REPORT

Spatial Clustering in Temporal Trends of Female Genital Mutilation Risk: Leveraging Sparse Data in Ethiopia, Kenya, and Somalia

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Female genital mutilation (FGM) is a harmful practice rooted in gender inequality. Its elimination is part of national and international agendas including the Sustainable Development Goals of the United Nations. Understanding its geographical evolution is crucial for targeted programming. However, due to sparse data, it is challenging to establish international comparability and statistical reliability. Data on FGM is observed at different points in time and periodicity across countries and in contexts with varying age-risk patterns, all of which can be a source of inaccurate and biased estimates. We perform an exemplary analysis, drawing on survival and complex survey analysis in Ethiopia, Kenya, and Somalia. This novel approach addresses measurement challenges specific to FGM data and produces an internationally comparable indicator—the probability of not experiencing FGM by age 20. We pinpoint the onset of statistically significant FGM decline at the subnational level from cohorts born in the 1970s until the 1990s. In the same period, we observe no decline in FGM risk across regions clustered around international borders and increasing subnational inequalities within countries. Our methods thus provide crucial insights into the geographical pattern of temporal trends in FGM risk.

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INTRODUCTION

According to the World Health Organization, "female genital mutilation (FGM) comprises all procedures that involve partial or total removal of the external female genitalia, or other injury to the female genital organs for non-medical reasons" (WHO 2022). It is a practice rooted in gender inequality and constitutes a human rights violation (WHO 2022). Its eradication has been the focus of national and international policy for decades. The Member States of the United Nations pledged to eliminate FGM by 2030 as part of the Sustainable Development Goals (SDGs) of the United Nations (United Nations 2015).

Reliable and statistically robust estimates on FGM are crucial to monitor progress towards its elimination. The official SDG indicator to do so is the "proportion of girls and women aged 15–49 years who have undergone female genital mutilation/cutting, by age" (UNSD 2021). Progress towards the elimination of FGM is measured by comparing the FGM experience of younger girls aged 15–19 to the experience of older women (UNSD 2021).

The SDG targets and many other statistics measure FGM risk descriptively at the national level by reporting the proportion of girls and women who have undergone FGM for countries with available data. However, FGM displays high subnational heterogeneity and is a geographically clustered phenomenon (UNFPA 2019; UNICEF 2013). High prevalence areas of FGM tend to exist in geographically connected areas following localized social and cultural differences (Ashford, Naik, and Greenbaum 2020). Accordingly, FGM interventions also have to address the practice at the communal level (Ashford, Naik, and Greenbaum 2020). In addition, FGM hot spots are not bound by international borders, thwarting national programs (Diop et al. 2006) and regulations limiting state capacity to implement laws banning FGM (Meroka-Mutua et al. 2021). Where cross-border dynamics in FGM are evident, international coordination and common mechanisms are essential to effectively target high-prevalence areas (Wouango, Ostermann, and Mwanga 2020).

For these reasons, precise, statistically robust, and internationally comparable estimates at the subnational level are crucial for advocacy, policy implementation, international coordination, and ultimately monitoring of progress towards the Sustainable Development Goal to eliminate FGM. Data on FGM are mainly derived from population-level household surveys, such as Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS), and have been extensively published and studied (e.g., Yoder and Wang 2013; or UNICEF 2022). As outlined earlier, descriptive statistics based on survey results do not necessarily fulfill the specific needs of policymakers in the framework of geographically clustered phenomena across international boundaries.

Table 1 demonstrates this with the example of Ethiopia, Kenya, and Somalia. Surveys take place in different years, with varying periodicity and geographical coverage, and are reported separately for women and girls. Without robust statistical techniques, it is difficult to ascertain how to compare, for example, a decline in prevalence from 38 percent to 32 percent between 1998 and 2003 in Kenya to a decline from 80 percent to 74 percent from 2000 to 2005 in Ethiopia. Similarly, a decrease in the prevalence of FGM among girls cannot be compared to those of women unless we take age-risk patterns of FGM into account (UNFPA 2020). Finally, changes in FGM prevalence might be a product of sample variance as well as real change in FGM risk. This problem is exacerbated when it comes to the subnational level, with smaller

TABLE 1 Population level survey data on FGM prevalence in Ethiopia, Kenya, and Somalia

Year	Ethiopia	Kenya	Somalia
1998		38% of women age 15-49	
1999			
2000	80% of women age 15-49		
2001			
2002			
2003		32% of women age 15-49	
2004			
2005	74% of women age 15-49		
2006			98% of women age 15-49
2007			
2008			
2009		27% of women age 15-49	
2010			
2011			Northeast Zone: 98% of women age 15-49 31% of girls 0-14 Somaliland: 99% of women age 15-49 28% of girls 0-14
2012			
2013			
2014		21% of women age 15-49 3% of girls 0-14	
2015			
2016	65% of women age 15-49 16% of girls 0-14		

SOURCE: Data from Demographic and Health Surveys and Multiple Indicator Cluster Surveys (NCPD et al. 1999; KNBS 2010 and 2015; CSA and ORC Macro 2001 and 2006; CRA and ICF 2016; UNICEF 2014a and 2014b).

sample sizes and greater statistical measurement uncertainty. For a geographically clustered phenomenon like FGM, this is especially problematic.

Consