework for FP (CSNPF) and sets ambitious new targets for FP2030, policymakers should consider the introduction of contraceptive ideational profiling to complement and enhance current SBC approaches. Standardizing the development and use of contraceptive ideational profiles on a periodic basis will improve the ability of decision makers and health communication programs to identify the ideational states and needs of the population and respond effectively to those needs through national programming and allocation of financial

and human resources. Future research might build on these findings to explore how specific health communication programming exposures influence transition between CIPs over time.

Figures

Figure 2. Latent Profile Analysis Conceptual Model

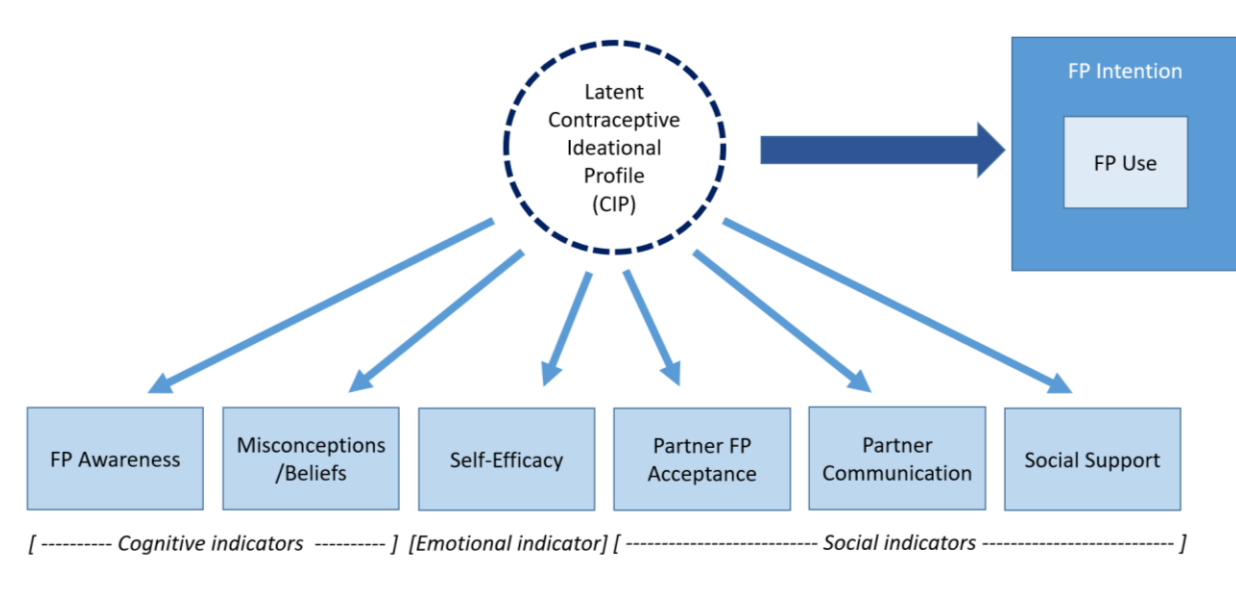
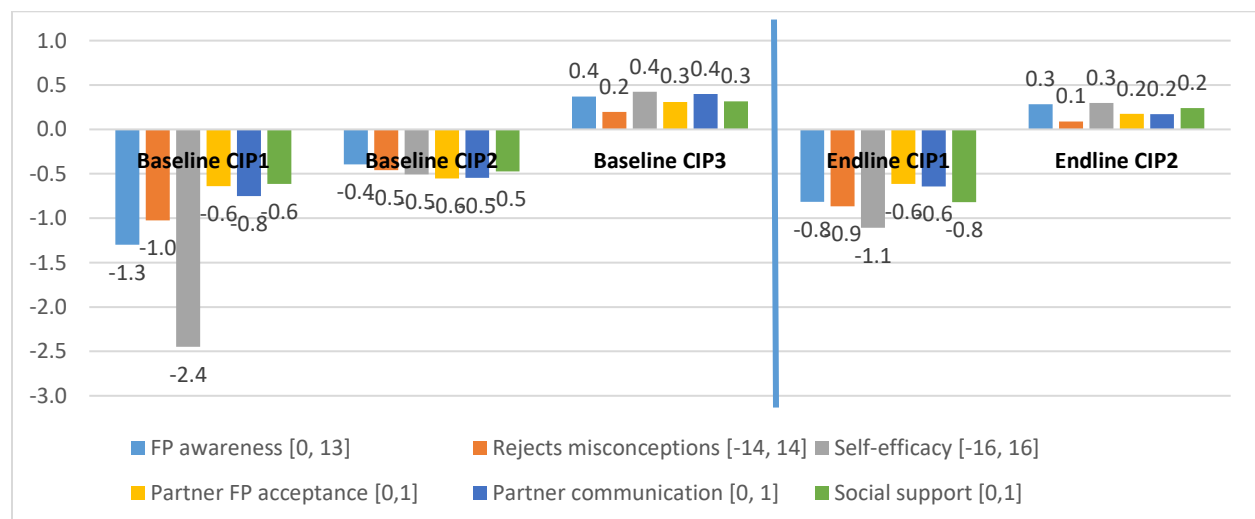


Figure 3. Item Response Probability z-scores at Baseline and Endline



Tables

Table 2. Evidence of Important Ideational Constructs in Contraceptive Decision Making

| Domain | Indicator (Construct) | Justification | Evidence Citation | Indicator in previous CIP analyses²⁴ |
|---------------|---|--|--------------------------|--|
| Cognitive | FP awareness and knowledge | Women who have low levels of knowledge or awareness of contraceptive methods are unable to make informed decisions around contraceptive uptake and continuation | 14,36,37 | ✓ |
| | FP beliefs, misconceptions, values, and attitudes | Women who hold misconceptions or negative beliefs about contraception are less likely to use FP | 11,12,40–42 | ✓ |
| Emotional | Efficacy beliefs/ Self-efficacy/ Autonomy | Higher levels of confidence in one's ability to take action is positively associated with contraceptive intention to use, uptake, and continued use | 15,43,47,76–78 | ✓ |
| Social | Partner FP acceptance | Male partners can influence a woman's uptake of contraception based on her perceptions of his approval or disapproval | 13,14,48–52 | ✗ |
| | Partner communication | Women's perception of the acceptability and normalcy of communication about FP between husbands and wives can influence her contraceptive decision-making | 49,50,54,55 | ✓ |
| | Social/community support | Women who feel comfortable discussing FP with their spouse, friends, or family, or who believe that there is community acceptance of FP are more likely to use contraception | 41,42,56–58 | ✓ |

Table 3. Overview of Selected Indicators of Contraceptive Ideation

| Indicator | Indicator Description | Survey Questions |
|--|---|---|
| FP Awareness <u>Baseline</u> Range: [0, 13] Mean (SE): 6.14 (0.03) Cronbach's alpha: 0.72 Missing n (%): 49 (1.2%) <u>Endline</u> Range: [0, 13] Mean (SE): 6.92 (0.08) Cronbach's alpha: 0.77 Missing n (%): 19 (0.5%) | All contraceptive methods mentioned unprompted received a score of 1; methods acknowledged after interviewer prompting received a score of .5. Scores were summed across contraceptives to create an overall awareness indicator of 0 to 13. Higher values indicate higher awareness of methods. | Heard of female sterilization |
| | | Heard of male sterilization |
| | | Heard of oral pills |
| | | Heard of IUD |
| | | Heard of injectables |
| | | Heard of implants |
| | | Heard of male condoms |
| | | Heard of female condoms |
| | | Heard of emergency contraception (EC) |
| | | Heard of rhythm method |
| | | Heard of withdrawal |
| Rejection of FP Myths and Misconceptions <u>Baseline</u> Range: [-14, 14] Mean (SE): 3.03 (0.30) Cronbach's alpha: 0.90 Missing n (%): 96 (2.4%) <u>Endline</u> Range: [-14, 14] Mean (SE): 5.21 (0.20) Cronbach's alpha: 0.87 Missing n (%): 10 (0.3%) | This indicator summarizes responses to seven questions about common myths and misperceptions about FP. Possible responses included: totally agree (-2), agree (-1), don't agree (1), and totally disagree (2). Responses were summed to create an indicator with values ranging from -14 to 14. Higher values indicate stronger rejection of myths and misconceptions. | Being injected with a contraceptive product makes a woman permanently sterile |
| | | People who use contraceptives end up having health problems |
| | | Contraceptives can harm the uterus |
| | | Contraceptives reduce sexual desire |
| | | Contraceptives can cause cancer |
| | | Contraceptives can cause birth defects |
| | | Contraceptives are dangerous for one's health |
| | | |
| Perceived Self-Efficacy <u>Baseline</u> Range: [-16, 16] Mean (SE): 5.69 (0.22) Cronbach's alpha: 0.81 Missing n (%): 52 (1.3%) <u>Endline</u> Range: [-16, 16] Mean (SE): 5.06 (0.24) Cronbach's alpha: 0.79 | The contraceptive efficacy beliefs indicator uses eight questions about a woman's ability to act in her own interest regarding family planning use. Possible responses included: totally agree (2), agree (1), don't agree (-1), and totally disagree (-2). Responses were summed to create an indicator with values ranging from -16 to 16. | Able to initiate conversation about family planning with partner |
| | | Able to convince partner that you should use FP |
| | | Able to go to a place where FP is available to get an FP method if desired |
| | | Able to obtain a method |
| | | Able to use a method even if partner doesn't want to |

| | | |
|--|--|---|
| <i>Missing n (%): 10 (0.3%)</i> | Higher values indicate higher perceived self-efficacy. | Able to use a method even if none of your friends or neighbors use one |
| | | Able to use family planning even if your religious leader did not approve |
| | | Able to use a method even if have side effects |
| Partner FP acceptance <u>Baseline Statistics</u> Range: [0, 1] Mean (SE): 0.81 (0.01) Missing n (%): 288 (5.6%) <u>Endline Statistics</u> Range: [0, 1] Mean (SE): 0.83 (0.01) Missing n (%): 236 (5.3%) | This indicator represents whether a partner forbids FP use (does not forbid=1). | Does your partner forbid FP? |
| Partner Communication <u>Baseline</u> Range: [0, 1] Mean (SE): 0.41 (0.01) Missing n (%): 10 (0.3%) <u>Endline</u> Range: [0, 1] Mean (SE): 0.36 (0.01) Missing n (%): 240 (5.9%) | The partner communication indicator is a binary indicator that indicates whether a woman has discussed FP with her partner in the last six months (yes=1). | Have you discussed FP with your partner in the last six months? |
| Perceived Social Support <u>Baseline</u> Range: [0, 1] Mean (SE): 0.50 (0.02) Missing n (%): 7 (0.2%) <u>Endline</u> Range: [0, 1] Mean (SE): 0.57 (0.02) Missing n (%): 6 (0.2%) | The Social Support indicator includes one question about perceived support for FP use by community members (yes=1) | Are there people in your community who would congratulate you for using FP? |

Estimates account for six-city probability weights and clustering at district level

Table 4. Correlation Matrix for Indicators at Baseline and Endline

| | Indicator 1 | Indicator 2 | Indicator 3 | Indicator 4 | Indicator 5 | Indicator 6 |
|------------------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Baseline (2011) | | | | | | |
| Indicator 1 | 1.00 | | | | | |
| Indicator 2 | 0.07 | 1.00 | | | | |
| Indicator 3 | 0.39 | 0.34 | 1.00 | | | |
| Indicator 4 | 0.25 | 0.14 | 0.28 | 1.00 | | |
| Indicator 5 | 0.14 | 0.18 | 0.29 | 0.18 | 1.00 | |
| Indicator 6 | 0.18 | 0.17 | 0.26 | 0.14 | 0.12 | 1.00 |
| Endline (2015) | | | | | | |
| Indicator 1 | 1.00 | | | | | |
| Indicator 2 | 0.19 | 1.00 | | | | |
| Indicator 3 | 0.36 | 0.31 | 1.00 | | | |
| Indicator 4 | 0.25 | 0.19 | 0.27 | 1.00 | | |
| Indicator 5 | 0.17 | 0.16 | 0.21 | 0.18 | 1.00 | |
| Indicator 6 | 0.24 | 0.18 | 0.35 | 0.23 | 0.12 | 1.00 |

Indicators

1. *FP awareness*
2. *Rejects misconceptions*
3. *Perceived self-efficacy*
4. *Partner FP communication*
5. *Partner FP acceptance*
6. *Social support*

Table 5. Demographic Characteristics of Women in Balanced Sample (n=4,047)

| Demographic Characteristics | Baseline N (weighted %) | Endline N (weighted %) |
|----------------------------------|----------------------------|---------------------------|
| Age | | |
| Adolescent (15-19) | 164 (3.3%) | 9 (0.1%) |
| Youth (20-24) | 641 (13.2%) | 209 (5.1%) |
| Adult (25-34) | 1,643 (40.8%) | 1,550 (37.2%) |
| Mature (35-49) | 1,599 (42.8%) | 2,279 (57.5%) |
| Religion | | |
| Muslim | 3,905 (94.0%) | 3,962 (94.3%) |
| Christian | 137 (5.6%) | 125 (5.4%) |
| Other | 4 (0.4%) | 9 (0.2%) |
| Missing | 1 (0.0%) | 1 (0.0%) |
| Education | | |
| None or Koranic only | 1,825 (38.7%) | 1,852 (40.9%) |
| Primary | 1,485 (37.9%) | 1,452 (35.8%) |
| Secondary or higher | 737 (23.4%) | 741 (23.3%) |
| Missing | 0 (0.0%) | 2 (0.0%) |
| Parity | | |
| No children | 425 (10.4%) | 166 (3.5%) |
| 1 child | 627 (15.9%) | 333 (9.8%) |
| 2 children | 675 (16.9%) | 679 (17.8%) |
| 3 children | 616 (15.8%) | 740 (19.6%) |
| 4 children | 493 (11.6%) | 641 (16.2%) |
| 5 or more children | 1,211 (29.4%) | 1,488 (33.1%) |
| Wealth quintile | | |
| Poorest | 745 (16.7%) | 745 (22.8%) |
| Second | 873 (21.3%) | 873 (20.6%) |
| Middle | 954 (21.1%) | 954 (18.2%) |
| Fourth | 829 (20.5%) | 829 (21.2%) |
| Richest | 646 (20.3%) | 646 (17.1%) |
| City of residence | | |
| Dakar | 595 (36.4%) | 612 (36.7%) |
| Guédiawaye | 481 (11.0%) | 470 (10.6%) |
| Pikine | 488 (13.2%) | 465 (12.1%) |
| Mbao | 436 (22.5%) | 478 (24.1%) |
| Mbour | 999 (8.1%) | 1,002 (7.9%) |
| Kaolack | 1,048 (8.7%) | 1,020 (8.5%) |
| Contraceptive use | | |
| Currently using a modern method* | 1,168 (26.0%) | 1,534 (35.2%) |
| Have ever used any method | 2,314 (62.1%) | 2,898 (74.5%) |

*Modern methods include: pill, implant, IUD, injectables, male or female condoms, male or female sterilization, emergency contraception, LAM

Weighted using baseline and endline six-city probability weights

Table 6. Model Fit Statistics for Latent Profile Analyses at Baseline and Endline

| Statistic | 2 Profiles | 3 Profiles | 4 Profiles | 5 Profiles | 6 Profiles | 7 Profiles | 8 Profiles |
|------------------------|------------|------------|------------|------------|------------|------------|------------|
| Baseline (2011) | | | | | | | |
| Log likelihood | -40,492 | -40,365 | -40,275 | -40,195 | -40,146 | -40,098 | -40,040 |
| AIC | 81,416 | 80,777 | 80,611 | 80,464 | 80,381 | 80,299 | 80,095 |
| BIC | 81,517 | 80,922 | 80,800 | 80,697 | 80,658 | 80,620 | 80,461 |
| Adjusted BIC | 81,466 | 80,849 | 80,705 | 80,580 | 80,518 | 80,458 | 80,276 |
| LMR LRT | 2,523 | 642 | 176 | 158 | 95 | 93 | 99 |
| LRT p-value | 0.010 | 0.047 | 0.486 | 0.681 | 0.691 | 0.609 | 0.708 |
| Entropy | 0.844 | 0.769 | 0.676 | 0.722 | 0.643 | 0.672 | 0.690 |
| Endline (2015) | | | | | | | |
| Log likelihood | -40,331 | -40,051 | -39,899 | -39,802 | -39,774 | -39,731 | -39,662 |
| AIC | 80,695 | 80,148 | 79,859 | 79,679 | 79,636 | 79,565 | 79,440 |
| BIC | 80,795 | 80,293 | 80,048 | 79,912 | 79,914 | 79,887 | 79,806 |
| Adjusted BIC | 80,745 | 80,220 | 79,953 | 79,795 | 79,774 | 79,725 | 79,621 |
| LMR LRT | 2,105 | 551 | 297 | 190 | 55 | 66 | 74 |
| LRT p-value | 0.025 | 0.055 | 0.479 | 0.351 | 0.796 | 0.718 | 0.373 |
| Entropy | 0.766 | 0.669 | 0.743 | 0.742 | 0.676 | 0.658 | 0.745 |

Table 7. Mean Item Response Probabilities for Selected Models at Baseline and Endline

| Baseline Indicator [Response range] | Baseline CIP 1 Mean [95% CI] | Baseline CIP 2 Mean [95% CI] | Baseline CIP 3 Mean [95% CI] |
|---|---------------------------------|---------------------------------|---------------------------------|
| FP awareness [0, 13] | 3.65 [3.05 – 4.25] | 5.31 [4.92 – 5.70] | 6.71 [6.60 – 6.81] |
| Rejects misconceptions [-14, 14] | -4.19 [-6.68 – -1.70] | -0.02 [-0.89 – 0.86] | 4.80 [3.94 – 5.66] |
| Perceived self-efficacy [-16, 16] | -11.16 [-12.96 – -9.37] | 2.20 [0.92 – 3.48] | 8.59 [8.06 – 9.12] |
| Partner FP acceptance [0,1] | 0.55 [0.44 – 0.65] | 0.58 [0.51 – 0.61] | 0.92 [0.90 – 0.95] |
| FP communication in past 6 months [0, 1] | 0.02 [0.00 – 0.04] | 0.12 [0.05 – 0.18] | 0.57 [0.53 – 0.62] |
| Social support [0,1] | 0.17 [0.08 – 0.27] | 0.24 [0.16 – 0.32] | 0.64 [0.59 – 0.69] |
| Proportional membership | 0.06 | 0.27 | 0.67 |
| Endline Indicator [Response range] | Endline CIP 1 Mean [95% CI] | Endline CIP 2 Mean [95% CI] | Endline CIP 3 Mean [95% CI] |
| FP awareness [0, 13] | | 5.24 [4.72 – 5.76] | 7.36 [7.18 – 7.54] |
| Rejects misconceptions [-14, 14] | | 0.55 [-0.96 – 2.06] | 6.41 [5.88 – 9.93] |
| Perceived self-efficacy [-16, 16] | | -1.98 [-4.08 – 0.13] | 6.90 [6.34 – 7.46] |
| Partner FP acceptance [0,1] | | 0.59 [0.46 – 0.72] | 0.90 [0.87 – 0.92] |
| FP communication in past 6 months [0, 1] | | 0.05 [0.00 – 0.11] | 0.44 [0.40 – 0.48] |
| Social support [0,1] | | 0.15 [0.07 – 0.23] | 0.68 [0.63 – 0.73] |
| Proportional membership | | 0.21 | 0.79 |

Table 8. Odds Ratios for Demographic Predictors of Profile Membership

| | Baseline (2011) | | | Endline (2015) |
|----------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| | CIP 3 [Ref. CIP 1] OR (SE) | CIP 2 [Ref. CIP 1] OR (SE) | CIP 3 [Ref. CIP 2] OR (SE) | CIP 2 [Ref. CIP 1] OR (SE) |
| Age Group | | | | |
| Youth (15-24) | [ref] | [ref] | [ref] | [ref] |
| Adult (25-34) | 1.89 (0.67) | 1.16 (0.45) | 1.63 (0.36) | 3.60 (2.08) |
| Mature (35-49) | 1.31 (0.48) | 1.30 (0.59) | 1.00 (0.29) | 1.29 (0.73) |
| Education | | | | |
| No education | [ref] | [ref] | [ref] | [ref] |
| Primary education | 3.62** (0.87) | 1.59 (0.45) | 2.28** (0.39) | 3.03** (0.60) |
| Secondary education+ | 23.51 (12.81) | 3.81 (2.25) | 6.18** (1.79) | 4.71* (1.70) |
| Wealth | | | | |
| Poorest quintile | [ref] | [ref] | [ref] | [ref] |
| Second quintile | 2.09 (0.60) | 1.05 (0.37) | 1.99* (0.41) | 0.86 (0.33) |
| Middle quintile | 1.46 (0.51) | 0.71 (0.28) | 2.06 (0.58) | 2.13 (0.61) |
| Fourth quintile | 1.67 (0.54) | 0.69 (0.25) | 2.44* (0.57) | 1.70 (0.48) |
| Richest quintile | 3.30 (1.44) | 1.47 (0.72) | 2.25 (0.66) | 1.60 (0.46) |
| City | | | | |
| Dakar | [ref] | [ref] | [ref] | [ref] |
| Guédiawaye | 1.38 (0.66) | 1.62 (0.75) | 0.85 (0.34) | 2.39 (0.83) |
| Pikine | 4.67 (2.29) | 7.21 (4.16) | 0.65 (0.22) | 5.20 (2.31) |
| Mbao | 2.30 (1.06) | 4.31 (2.44) | 0.54* (0.18) | 0.45** (0.14) |
| Mbour | 1.51 (0.49) | 1.35 (0.56) | 1.11 (0.37) | 1.05 (0.27) |
| Kaolack | 1.11 (0.35) | 1.67 (0.65) | 0.67 (0.22) | 0.41** (0.10) |
| Parity | 1.17 (0.10) | 0.97 (0.09) | 1.20** (0.05) | 1.20** (0.06) |

*Significant at $p < 0.05$ **Significant at $p < 0.01$

Table 9. Average Contraceptive Use and Intention to Use by Profile

| | Baseline (2011) | | | Endline (2015) | |
|---|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| | CIP 1 Mean (SE) | CIP 2 Mean (SE) | CIP 3 Mean (SE) | CIP 1 Mean (SE) | CIP 2 Mean (SE) |
| Current modern method use [0,1] | 0.022 (0.01) | 0.018 (0.02) | 0.447 (0.02) | 0.048 (0.03) | 0.466 (0.02) |
| Intention to use any method in next 12 months among non-users [0-3] | 0.050 (0.03) | 0.379 (0.04) | 0.929 (0.06) | 0.185 (0.06) | 0.657 (0.05) |

Bold indicates that means were significantly different across profiles ($p > 0.01$).

Table 10. Mean Self-Reported Principal Sources of Health Information by Profile Membership

| | Baseline (2011) | | | Endline (2015) | |
|--------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| | CIP 1 | CIP 2 | CIP 3 | CIP 1 | CIP 2 |
| Media Sources | | | | | |
| Any media | 0.49 (0.06) | 0.69 (0.04) | 0.81 (0.02) | 0.88 (0.01) | 0.89 (0.02) |
| TV | 0.42 (0.05) | 0.64 (0.03) | 0.76 (0.02) | 0.83 (0.02) | 0.87 (0.01) |
| Radio | 0.19 (0.04) | 0.29 (0.03) | 0.39 (0.02) | 0.44 (0.03) | 0.53 (0.02) |
| Newspaper | 0.01 (0.01) | 0.03 (0.01) | 0.04 (0.01) | 0.00 (0.00) | 0.05 (0.01) |
| Magazines | 0.00 (0.00) | 0.00 (0.00) | 0.01 (0.00) | 0.00 (0.00) | 0.01 (0.00) |
| Billboards | 0.02 (0.01) | 0.04 (0.01) | 0.01 (0.01) | 0.04 (0.01) | 0.08 (0.01) |
| Internet | 0.04 (0.00) | 0.00 (0.00) | 0.02 (0.01) | 0.00 (0.01) | 0.03 (0.01) |
| Medical Sources | | | | | |
| Any med. practitioner | 0.39 (0.05) | 0.43 (0.03) | 0.63 (0.02) | 0.25 (0.04) | 0.47 (0.02) |
| Midwife | 0.21 (0.04) | 0.32 (0.03) | 0.45 (0.02) | 0.19 (0.04) | 0.38 (0.02) |
| Doctor | 0.18 (0.04) | 0.18 (0.03) | 0.26 (0.02) | 0.12 (0.03) | 0.17 (0.02) |
| Nurse | 0.05 (0.02) | 0.04 (0.01) | 0.07 (0.01) | 0.01 (0.01) | 0.04 (0.01) |
| Pharmacist | 0.00 (0.00) | 0.02 (0.01) | 0.02 (0.00) | 0.01 (0.00) | 0.04 (0.01) |
| Traditional healer | 0.04 (0.03) | 0.01 (0.00) | 0.01 (0.00) | 0.01 (0.00) | 0.00 (0.00) |
| Matrones/ASC | 0.00 (0.00) | 0.01 (0.01) | 0.01 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| Interpersonal Sources | | | | | |
| Any interpers. source | 0.31 (0.05) | 0.45 (0.03) | 0.47 (0.03) | 0.52 (0.05) | 0.42 (0.02) |
| Friends/neighbors | 0.25 (0.04) | 0.40 (0.03) | 0.42 (0.03) | 0.45 (0.05) | 0.35 (0.02) |
| Parents | 0.03 (0.02) | 0.09 (0.02) | 0.07 (0.01) | 0.13 (0.05) | 0.03 (0.01) |
| Others/acquaintances | 0.12 (0.03) | 0.07 (0.02) | 0.06 (0.01) | 0.06 (0.02) | 0.08 (0.01) |
| Siblings | 0.01 (0.01) | 0.02 (0.01) | 0.05 (0.01) | 0.02 (0.01) | 0.03 (0.01) |
| Spouse | 0.02 (0.01) | 0.00 (0.00) | 0.03 (0.01) | 0.00 (0.00) | 0.04 (0.01) |
| Community Sources | | | | | |
| Community liaison | 0.03 (0.01) | 0.04 (0.01) | 0.05 (0.01) | 0.08 (0.02) | 0.11 (0.01) |
| School | 0.00 (0.00) | 0.00 (0.00) | 0.03 (0.01) | 0.00 (0.00) | 0.01 (0.00) |
| CBO | 0.01 (0.00) | 0.01 (0.00) | 0.02 (0.00) | 0.00 (0.00) | 0.01 (0.00) |
| Volunteer/peer educators | 0.00 (0.00) | 0.01 (0.00) | 0.01 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| Total number of sources | 1.56 (0.13) | 2.19 (0.11) | 2.80 (0.08) | 2.41 (0.14) | 2.85 (0.06) |

Bold indicates means were significantly different across profiles ($p > 0.01$).

Table 11. Profile Membership at Baseline and Endline

| | Endline CIP 1 | Endline CIP 2 | Total |
|-----------------------|------------------|--------------------|---------------------|
| Baseline CIP 1 | 155 (53%) | 137 (47%) | 292 (6%) |
| Baseline CIP 2 | 353 (33%) | 725 (67%) | 1,078 (27%) |
| Baseline CIP 3 | 343 (13%) | 2,334 (87%) | 2,677 (67%) |
| Total | 851 (21%) | 3,196 (79%) | 4,047 (100%) |

REFERENCES

1. Lee M, Finlay J. *The Effect of Reproductive Health Improvements on Women's Economic Empowerment: A Review Through the Population and Poverty (PopPov) Lens.*; 2017. Accessed March 3, 2020. https://www.prb.org/wp-content/uploads/2017/09/17-246_POPPOV_Women_Empower.pdf
2. Starbird E, Norton M, Marcus R. Investing in family planning: Key to achieving the sustainable development goals. *Global Health Science and Practice*. 2016;4(2):191-210. doi:10.9745/GHSP-D-15-00374
3. Track20. *Senegal FP2020 2019 Core Indicators 1-9 Country Fact Sheet.*; 2019.
4. Track20. FP2020 Data Dashboard | Family Planning 2020. Published 2019. Accessed January 19, 2021. <http://www.familyplanning2020.org/data-dashboard>
5. Daff BM, Seck C, Belkhatat H, Sutton P. Informed push distribution of contraceptives in Senegal reduces stockouts and improves quality of family planning services. *Global health, science and practice*. 2014;2(2):245-252. doi:10.9745/GHSP-D-13-00171
6. Hasselback L, Gueye B, Ndao O, Ndour SK, Cissé C. Incentivizing access to family planning in Senegal via the informed push model. *Journal of Pharmaceutical Policy and Practice*. 2014;7(1):O12. doi:10.1186/2052-3211-7-S1-O12
7. Krug C, Cavallaro FL, Wong KLM, Gasparrini A, Faye A, Lynch CA. Evaluation of Senegal supply chain intervention on contraceptive stockouts using routine stock data. Hodges MH, ed. *PLOS ONE*. 2020;15(8):e0236659. doi:10.1371/journal.pone.0236659
8. Aichatou B, Seck C, Anne TSB, Deguenovo GC, Ntabona A, Simmons R. Strengthening government leadership in family planning programming in Senegal: From proof of concept to proof of implementation in 2 districts. *Global Health Science and Practice*. 2016;4(4):568-581. doi:10.9745/GHSP-D-16-00250
9. Winston J, Calhoun LM, Corroon M, Guilkey D, Speizer I. Impact of the Urban Reproductive Health Initiative on family planning uptake at facilities in Kenya, Nigeria, and Senegal. *BMC women's health*. 2018;18(1):9. doi:10.1186/s12905-017-0504-x
10. MLE. Measurement Learning and Evaluation of the Urban Reproductive Health Initiative: Senegal 2015 Endline Survey executive summary. Published online 2016. Accessed September 22, 2018. <https://www.popline.org/node/652195>
11. Gueye A, Speizer IS, Corroon M, Okigbo CC. Belief in Family Planning Myths at the Individual and Community Levels and Modern Contraceptive Use in Urban Africa. *International Perspectives on Sexual and Reproductive Health*. 2015;41(04):191-199. doi:10.1363/4119115
12. Kaneda T. *Special Analysis of Senegal Demographic and Health Survey (2010-2011) to Explore the Magnitude of Unmet Need across the Previous Five Years Using the DHS*

- Calendar Data.*; 2013. <https://www.prb.org/wp-content/uploads/2014/07/senegal-unmet-need-contraception.pdf>
13. ANSD/Sénégal AN de la S et de la D and I, ICF. Senegal Enquête Démographique et de Santé Continue (EDS-Continue) 2017. Published online 2018. Accessed August 31, 2018. <https://dhsprogram.com/publications/publication-FR331-DHS-Final-Reports.cfm>
 14. Sidibe AM, Kadetz PI, Hesketh T. Factors impacting family planning use in mali and senegal. *International Journal of Environmental Research and Public Health*. 2020;17(12):1-15. doi:10.3390/ijerph17124399
 15. Sougou NM, Bassoum O, Faye A, Leye MMM. Women's autonomy in health decision-making and its effect on access to family planning services in Senegal in 2017: A propensity score analysis. *BMC Public Health*. 2020;20(1). doi:10.1186/s12889-020-09003-x
 16. Cleland J, Wilson C. Demand Theories of the Fertility Transition: An Iconoclastic View. *Population Studies*. 1987;41(1):5-30. doi:10.1080/0032472031000142516
 17. van de Kaa DJ. Anchored Narratives: The Story and Findings of Half a Century of Research into the Determinants of Fertility. *Population Studies*. 1996;50(3):389-432. doi:10.1080/0032472031000149546
 18. Bongaarts J, Watkins SC. Social Interactions and Contemporary Fertility Transitions. *Population and Development Review*. 1996;22(4):639. doi:10.2307/2137804
 19. Mason KO. Explaining fertility transitions. *Demography*. 1997;34(4):443-454. Accessed September 19, 2018. <http://www.ncbi.nlm.nih.gov/pubmed/9545624>
 20. Babalola S, Vonrasek C. Communication, ideation and contraceptive use in Burkina Faso: an application of the propensity score matching method. *The journal of family planning and reproductive health care*. 2005;31(3):207-212. doi:10.1783/1471189054484022
 21. Kincaid DL. Social networks, ideation, and contraceptive behavior in Bangladesh: a longitudinal analysis. *Social science & medicine*. 2000;50(2):215-231. Accessed July 13, 2018. <http://www.ncbi.nlm.nih.gov/pubmed/10619691>
 22. Kincaid DL. Mass Media, Ideation, and Behavior. *Communication Research*. 2000;27(6):723-763. doi:10.1177/009365000027006003
 23. Babalola S, Kincaid DL. New Methods for Estimating the Impact of Health Communication Programs. *Communication Methods and Measures*. 2009;3(1-2):61-83. doi:10.1080/19312450902809706
 24. Babalola S. Changes in Ideational Profiles of Women of Reproductive Age in Urban Nigeria: The Role of Health Communication. *Health Education and Behavior*. Published online 2017. doi:10.1177/1090198117699510

25. Benson A, Calhoun L, Corroon M, et al. The Senegal urban reproductive health initiative: a longitudinal program impact evaluation. *Contraception*. 2018;97(5):439-444. doi:10.1016/j.contraception.2018.01.003
26. Measurement Learning & Evaluation Project for the Urban Reproductive Health Initiative. MLE Senegal Study Design.docx - MLE Senegal Dataverse. Published 2017. Accessed August 31, 2018. <https://dataverse.unc.edu/file.xhtml?fileId=7491126&version=RELEASED&version=.0>
27. Petersen KJ, Qualter P, Humphrey N. The application of latent class analysis for investigating population child mental health: A systematic review. *Frontiers in Psychology*. 2019;10(MAY). doi:10.3389/fpsyg.2019.01214
28. Miranda VPN, dos Santos Amorim PR, Bastos RR, et al. Evaluation of lifestyle of female adolescents through latent class analysis approach. *BMC Public Health*. 2019;19(1):184. doi:10.1186/s12889-019-6488-8
29. Ingledew DK, Hardy L, Cooper CL. Latent class analysis applied to health behaviours. *Personality and Individual Differences*. 1995;19(1):13-20. doi:10.1016/0191-8869(95)00045-8
30. Collins L, Lanza S. *Latent Class and Latent Transition Analysis*. Wiley; 2010. Accessed September 1, 2018. <https://www.wiley.com/en-us/Latent+Class+and+Latent+Transition+Analysis%3A+With+Applications+in+the+Soci+al%2C+Behavioral%2C+and+Health+Sciences-p-9780470228395>
31. Kongsted A, Nielsen AM. Latent Class Analysis in health research. *Journal of Physiotherapy*. 2017;63(1):55-58. doi:10.1016/j.jphys.2016.05.018
32. Opollo D, Pillai VK. Latent class analysis of reproductive decision making in Zambia. *African and Asian Studies*. 2012;11(3):371-383. doi:10.1163/15692108-12341238
33. Dalglish SL, Vandermark J, Rossier C, Kemou A, Neighbor H. Using Marketing Science to Understand Contraceptive Demand in High-Fertility Niger. *Studies in Family Planning*. 2018;49(4):367-383. doi:10.1111/sifp.12078
34. Babalola S, Kusemiju B, Calhoun L, Corroon M, Ajao B. Factors associated with contraceptive ideation among urban men in Nigeria. *International Journal of Gynecology & Obstetrics*. 2015;130:E42-E46. doi:10.1016/j.ijgo.2015.05.006
35. Wurpts IC, Geiser C. Is adding more indicators to a latent class analysis beneficial or detrimental? Results of a Monte-Carlo study. *Frontiers in Psychology*. 2014;5(AUG):920. doi:10.3389/fpsyg.2014.00920
36. Wulifan JK, Brenner S, Jahn A, de Allegri M. A scoping review on determinants of unmet need for family planning among women of reproductive age in low and middle income countries. *BMC Women's Health*. 2016;16(1). doi:10.1186/S12905-015-0281-3

37. Semachew Kasa A, Tarekegn M, Embiale N. Knowledge, attitude and practice towards family planning among reproductive age women in a resource limited settings of Northwest Ethiopia. *BMC Research Notes*. 2018;11(1):577. doi:10.1186/S13104-018-3689-7
38. Voluntarism and Informed Choice | U.S. Agency for International Development. Accessed December 10, 2021. <https://www.usaid.gov/global-health/health-areas/family-planning/voluntarism-and-informed-choice>
39. FP2020. *RIGHTS AND EMPOWERMENT PRINCIPLES FOR FAMILY PLANNING.*; 2015. Accessed December 10, 2021. https://fp2030.org/sites/default/files/FP2020_Statement_of_Principles_11x17_EN_092215.pdf
40. Population Council. *Contraceptive Discontinuation: Reasons, Challenges, and Solutions / Family Planning 2030.*; 2015. Accessed December 10, 2021. <https://fp2030.org/resources/contraceptive-discontinuation-reasons-challenges-and-solutions>
41. Sedgh G, Hussain R. Reasons for Contraceptive Nonuse among Women Having Unmet Need for Contraception in Developing Countries. *Studies in Family Planning*. 2014;45(2):151-169. doi:10.1111/j.1728-4465.2014.00382.x
42. Ankomah A, Oladosu J, Anyanti M, Oladosu M, Anyanti J. Myths, misinformation, and communication about family planning and contraceptive use in Nigeria. *Open Access Journal of Contraception*. 2011;2:95. doi:10.2147/OAJC.S20921
43. Whiting-Collins L, Grenier L, Winch PJ, Tsui A, Donohue PK. Measuring contraceptive self-efficacy in sub-Saharan Africa: development and validation of the CSESSA scale in Kenya and Nigeria. *Contraception*. 2020;2. doi:10.1016/j.conx.2020.100041
44. Rosenstock IM. The Health Belief Model and Preventive Health Behavior. *Health Education Monographs*. 1974;2(4):354-386. doi:10.1177/109019817400200405
45. Peyman N, Oakley D. Effective contraceptive use: An exploration of theory-based influences. *Health Education Research*. 2009;24(4):575-585. doi:10.1093/her/cyn058
46. Bandura A. The Explanatory and Predictive Scope of Self-Efficacy Theory. *Journal of Social and Clinical Psychology*. 1986;4(3):359-373. doi:10.1521/jscp.1986.4.3.359
47. Levinson RA, Wan CK, Beamer LAJ. The contraceptive self-efficacy scale: Analysis in four samples. *Journal of Youth and Adolescence*. 1998;27(6):773-793. doi:10.1023/A:1022865900546
48. Balogun O, Adeniran A, Fawole A, Adesina K, Aboyeji A, Adeniran P. Effect of Male Partner's Support on Spousal Modern Contraception in a Low Resource Setting. *Ethiopian journal of health sciences*. 2016;26(5):439-448. doi:10.4314/ejhs.v26i5.5

49. Kraft JM, Harvey SM, Hatfield-Timajchy K, et al. Pregnancy motivations and contraceptive use: Hers, His, or Theirs? *Women's Health Issues*. 2010;20(4):234-241. doi:10.1016/j.whi.2010.03.008
50. Ezeanolue EE, Iwelunmor J, Asaolu I, et al. Impact of male partner's awareness and support for contraceptives on female intent to use contraceptives in southeast Nigeria Health behavior, health promotion and society. *BMC Public Health*. 2015;15(1). doi:10.1186/s12889-015-2216-1
51. Vouking MZ, Evina CD, Tadenfok CN. Male involvement in family planning decision making in sub-Saharan Africa- what the evidence suggests. *Pan African Medical Journal*. 2014;19. doi:10.11604/pamj.2014.19.349.5090
52. Sarnak DO, Wood SN, Zimmerman LA, et al. The role of partner influence in contraceptive adoption, discontinuation, and switching in a nationally representative cohort of Ugandan women. *PLOS ONE*. 2021;16(1):e0238662. doi:10.1371/JOURNAL.PONE.0238662
53. UN Women. Senegal: Global Database on Violence against Women. Published 2021. Accessed December 10, 2021. <https://evaw-global-database.unwomen.org/fr/countries/africa/senegal#3>
54. Yue K, O'Donnell C, Sparks PL. The effect of spousal communication on contraceptive use in Central Terai, Nepal. *Patient Education and Counseling*. 2010;81(3):402-408. doi:10.1016/j.pec.2010.07.018
55. Grabert BK, Speizer IS, Domino ME, Frerichs L, Corneli A, Fried BJ. Couple communication and contraception use in urban Senegal. *SAGE Open Medicine*. 2021;9:205031212110233. doi:10.1177/20503121211023378
56. Oladeji D. Communication and Decision-Making Factors Influencing Couples Interest in Family Planning and Reproductive Health Behaviours in Nigeria. *Studies of Tribes and Tribals*. 2008;6(2):99-103. doi:10.1080/0972639X.2008.11886582
57. Sileo KM, Wanyenze RK, Lule H, Kiene SM. Determinants of family planning service uptake and use of contraceptives among postpartum women in rural Uganda. *International journal of public health*. 2015;60(8):987-997. doi:10.1007/s00038-015-0683-x
58. Mutumba M, Wekesa E, Stephenson R. Community influences on modern contraceptive use among young women in low and middle-income countries: a cross-sectional multi-country analysis. *BMC Public Health*. 2018;18(1):430. doi:10.1186/s12889-018-5331-y
59. Vermunt JK. Latent Class Modeling with Covariates: Two Improved Three-Step Approaches. *Political Analysis*. 2010;18:450-469. doi:10.2307/25792024
60. Asparouhov T, Muthén B. *Auxiliary Variables in Mixture Modeling: 3-Step Approaches Using Mplus*.; 2013.

61. Asparouhov T, Muthén B. *Auxiliary Variables in Mixture Modeling: Using the BCH Method in Mplus to Estimate a Distal Outcome Model and an Arbitrary Secondary Model.*; 2020.
62. Lanza ST, Tan X, Bray BC. Latent Class Analysis With Distal Outcomes: A Flexible Model-Based Approach. *Structural Equation Modeling*. 2013;20(1):1-26. doi:10.1080/10705511.2013.742377
63. Bakk Z, Tekle FB, Vermunt JK. Estimating the Association between Latent Class Membership and External Variables Using Bias-adjusted Three-step Approaches. *Sociological Methodology*. 2013;43(1):272-311. doi:10.1177/0081175012470644
64. Muthen, Muthen. Mplus Software - Muthen & Muthen. Published 2020. Accessed March 4, 2020. <https://www.statmodel.com/orderonline/categories.php?category=Mplus-Software>
65. Nylund-Gibson K, Choi AY. Ten frequently asked questions about latent class analysis. *Translational Issues in Psychological Science*. 2018;4(4):440-461. doi:10.1037/tps0000176
66. Vermunt JK, Magidson J. Latent Class Analysis With Sampling Weights. *Sociological Methods & Research*. 2007;36(1):87-111. doi:10.1177/0049124107301965
67. Nylund KL, Asparouhov T, Muthén BO. *Deciding on the Number of Classes in Latent Class Analysis and Growth Mixture Modeling: A Monte Carlo Simulation Study*. Vol 14.; 2007.
68. Akaike H. Factor analysis and AIC. *Psychometrika*. 1987;52(3):317-332. doi:10.1007/BF02294359
69. Schwarz G. Estimating the Dimension of a Model. *The Annals of Statistics*. 1978;6(2):461-464. doi:10.1214/aos/1176344136
70. Tein JY, Coxe S, Cham H. Statistical Power to Detect the Correct Number of Classes in Latent Profile Analysis. *Structural equation modeling : a multidisciplinary journal*. 2013;20(4):640-657. doi:10.1080/10705511.2013.824781
71. Wang MC, Deng Q, BI X, Ye H, Yang W. Performance of the entropy as an index of classification accuracy in latent profile analysis: A Monte Carlo simulation study. *Acta Psychologica Sinica*. 2017;49(11):1473. doi:10.3724/sp.j.1041.2017.01473
72. Bolck A, Croon M, Hagenaars J. Estimating Latent Structure Models with Categorical Variables: One-Step Versus Three-Step Estimators | Request PDF. *Political Analysis*. 2004;12(1).
73. Huang L, Dziak JJ, Bray BC, Wagner AT. LCA distal Stata function users' guide (Version 1.1). University Park: The Methodology Center, Penn State. Published 2017. Accessed April 30, 2020.

https://www.methodology.psu.edu/files/2019/03/LCADistal_Stata_BCH_UG_1.1-1ra0fc6.pdf

74. Vermunt J. Latent Class Modeling with Covariates: Two Improved Three-Step Approaches. *Political Analysis*. 2010;18(4).
75. World Health Organization. Family planning/Contraception. Published 2018. Accessed June 29, 2018. <http://www.who.int/news-room/fact-sheets/detail/family-planning-contraception>
76. Bogale GW, Boer H, Seydel ER. Condom use among low-literate, rural females in Ethiopia: the role of vulnerability to HIV infection, condom attitude, and self-efficacy. *AIDS Care*. 2010;22(7):851-857. doi:10.1080/09540120903483026
77. Wegs C, Creanga AA, Galavotti C, Wamalwa E. Community Dialogue to Shift Social Norms and Enable Family Planning: An Evaluation of the Family Planning Results Initiative in Kenya. Bhattacharya S, ed. *PLOS ONE*. 2016;11(4):e0153907. doi:10.1371/journal.pone.0153907
78. Babalola S, John N, Ajao B, Speizer IS. Ideation and intention to use contraceptives in Kenya and Nigeria. *Demographic Research*. Published online 2015. doi:10.4054/DemRes.2015.33.8
79. World Health Organization. Sexual and reproductive health | Unmet need for family planning. Accessed December 25, 2021. https://www.who.int/reproductivehealth/topics/family_planning/unmet_need_fp/en/

CHAPTER 3. TRANSITIONS IN CONTRACEPTIVE IDEATION AMONG URBAN WOMEN IN SENEGAL: THE ROLE OF HEALTH COMMUNICATION

Background

Family Planning Communication in Senegal

Social and behavior change (SBC) communication via mass and social media, interpersonal communication, community group engagement, and digital channels is a crucial component of family planning (FP) programming because it created and shapes demand for information, products, and services and influences client-provider communication, partner communication, and accepted social behaviors and norms.¹ Global evidence indicates that exposure to FP health communication messages can increase FP knowledge, influence attitudes and social norms, and ultimately create informed, voluntary demand for FP.²⁻⁵ Positive communication campaigns around the benefits of FP are particularly important in countries like Senegal, in which modern contraceptive prevalence (MCP) among married women remains low (27.7%) due to fears, misconceptions, socio-cultural norms, and religious beliefs.⁶⁻⁹

Several studies have examined the impact of various modalities of health communication on modern contraceptive use in Senegal.¹⁰⁻¹⁵ A longitudinal impact evaluation examined whether exposure to FP information through newspapers/magazines, radio programming, radio advertisements, TV programming, religious leaders, community-based events, and SMS messages predicted modern contraceptive method use among urban Senegalese women and found that only participation in community-based activities was significantly associated with modern contraceptive use.¹⁵ When the sample was restricted to poor urban women, FP messaging via radio also became significant in predicting contraceptive use. A related study of

sexually active urban Senegalese men who reported the same FP exposures found additional associations; men who heard FP messages on TV, heard a religious leader speak favorably about FP, attended community-level religious talks on FP, or participated in community-level FP activities were all significantly more likely to use a modern contraceptive method compared with men who were not exposed.¹⁴ Additionally, the study found that hearing a religious leader speak favorably about FP, participation in community activities, and exposure to FP messaging via TV or radio were significantly associated with an increased probability of men having discussed FP with their partner in the prior six months. A third study in Senegal found that reading about FP and hearing about FP on the TV or radio were significantly associated with an increased likelihood of visiting a health center in the past year and that for those exposed to FP messaging through TV and radio, the healthcare visits were more likely to result in FP use.¹⁰ A fourth study reinforced the longitudinal impact evaluation results discussed previously that SMS-based FP communication had no impact on modern contraceptive use among urban and rural Senegalese mothers but that it did significantly increase the odds of other positive health behaviors including facility-based delivery.¹³

Although these studies offer good evidence that SBC communication can impact reproductive health behaviors, there are two main limitations to this body of evidence. The first limitation is that analyses primarily assess average effects across large, heterogeneous populations of women among which subgroups may have important characteristics that could differentiate their responses to the FP interventions. Effective SBC programming relies on audience segmentation, which typically identifies population subgroups based on geographic, demographic, or other characteristics that influence decision making and predict priority outcomes.¹⁶ Advanced audience segmentation offers greater nuance and deeper insights into the

identities and needs of subpopulations to shape message content and engagement strategies. However, more nuanced profiles of women are rarely explored. The second limitation is that studies often focus on desired behavioral outcomes (use of contraception, visited a health facility). Although measurable changes in behavior are ideal for impacting health outcomes, focusing only on behavioral outcomes risks missing more subtle but still important evolutions of cognitive, social, and emotional factors that underpin a woman's decision to use FP. Changes in these "ideational" factors in response to FP communication programming may indicate incremental positive impacts on FP empowerment, readiness, and support, even when a woman ultimately does not use contraception.

Contraceptive Ideation & Audience Segmentation

Ideation is defined as "the perceptions and ideas that individuals hold that reflect various social, environmental, and personal influences."^{17,18} Several studies have identified associations between positive health ideation and healthy behavioral outcomes including modern contraceptive use.^{4,19–23} Contraceptive ideation comprises three primary domains of psychosocial variables: cognitive (attitudes, values, knowledge, subjective norms, self-image), emotional (preferences and self-efficacy), and social (interpersonal communication, social support, and social influence).^{20,24,25} These psychosocial variables are foundational to women's contraceptive decision making. In the past decade, researchers have begun to use more specialized techniques such as latent class and latent profile analysis to identify latent prototypical subgroups in heterogeneous populations that share key characteristics related to contraceptive ideation and use.^{4,20,21,26,27} One latent class analysis among urban women of reproductive age in Nigeria identified prototypical classes of women who shared similar patterns of cognitive, emotional, and social indicators of contraceptive ideation.²³ The study found a direct relationship between membership in certain classes and contraceptive use and suggested that a better understanding of

contraceptive ideational profiles (CIPs) of women may improve how FP communication programs tailor messages to different audience segments.

Conceptually, the objective of audience segmentation is to identify groups of individuals who share similar characteristics, needs, or values and who may respond differently to various messages or interventions.¹⁶ Audience segmentation is an important technique that can enhance FP communication campaigns by providing insight into who to reach, how to reach them, and what messages to communicate. Segmentation is often used to target people based on demographic characteristics such as gender, age, and income, but more nuanced segmentation is becoming common in both health communication and market research. Research in Nigeria, Burkina Faso, and Kenya indicated that audience segmentation based on contraceptive ideation should be routinely applied to the development of health communication programming.^{3,4,23,28,29} Ideational profiling as a method of audience segmentation takes a person-centered approach in that it seeks out prototypical patterns of key ideational indicators such as FP awareness, beliefs, efficacy, partner communication, partner support, and community support whereas standard regression approaches often examine the contributions of these indicators in isolation by controlling for covariates. Additionally, examining whether and how these patterns change over time can reveal nuances about how sub-populations are changing and evolving. These insights can inform responsive and impactful communications campaigns.

Study Objectives

The objectives of this study were to 1) identify and describe longitudinal contraceptive ideational profiles (CIPs) of urban, partnered women of reproductive age in Senegal, 2) examine how membership in those CIPs changed over time, and 3) determine whether exposures to various health communication interventions were predictive of transitions between CIPs over

time. Analyzing the relative stability of ideational profiles over time and the impact of health communication on transitions between more empowered and less empowered ideational profiles can help communication programs better tailor FP message content and modalities. To our knowledge, this was the first application of latent transition analysis to advance the understanding of contraceptive ideation in low-resource settings.

Methods

Data

We analyzed data from the Measurement, Learning and Evaluation (MLE) project for the Urban Reproductive Health Initiative in Senegal that included survey data from a longitudinal (2011–2015) sample of urban Senegalese women of reproductive age (15–49) who lived in Dakar, Guédiawaye, Pikine, Mboi, Mbour, and Kaolack.^{15,30} A two-stage sampling design was used to collect data from a random sample of 21 households in 268 districts, stratified by poor and non-poor, based on a probability proportional to their populations. Poor strata were oversampled to increase inclusion of poor households and women. All women ages 15–49 years in the selected households were eligible to participate in the baseline survey. At baseline (2011), 9,614 women were interviewed and 6,927 of these women were re-interviewed at endline (2015) for a follow up of 73.5%.^{15,30} We restricted our dataset to 4,047 women who were in-union (married or living with a partner) at baseline and who responded to the endline survey. Several important survey questions were only asked of women who were in union because premarital sex is taboo in Senegal. Additionally, initial exploratory analyses of latent profiles at baseline compared profiles of women without endline data and profiles of women with endline data and found no significant or meaningful differences in those profiles. A balanced dataset allowed us to

clearly articulate and quantify movement between CIPs over time and endline probability weights accounted for attrition.

Analytical Plan

To estimate and characterize transitions between latent profiles over time, we conducted a latent transition analysis (LTA). LTA is an extension of latent profile analysis that focuses on modeling transitions between profiles over time. LTA has become an important person-centered tool for examining changes and trends in groupings of health and behavioral characteristics.^{31,32} In an earlier study, we used a theory-driven approach to conduct two latent profile analyses, one at baseline and one at endline, to better understand and describe contraceptive ideation of women at two separate time points.³³ However, the best fitting latent profile model at each time point may not be the same as the best fitting latent transition model, which must fit an exponentially larger contingency table.³⁴ In this analysis we used the same six indicators of the latent variable that were developed and applied in the earlier study to extend that research longitudinally.³³ The six theory-driven, evidence-based indicators were FP awareness, rejection of misconceptions, FP self-efficacy, partner acceptance of FP, partner communication about FP in the past six months, and perceived social support for FP use.

Conceptual Model

Figure 4 visualizes the latent transition model for contraceptive ideation. In this model, we hypothesize that there is a categorical latent variable that explains similarities in contraceptive ideation among subgroups of women. The latent variable is indicated by response patterns to survey questions about FP awareness, FP misconceptions, self-efficacy, partner support for FP, partner communication about FP, and perceived social support for FP. These indicators represent three primary domains of contraceptive ideation: cognitive, emotional, and social.^{20,24,25} This latent variable comprises prototypical profiles of women with similar

contraceptive ideation. We hypothesize that the interpretation of these latent CIPs stays the same over time but that women tend to transition to more empowered CIPs. Four years would be ample time to detect real evolution in contraceptive ideation and movement between CIPs. We also hypothesize that exposures to various types of FP health communication programming may differentially affect membership in the endline CIPs and transitions between baseline and endline CIPs.

The equation for this LTA with two time points denotes the probability of the occurrence of a specific vector of responses as a function of 1) the probabilities of membership in each latent CIP at time 1 (δ_{s1}), 2) the probabilities of transitioning to a latent CIP at time 2 conditional on latent CIP membership in the previous time period (τ), and 3) the probabilities of the occurrence of each response at each time point conditional on latent CIP membership (ρ).³⁴ An LTA model with S latent CIPs is estimated based on a dataset that includes J observed indicators (six constructs in this analysis) measured T times ($T=2$), for a total for JT times. Y represents a vector of the individual's responses, which has W rows and $T \times J$ columns. The probability of observing each response pattern is $P(Y=y)$ which sums to 1. R_{jt} are the responses to the observed constructs at a given time point. LTA accepts both categorical and continuous observed indicators. Equation 1 below is the fundamental equation for LTA with two time points.³⁴

Equation 1. Fundamental equation for LTA with two time points

$$P(Y = y) = \sum_{s_1=1}^S \sum_{s_2=2}^S \delta_{s1} \tau_{s2|s1} \prod_{t=1}^2 \prod_{j=1}^J \prod_{r_{jt}=1}^{R_j} \frac{I(y_{jt} = r_{jt})}{P_{jr_{jt}|s_t}}$$

LTA begins with the establishment of a contingency table that cross-tabulates all observed variables. The degrees of freedom associated with LTAs are calculated as $df = W - P_{\delta} - P_{\rho} - P_{\tau} - 1$, where W is the number of cells in the contingency table; P_{δ} is the number of latent CIP prevalences estimated; P_{ρ} is the number of item response probabilities estimated; and P_{τ} is the number of transition probabilities estimated.³⁴

Model specification and selection

Using six indicators of contraceptive ideation from the three ideational domains, we estimated longitudinal latent models with two to eight CIPs. We relied on Akaike information criteria (AIC), Bayesian information criteria (BIC), and sample-size adjusted BIC (ABIC) to make relative decisions about model fit.^{34–36} AIC and BIC are log likelihood–based statistics that compare competing models by identifying the best model fit for the smallest number of parameters.^{37–39} The AIC statistic favors more complex models while the BIC and the adjusted BIC represent the fewest number of profiles that should be selected. For AIC, BIC, and ABIC, the model with the smallest statistic indicates the best model fit. We considered entropy, which is a standardized index of assignment accuracy where higher values indicate a more accurate assignment of individuals to latent profiles and better separation between those profiles.⁴⁰ We also considered the proportional membership in each status as well as the utility of the interpretations for FP communication programs. Because of the large degrees of freedom and likelihood of sparseness, the distribution of the G^2 test statistic of absolute model fit is not approximated by the chi-square distribution, which makes p-values unreliable.³⁴ Further, there is not a chi-square test of absolute model fit for latent transition models with continuous variables and we were unable to use the Lo-Mendell-Rubin (LMR) or the bootstrapped likelihood (BLRT)

tests, which compare models with k and k-1 classes to assess superior model fit between two latent categorical variables.

After selecting the optimal number of CIPs, we tested our hypothesis of measurement invariance by constraining the item-response probabilities to be equal at baseline and endline. In LTA models, there is measurement invariance across two time points when the relationship between the latent variable and the observed constructs are the same, even if the distribution of the latent variable is different across time points.³⁴ Conceptually, it is useful to have measurement invariance because it assures that latent CIPs can be interpreted the same way over time and across groups. To test for measurement invariance we conducted a likelihood ratio test, which indicates whether imposing equality constraints significantly changes model fit.⁴¹ Practically, constraining item-response probabilities also stabilizes estimation and improves identification by decreasing the number of estimated parameters.³⁴

Estimating parameters

We estimated three sets of parameters: latent CIP prevalences, item-response probabilities, and transition probabilities. Once the model was identified, we imposed parameter restrictions so that the item-response probabilities were identical in both time periods, allowing us to maintain consistent profiles across time. We calculated transition probabilities to help us understand where women in a certain CIP at baseline transitioned at endline. Because each row in the transition probability matrix is conditioned on baseline CIP, our analyses of the changes in profiles over time implicitly control for baseline status.

Covariates

Once we understood the structure and interpretation of our LTA model, we introduced covariates to determine whether exposures to FP messages are associated with endline CIP

membership and transitions between different CIPs over time. At endline, women were asked whether they had heard or seen FP messages from mass media modalities in the past 3 months and community-based sources in the past 12 months. All questions about FP exposures were coded as binary variables. We also developed a count variable [0–11] that summed all reported modalities to determine whether additional modalities of FP messaging influenced transitions over time. Finally, women were also asked about the content of the FP messages that they had heard. Table 12 presents descriptive statistics for the covariates of interest among in-union women at endline. We did not include wealth or age because those covariates were not significant predictors of baseline or endline profile membership in initial exploratory latent profile analyses. Because Models 1 and 3 included covariates representing similar constructs (e.g., heard about FP through radio, TV, news, etc.), we calculated correlation tables across all included covariates to determine whether there was significant overlap in the general population (data available upon request). For Models 1 and 3 the highest correlations between covariates were 0.41 and 0.31, respectively, indicating sufficiently distinct indicators.

Covariates are incorporated into LTA in the same manner as an LPA/LCA in that they use a multinomial logistic regression framework that estimates the effect for each latent CIP in comparison to a reference class.³⁴ We estimated three multinomial logistic regression models to test whether FP communication modalities, multiple modalities, message content, and message content through specific modalities influenced membership in endline profiles. We selected covariates in the model to which at least 10 percent of surveyed women reported exposure. In Model 1, we included exposures to FP information via TV and radio from the mass media category and religious leaders and community conversations with community health workers (CHW) from the community category. We also controlled for education, city, and parity, all of

which proved to be significant in predicting profile membership in earlier research.³³ In Model 2, our covariate of interest was the count variable of communication modalities as well as the control covariates. In Model 3, we included whether women had reported hearing messages about spacing births, the legitimacy of FP, spousal communication, the position of Islam on FP, limiting family size, and rumors and fears about FP, as well as the control covariates.

Next, we ran three multinomial logistic regression models which estimated transitions between latent CIPs over time, conditional on baseline CIP membership. Predictions of the probability of transition of individual i moving to latent CIP 2 at endline is conditional on current membership in latent CIP 1 at baseline given membership in group G and covariate X .³¹ When testing the statistical significance of the covariate in predicting latent CIP when there is more than one covariate in the model, we would reject the null hypothesis when the covariate of interest contributes significantly to the prediction of latent model beyond the contributions of the other covariates in the model.³⁴

To address misclassification, we used the manual BCH three-step approach for longitudinal LTA.^{42–44} The three-step approach ensures that covariates do not influence the measurement model of latent contraceptive ideation and the BCH weighting approach accounts for error in classification. In Step 1, we ran the LTA without incorporating covariates and generated BCH weights w_{ij} that represent the measurement error of the latent variable. BCH weights are obtained from the j^{th} row of the inverse of the matrix H , which presents classification probabilities for the most likely latent CIP membership (column) by latent profile (row) where j is the most likely CIP for that observation.⁴⁴ In Step 3, the i^{th} observation in CIP/status j receives a weight of w_{ij} in the auxiliary model, which includes covariates, and the model is estimated as a multiple group model using these weights.⁴⁵ LTA allows for the incorporation of complex survey

design features and we applied endline six-city probability weights that account for attrition in the endline sample and clustering at the district level.

Results

Model Selection

LTA model selection considerations included model fit, parsimony, interpretation, and utility for answering our research questions of interest. We analyzed LTA models with two to eight profiles at baseline and endline, considering AIC, BIC, ABIC, and entropy. In addition to the unconstrained LTA models, we examined measurement invariance in the models by constraining the item response probabilities to be the same at baseline and endline. Model fit statistics for unconstrained and constrained models are presented in Table 13. We used the likelihood ratio test to compare models and rejected the null hypotheses for all models that the constrained and unconstrained models were the same ($p < 0.001$), which indicated that there was measurement variance. Measurement variance may have been due to overall improvements in contraceptive ideation over time, as indicated by overall increases in the scores of indicators at endline. The constrained model fit statistics represented only slight decreases in model fit compared to the unconstrained models but in some cases improved classification accuracy (entropy).

We ultimately selected the LTA model with four CIPs at baseline and endline because it represented improved model fit over the two- and three-CIP models. We did not select the five-CIP or higher models because they had issues of extreme sparseness in their contingency tables, with several CIPs having no members. Sparseness is problematic for examining how key covariates influence transitions between CIPs over time. Although we did not identify measurement invariance over time, we still found it useful to constrain the item response

probabilities so that the interpretation of the statuses was the same at baseline and endline.

Constraining the item response probabilities improved individual classification for the four-status model and supports a more quantitative assessment of status transitions over time.

Latent Status Interpretation

Once we selected the model, we analyzed the item response probabilities for each of the six indicators to decipher the interpretation of each of the four latent CIPs. Table 14 presents the item response probabilities for each indicator for the constrained four CIP LTA model. For all mean item response probabilities, CIP 1 had the lowest (least desirable) scores across all indicators, though some were not statistically different from CIP 2. CIP 4 had the highest (more desirable) scores across all indicators, with no overlap of confidence intervals with other CIPs. CIP 1 had the smallest proportional membership at baseline and endline. At endline, the proportional memberships of CIP 1 decreased and CIP 4 increased compared to baseline, indicating improvements in contraceptive ideation over time.

Figure 5 presents a standardized z-score distribution of the constrained latent CIP indicators by CIP using baseline population means and standard deviations. This figure visualizes the directionality and strength of the mean estimate of the indicator for each latent CIP related to the mean of the population (z-score of 0). We also calculated the z-scores using endline population means and standard deviations but, because that figure looked very similar to Figure 3, it was not included. This visualization aided in labeling the CIPs.

CIP 1: Lowest efficacy and FP awareness, highest misconceptions, unsupported

The three most notable attributes for CIP 1 were extremely low self-efficacy, high misconceptions about FP, and low contraceptive awareness. These were the indicators representing the emotional and cognitive domains of contraceptive ideation. Women in CIP 1

also were more likely to report that their partners forbid FP use and did not believe that their communities would support their decisions to use FP. This CIP had the smallest membership at baseline (7%) and endline (4%).

CIP 2: Low efficacy and FP awareness, rejects misconceptions, unsupported

In CIP 2, women still had low perceived self-efficacy as the strongest attribute, but it was much less negative than CIP 1. Partner communication, social support, partner support, and contraceptive awareness were all fairly low. One notable positive attribute for this group was their rejection of misconceptions about FP. CIP 2 had the second smallest proportional membership at baseline (12%) and endline (17%).

CIP 3: Moderate efficacy, high FP awareness, high misconceptions, moderate support

In CIP 3 the defining attribute was high misconceptions about FP. Otherwise, women had above-average contraceptive awareness and average efficacy, social, and partner support. CIP 3 was the second largest group at baseline (34%) and endline (19%).

CIP 4: Highest efficacy and FP awareness, fewest misconceptions, most supported

In CIP 4, women had relatively high contraceptive awareness, strongly rejected misconceptions, had high perceived self-efficacy, had good partner support for FP, were more likely to have discussed FP with their partners in the past six months, and were likely to believe that their communities would support their decisions to use an FP method. CIP 4 had the largest membership at both baseline (47%) and endline (60%).

Table 15 presents the latent transition probabilities and profile counts based on the most likely latent profile pattern across baseline and endline. Only the baseline latent CIP prevalences are estimated independently; endline prevalences are estimated based on the latent status prevalences at baseline and the transition probabilities. Women who started in baseline CIP 1

were fairly equally distributed across Statuses 1–4 at endline, with about one-third of the group moving into endline CIP 4. Of women who started in CIPs 2 and 3 at baseline, about half moved to CIP 4 at endline, representing improvement in ideation. Cells shaded in green represent transitions to improved contraceptive ideational states over time. Cells shaded in orange represent transitions to less desirable contraceptive ideational states over time.

Predictors of Endline CIP Membership

Once we identified and labeled latent CIPs and examined how women moved over time, we introduced covariates into three multinomial logistic regression models to determine whether these covariates were predictive of endline status membership and transition between profiles over time. For these analyses, we constrained the item-response probabilities to be equal at baseline and endline so that the interpretation of the profiles was the same. Although we were most interested in identifying covariates that increased the odds of transitions to more empowered CIPs over time (CIPs 2, 3, and 4) making CIP 1 the preferred reference category, CIP 1 at baseline and endline had very small membership, and so the more empowered CIPs with larger membership were used as the reference category. We did not test whether covariates differentiated membership or transitions between CIP 2 and CIP 3 because these were qualitatively different groups and neither represented absolute improvement over the other.

In the first model we ran a multinomial logistic regression to examine whether individual communication modalities predicted endline CIP membership (Table 16). We found that hearing about FP from the TV, radio, a religious leader, or a CHW were all associated with significantly lower odds of membership in endline CIP 1 compared to endline CIP 4 and endline CIP 3, indicating that exposure was associated with improved contraceptive ideation. Exposure to FP messages via TV was also associated with significantly lower odds of membership in CIP 1

compared to CIP 2 and CIP 3 compared to CIP 4. In contrast, exposure to FP messages via radio or via a religious leader was associated with significantly lower odds of membership in CIP 2 compared to CIP 4. Hearing about FP through community conversations with a CHW was also associated with significantly lower odds of membership in endline CIP 1 compared to CIP 2, but a visit from a CHW was not significant in predicting CIP membership.

In our second model, we summed the total number of modalities through which women reported having heard about FP (0–11) to create a count variable of modality breadth to determine whether hearing about FP through additional modalities influenced endline status membership. Table 17 presents the results of the multinomial logistic regression to determine whether exposure to FP communication through additional modalities predicted the odds of endline profile membership. The results indicate that each additional modality significantly decreased the odds of membership in endline CIP 1 compared to endline CIPs 2, 3, and 4. Further, additional modalities significantly decreased the odds of membership in endline CIP 2 compared to endline CIP 4 but was not significant in differentiating endline CIP 3 compared to endline CIP 4.

In our third model, we examined whether the content of the messages that women reported receiving influenced CIP membership. We included six different messages that at least 10 percent of women had reported hearing. Table 18 presents the results of this multinomial logistic regression analysis. Only exposure to messages about the legitimacy of FP and birth spacing were significant in predicting more empowered CIP membership at endline. Women who heard messages about the legitimacy of FP had significantly lower odds of being members of endline CIPs 1 and 2 compared to endline CIP 4. Women who heard messages about birth

spacing had significantly lower odds of being in endline CIP 1 compared to endline CIPs 2, 3 and 4 and of being in endline CIP 3 compared to endline CIP 4.

Predictors of Transitions Between CIPs Over Time

For each model, we examined whether the significant covariates of interest influenced the odds of transition conditional on baseline CIP membership. In these models, we only included the key covariates of interest that had been significant in the earlier models. We also did not include education or city as covariates because the analysis conditions on baseline profile membership, so covariates that do not change substantially over time are already accounted for in that membership. A second rationale for this decision was that the transition contingency table had extremely small cell sizes so we had to be parsimonious about selecting which covariates to include. For each baseline status, we estimated the odds of remaining in that CIP at endline compared to the odds of transitioning to a more empowered endline CIP. Table 19 presents the odds ratios for transitions to endline CIP conditional on baseline CIP for the three models.

In Model 4, among women who were in baseline CIP 1, exposure to FP content on TV was associated with significantly lower odds of staying in CIP 1 at endline compared to transitioning to endline CIP 2 and hearing about FP on the radio or from a religious leader was associated with significantly lower odds staying in endline CIP 1 compared to transitioning to endline CIP 3 and endline CIP 4. For women who were in baseline CIP 2, hearing about FP from a religious leader or from a CHW was associated with significantly lower odds of staying in CIP 2 at endline compared with transitioning to endline CIP 4. For women who were in baseline CIP 3, only hearing about FP on TV was associated with significantly lower odds of staying in endline CIP 3 compared to transitioning to endline CIP 4.

In Model 5, we examined whether additional modalities influenced the odds of transition conditional on baseline CIP membership. For this model, we only included the total communication modalities covariate for reasons discussed earlier. Results indicated that hearing about FP through additional sources was associated with significantly lower odds of staying in lower CIPs compared to transitions to higher CIPs except from baseline CIP 1 to endline CIP 2.

In Model 6, we examined whether FP message content influenced the odds of transition conditional on baseline CIP membership. We only included content messages about the legitimacy of FP and birth spacing because those were the only two messages that were significant in predicting endline CIP in earlier models. When we conditioned on baseline CIP, the message about the legitimacy of FP was only associated with a significantly lower odds of staying in CIP 1 compared with transition to endline CIP 3. The message about birth spacing was associated with significantly lower odds of staying in a lower CIP at endline compared to transitioning to all more empowered CIPs at endline except between baseline CIP 1 and endline CIP 2.

Due to small contingency tables and transition sample sizes and concerns around multicollinearity, we were not powered to identify a model that included both modality and message content as well as their interactions.

Discussion

To our knowledge, this study is the first to demonstrate the utility of longitudinal latent variable modeling of contraceptive ideation and its particular relevance to health communication programs. We identified four prototypical profiles of women who demonstrated unique defining characteristics of contraceptive ideation that indicated that they might be differentially receptive to various FP communication modalities and messages. The four profiles included a group of

women who reported very low scores on all six ideational indicators (CIP 1: *Lowest efficacy and FP awareness, highest misconceptions, unsupported*); two qualitatively different profiles of women, one of which was driven by low self-efficacy but a rejection of misconceptions about FP and the other of which was characterized by strong misconceptions about FP but fairly high contraceptive awareness (CIP 2: *Low efficacy and FP awareness, rejects misconceptions, unsupported*, and CIP 3: *Moderate efficacy, high FP awareness, high misconceptions, moderate support*, respectively); and a fourth profile in which women were cognitively, emotionally, and socially empowered in their contraceptive ideation (CIP 4: *Highest efficacy and FP awareness, fewest misconceptions, most supported*). The identification of these CIPs and the insights that they reveal can help policy and decision makers in Senegal better understand demand-side challenges to FP uptake and continuation from a person-centered perspective. The insights about these groups of women can help decision makers appropriately allocate resources to the design of responsive FP interventions and messages. For example, women in CIPs 1 and 2 might benefit from empowering messages that focus on bolstering their self-efficacy whereas women in CIP 3 might benefit from myth-busting positive messaging. Using longitudinal data, we found that over a four-year period (2011–2015) women generally transitioned to become members of more empowered CIPs.

To better understand whether and how FP communication programming influenced endline CIP membership and transitions between CIPs over time, we examined key exposures to FP programming. In terms of predictors of endline CIP membership, we found that TV, radio, religious leaders, and community conversations with CHW were all effective modalities in that they each were associated with lower odds of membership in less empowered endline CIPs compared to more empowered CIP 4. Only TV and CHWs differentiated endline membership

between endline CIP 1 and endline CIP 2. Unsurprisingly, exposure to additional communication modalities was also predictive of membership in more empowered endline CIPs. Programs should therefore strive to reinforce FP messages through different channels, as this may increase the credibility, strength, or internalization of the messages for women, their partners, and their communities, all of which can contribute to more positive ideation. In terms of content, we found that messages about the legitimacy of FP and birth spacing were the strongest predictors of membership in more empowered ideational CIPs among the different communication messages used in this program. Programs should consider weaving these themes into their other messages around spousal communication, the position of Islam on FP, the limitation of family size, or rumors and fears about FP.

FP programs can use LTA methodology with nationally representative population data or with smaller programmatic datasets to target women and communities with positive health messaging through appropriate communication channels. In a first prospective iteration, this approach can generate latent profiles that can be followed over time through LTA. Knowing how women in different CIPs access and respond to communication content and modalities can help programs reach the audience segments with effective messages through trusted channels.

Limitations

This study was subject to several limitations. For our selected four-CIP LTA model, the entropy score was slightly lower than the desired 0.80 threshold, indicating a greater degree of classification uncertainty. However, for all the covariate model analyses, we used widely accepted three-step BCH method to correct for bias in the estimation of the effect of the covariates on status membership and transition. A second challenge was sparseness due to the large number of cells in the contingency table. Sparseness refers to having a small number of

individuals with certain response patterns because there are so many response pattern options, which leads to small or no counts for each cell. Sparseness increases with the number of indicators and statuses that are selected for inclusion. This was particularly problematic for the latent transition analysis and meant that we had to be judicious about the number of covariates to include. Although we included the covariates that we felt were most essential to our research questions, additional covariates may have provided additional insight and improved model specification. A third limitation is that the data does not always make it clear whether the FP communication was positive or negative. For example, FP messages about the legitimacy of FP may have been negative. However, we allowed for bidirectional impacts and the results indicated that these messages improved contraceptive ideation. Another limitation was that we did not control for the total number of exposures in any of the models. For example, we do not know how many times a woman heard about FP on the TV or the radio. Therefore, it is possible that TV was more effective than other modalities because a woman heard about FP multiple times on TV, rather than simply trusting TV as a source that influenced transition.

Conclusion

This study is novel and important for three reasons. First, we demonstrated that latent variable modeling can effectively identify and characterize homogeneous or prototypical health communication audience segments based on their contraceptive ideation. Second, our analysis shed light on women's transitions between ideational statuses over time. Third, we explored how health communication message content and modality may have influenced those transitions. Using this information, we provided several recommendations for combinations of message content and modality based on the ideational audience segment of interest in Senegal. These steps can be replicated in other settings using indicators that are locally available and relevant.

The results of this study have important implications for FP communication programs and policy makers in Senegal and other settings in which socio-cultural norms limit the ability of women to benefit from modern contraceptive methods. National communication strategies should apply contraceptive ideational profiling as an enhanced SBC approach to achieve a more nuanced understanding of the ideational states and needs of the population and to respond effectively to those needs. Future research might include further examination of how non-invariant ideational profiles themselves evolve over time in addition to examining how women transition between consistently measured profiles over time.

Figures

Figure 4. Conceptual Model of Latent Transition Analysis with Health Communication Covariates

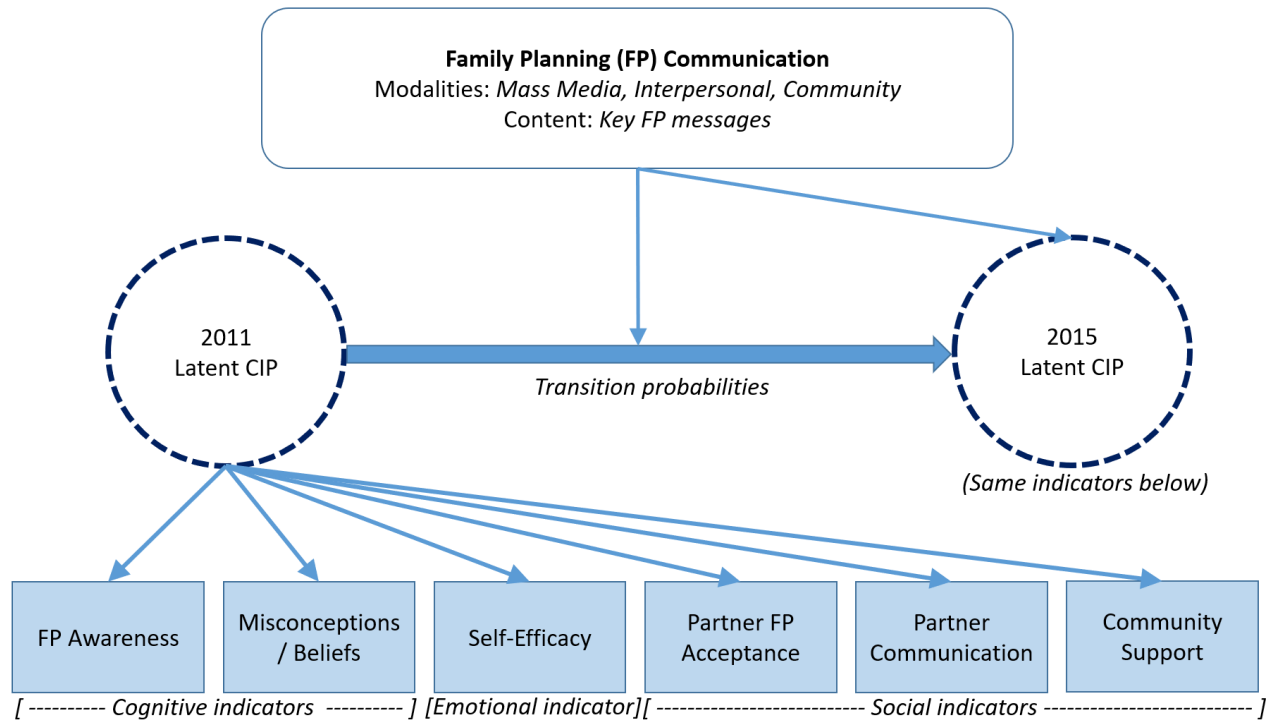
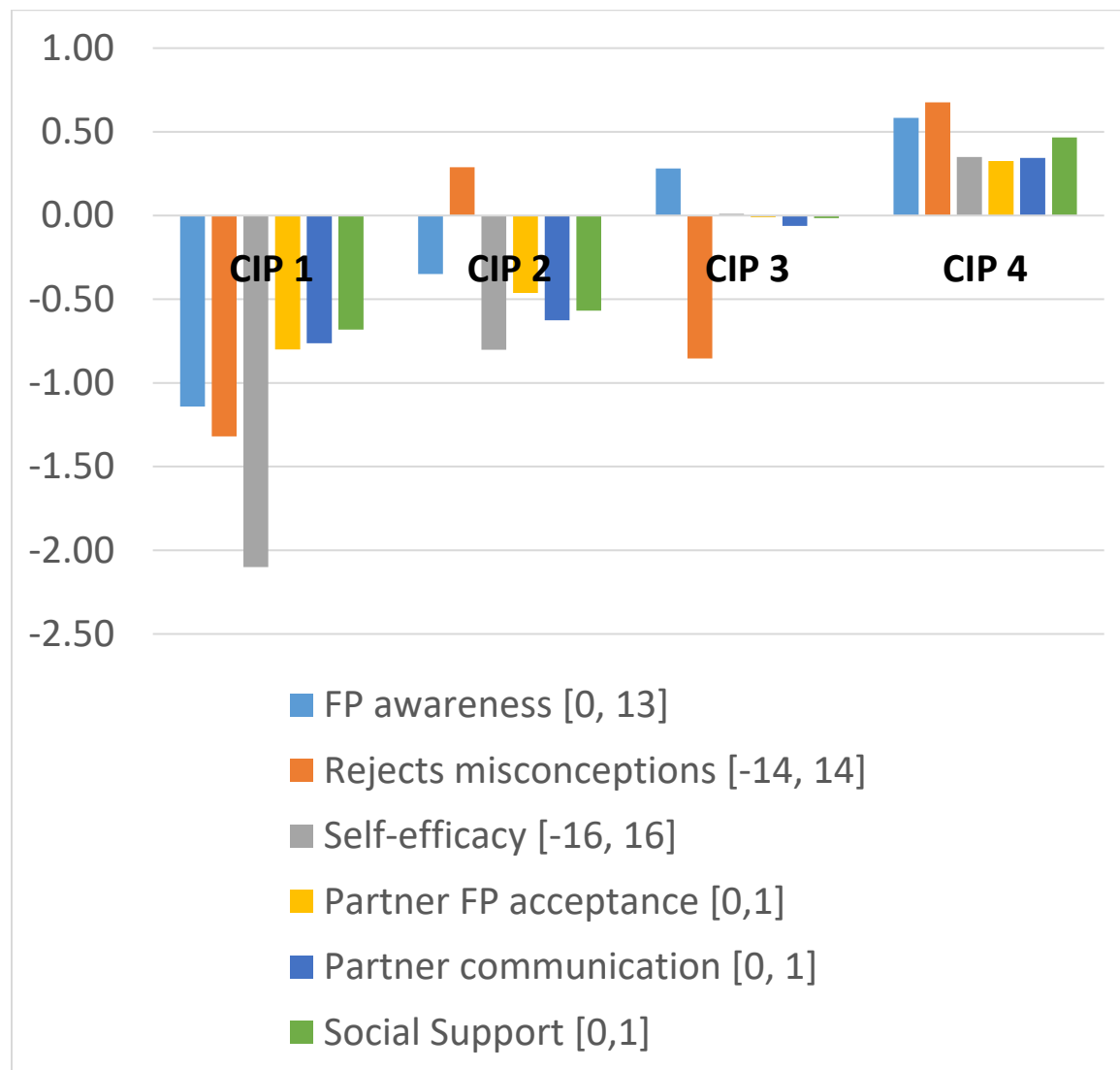


Figure 5. Standardized z-score Distribution of Constrained Contraceptive Ideational Profile Indicators by Latent Status at Baseline



Tables

Table 12. Covariates of Interest Among In-Union Women at Endline (n=4,047)

| Covariates of Interest | Weighted ^a Endline Mean (SE) |
|--|---|
| Model 1: FP Exposure Modalities | |
| <i>Mass Media Exposures (Past 3 months)</i> | |
| Have you seen information about FP on TV ? | 77% (0.02) |
| Have you heard about FP on the radio ? | 51% (0.02) |
| Have you read about FP in a newspaper/magazine ? | 7% (0.01) |
| Have you seen message about FP on the internet, web, Facebook, or email ? | 3% (0.05) |
| Have you received SMS messages on FP/contraception? | 1% (0.00) |
| <i>Community and Interpersonal Exposures (Past 12 months)</i> | |
| Have you heard an Imam, religious leader , or preacher speak about FP? | 74% (0.01) |
| Have you participated in a community conversation led by a volunteer/CHW or village godmother where someone spoke about FP? | 19% (0.01) |
| Have you received a visit from a volunteer/CHW or village godmother who spoke about FP? | 11% (0.01) |
| Have you participated in a religious talk where someone spoke about FP? | 7% (0.01) |
| Have you participated in a workshop/meeting led by a volunteer/CHW or village godmother who spoke about FP? | 6% (0.01) |
| Have you participated in a public activity where someone spoke about FP? | 5% (0.01) |
| Model 2: Diversity of Exposure Modalities | |
| Total number of FP exposure modalities [0-11] | 2.8 (0.05) |
| Model 3: FP Content | |
| <i>What information have you read/heard/seen about family planning?</i> | |
| Spacing births | 76% (0.02) |
| Legitimacy of FP | 45% (0.02) |
| Spousal communication | 23% (0.02) |
| Position of Islam on FP | 19% (0.01) |
| Limitation of family size | 12% (0.01) |
| Rumors and fears about FP | 11% (0.01) |
| Delay the age of first sex or delay the first birth | 2% (0.00) |
| Control Covariates of Interest | |
| Parity (0-14) | 3.8 (0.07) |
| <i>Education</i> | |
| No education or Koranic only | 41% (0.02) |
| Primary education | 36% (0.01) |
| Secondary education or higher | 23% (0.02) |
| <i>City</i> | |
| Dakar | 37% (0.04) |
| Guédiawaye | 11% (0.02) |
| Pikine | 12% (0.02) |
| Mbao | 24% (0.04) |
| Mbour | 8% (0.01) |
| Kaolack | 9% (0.01) |

^a Weighted using endline six-city probability weights

Table 13. Model Fit Statistics for Unconstrained and Constrained Latent Transition Models (n=4,047)

| | Latent Statuses | | | | | | |
|--|------------------------|------------|------------|------------|------------|------------|------------|
| | 2/2 | 3/3 | 4/4 | 5/5 | 6/6 | 7/7 | 8/8 |
| Unconstrained Models | | | | | | | |
| Log likelihood | -81064 | -80446 | -80210 | -80027 | -79896 | -79777* | -79673* |
| AIC | 162192 | 160984 | 160539 | 160203 | 159968 | 159758 | 159578 |
| BIC | 162394 | 161275 | 160918 | 160670 | 160523 | 160401 | 160310 |
| Adjusted BIC | 162293 | 161128 | 160727 | 160435 | 160243 | 160077 | 159941 |
| Entropy | 0.804 | 0.720 | 0.709 | 0.731 | 0.708 | 0.721 | 0.721 |
| Constrained Item Response Probabilities | | | | | | | |
| Log likelihood | -81439 | -80914 | -80587 | -80361 | -80248 | -80104 | -79997 |
| AIC | 162918 | 161884 | 161246 | 160811 | 160600 | 160328 | 160130 |
| BIC | 163044 | 162060 | 161473 | 161088 | 160928 | 160707 | 160559 |
| Adjusted BIC | 162980 | 161971 | 161359 | 160949 | 160763 | 160516 | 160342 |
| Entropy | 0.811 | 0.694 | 0.744 | 0.784 | 0.756 | 0.736 | 0.705 |

*Best log likelihood value not replicated

Table 14. Constrained Mean Item Response Probabilities for Selected LTA Model at Baseline and Endline

| Indicator [Response range] | Status 1 Mean [95% CI] | Status 2 Mean [95% CI] | Status 3 Mean [95% CI] | Status 4 Mean [95% CI] |
|---|-----------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| FP awareness [0, 13] | 3.94 [3.47 – 4.42] | 5.39 [4.88 – 5.90] | 6.54 [6.36 – 6.72] | 7.10 [6.97 – 7.23] |
| Rejects misconceptions [-14, 14] | -6.35 [-8.09 – -4.60] | 5.49 [4.79 – 6.18] | -2.93 [-3.43 – -2.42] | 8.34 [7.91 – 8.77] |
| Perceived self-efficacy [-16, 16] | -8.77 [-10.24 – -7.30] | 0.16 [-1.14 – 1.46] | 5.76 [5.23 – 6.28] | 8.09 [7.62 – 8.55] |
| Partner Support [0,1] | 0.48 [0.39 – 0.57] | 0.62 [0.54 – 0.69] | 0.80 [0.76 – 0.84] | 0.93 [0.90 – 0.96] |
| Partner communication [0, 1] | 0.01 [0.00 – 0.03] | 0.08 [0.02 – 0.14] | 0.35 [0.31 – 0.39] | 0.55 [0.51 – 0.58] |
| Social support [0,1] | 0.14 [0.08 – 0.20] | 0.20 [0.12 – 0.27] | 0.47 [0.42 – 0.52] | 0.71 [0.67 – 0.75] |
| Proportional baseline membership | 0.07 | 0.12 | 0.34 | 0.47 |
| Proportional endline membership | 0.04 | 0.17 | 0.19 | 0.60 |

Table 15. Latent Transition Counts and Probabilities Based on Most Likely Latent Profile

| | Endline | | | | |
|--------------|--|--|--|--|----------------|
| Baseline | CIP 1 Count (Transition probability) | CIP 2 Count (Transition Probability) | CIP 3 Count (Transition Probability) | CIP 4 Count (Transition Probability) | Total Count |
| CIP 1 | 49 (0.17) | 80 (0.27) | 63 (0.22) | 99 (0.34) | 291 |
| CIP 2 | 49 (0.10) | 117 (0.24) | 90 (0.19) | 229 (0.47) | 484 |
| CIP 3 | 44 (0.03) | 259 (0.19) | 309 (0.22) | 770 (0.56) | 1382 |
| CIP 4 | 26 (0.01) | 226 (0.12) | 297 (0.16) | 1339 (0.71) | 1888 |
| Total | 168 | 682 | 759 | 2437 | 4047 |

Table 16. Model 1: Individual Communication Modalities as Predictors of Endline CIP Membership

| | eCIP 1 [Ref. eC4] OR (SE) | eCIP 1 [Ref. eC3] OR (SE) | eCIP 1 [Ref. eC2] OR (SE) | eCIP 2 [Ref. eC4] OR (SE) | eCIP 3 [Ref. eC4] OR (SE) |
|---|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Heard about FP on TV | 0.33** (0.10) | 0.58* (0.21) | 0.40** (0.17) | 0.83 (0.37) | 0.56** (0.12) |
| Heard about FP on radio | 0.53** (0.16) | 0.49** (0.19) | 1.09 (0.42) | 0.49** (0.13) | 1.01 (0.22) |
| Heard about FP from relig. leader | 0.43** (0.13) | 0.46** (0.15) | 0.70 (0.21) | 0.61** (0.13) | 0.94 (0.24) |
| Heard about FP CHW discussion | 0.34** (0.15) | 0.32** (0.16) | 0.51* (0.25) | 0.67 (0.21) | 1.06 (0.32) |
| Heard about FP CHW visits | 1.14 (0.52) | 1.19 (0.69) | 1.54 (0.80) | 0.74 (0.27) | 0.96 (0.32) |
| Parity | 1.03 (0.06) | 1.06 (0.07) | 1.10 (0.07) | 0.94 (0.04) | 0.97 (0.05) |
| Primary Education [Ref. none/Koranic only] | 0.43** (0.18) | 0.49* (0.22) | 0.62 (0.26) | 0.69* (0.14) | 0.86 (0.20) |
| Secondary Education [Ref. none/Koranic only] | 0.26** (0.22) | 0.31* (0.27) | 0.54 (0.49) | 0.48** (0.19) | 0.83 (0.19) |
| City: Guédiawaye [Ref. Dakar] | 0.20** (0.15) | 0.42 (0.34) | 0.14** (0.11) | 1.46 (0.65) | 0.50** (0.14) |
| City: Pikine [Ref. Dakar] | 0.11** (0.10) | 0.39 (0.37) | 0.07** (0.08) | 1.51 (0.82) | 0.29** (0.09) |
| City: Mbao [Ref. Dakar] | 1.58 (0.99) | 5.26 (3.08) | 0.27** (0.19) | 5.81 (2.56) | 0.30** (0.09) |
| City: Mbour [Ref. Dakar] | 0.80 (0.37) | 2.96 (1.51) | 0.30** (0.19) | 2.66 (1.09) | 0.27** (0.07) |
| City: Kaolack [Ref. Dakar] | 0.40** (0.21) | 1.30 (0.70) | 0.04** (0.03) | 10.05* (4.27) | 0.31** (0.09) |

eC: Endline CIP; * $p < 0.05$; ** $p < 0.01$

Table 17. Model 2: Total Communication Modalities as a Predictor of Endline CIP Membership

| | eCIP 1 [Ref. eC4] OR (SE) | eCIP 1 [Ref. eC3] OR (SE) | eCIP 1 [Ref. eC2] OR (SE) | eCIP 2 [Ref. eC4] OR (SE) | eCIP 3 [Ref. eC4] OR (SE) |
|--|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| Number of communication modalities | 0.50** (0.06) | 0.55** (0.07) | 0.74** (0.10) | 0.69** (0.05) | 0.91 (0.06) |
| Parity | 1.03 (0.06) | 1.06 (0.07) | 1.11 (0.08) | 0.93 (0.04) | 0.98 (0.05) |
| Primary education [Ref. none/Koranic only] | 0.43** (0.18) | 0.50* (0.22) | 0.61 (0.25) | 0.70* (0.15) | 0.85 (0.20) |
| Secondary education [Ref. none/Koranic only] | 0.27** (0.22) | 0.32* (0.28) | 0.53 (0.49) | 0.51* (0.21) | 0.83 (0.19) |
| City: Guédiawaye [Ref. Dakar] | 0.23** (0.17) | 0.45 (0.37) | 0.14** (0.11) | 1.61 (0.72) | 0.53** (0.15) |
| City: Pikine [Ref. Dakar] | 0.11** (0.10) | 0.38 (0.37) | 0.08** (0.08) | 1.49 (0.79) | 0.30** (0.09) |
| City: Mbao [Ref. Dakar] | 1.64 (1.00) | 5.30 (3.12) | 0.28** (0.19) | 5.83 (2.50) | 0.31** (0.09) |
| City: Mbour [Ref. Dakar] | 1.11 (0.52) | 3.55 (1.82) | 0.37** (0.24) | 3.00 (1.26) | 0.31** (0.08) |
| City: Kaolack [Ref. Dakar] | 0.47* (0.25) | 1.38 (0.78) | 0.05** (0.03) | 10.14* (4.25) | 0.34** (0.10) |

*eC: Endline CIP; *p<0.05; **p<0.01*

Table 18. Model 3: FP Message Content as Predictors of Endline CIP Membership

| | eCIP 1 [Ref. eC4] OR (SE) | eCIP 1 [Ref. eC3] OR (SE) | eCIP 1 [Ref. eC2] OR (SE) | eCIP 2 [Ref. eC4] OR (SE) | eCIP 3 [Ref. eC4] OR (SE) |
|--|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Legitimacy of FP | 0.41** (0.17) | 0.57 (0.27) | 0.61 (0.29) | 0.66* (0.16) | 0.71 (0.16) |
| Spacing births | 0.16** (0.07) | 0.24** (0.11) | 0.24** (0.11) | 0.69 (0.22) | 0.66* (0.13) |
| Spousal communication | 1.06 (0.67) | 0.93 (0.60) | 0.58 (0.39) | 1.83 (0.59) | 1.13 (0.32) |
| Position of Islam | 2.11 (1.07) | 1.73 (0.89) | 2.92 (1.72) | 0.72 (0.29) | 1.22 (0.36) |
| Limitation of family size | 0.39 (0.40) | 0.35 (0.37) | 0.46 (0.49) | 0.85 (0.24) | 1.14 (0.31) |
| Rumors and fears around FP | 0.71 (0.49) | 0.63 (0.44) | 1.37 (1.12) | 0.52 (0.25) | 1.13 (0.37) |
| Parity | 1.02 (0.07) | 1.04 (0.07) | 1.08 (0.08) | 0.95 (0.04) | 0.98 (0.05) |
| Primary education [Ref. none/Koranic only] | 0.37** (0.16) | 0.43** (0.19) | 0.56 (0.24) | 0.67* (0.14) | 0.85 (0.20) |
| Secondary education [Ref. none/Koranic only] | 0.27** (0.23) | 0.32* (0.29) | 0.61 (0.56) | 0.45** (0.18) | 0.84 (0.19) |
| City: Guédiawaye [Ref. Dakar] | 0.20** (0.15) | 0.40 (0.34) | 0.13** (0.11) | 1.51 (0.66) | 0.52** (0.14) |
| City: Pikine [Ref. Dakar] | 0.10** (0.09) | 0.36 (0.35) | 0.08** (0.08) | 1.23 (0.69) | 0.26** (0.09) |
| City: Mbao [Ref. Dakar] | 1.41 (0.83) | 4.81 (2.74) | 0.25** (0.16) | 5.62 (2.36) | 0.29** (0.09) |
| City: Mbour [Ref. Dakar] | 0.82 (0.41) | 2.74 (1.48) | 0.30** (0.20) | 2.71 (1.12) | 0.30** (0.08) |
| City: Kaolack [Ref. Dakar] | 0.34** (0.21) | 1.17 (0.73) | 0.03** (0.03) | 10.04* (3.99) | 0.29** (0.09) |

eC: Endline CIP; * $p < 0.05$; ** $p < 0.01$

Table 19. Predictors of Transitions Between Latent CIPs Over Time

| | Baseline CIP 1 | | | Baseline CIP 2 | Baseline CIP 3 |
|---|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| | eC1 (Ref. eC2) OR (SE) | eC1 (Ref. eC3) OR (SE) | eC1 (Ref. eC4) OR (SE) | eC2 (Ref. eC4) OR (SE) | eC3 (Ref. eC4) OR (SE) |
| Model 4: Individual Communication Modalities | | | | | |
| Heard about FP on TV | 0.18** (0.16) | 0.69 (0.70) | 0.43 (0.32) | 0.31 (0.45) | 0.30** (0.14) |
| Heard about FP on radio | 4.14 (5.14) | 0.17** (0.18) | 0.14** (0.13) | 0.46 (0.64) | 0.79 (0.32) |
| Heard about FP from religious leader | 1.76 (1.62) | 0.29* (0.32) | 0.28** (0.25) | 0.16** (0.14) | 1.49 (0.85) |
| Heard about FP from CHW | 0.95 (0.99) | 0.96 (1.09) | 2.49 (2.24) | 0.22** (0.23) | 0.91 (0.42) |
| Model 5: Total Communication Modalities | | | | | |
| Number of communication modalities | 0.89 (0.30) | 0.49** (0.15) | 0.46** (0.13) | 0.34** (0.14) | 0.80* (0.08) |
| Model 6: FP Message Content | | | | | |
| Legitimacy of FP | 0.88 (0.85) | 0.31* (0.29) | 0.63 (0.54) | 0.44 (0.29) | 0.55 (0.25) |
| Spacing births | 0.44 (0.35) | 0.14** (0.14) | 0.15** (0.10) | 0.29* (0.31) | 0.39** (0.15) |

eC: Endline CIP; * $p < 0.05$; ** $p < 0.01$

REFERENCES

1. High-Impact Practices in Family Planning (HIPs). Social and Behavior Change: A Critical Part of Effective Family Planning Programs. . Washington, DC: USAID. Published April 2018. Accessed September 12, 2021. <https://www.fphighimpactpractices.org/briefs/sbc-overview/>
2. Mwaikambo L, Speizer IS, Schurmann A, Morgan G, Fikree F. What works in family planning interventions: a systematic review. *Studies in family planning*. 2011;42(2):67-82. Accessed September 18, 2018. <http://www.ncbi.nlm.nih.gov/pubmed/21834409>
3. Babalola S, Figueroa ME, Krenn S. Association of Mass Media Communication with Contraceptive Use in Sub-Saharan Africa: A Meta-Analysis of Demographic and Health Surveys. *Journal of Health Communication*. 2017;22(11):885-895. doi:10.1080/10810730.2017.1373874
4. Krenn S, Cobb L, Babalola S, Odeku M, Kusemiju B. Using behavior change communication to lead a comprehensive family planning program: the Nigerian Urban Reproductive Health Initiative. *Global health, science and practice*. 2014;2(4):427-443. doi:10.9745/GHSP-D-14-00009
5. Hutchinson PL, Meekers D. Estimating Causal Effects from Family Planning Health Communication Campaigns Using Panel Data: The “Your Health, Your Wealth” Campaign in Egypt. Eisele T, ed. *PLoS ONE*. 2012;7(9):e46138. doi:10.1371/journal.pone.0046138
6. Track20. *Senegal FP2020 2019 Core Indicators 1-9 Country Fact Sheet.*; 2019.
7. Sidibe AM, Kadetz PI, Hesketh T. Factors impacting family planning use in mali and senegal. *International Journal of Environmental Research and Public Health*. 2020;17(12):1-15. doi:10.3390/ijerph17124399
8. Sougou NM, Bassoum O, Faye A, Leye MMM. Women’s autonomy in health decision-making and its effect on access to family planning services in Senegal in 2017: A propensity score analysis. *BMC Public Health*. 2020;20(1). doi:10.1186/s12889-020-09003-x
9. ANSD/Sénégal AN de la S et de la D and I, ICF. Senegal Enquête Démographique et de Santé Continue (EDS-Continue) 2017. Published online 2018. Accessed August 31, 2018. <https://dhsprogram.com/publications/publication-FR331-DHS-Final-Reports.cfm>
10. Kim TY, Haider M, Hancock GR, Boudreaux MH. The Role of Health Literacy in Family Planning Use among Senegalese Women. *Journal of Health Communication*. 2019;24(3):244-261. doi:10.1080/10810730.2019.1601299
11. Okigbo CC, Speizer IS, Corroon M, Gueye A. Exposure to family planning messages and modern contraceptive use among men in urban Kenya, Nigeria, and Senegal: A cross-sectional study. *Reproductive Health*. 2015;12(1). doi:10.1186/s12978-015-0056-1

12. Speizer IS, Corroon M, Calhoun L, et al. Demand generation activities and modern contraceptive use in urban areas of four countries: A longitudinal evaluation. *Global Health Science and Practice*. 2014;2(4):410-426. doi:10.9745/GHSP-D-14-00109
13. Hu Y, Huang R, Ghose B, Tang S. SMS-based family planning communication and its association with modern contraception and maternal healthcare use in selected low-middle-income countries. *BMC Medical Informatics and Decision Making*. 2020;20(1). doi:10.1186/s12911-020-01228-5
14. Speizer IS, Corroon M, Calhoun LM, Gueye A, Guilkey DK. Association of men's exposure to family planning programming and reported discussion with partner and family planning use: The case of urban Senegal. *PLoS ONE*. 2018;13(9). doi:10.1371/journal.pone.0204049
15. Benson A, Calhoun L, Corroon M, et al. The Senegal urban reproductive health initiative: a longitudinal program impact evaluation. *Contraception*. 2018;97(5):439-444. doi:10.1016/j.contraception.2018.01.003
16. Breakthrough-ACTION Project. Accelerating Family Planning Demand through Advanced Audience Segmentation | The Compass for SBC. The Compass for SBC. Published 2018. Accessed September 12, 2021. <https://www.thecompassforsbc.org/trending-topics/accelerating-family-planning-demand-through-advanced-audience-segmentation>
17. Cleland J, Wilson C. Demand Theories of the Fertility Transition: An Iconoclastic View. *Population Studies*. 1987;41(1):5-30. doi:10.1080/0032472031000142516
18. van de Kaa DJ. Anchored Narratives: The Story and Findings of Half a Century of Research into the Determinants of Fertility. *Population Studies*. 1996;50(3):389-432. doi:10.1080/0032472031000149546
19. Do M, Babalola S, Awantang G, Toso M, Lewicky N, Tompsett A. Associations between malaria-related ideational factors and care-seeking behavior for fever among children under five in Mali, Nigeria, and Madagascar. Carvalho LH, ed. *PLOS ONE*. 2018;13(1):e0191079. doi:10.1371/journal.pone.0191079
20. Babalola S, Kincaid DL. New Methods for Estimating the Impact of Health Communication Programs. *Communication Methods and Measures*. 2009;3(1-2):61-83. doi:10.1080/19312450902809706
21. Babalola S, Oyenubi O, Speizer IS, Cobb L, Akiode A, Odeku M. Factors affecting the achievement of fertility intentions in urban Nigeria: Analysis of longitudinal data. *BMC Public Health*. Published online 2017. doi:10.1186/s12889-017-4934-z
22. Babalola S, Awasum D, Quenum-Renaud B. The correlates of safe sex practices among Rwandan youth: a positive deviance approach. *African journal of AIDS research : AJAR*. 2002;1(1):11-21. doi:10.2989/16085906.2002.9626540

23. Babalola S. Changes in Ideational Profiles of Women of Reproductive Age in Urban Nigeria: The Role of Health Communication. *Health Education and Behavior*. Published online 2017. doi:10.1177/1090198117699510
24. Kincaid DL. Social networks, ideation, and contraceptive behavior in Bangladesh: a longitudinal analysis. *Social science & medicine*. 2000;50(2):215-231. Accessed July 13, 2018. <http://www.ncbi.nlm.nih.gov/pubmed/10619691>
25. Kincaid DL. Mass Media, Ideation, and Behavior. *Communication Research*. 2000;27(6):723-763. doi:10.1177/009365000027006003
26. Dalglish SL, Vandermark J, Rossier C, Kemou A, Neighbor H. Using Marketing Science to Understand Contraceptive Demand in High-Fertility Niger. *Studies in Family Planning*. 2018;49(4):367-383. doi:10.1111/sifp.12078
27. Harris ML, Egan N, Forder PM, Coombe J, Loxton D. Contraceptive use among women through their later reproductive years: Findings from an Australian prospective cohort study. *PloS one*. 2021;16(8). doi:10.1371/JOURNAL.PONE.0255913
28. Babalola S, Vonrasek C. Communication, ideation and contraceptive use in Burkina Faso: an application of the propensity score matching method. *The journal of family planning and reproductive health care*. 2005;31(3):207-212. doi:10.1783/1471189054484022
29. Babalola S, Kusemiju B, Calhoun L, Corroon M, Ajao B. Factors associated with contraceptive ideation among urban men in Nigeria. *International Journal of Gynecology & Obstetrics*. 2015;130:E42-E46. doi:10.1016/j.ijgo.2015.05.006
30. MLE. Measurement Learning and Evaluation of the Urban Reproductive Health Initiative: Senegal 2015 Endline Survey executive summary. Published online 2016. Accessed September 22, 2018. <https://www.popline.org/node/652195>
31. Lanza ST, Patrick ME, Maggs JL. Latent transition analysis: Benefits of a latent variable approach to modeling transitions in substance use. *Journal of Drug Issues*. 2010;40(1):93-120. doi:10.1177/002204261004000106
32. Ryoo JH, Wang C, Swearer SM, Hull M, Shi D. Longitudinal Model Building Using Latent Transition Analysis: An Example Using School Bullying Data. *Frontiers in Psychology*. 2018;9(MAY):675. doi:10.3389/fpsyg.2018.00675
33. Mangone ER, Gottfredson N, Speizer I, Domino M, Fried B, Lich K. *Chapter 2: The Development of Contraceptive Ideation Profiles among Urban in-Union Women in Senegal: A Latent Profile Analysis.*; 2021.
34. Collins L, Lanza S. *Latent Class and Latent Transition Analysis*. Wiley; 2010. Accessed September 1, 2018. <https://www.wiley.com/en-us/Latent+Class+and+Latent+Transition+Analysis%3A+With+Applications+in+the+Soc+ial%2C+Behavioral%2C+and+Health+Sciences-p-9780470228395>

35. Kongsted A, Nielsen AM. Latent Class Analysis in health research. *Journal of Physiotherapy*. 2017;63(1):55-58. doi:10.1016/j.jphys.2016.05.018
36. Nylund KL, Asparouhov T, Muthén BO. *Deciding on the Number of Classes in Latent Class Analysis and Growth Mixture Modeling: A Monte Carlo Simulation Study*. Vol 14.; 2007.
37. Akaike H. Factor analysis and AIC. *Psychometrika*. 1987;52(3):317-332. doi:10.1007/BF02294359
38. Schwarz G. Estimating the Dimension of a Model. *The Annals of Statistics*. 1978;6(2):461-464. doi:10.1214/aos/1176344136
39. Tein JY, Coxe S, Cham H. Statistical Power to Detect the Correct Number of Classes in Latent Profile Analysis. *Structural equation modeling : a multidisciplinary journal*. 2013;20(4):640-657. doi:10.1080/10705511.2013.824781
40. Wang MC, Deng Q, Bi X, Ye H, Yang W. Performance of the entropy as an index of classification accuracy in latent profile analysis: A Monte Carlo simulation study. *Acta Psychologica Sinica*. 2017;49(11):1473. doi:10.3724/sp.j.1041.2017.01473
41. Perra O. Latent Transition Analysis. Queens University of Belfast. Published 2012. Accessed May 6, 2020. [http://www.restore.ac.uk/latentvariablemodels/workshopfiles/Latent Transition Analysis_Oliver Perra/Course Presentation and Exercises/LTA_course_UU.pdf](http://www.restore.ac.uk/latentvariablemodels/workshopfiles/Latent%20Transition%20Analysis_Oliver%20Perra/Course%20Presentation%20and%20Exercises/LTA_course_UU.pdf)
42. Collier ZK, Leite WL. A Comparison of Three-Step Approaches for Auxiliary Variables in Latent Class and Latent Profile Analysis. *Structural Equation Modeling*. 2017;24(6):819-830. doi:10.1080/10705511.2017.1365304
43. Bakk Z, Tekle FB, Vermunt JK. Estimating the Association between Latent Class Membership and External Variables Using Bias-adjusted Three-step Approaches. *Sociological Methodology*. 2013;43(1):272-311. doi:10.1177/0081175012470644
44. Asparouhov T, Muthén B. *Auxiliary Variables in Mixture Modeling: Using the BCH Method in Mplus to Estimate a Distal Outcome Model and an Arbitrary Secondary Model*.; 2020.
45. Asparouhov T, Muthén B. *Auxiliary Variables in Mixture Modeling: Using the BCH Method in Mplus to Estimate a Distal Outcome Model and an Arbitrary Secondary Model*.; 2021. Accessed March 1, 2021. <https://www.statmodel.com/examples/webnotes/webnote21.pdf>

CHAPTER 4: AN ASSESSMENT OF THE RELATIONSHIPS BETWEEN WOMEN'S CONTRACEPTIVE IDEATIONAL PROFILES AND FAMILY PLANNING USE AND INTENTION TO USE IN URBAN SENEGAL

Introduction

Ideation is defined as the “perceptions and ideas that individuals hold that reflect various social, environmental, and personal influences” but conceptually, it can be thought of as a person’s readiness to act.^{1,2} Ideation is comprised of three domains; cognitive (knowledge, beliefs, values), emotional (self-efficacy, preferences), and social (interpersonal communication, social support and influence).^{3,4} In the context of family planning (FP) and reproductive health, improvements in ideational variables have been associated with use of and intention to use contraception.⁴⁻⁷ Although most research has examined ideational domains and indicators using variable centered approaches such as regression and factor analyses, the application of person-centered approaches to longitudinal data has the potential to reveal new insights about contraceptive ideation, intention, and use.⁸

Person-centered approaches such as latent class, latent profile, and latent transition analysis assume a heterogeneous population in regards to how predictors influence dependent variables and seek groups of individuals that exhibit similar characteristics or patterns.^{8,9} In the field of reproductive health and FP, person-centered approaches have identified important, recurring patterns of social, cognitive, and emotional indicators that drive contraceptive ideation, motivation, autonomy, and decision making.^{7,10-12} These patterns, or contraceptive ideational profiles (CIPs), have the potential to help FP programs tailor supportive and effective interventions to women who are most in need or who may be more receptive to certain message

content or forms of engagement.^{7,12} In addition to identifying and exploring the underlying indicators and interpretations of CIPs, it can also be useful to assess the relationships between profile membership and programmatic outcomes of interest, especially as populations transition between CIPs over time.^{7,13,14}

The informed, voluntary use of modern contraceptive methods improves health, economic, and social outcomes for women, children, and families.^{15,16} Modern methods include male and female sterilization, daily oral pill, intra-uterine devices (IUDs), implants, injectables, male and female condoms, emergency contraception, Standard Days Method (SDM), and lactational amenorrhea.¹⁷ Intention to use any contraceptive method in the next twelve months among women not currently using is also an important construct that can mark ideational evolution even when there are other barriers to actual use (financial, geographic, supply, provider, etc.). FP intent has also been found to be predictive of future FP use.^{5,18,19} A better understanding of the dynamic relationships between contraceptive ideation, intention, and use over time can offer a more nuanced, holistic picture of women's reproductive journeys.

Contraceptive Ideational Profiles in Senegal

Senegal, a low-income country in western Africa, declared FP to be a national public health objective in 2012 and doubled its modern contraceptive prevalence (MCP) among married women from an estimated 14 percent in 2012 to 28 percent in 2020.²⁰ However, this MCP fell well short of the government's goal of reaching an MCP of 45 percent by 2020.²¹ Social, cultural, and cognitive factors were probable barriers to more rapid gains in MCP; although Senegal made important supply chain improvements to expand access to modern methods, fears and misconceptions around FP persisted and knowledge and social support remained low.^{22–27} This suggests that approaches are needed to help FP communications programs identify, reach,

and engage populations effectively. A recent study sought to advance person-centered methods of FP audience segmentation to offer greater insights into the identities and needs of subpopulations to shape message content and engagement strategies.¹² Using longitudinal data collected in 2011 (baseline) and 2015 (endline) from 4,047 in-union, urban women of reproductive age (15–49), Mangone et al. (2021) identified four latent CIPs using six ideational indicators of contraceptive awareness, misconceptions, perceived self-efficacy, partner acceptance of FP use, communication about FP with partner, and perceived community support.¹² In addition to identifying these CIPs, this research examined whether and how health communication message content and modalities influenced those transitions. However, the study did not examine relationships between the CIPs and key programmatic outcomes of interest such as current modern contraceptive use and intention to use a method.

In the current manuscript, we build on this body of work to examine FP outcomes of interest: current modern method use among all women and intention to use any method in the next 12 months among current non-users as a function of membership in these profiles. Figure 6 depicts the hypothesized relationship between the CIPs at two time points and contraceptive use and intention to use. Although the outcomes of interest were captured at the same time as the profiles, ideation is generally a prerequisite to behavior and therefore simultaneity, a form of endogeneity, was not a concern. For example, a woman would not typically use a method before she had knowledge and positive beliefs about FP. For this reason, the arrows between the CIPs and FP use and intention to use are not bi-directional. The bottom of the figure indicates that the latent CIP variable drives women's FP awareness, beliefs, self-efficacy, partner support, partner communication, and community support. The interpretation of the CIPs were invariant, meaning that the qualitative characteristics did not change over time, but membership did change as

women transitioned between CIPs between baseline and endline. We hypothesized that CIP 4 membership in 2011 and 2015 was associated with the highest levels of contraceptive use and intention to use among non-users, followed by CIP 3, CIP 2, then CIP 1.

Contraceptive Ideational Profiles Identified in Mangone et al. (2021)¹²

CIP 1: Lowest efficacy and FP awareness, highest misconceptions, unsupported

The three most notable attributes for CIP 1 were extremely low self-efficacy, high misconceptions about FP, and low contraceptive awareness. These were the indicators representing the emotional and cognitive domains of contraceptive ideation. Women in CIP 1 also were more likely to report that their partners forbid FP use and did not believe that their communities would support their decisions to use FP. This CIP had the smallest membership at baseline (7%) and endline (4%).

CIP 2: Low efficacy and FP awareness, rejects misconceptions, unsupported

In CIP 2, women still had low perceived self-efficacy as the strongest attribute, but it was much less negative than CIP 1. Partner communication, social support, partner support, and contraceptive awareness were all fairly low. One notable positive attribute for this group was their rejection of misconceptions about FP. CIP 2 had the second smallest proportional membership at baseline (12%) and endline (17%).

CIP 3: Moderate efficacy, high FP awareness, high misconceptions, moderate support

In CIP 3 the defining attribute was high misconceptions about FP. Otherwise, women had above-average contraceptive awareness and otherwise very average efficacy and community and partner support. CIP 3 was the second largest group at baseline (34%) and endline (19%).

CIP 4: Highest efficacy and FP awareness, fewest misconceptions, most supported

In CIP 4, women had relatively high contraceptive awareness, strongly rejected misconceptions, had high perceived self-efficacy, had good partner support for FP, were more likely to have discussed FP with their partners in the past six months, and were likely to believe that their communities would support their decisions to use an FP method. CIP 4 had the largest membership at both baseline (47%) and endline (60%).

In our second analysis, we further examine whether transitions, represented by the dashed lines in Figure 7, from lower to higher CIPs, conditional on profile membership at baseline are also predictive of FP use at endline. This analysis helps us understand not just whether a

woman's current profile matters for family planning use but whether her history (previous profile membership) matters. The deep examination of the transitions of women from each baseline CIP and their future contraceptive use can provide additional insight into how ideational journeys relate to behavioral outcomes.

Objective

The objective of this study is to test whether there are significant differences in modern method use and, for those not currently using, intention to use any method between women in different CIPs while controlling for key covariates and accounting for correlation inherent in longitudinal data. We hypothesized that membership in higher numbered CIPs is associated with higher probabilities of modern method use, even when controlling for key covariates. We also tested whether CIP membership at endline is associated with contraceptive use conditional on baseline CIP to determine whether ideational history, not just a woman's current status, is associated with modern method use.

This study is important because it tests whether CIP membership is a meaningful targeting variable that can be used in health communication programming to predict important behavioral outcomes. CIP membership indicates whether and how women might be ideationally empowered or ready to act on their contraceptive intentions. This analysis provided evidence of the utility of CIPs as tools for segmenting women to understand their contraceptive decision making, intention, and use and, ultimately, provide supportive, person-centered interventions designed to help women achieve their reproductive intentions.

Methods

Dataset

This study uses data from the Measurement, Learning and Evaluation (MLE) Project for the Urban Reproductive Health Initiative in Senegal which included survey data from urban Senegalese women of reproductive age (15–49) who lived in Dakar, Guédiawaye, Pikine, Mbao, Mbour, and Kaolack between 2011 and 2015.²⁸ A two-stage sampling design was employed in which the 2002 Population and Housing Census's districts were used as the primary sampling units (PSU) in the first stage and a random sample of 268 districts was selected in each city based on a probability proportional to their populations. To increase the inclusion of poor women, PSU were stratified by poor and non-poor and were selected equally. In each PSU, 21 households were randomly selected for interview with equal probability to create a sample of 5,628 households. All women of reproductive age (15–49 years old) in selected households were eligible for baseline survey participation. At baseline, 9,614 women were surveyed and 6,927 of these women were identified and re-surveyed at endline. Women were re-weighted at endline to account for attrition.

Key Variables

CIPs were developed in earlier research using latent transition analysis with a balanced dataset of Senegalese women of reproductive age who were in-union (married or living with a partner) at baseline (2011) and who responded to the endline survey in 2015 (n=4,047).¹² Four profiles were identified at baseline and endline using six evidence-based and theory-driven cognitive, social, and emotional indicators of contraceptive ideation including FP awareness, misconceptions about FP, contraceptive self-efficacy, partner FP acceptance, communication with a partner about FP in the past six months, and perceived social support for FP use. These

profiles were then constrained to retain the same interpretation over time. In this analysis, CIPs are the independent variable of interest.

Dependent variables of interest included 1) current use of a modern FP method among all 4,047 women in the sample in each of the two waves (n=7,634) and 2) women's intention to use any FP method in the next twelve months among women not using a method at baseline (n=2,618) or endline (2,314). Although current use of a modern method measures overt behaviors, intention to use a method is an important measurement of ideational status that can help identify ideational changes even when behaviors remain the same.

We used listwise deletion of missing variables and examined whether our complete case analysis approach had evidence of selection bias. To determine whether women with certain characteristics were more likely to have missing outcome values, we regressed a dummy indicator for missing FP use values on the covariates included in the model. In our sensitivity analysis, only age was significant at the $p < 0.01$ level, indicating that older women were significantly ($p < 0.000$) more likely to have missing values, though only by a small margin (ME 0.009, SE 0.001). This indicated that non-response was not strongly correlated with the covariates in the model.

Analytical Approach

We used the straightforward classify-analyze approach to model the complex relationships between CIPs and FP intention and use while controlling for multiple covariates and addressed classification uncertainty and potential attenuation of estimates through a pseudo-class analysis.²⁹ To create the CIPs, we used the posterior probability of each individual's membership in each of the four latent CIPs and assigned each individual to the CIP that maximized her probability of membership.¹² Once the CIPs were defined, we conducted all

analyses in STATA16 using generalized estimating equations (GEE) to estimate the association between membership in the four latent CIPs and two FP outcomes of interest while controlling for key covariates.³⁰

Standard logistic regression models for a binary dependent variable rely on the assumption that observations are independent and a violation of this assumption can result in biased standard errors.³¹ Developed by Zeger and Liang in 1986, GEE extend the generalized linear model (GLM) framework and can be used when observations are correlated or clustered and errors are correlated.³² GEE models use quasi-likelihood estimation, rather than maximum likelihood or ordinary least squares, to estimate parameters. A quasi-likelihood estimator estimates β by maximizing the normality-based log likelihood without assuming a normally distributed response. Instead of modeling within-subject covariance, GEE models incorporate the specified covariance function in estimating the mean response.³³ Because our outcomes of interest (modern method use and intention to use) are binary, we assumed a binomial distribution and the logit link function.

Associations between CIP membership and modern method use and intention

The working correlation matrix specifies the correlation between the repeated observations and correct specification of the correlation matrix ensures that the estimators of the regression coefficients are efficient.³⁴ In our analyses conceptualized in Figure 6, we considered exchangeable and unstructured correlation structures. To identify the best correlation structure, we estimated the quasi-information criteria (QIC) likelihood function using a working independence structure for which the lowest value suggests the best correlation structure.^{35,36} To test the associations between CIP membership and our outcomes of interest while accounting for covariates as well as repeated measures (baseline and endline) within-subject, we selected the

correlation structure to account for panel data over time. Although the exchangeable and unstructured correlation structures returned identical QIC values, the unstructured correlation requires fewer assumptions about the nature of the correlation and therefore we opted for this structure (Table 20).

To account for confounding factors in the relationship between CIPs and FP outcomes, we controlled for demographic characteristics that were associated with both FP use and CIP membership in earlier bivariate models including age in years, parity, wealth quintiles, education (no education, primary, secondary), city of residence, and a time dummy for endline to control for possible effects of time on outcomes and used probability weights to account for the complex sampling framework. We also used the QIC to help determine the functional form of the included theory-driven covariates. We tested a version of the model with age groups instead of continuous age as well as age in quadratic format and selected the quadratic form because of the lower QIC for both outcomes. Finally, we used a chi-squared test to determine whether the average marginal effects of CIP membership on FP use and intention to use were significantly different across CIPs.

Uncertainty analysis

One limitation of using the classify-analyze approach is that it treats the CIPs as an observed variable. This means that the relationship between the CIPs and the outcomes of interest may be attenuated to the extent that there is uncertainty in the unknowable actual latent profile membership.^{37,38} To account for uncertainty in membership assignment, we conducted a pseudo-class analysis in which latent profile membership was assigned probabilistically according to each individual's posterior distribution.^{37–39} Twenty pseudo-CIP variables were drawn in this way, consistent with earlier studies, and the outcomes of interest were regressed on

the pseudo-class CIPs and covariates to assess variability in the outcomes due to uncertainty in latent profile membership.³⁷ Results of the uncertainty analysis were consistent with the primary analyses and no statistical or meaningful differences were identified.

Associations between CIP transitions and FP use

In our second analysis, conceptualized in Figure 7, our research question of interest was whether transitions to higher CIPs were associated with a higher probability of FP use conditional on baseline CIP. We did not examine intention to use an FP method as an outcome because the transition sample sizes were insufficient to achieve reliable coefficients and several transitions were omitted in initial analyses. For this analysis, we used GEE models with the correlation modeled at the level of the Senegalese 2002 Population and Housing Census districts (updated in 2009).⁴⁰ We interacted the baseline and endline CIP variables to represent each transition (e.g., baseline CIP 1 to endline CIPs 1, 2, 3, and 4, etc.) in a pooled model. We used the unstructured correlation structure again in this analysis under the same generalized assumptions.

Results

Table 21 presents a summary of the demographic characteristics of the women in the sample at baseline and endline. At baseline, about one-fourth of women were currently using an FP method and one-fourth of non-users had stated an intention to use a method in the next 12 months. Less than 8 percent of women were in CIP 1 (*Lowest efficacy and FP awareness, highest misconceptions, unsupported*) at baseline with most women (47%) in CIP 4 (*Highest efficacy and FP awareness, fewest misconceptions, most supported*). A little over half (57%) of women were age 15 to 34 with only a small proportion of adolescents. Nearly 40 percent of women had no education or Koranic only and only 10 percent of women were nulliparous. At

endline, over one-third of women reported currently using a modern method and about 20 percent of non-users intended to use a method in the next 12 months. Membership in CIP 1 decreased to less than 4 percent and membership in CIP 4 increased to 60 percent. Very few women at endline were nulliparous.

CIP Membership and FP Use and Intention

For FP use, we found that, compared to membership in CIP 4 (modal CIP), membership in CIPs 1, 2, and 3 was associated with a significantly lower probability of using a modern FP method ($p < 0.001$), even when controlling for age, parity, education, wealth, city of residence, and general time trends (Table 22). Being a member of CIP 3 was associated with a 19.0 percentage point lower predicted probability of using a modern FP method compared with membership in CIP 4. Membership in CIP 2 was associated with a 29.0 percentage point lower probability of modern FP use, and membership in CIP 1 was associated with a 40.7 percentage point lower predicted probability of FP use compared to CIP 4. We also found that the relationship between CIP 2 and CIP 4 was significantly different ($p < 0.001$) from that between CIP 3 and CIP 4, indicating a significantly higher probability of use in CIP 3 than CIP 2. Age and parity were also significant predictors of modern FP use ($p < 0.001$). Interestingly, they had opposite effects with increases in age associated with a lower probability of use but additional children resulting in a higher probability of use, though both with small magnitudes of impact. Residence of the city of Kaolack was also associated with a significantly lower probability of FP use compared to residency in the city of Dakar. Finally, the time dummy for the endline year was also positive and significant indicating that overall FP use increased by 6.5 percentage points between 2011 and 2015.

For intention to use a method among current non-users, effects were similar to those in the FP use model. Compared to membership in CIP 4, membership in CIP 1 was associated with a 36.1 percentage point lower probability of intending to use a method, membership in CIP 2 was associated with a 19.6 percentage point lower probability of intending to use a method, and membership in CIP 3 was associated with a 15.4 percentage point lower probability of intending to use a method. In contrast to the FP use analysis, the marginal effect of membership in CIP 2 was not significantly different from that of CIP 3 in terms of CP intention to use ($p=0.153$). We also saw similar effects of age and parity, as well as residence in Kaolack and the time dummy. We also ran both models with only the CIP variable without controlling for the covariates to determine how sensitive the results were to this set of covariates. Although the marginal effects for the CIP were greater without covariates in the models, they were not significantly different from the marginal effects in the main models (data not shown).

To test the sensitivity of the model to the uncertainty of profile assignment, we drew 20 pseudo-CIP variables. As expected, adding an element of random chance to CIP membership assignment attenuated the average marginal effect across pseudo-CIPs. However, this analysis produced no differences in the significance of the relationships between the pseudo-CIPs and FP use or the relationships between the pseudo-CIPs and FP intent.

CIP Transitions and FP Use

In our second analysis, we tested whether transitions between profiles over time were associated with higher or lower predicted probabilities of modern FP use at endline conditional on baseline CIP (Table 23). The top half of the table presents the marginal effects of the interactions between baseline and endline CIP membership and the bottom half of the table presents the average marginal effects of the covariates in the model. Among women who were in

endline CIP 1, maintaining membership in CIP 1 from baseline or transitioning from baseline CIP 2 or baseline CIP 3 was associated with a significantly lower predicted probability of using FP at endline compared to transitioning to endline CIP 4 by 40.9 percentage points, 25.6 percentage points, and 37.6 percentage points, respectively. Transition to endline CIP 1 from baseline CIP 4 was perfectly predictive of non-use of FP and was therefore omitted from the model. All marginal effects of the interactions with membership in endline CIP 1 compared to membership in endline CIP 4 on modern FP were consistent with what we found in our first GEE model, which also found that the predicted probability of FP use was significantly lower in CIP 1 than CIP 4. However, a chi-square test found that the average marginal effects of the endline CIPs given different baseline CIPs were not significantly different from each other. This suggested that for women in endline CIP 1, their ideational profile history, or baseline CIP, did not matter in terms of their FP use. The same was true of women in CIP 2. For women in endline CIP 2, transitions from baseline CIP 1, CIP 2, CIP 3, and CIP 4 were all associated with a lower probability of FP use compared to women in CIP 4 by 39.3 percentage points, 27.2 percentage points, 27.1 percentage points, and 33.5 percentage points, respectively. However, the marginal effects of these interactions were not significantly different from each other, which again suggested that for women in endline CIP 2, their ideational profile history, or baseline CIP, did not matter in terms of their FP use. For women in endline CIP 3, transitions from baseline CIP 1, CIP 2, CIP 3 and CIP 4 were all associated with a lower probability of FP use compared to women in CIP 4 by 35.2 percentage points, 24.2 percentage points, 19.7 percentage points, and 12.6 percentage points, respectively. For women in endline CIP 3, there was no significant difference in the marginal effect of transitioning from CIP 1, CIP 2, or CIP 3 at baseline. However, there was a significant difference between the marginal effects of transitioning from

CIP 1 at baseline and transitioning from CIP 4 at baseline. This indicates that for women in endline CIP 1, those that transitioned from baseline CIP 1 were significantly less likely to use FP than women who transitioned from baseline CIP 4. In short, for women in CIP 3 at endline, ideational history did matter, with women transitioning from lower CIPs still less likely to use FP than those transitioning from higher CIPs. In terms of covariates, increases in parity and education were also significantly associated with higher predicted probabilities of FP use, and increased age was significantly associated with lower predicted probability of FP use in the model.

Given the perfect prediction of FP non-use at endline among women who transitioned from CIP 4 at baseline to CIP 1 at endline and the fact that there are many reasons that women may choose not to use FP, we presented the average item response probabilities for women in this transition group (Table 24). Although FP awareness did not change substantially, the other five indicators were much lower in 2015 compared to 2011.

Discussion

The results of this study were consistent with our hypotheses about the relationships between CIP membership and intentional and behavioral FP outcomes. As anticipated, membership in CIP 4 and transition to CIP 4 from a lower CIP were the strongest predictors of FP use and intention to use, even when controlling for general time trends and other demographic characteristics that drive contraceptive use and intention to use over time. Although it was already apparent that women in CIP 4 were, on average, more empowered in their contraceptive ideation based on underlying ideational indicators, the results of this analysis suggest that women in CIP 4 are more enabled to use FP as well. This finding indicates that CIPs

can be helpful to FP programs and decision makers as a broader measurement of positive ideation, empowerment, and programmatic success even when contraceptive use is not achieved.

Another important finding is that in terms of overall current modern method use, women in CIP 3 have a significantly higher probability of FP use compared to CIP 2. CIP 3 was qualitatively different from CIP 2 in that women in CIP 3 were characterized by strong misconceptions but had higher scores on the other five of the six underlying indicators. This indicated that even though women who were members of CIP 3 were, on average, more likely to espouse myths and misconceptions about FP (e.g., FP can cause infertility, cancer, birth defects, and other health concerns), they were still more likely to use a modern method than those who rejected misconceptions but had low contraceptive awareness, partner support, partner communication, community support, and perceived self-efficacy, as women did in CIP 2. However, this relationship did not hold for intention to use, and there were no significant differences of intention to use an FP method among non-users in CIP 2 and CIP 3.

When we examined specific transitions between baseline and endline CIPs, we reaffirmed that transitions to lower CIPs from higher CIPs were significantly associated with lower probabilities of FP use, but with a few nuances. When we examined interactions between baseline and endline CIPs to determine whether not just current profile matters but profile history matters for FP use, we found mixed results. For women who transitioned into CIP 1 and CIP 2 at endline, their previous ideational profile histories did not seem to have a differential effect on their probability of FP use. However, we also may not have been powered to differentiate FP use given the small numbers of women who transitioned into CIP 1 and 2 at endline. In contrast, for women in CIP 3 at endline, women who transitioned from CIP 1 at endline were associated with a significantly lower probability of FP use compared to women who transitioned from CIP 4.

This finding suggests that there may be variations within CIPs and these variations may be explained by women's ideational evolution.

Interpreting the findings another way, for women in CIP 1 and CIP 2 at baseline, we found that transitions into CIP 1, CIP 2, or CIP 3 at endline were associated with equally lower predicted probabilities of FP use compared with transition into CIP 4. For these women, only transition into CIP 4 was associated with higher probability of FP use. This means that FP programs and decision makers may not immediately see behavioral outcomes for women in lower ideational profiles even when women experience positive ideational growth (improved awareness, beliefs, partner communication, etc.) unless those changes are strong enough to classify women as members of CIP 4. These analyses suggest that CIP 4 is both the most desirable profile from the perspective of FP policy makers in terms of underlying ideational indicators and because women in CIP 4 were largely enabled to act on their contraceptive intentions and use FP. It also suggested that FP programs and policy makers should spend effort targeting women in CIPs 1 and 2, who, though smaller in proportional membership, may be most in need of ideational empowerment to make informed, voluntary decisions about their contraceptive use.

This study had several limitations. The first limitation was the uncertainty of CIP membership stemming from imperfect probabilistic assignment in our classify-analyze approach. Other methods for relating latent variables to distal outcomes such as the BCH and Lanza-Tan-Bray (LTB) methods have been shown to reduce bias related to the uncertainty of latent profile assignment compared to the classify-analyze approach under some circumstances. However, a limitation of the BCH method is that if the entropy is not sufficient the BCH weights become negative and the estimates for the auxiliary model with a distal outcome become unusable.⁴¹

Similarly, the LTB approach performs poorly when entropy is insufficient and when the distal outcome is categorical, and the three-step approach does not entirely fix the dilemma of classes shifting when the auxiliary variables are included in the final stage.⁴¹ We therefore selected the straightforward classify-analyze approach and addressed the uncertainty of class assignment through our pseudo-class analysis, which indicated that even if women were not perfectly classified, the attenuation of the estimates towards the null did not prevent us from identifying significant and meaningful relationships between the latent profiles and the distal outcomes. The estimated relationships remained significant in all scenarios and reflected the directionality of our primary model results. As newer methods emerge to address potential bias in estimating distal outcomes from latent variable models, they may provide further evidence of the strength of the relationship between CIPs and FP use and intention.

A second limitation was that several of the transition groups were small, particularly in the lower-number CIPs (transitions to and from CIP 1 and CIP 2) and this may have impacted our ability to differentiate significant relationships between those transitions and FP use. It also meant that any sampling or measurement errors in the data could have had a greater impact on these estimates. A third limitation was that there were minimal differences between model statistics for independent, unstructured, and exchangeable correlation structures, indicating that there may not be substantial gains from using generalized estimating equations over maximum likelihood approaches. Nevertheless, GEE methods offer a robust and compelling approach to statistical inference and alternative to maximum likelihood models even when the correlation is misspecified or the parameter of interest is not the true mean model.⁴²

Conclusion

The conclusion of this study is that CIPs can be useful tools for identifying, evaluating, and understanding evolving dynamics between contraceptive ideation, intention, and use. FP programs that seek to improve behavioral outcomes can apply latent CIP methodologies to identify subpopulations of women with shared contraceptive ideation, use these profiles to tailor FP communication content and modalities, and ultimately measure cognitive, social, emotional, and behavioral changes across groups and over time. Although we focused on FP use, future studies could expand on this research and examine important negative outcomes such as sexually transmitted infections, intimate partner violence, or abortion. As this field develops new methods for relating latent variables to behavioral outcomes over time, this person-centered approach has potential become an invaluable tool in the global FP toolkit and may, in time, become a high-impact practice in family planning. Given the Government of Senegal's ambitious new FP2030 targets of reaching a modern contraceptive prevalence of 46 percent among in-union women by 2025, policymakers in Senegal and SBC advocates and researchers at the global level should consider exploring contraceptive ideational profiling as an enhanced SBC audience segmentation approach that can articulate latent ideational states and needs of the population as well as relate those ideational states to contraceptive use and intention.⁴³

Figures

Figure 6. Conceptual Model of Latent CIPs and Contraceptive Use and Intention to Use

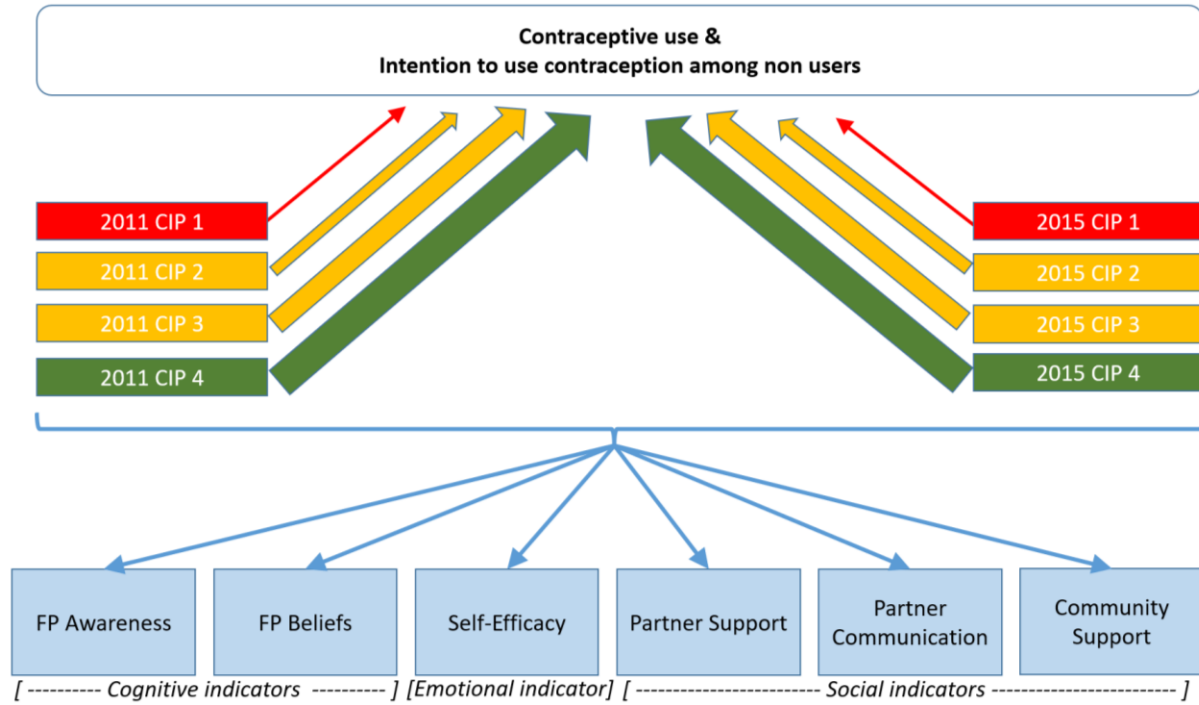
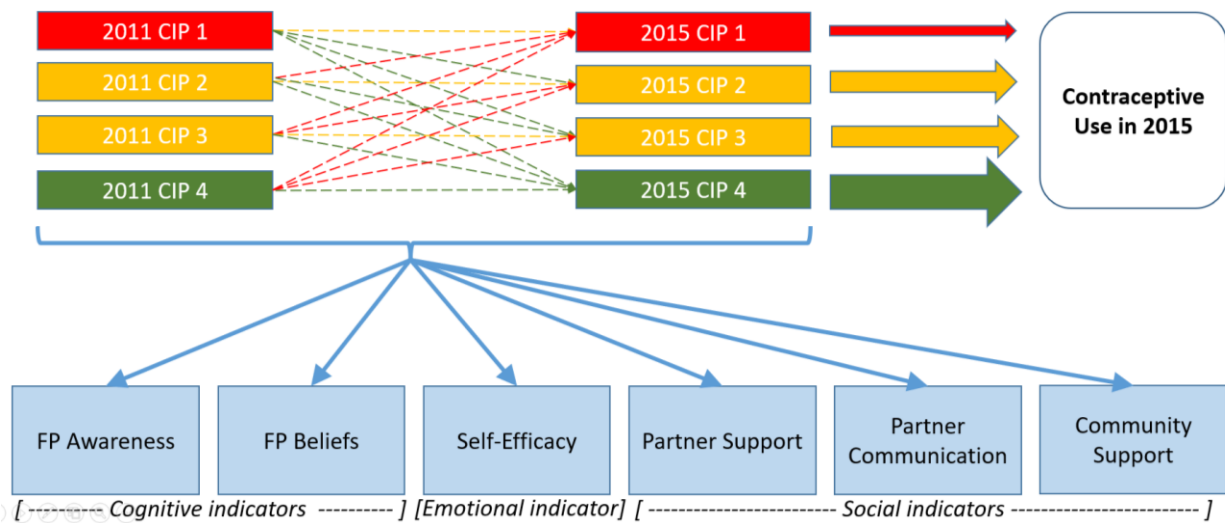


Figure 7. Conceptual Model of Latent CIP Transitions and Contraceptive Use in 2015



Tables

Table 20. Results of the Quasi-Likelihood Information Criteria for Correlation Structure

| Correlation | Covariates | QIC FP Use | QIC FP Intent |
|--------------------|---|-----------------------|--------------------------|
| Exchangeable | CIP, age, parity, education, wealth, city | 8408.88 | 4040.17 |
| Unstructured | CIP, age, parity, education, wealth, city | 8408.88 | 4040.17 |

Table 21. Demographic Characteristics of In-Union Urban Women in Sample (n=4,047)

| | Baseline (2011) N (weighted %) | Endline (2015) N (weighted %) |
|---|---|--|
| Dependent variables of interest | | |
| Currently using a modern method | 1,168 (26%) | 1,534 (35%) |
| Intends to use a method (non users) | 768 (26%) | 587 (20%) |
| Contraceptive Ideational Profile ^a | | |
| CIP 1 | 317 (7%) | 154 (4%) |
| CIP 2 | 507 (12%) | 844 (17%) |
| CIP 3 | 1,314 (34%) | 599 (19%) |
| CIP 4 | 1,909 (47%) | 2,450 (60%) |
| Age | | |
| Adolescent (15-19) | 164 (3%) | 9 (0%) |
| Youth (20-24) | 641 (13%) | 209 (5%) |
| Adult (25-34) | 1,643 (41%) | 1,550 (37%) |
| Mature (35-49) | 1,599 (43%) | 2,279 (58%) |
| Education | | |
| None or Koranic only | 1,825 (39%) | 1,852 (41%) |
| Primary | 1,485 (38%) | 1,452 (36%) |
| Secondary or higher | 737 (23%) | 741 (23%) |
| Parity | | |
| No children | 425 (10%) | 166 (4%) |
| 1 child | 627 (16%) | 333 (10%) |
| 2 children | 675 (17%) | 679 (18%) |
| 3 children | 616 (16%) | 740 (20%) |
| 4 children | 493 (12%) | 641 (16%) |
| 5 or more children | 1,211 (29%) | 1,488 (33%) |
| Wealth quintile | | |
| Poorest | 745 (17%) | 745 (23%) |
| Second | 873 (21%) | 873 (21%) |
| Middle | 954 (21%) | 954 (18%) |
| Fourth | 829 (21%) | 829 (21%) |
| Richest | 646 (20%) | 646 (17%) |
| City of residence | | |
| Dakar | 595 (36%) | 612 (37%) |
| Guédiawaye | 481 (11%) | 470 (11%) |
| Pikine | 488 (13%) | 465 (12%) |
| Mbao | 436 (23%) | 478 (24%) |
| Mbour | 999 (8%) | 1,002 (8%) |
| Kaolack | 1,048 (9%) | 1,020 (9%) |

^aMembership assigned based on maximized estimated posterior probability. Counts are weighted by survey weights such that if a person is classified to be in CIP 1, that person not counted as 1 but as the standardized sampling weight. The final number is rounded to an integer.

Modern methods include: pill, implant, IUD, injectables, male or female condoms, male or female sterilization, emergency contraception, LAM

Weighted using baseline and endline six-city probability weights

Table 22. Average Marginal Effects of CIP Membership on FP Use and FP Intent

| | FP Use Model 1 obs=7,634, individuals=4,022 | | FP Intent Model 2 obs=4,463; individuals=3,053 | |
|---|---|-------------------|--|-------------------|
| | Marginal Effect | Standard Error | Marginal Effect | Standard Error |
| <i>CIP Membership [Reference: CIP 4]</i> | | | | |
| CIP 1 | -0.407** | 0.029 | -0.361** | 0.022 |
| CIP 2 | -0.290** | 0.025 | -0.196** | 0.032 |
| CIP 3 | -0.190** | 0.021 | -0.154** | 0.025 |
| Age | -0.010** | 0.001 | -0.015** | 0.001 |
| Parity | 0.039** | 0.006 | 0.051** | 0.006 |
| <i>Education [Reference: No education]</i> | | | | |
| Prime Education | 0.057 | 0.024 | 0.066 | 0.026 |
| Secondary Education | 0.041 | 0.032 | 0.068 | 0.035 |
| <i>Wealth Quintile [Reference: Quintile 1/ Poorest]</i> | | | | |
| Wealth Quintile 2 | 0.014 | 0.027 | 0.080 | 0.039 |
| Wealth Quintile 3 | 0.043 | 0.030 | 0.013 | 0.036 |
| Wealth Quintile 4 | 0.039 | 0.032 | 0.025 | 0.036 |
| Wealth Quintile 5 | 0.074 | 0.035 | -0.005 | 0.039 |
| <i>City of Residence [Reference: Dakar]</i> | | | | |
| Guédiawaye | 0.012 | 0.030 | -0.061 | 0.033 |
| Pikine | -0.042 | 0.029 | -0.024 | 0.032 |
| Mbao | -0.041 | 0.030 | -0.067 | 0.032 |
| Mbour | -0.015 | 0.027 | -0.069 | 0.028 |
| Kaolack | -0.074* | 0.027 | -0.100** | 0.026 |
| Endline time dummy | 0.065** | 0.017 | 0.067* | 0.022 |

* $p < 0.01$; ** $p < 0.001$ These models used repeated measures in 2011 and 2015

Table 23. Model 3: Average Marginal Effects of CIP Transition on Current FP Use in 2015

| | Marginal Effect | Standard Error | p-value | Confidence Interval | |
|--|-----------------|----------------|---------|---------------------|--------|
| | | | | High | Low |
| Transition to endline CIP 1 [Ref: Endline CIP 4] | | | | | |
| Baseline CIP 1 | -0.409 | 0.062 | 0.000 | -0.528 | -0.286 |
| Baseline CIP 2 | -0.256 | 0.070 | 0.000 | -0.393 | -0.117 |
| Baseline CIP 3 | -0.376 | 0.048 | 0.000 | -0.472 | -0.283 |
| Baseline CIP 4 | --- | --- | --- | --- | --- |
| Transition to endline CIP 2 [Ref: Endline CIP 4] | | | | | |
| Baseline CIP 1 | -0.393 | 0.061 | 0.000 | -0.511 | -0.270 |
| Baseline CIP 2 | -0.272 | 0.052 | 0.000 | -0.373 | -0.169 |
| Baseline CIP 3 | -0.271 | 0.031 | 0.000 | -0.334 | -0.210 |
| Baseline CIP 4 | -0.335 | 0.033 | 0.000 | -0.401 | -0.271 |
| Transition to endline CIP 3 [Ref: Endline CIP 4] | | | | | |
| Baseline CIP 1 | -0.352 | 0.067 | 0.000 | -0.489 | -0.226 |
| Baseline CIP 2 | -0.242 | 0.061 | 0.000 | -0.354 | -0.114 |
| Baseline CIP 3 | -0.197 | 0.032 | 0.000 | -0.263 | -0.136 |
| Baseline CIP 4 | -0.126 | 0.034 | 0.000 | -0.193 | -0.060 |
| Age (2015) | -0.016 | 0.001 | 0.000 | -0.018 | -0.014 |
| Parity (2015) | 0.041 | 0.004 | 0.000 | 0.033 | 0.050 |
| <i>Education (2015) [Ref: No education]</i> | | | | | |
| Primary education | 0.065 | 0.019 | 0.000 | 0.029 | 0.102 |
| Secondary education | 0.009 | 0.022 | 0.674 | -0.035 | 0.054 |
| <i>Wealth Quintile (2015) [Reference: Quintile 1/ Poorest]</i> | | | | | |
| Wealth Quintile 2 | 0.013 | 0.024 | 0.576 | -0.034 | 0.061 |
| Wealth Quintile 3 | 0.044 | 0.025 | 0.075 | -0.004 | 0.093 |
| Wealth Quintile 4 | 0.026 | 0.025 | 0.300 | -0.023 | 0.074 |
| Wealth Quintile 5 | 0.033 | 0.026 | 0.207 | -0.018 | 0.085 |
| <i>City (2015) [Reference: Dakar]</i> | | | | | |
| Guédiawaye | 0.002 | 0.028 | 0.931 | -0.052 | 0.057 |
| Pikine | -0.034 | 0.026 | 0.199 | -0.086 | 0.018 |
| Mbao | 0.014 | 0.023 | 0.551 | -0.031 | 0.059 |
| Mbour | 0.026 | 0.032 | 0.422 | -0.037 | 0.089 |
| Kaolack | -0.046 | 0.033 | 0.164 | -0.110 | 0.019 |

Table 24. Item Response Probabilities for Women Who Transitioned from Baseline CIP 4 to Endline CIP 1

| CIP Indicators | 2011 | | 2015 | |
|--------------------------------------|-----------------|-----------|-----------------|-----------|
| | Mean IRP | SD | Mean IRP | SD |
| FP awareness [0,13] | 6.17 | 1.57 | 5.54 | 1.90 |
| Rejection of misconceptions [-14,14] | 10.17 | 3.31 | -5.96 | 4.15 |
| Efficacy [-16,16] | 10.32 | 4.10 | -8.24 | 3.61 |
| Partner Communication [0,1] | 0.24 | 0.44 | 0.00 | 0.00 |
| Partner Support [0,1] | 1.00 | 0.00 | 0.56 | 0.51 |
| Community Support [0,1] | 0.44 | 0.51 | 0.12 | 0.33 |

REFERENCES

1. Cleland J, Wilson C. Demand Theories of the Fertility Transition: An Iconoclastic View. *Population Studies*. 1987;41(1):5-30. doi:10.1080/0032472031000142516
2. van de Kaa DJ. Anchored Narratives: The Story and Findings of Half a Century of Research into the Determinants of Fertility. *Population Studies*. 1996;50(3):389-432. doi:10.1080/0032472031000149546
3. Kincaid DL. Mass Media, Ideation, and Behavior. *Communication Research*. 2000;27(6):723-763. doi:10.1177/009365000027006003
4. Kincaid DL. Social networks, ideation, and contraceptive behavior in Bangladesh: a longitudinal analysis. *Social science & medicine*. 2000;50(2):215-231. Accessed July 13, 2018. <http://www.ncbi.nlm.nih.gov/pubmed/10619691>
5. Babalola S, John N, Ajao B, Speizer IS. Ideation and intention to use contraceptives in Kenya and Nigeria. *Demographic Research*. Published online 2015. doi:10.4054/DemRes.2015.33.8
6. Babalola S, Vonrasek C. Communication, ideation and contraceptive use in Burkina Faso: an application of the propensity score matching method. *The journal of family planning and reproductive health care*. 2005;31(3):207-212. doi:10.1783/1471189054484022
7. Babalola S. Changes in Ideational Profiles of Women of Reproductive Age in Urban Nigeria: The Role of Health Communication. *Health Education and Behavior*. Published online 2017. doi:10.1177/1090198117699510
8. Laursen B, Hoff E. Person-centered and variable-centered approaches to longitudinal data. *Merrill-Palmer Quarterly*. 2006;52(3):377-389. doi:10.1353/MPQ.2006.0029
9. Meeusen C, Meuleman B, Abts K, Bergh R. Comparing a Variable-Centered and a Person-Centered Approach to the Structure of Prejudice: <https://doi.org/10.1177/1948550617720273>. 2017;9(6):645-655. doi:10.1177/1948550617720273
10. Opollo D, Pillai VK. Latent class analysis of reproductive decision making in Zambia. *African and Asian Studies*. 2012;11(3):371-383. doi:10.1163/15692108-12341238
11. Mangone ER, Gottfredson N, Speizer I, Domino M, Fried B, Hassmiller Lich K. *Chapter 2: The Development of Contraceptive Ideation Profiles among Urban in-Union Women in Senegal: A Latent Profile Analysis.*; Working paper. 2021.
12. Mangone ER, Gottfredson N, Speizer I, Domino M, Fried B, Hassmiller Lich K. *Chapter 3: Transitions in Contraceptive Ideation among Urban Women in Senegal: The Role of Health Communication.*; Working paper. 2021.

13. Piper KN, Haardörfer R, Escoffery C, Sheth AN, Sales J. Exploring the heterogeneity of factors that may influence implementation of PrEP in family planning clinics: a latent profile analysis. *Implementation Science Communications*. 2021;2(1). doi:10.1186/S43058-021-00148-3
14. Saunders R, Buckman JEJ, Pilling S. Latent variable mixture modelling and individual treatment prediction. *Behaviour Research and Therapy*. 2020;124. doi:10.1016/J.BRAT.2019.103505
15. Sonfield A, Hasstedt K, Kavanaugh ML, Anderson R. *The Social and Economic Benefits of Women's Ability To Determine Whether and When to Have Children.*; 2013.
16. Brown W, Ahmed S, Roche N, Sonneveldt E, Darmstadt G. Impact of family planning programs in reducing high-risk births due to younger and older maternal age, short birth intervals, and high parity. *Seminars in perinatology*. 2015;39(5):338-344. doi:10.1053/J.SEMPERI.2015.06.006
17. World Health Organization. Family planning/Contraception. Published 2018. Accessed June 29, 2018. <http://www.who.int/news-room/fact-sheets/detail/family-planning-contraception>
18. Curtis S, Westoff C. Intention to use contraceptives and subsequent contraceptive behavior in Morocco. *Studies in Family Planning*. 1996;27(5):239-250. doi:10.1177/1557988309350492
19. Callahan R, Becker S. *Contraceptive Intentions and Use in Rural Bangladesh.*; 2013.
20. Senegal | Family Planning 2020. Accessed November 13, 2021. <https://www.familyplanning2020.org/senegal>
21. Track20. FP2020 Data Dashboard | Family Planning 2020. Published 2019. Accessed January 19, 2021. <http://www.familyplanning2020.org/data-dashboard>
22. Aichatou B, Seck C, Anne TSB, Deguenovo GC, Ntabona A, Simmons R. Strengthening government leadership in family planning programming in Senegal: From proof of concept to proof of implementation in 2 districts. *Global Health Science and Practice*. 2016;4(4):568-581. doi:10.9745/GHSP-D-16-00250
23. Daff BM, Seck C, Belkhatat H, Sutton P. Informed push distribution of contraceptives in Senegal reduces stockouts and improves quality of family planning services. *Global health, science and practice*. 2014;2(2):245-252. doi:10.9745/GHSP-D-13-00171
24. Gueye B, Jacobs J, Ndiaye A, Sutton P. Senegal has practically eliminated contraceptive shortages. Here's how. World Economic Forum. Published 2017. Accessed July 13, 2018. <https://www.weforum.org/agenda/2017/11/senegal-has-practically-eliminated-contraceptive-shortages-here-s-how/>

25. Hasselback L, Gueye B, Ndao O, Ndour SK, Cissé C. Incentivizing access to family planning in Senegal via the informed push model. *Journal of Pharmaceutical Policy and Practice*. 2014;7(1):O12. doi:10.1186/2052-3211-7-S1-O12
26. Krug C, Cavallaro FL, Wong KLM, Gasparrini A, Faye A, Lynch CA. Evaluation of Senegal supply chain intervention on contraceptive stockouts using routine stock data. Hodges MH, ed. *PLOS ONE*. 2020;15(8):e0236659. doi:10.1371/journal.pone.0236659
27. Winston J, Calhoun LM, Corroon M, Guilkey D, Speizer I. Impact of the Urban Reproductive Health Initiative on family planning uptake at facilities in Kenya, Nigeria, and Senegal. *BMC women's health*. 2018;18(1):9. doi:10.1186/s12905-017-0504-x
28. Measurement Learning & Evaluation Project for the Urban Reproductive Health Initiative. MLE Senegal Study Design.docx - MLE Senegal Dataverse. Published 2017. Accessed August 31, 2018. <https://dataverse.unc.edu/file.xhtml?fileId=7491126&version=RELEASED&version=.0>
29. Clogg C. Recent developments and prospects for the future. In: Arminger G, Clogg CC, Sobel ME, eds. *Handbook of Statistical Modeling for the Social and Behavioral Sciences*. Plenum Press; 1995:311-359.
30. StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC.
31. Hosmer DW, Lemeshow S. Applied Logistic Regression. John Wiley & Sons, Inc.; 2000. doi:10.1002/0471722146
32. Zeger SL, Liang KY. Longitudinal Data Analysis for Discrete and Continuous Outcomes. *Biometrics*. 1986;42(1):121. doi:10.2307/2531248
33. Evans SR, Hosmer DW. Goodness of Fit Tests for Logistic GEE Models: Simulation Results. *Communications in Statistics Part B: Simulation and Computation*. 2004;33(1):247-258. doi:10.1081/SAC-120028443
34. Hardin JW, Hilbe JM. *Generalized Estimating Equations*. Second Edition. CRC Press LLC; 2012.
35. Jaman A, Latif MAHM, Bari W, Wahed AS. A determinant-based criterion for working correlation structure selection in generalized estimating equations. *Statistics in Medicine*. 2016;35(11):1819-1833. doi:10.1002/sim.6821
36. Pan W. Akaike's Information Criterion in Generalized Estimating Equations. *Biometrics*. 2001;57(1):120-125. doi:10.1111/j.0006-341X.2001.00120.x
37. Bray BC, Lanza ST, Tan X. Eliminating Bias in Classify-Analyze Approaches for Latent Class Analysis. *Structural Equation Modeling*. 2015;22(1):1-11. doi:10.1080/10705511.2014.935265

38. Lanza ST, Tan X, Bray BC. Latent Class Analysis With Distal Outcomes: A Flexible Model-Based Approach. *Structural Equation Modeling*. 2013;20(1):1-26. doi:10.1080/10705511.2013.742377
39. Bandeen-roche K, Miglioretti DL, Zeger SL, Rathouz PJ. Latent Variable Regression for Multiple Discrete Outcomes. <https://doi.org/10.1080/01621459199710473658>. 2012;92(440):1375-1386. doi:10.1080/01621459.1997.10473658
40. Benson A, Calhoun L, Corroon M, et al. The Senegal urban reproductive health initiative: a longitudinal program impact evaluation. *Contraception*. 2018;97(5):439-444. doi:10.1016/j.contraception.2018.01.003
41. Asparouhov T, Muthén B. *Auxiliary Variables in Mixture Modeling: Using the BCH Method in Mplus to Estimate a Distal Outcome Model and an Arbitrary Secondary Model.*; 2021. Accessed March 1, 2021. <https://www.statmodel.com/examples/webnotes/webnote21.pdf>
42. Hubbard AE, Ahern J, Fleischer NL, et al. To GEE or not to GEE: Comparing population average and mixed models for estimating the associations between neighborhood risk factors and health. *Epidemiology*. 2010;21(4):467-474. doi:10.1097/EDE.0b013e3181caeb90
43. Senegal | Family Planning 2030. Accessed December 19, 2021. <https://fp2030.org/sites/default/files/Senegal-FP2030-commitment.pdf>

CHAPTER 5. CONCLUSION

Summary

The Ministry of Health and Social Action in Senegal has struggled to effectively address persistent cognitive, social, and emotional barriers to family planning (FP) ideation, intention, and use at scale.¹⁻⁴ Current practices of audience segmentation that focus on socio-demographic characteristics such as age, wealth, and location of residence may fail to identify, reach, and effectively respond to the varying ideational needs of women and their partners and communities. The identification and exploration of prototypical ideational profiles of women may help policy makers better understand the ideational patterns and needs of their constituencies related to family planning and provide insights that communications programs can use to reach members of distinct profile groups with messages tailored to their unique ideational profile. Previous research suggests that this may be a promising approach to effective FP social and behavior change (SBC) communication in sub-Saharan Africa.⁵ This dissertation used a person-centered approach to identify latent contraceptive ideational profiles (CIPs) among urban, partnered women of reproductive age in Senegal and assess changes and transitions in ideational typologies over time. The analysis demonstrates the utility and potential of cross-sectional and longitudinal latent variable modeling of contraceptive ideation and its particular relevance to FP communication programs in Senegal and globally.

In Chapter 2, we used a theory-driven model and evidence-based indicators to conduct two latent profiles analyses (LPAs) to identify and interpret latent CIPs at baseline (2011) and, separately, at endline (2015). Through this analysis, we identified three distinct profiles at

baseline and two profiles at endline. We found that cognitive, social, and emotional factors all trended together in the same direction, resulting in somewhat stepwise negative, neutral, and positive ideation at baseline and neutral and positive ideation at endline.

Of note was that the strongest attribute of women in CIP 1 at baseline and endline was extremely poor contraceptive self-efficacy, meaning that women disagreed strongly that they would be able to take action and successfully complete behaviors related to FP negotiation and use. Unsurprisingly therefore, women in CIP 1 also had the lowest average modern FP use and the lowest intention to use any method in the next 12 months among non-users. Although women in CIP 3 at baseline had the highest scores for all ideational factors, we noted that there was still room for substantial increases in all the scores except for partner FP acceptance (which was very high), indicating that in terms of FP programming, a general education campaign might be the best approach to increase scores in this baseline CIP with the largest proportional membership (67%). We also found that women in CIP 3 at baseline and endline were more likely to report more sources of health information than women in CIP 2 and CIP 1 except for interpersonal sources. At endline, women in CIP 1 were significantly more likely to seek health information from interpersonal sources compared to CIP 2. Programmatically this is important when trying to reach this most vulnerable group with FP interventions. Pragmatically, the three-profile solution at baseline provided more useful nuance and insight into the CIPs than the two-profile solution at endline in terms of how an FP program might act on this information to identify, reach, and engage potential beneficiaries.

Using the LPA methodology separately at baseline and endline allowed us to explore how profiles themselves might evolve over time using only the survey responses available at each time point. This was useful for deep consideration of women's CIPs as they present at a

single point in time. Further, Collins and Lanza recommend fitting a series of latent profile models at a single time point as a preliminary step to better understand how profile structure and interpretation changes across time points.⁶ In Chapter 3, we took an alternative approach by using latent transition analyses (LTA) to identify and describe CIPs using longitudinal data such that the structure and interpretation of the CIPs were informed by women's ideational patterns at both times. This approach was useful in capturing women's histories, trajectories, and ideational journeys as a whole. We identified four prototypical profiles of women at baseline and endline, including a group of women who reported very low scores on all six ideational indicators (CIP 1); two qualitatively different profiles of women, one which was driven by low self-efficacy but rejected misconceptions about FP and the other which was characterized by deep misconceptions about FP but fairly good contraceptive awareness (CIP 2 and CIP 3, respectively); and a fourth profile in which women were cognitively, emotionally, and socially empowered in their contraceptive ideation (CIP 4).

It was interesting to note the differences in the number and structure of the profiles between LPA and LTA. These differences stem from the contingency tables that are formed by cross-tabulating all observed variables that are the foundation of LPA and LTA. As a simplified example, an LPA at one time point with six constructs with binary responses has a contingency table with $2^6 = 64$ cells. In contrast, an LTA with two time points with the same constructs has a contingency table with $2^{12} = 4,096$ cells. This means that even though we used the same data cross-sectionally in the LPA, the LTA must identify a model that represents an exponentially larger contingency table. It is therefore not uncommon that the best fitting model based on the data from multiple time points results in a different number of profiles than the number of profiles identified at one time point.⁶ A cross-tabulation of the CIPs identified through LPA at

baseline and endline and CIPs identified through the LTA show that most women in LPA baseline CIP 1 were also assigned to be in LTA CIP 1 (83%) but some were assigned to LTA CIP 2 (17%). None were assigned to LTA CIP 3 or LTA CIP 4. Similarly, women who were assigned to LPA baseline CIP 3 were most likely to be assigned to LTA CIP 4 (71%) with some also in LTA CIP 3 (17%) but almost none assigned to LTA CIPs 1 or 2. Women who were in baseline LPA CIP 2 were split almost evenly between LTA CIP 2 (42%) and LTA CIP 3 (50%). Women in LPA endline CIP 1 were most likely to be assigned to LTA CIP 2 (64%) and women in LPA endline CIP 2 were most likely to be assigned to LTA CIP 4 (77%). The identification of four distinct CIPs through the LTA in Chapter 3 revealed more ideational nuance, particularly in parsing profiles in the middle of the ideational spectrum, compared to the three- and two-profile models that surfaced in the cross-sectional LPA. Although the LTA used more data and provided more nuance and utility in interpretation, the CIPs were constrained to have the same structure and interpretation over time. The LPA provided a useful glimpse of what might have emerged if only the most recent data had been considered. In this way, the two approaches complement each other even though in practice it is often only the results of the LTA that are ultimately reported.

Once we identified four CIPs through the LTA, we chose to constrain them to ensure that their interpretation was consistent at baseline and endline. This decision helped us better identify how women transitioned between known profiles over time. As in Chapter 2, CIP membership shifted toward more empowered (higher number) profiles over time. We examined key exposures to FP programming to better understand whether and how FP message content, intensity, and modality influenced endline ideational status membership and transitions between statuses over time. We found that hearing about FP through TV, radio, religious leaders, and community conversations with community health workers were each associated with higher odds

of membership in more empowered endline CIPs. Exposure to additional communication modalities was also predictive of membership in more empowered endline statuses. Finally, messages about the legitimacy of FP and birth spacing were the strongest predictors of membership in more empowered ideational statuses among the different communication messages used in this program. Programs should consider testing and integrating these approaches and messages as part of a comprehensive approach to social and behavior change communications.

In Chapter 4, we examined the relationship between the four longitudinal CIPs and two key outcomes: current use of a modern FP method and intention to use any FP method in the next 12 months among women not using a method. The results of this analysis were consistent with our hypotheses that membership in CIP 4 and transition to CIP 4 from a lower CIP were the strongest predictors of FP use and intention to use, even when controlling for general time trends and other demographic characteristics. This held true regardless of what baseline profile a woman started in.

In our first model, we also found that in terms of overall current modern method use, membership in CIP 3 was associated with a significantly higher probability of FP use compared to membership in CIP 2. This was interesting because, unlike women in CIPs 1 and 4 who objectively had the highest and lowest scores on the indicators, women in CIPs 2 and 3 were qualitatively different. Women in CIP 3 were characterized by their strong misconceptions but had higher scores on the other five of the six underlying indicators whereas women in CIP 2 rejected myths and misconceptions but had low contraceptive awareness, partner support, partner communication, community support, and perceived self-efficacy. This indicated that even though women who were members of CIP 3 were, on average, more likely to believe misconceptions

about FP (e.g., FP can cause infertility, cancer, birth defects, and other health concerns), women in these CIPs were still more likely to use a modern method. However, this relationship did not hold for intention to use in our second model. For programs and policy makers, this points to a need to focus on measures of self-efficacy to enable women to act on their contraceptive intentions. In our third model, we found evidence that women's ideational histories, not just their current profile, may influence their contraceptive use.

Limitations

This study had several limitations that are detailed in each chapter but are discussed broadly here. As with any model, the included indicators, though theory-driven and evidence-based, were ultimately subjective and limited to the available questions in the dataset. A slightly different set of indicators might have generated different profile interpretations and insights and potentially more cohesive profiles. Despite extensive exploration and testing of different ideational constructs as well as combinations and functional forms of the indicators, both the LPA and the LTA analyses produced entropy scores that were lower than desired, meaning that there was less separation between profiles and less precise assignment of individuals to CIPs. Although sensitivity analyses indicated that our analyses were generally robust to profile misspecification, more precise assignment of women to CIPs would have been a more convincing demonstration of the utility of this approach and may have generated additional insights within and across CIPs. However, though some consistency in the approach to contraceptive ideational profiling would be helpful, the selection of indicators for future contraceptive ideational profiling will likely vary based on different countries, cultural contexts, socio-demographic contexts, and available datasets.

A second limitation was that membership in CIPs 1 and 2 in the LPA at baseline and the LTA were small which, in the case of the LTA, also led to small transition groups. In these analyses, CIPs 1 and 2 represented the least empowered and most ideationally vulnerable women, which makes these groups of particular interest to FP programs and policy makers that seek to empower women. The small sample sizes may have impacted our ability to identify significant relationships between those groups and their transitions, covariates, and outcomes of interest. One way that we chose to stabilize and simplify estimation in the LTA was to move forward with a constrained LTA model to facilitate our ability to look at how women moved between profiles over time. However, this methodological choice did limit our exploration into how the interpretation of the profiles themselves might have evolved over time using the LTA. We did have some basis for understanding how these profiles might evolve from our discrete LPAs in Chapter 2 in 2011 and 2015 but an exploration of how longitudinal profiles evolve could be an interesting area for future research.

A third limitation to contraceptive ideational profiling is that it does not necessarily provide clarity on how to reach women in different CIPs without some further analysis. In Chapter 2 we examined the self-reported sources of health information by CIP and discovered that women across CIPs had similar preferences for health information sources (e.g. TV, friends/neighbors, midwife, radio, etc.) but that women in lower CIPs reported significantly lower consumption of most sources. Although this is informative, it was counterintuitive to our expectation that women in CIP 1 might prefer a different primary source of health information than women in CIPs 2, 3, or 4. Given that women consumed information in similar ways, similar channels might still be used for all CIPs, but messages might be tailored such that they resonate with women in different CIPs. For community and interpersonal outreach, additional analyses

would need to assess the geographic location of women in different CIPs, but it would still be harder to identify women's CIPs during those outreach activities compared to more traditional segmentation indicators such as age and parity. Contraceptive ideational profiling may therefore provide more functional utility at a community or higher level.

Knowledge Contribution

To our knowledge, this dissertation was the first to apply latent variable modeling to contraceptive ideation in Senegal and the first to apply longitudinal latent variable modeling in the context of contraceptive ideation in sub-Saharan Africa. We demonstrated that latent variable modeling can identify and characterize prototypical health communication audience segments based on their contraceptive ideation, both present and past, and generate insights that can help FP programs design responsive health communication messages and reach women through channels tailored to their information consumption preferences and patterns.

The findings from this dissertation research both corroborate and expand previous research on CIPs and contribute new approaches to FP social and behavior change communication programs. For example, this work corroborates the findings in Babalola (2017) that meaningful underlying patterns of contraceptive ideation in heterogeneous populations in sub-Saharan Africa can be surfaced using a person-centered approach and that health communication exposures are positively associated with membership in more empowered profiles.⁵ But this dissertation goes further by linking those profiles longitudinally and identifying not just associations between health communication and cross-sectional profile membership but positive relationships between health communication interventions and transitions between profiles over time. These insights add rich contextual nuance to other

variable-centered evaluations of demand-side interventions of the Senegal Urban Reproductive Health Initiative.^{7–11}

Although the CIPs identified in this research may share similarities to CIPs generated in other contexts, they should not be generalized outside of urban, partnered Senegalese women of reproductive age. National, cultural, economic, and social factors should determine the selection of latent profile indicators, as well as the identification and interpretation of CIPs, in different settings. This type of person-centered approach can be replicated in any setting using indicators that are locally available and relevant, but the approach must be contextualized and evidence-driven.

Policy Implications and Future Research

This dissertation applied latent profile and latent transition analyses to identify prototypical profiles of contraceptive ideation in heterogeneous populations and test relationships between these profiles, FP communication programming, and FP use and intention to use. The findings of these studies have important policy implications for the Department of Reproductive Health and Child Survival within the Ministry of Health and Social Action at an important juncture. Senegal is elaborating the next National Strategic Framework for FP and has just launched their FP2030 commitments through the Ouagadougou Partnership. One aspect of Senegal's vision for the future is an increased modern contraceptive prevalence of 46 percent by 2025 among in-union women and reduced unmet need among adolescents and youth.¹² Achievement of these milestones will require innovative approaches to generating demand and effectively meeting that demand. The creation and application of CIPs to understand, reach, and engage women is one such innovative approach that has important potential to address ideational barriers and unlock latent demand for FP. Policy makers in Senegal and elsewhere should

consider the application of these novel audience segmentation methods as an approach to better understanding the ideational states and needs of the population and to responding effectively to those needs through national communication strategies.

At the global level, there is a renewed emphasis on incorporating social and behavior change (SBC) in FP2030 commitments as an evidence-based high-impact practice.^{13,14} One of the recommended approaches is to “segment audiences into subgroups based on demographic, psychographic, and behavioral factors.”¹³ Contraceptive ideational profiling is a novel and promising approach to audience segmentation. Policy makers at the global level should fund implementation research to test the potential of this method to enhance current practices in audience segmentation.

Extensions of these person-centered approaches to include subpopulations and more consistent measurements of contraceptive behavior could generate additional important insights into contraceptive ideation and make the use of these approaches more accessible for FP programs to implement to inform their interventions. One extension of this work that could generate additional meaningful insights would be to incorporate fertility intentions into ideational profiling. Fertility intention, that is, a woman’s desire or intent to have a certain number of children and the timing around these births, are fluid and change over time but are intrinsically related to contraceptive ideation and family planning use.^{15–17} The introduction of fertility intention either as an indicator of underlying contraceptive ideation or as a subgroup analysis could help further shed light on how changes in fertility intention drive dynamic patterns of ideation and contraceptive use.

One barrier to a more widespread practice of using LPA and LTA methodologies to develop and benefit person-centered CIPs is the often subjective and time-consuming approach

to selecting indicators that can identify cohesive and meaningful profiles. Additional formative research that could validate and standardize key constructs and indicators for contraceptive ideational profiling in various country contexts could be beneficial for encouraging practical implementation by FP researchers, program managers, and practitioners who may desire a more turnkey process for applying this methodology. Going one step further and generating more evidence linking CIPs and behavioral outcomes would also help programs monitor, evaluate, and respond to evolutions in contraceptive ideation. The development of a “CIP toolkit,” similar to “how to” guides for audience segmentation for social and behavior change, could help break down some of the more complex processes and make this methodology more accessible for researchers and programs alike.¹⁸

Tables

Table 25. Cross-Tabulation of CIPs Created Through LPA and LTA

| | LTA CIP 1 | LTA CIP 2 | LTA CIP 3 | LTA CIP 4 | Total |
|---------------------------|------------------|------------------|------------------|------------------|--------------|
| LPA Baseline CIP 1 | 241 (0.83) | 51 (0.17) | 0 (0) | 0 (0) | 292 |
| LPA Baseline CIP 2 | 76 (0.07) | 450 (0.42) | 537 (0.50) | 15 (0.01) | 1078 |
| LPA Baseline CIP 3 | 0 (0) | 6 (0) | 777 (0.29) | 1894 (0.71) | 2677 |
| LPA Endline CIP 1 | 154 (0.18) | 546 (0.64) | 151 (0.17) | 0 (0) | 851 |
| LPA Endline CIP 2 | 0 (0) | 298 (0.09) | 448 (0.14) | 2450 (0.77) | 3196 |

REFERENCES

1. Track20. *Senegal FP2020 2019 Core Indicators 1-9 Country Fact Sheet.*; 2019.
2. Sidibe AM, Kadetz PI, Hesketh T. Factors impacting family planning use in mali and senegal. *International Journal of Environmental Research and Public Health*. 2020;17(12):1-15. doi:10.3390/ijerph17124399
3. Sougou NM, Bassoum O, Faye A, Leye MMM. Women's autonomy in health decision-making and its effect on access to family planning services in Senegal in 2017: A propensity score analysis. *BMC Public Health*. 2020;20(1). doi:10.1186/s12889-020-09003-x
4. ANSD/Sénégal AN de la S et de la D and I, ICF. Senegal Enquête Démographique et de Santé Continue (EDS-Continue) 2017. Published online 2018. Accessed August 31, 2018. <https://dhsprogram.com/publications/publication-FR331-DHS-Final-Reports.cfm>
5. Babalola S. Changes in Ideational Profiles of Women of Reproductive Age in Urban Nigeria: The Role of Health Communication. *Health Education and Behavior*. Published online 2017. doi:10.1177/1090198117699510
6. Collins L, Lanza S. *Latent Class and Latent Transition Analysis*. Wiley; 2010. Accessed September 1, 2018. <https://www.wiley.com/en-us/Latent+Class+and+Latent+Transition+Analysis%3A+With+Applications+in+the+Soc+ial%2C+Behavioral%2C+and+Health+Sciences-p-9780470228395>
7. Gueye A, Speizer IS, Corroon M, Okigbo CC. Belief in Family Planning Myths at the Individual and Community Levels and Modern Contraceptive Use in Urban Africa. *International Perspectives on Sexual and Reproductive Health*. 2015;41(04):191-199. doi:10.1363/4119115
8. Okigbo CC, Speizer IS, Corroon M, Gueye A. Exposure to family planning messages and modern contraceptive use among men in urban Kenya, Nigeria, and Senegal: A cross-sectional study. *Reproductive Health*. 2015;12(1). doi:10.1186/s12978-015-0056-1
9. Benson A, Calhoun L, Corroon M, et al. The Senegal urban reproductive health initiative: a longitudinal program impact evaluation. *Contraception*. 2018;97(5):439-444. doi:10.1016/j.contraception.2018.01.003
10. Speizer IS, Corroon M, Calhoun LM, Gueye A, Guilkey DK. Association of men's exposure to family planning programming and reported discussion with partner and family planning use: The case of urban Senegal. *PLoS ONE*. 2018;13(9). doi:10.1371/journal.pone.0204049
11. Speizer IS, Corroon M, Calhoun L, et al. Demand generation activities and modern contraceptive use in urban areas of four countries: A longitudinal evaluation. *Global Health Science and Practice*. 2014;2(4):410-426. doi:10.9745/GHSP-D-14-00109

12. Senegal | Family Planning 2030. Accessed December 19, 2021. <https://fp2030.org/sites/default/files/Senegal-FP2030-commitment.pdf>
13. FP2030. *FP2030 Resource Kit: Incorporating Social and Behavior Change in Commitments.*; 2021. Accessed December 19, 2021. https://commitments.fp2030.org/sites/default/files/final_SBC.pdf
14. High-Impact Practices in Family Planning (HIPs). Social and Behavior Change: A Critical Part of Effective Family Planning Programs. . Washington, DC: USAID. Published April 2018. Accessed September 12, 2021. <https://www.fphighimpactpractices.org/briefs/sbc-overview/>
15. Babalola S, Oyenubi O, Speizer IS, Cobb L, Akiode A, Odeku M. Factors affecting the achievement of fertility intentions in urban Nigeria: Analysis of longitudinal data. *BMC Public Health*. Published online 2017. doi:10.1186/s12889-017-4934-z
16. Speizer IS, Escamilla V, Lance PM, Guilkey DK. Longitudinal examination of changing fertility intentions and behaviors over a four-year period in urban Senegal. *Reproductive Health*. 2020;17(1):1-10. doi:10.1186/S12978-020-0893-4/TABLES/5
17. Speizer IS, Lance P. Fertility desires, family planning use and pregnancy experience: Longitudinal examination of urban areas in three African countries. *BMC Pregnancy and Childbirth*. 2015;15(1):1-13. doi:10.1186/S12884-015-0729-3/TABLES/5
18. How to Do Audience Segmentation | The Compass for SBC. Accessed November 13, 2021. <https://www.thecompassforsbc.org/how-to-guides/how-do-audience-segmentation>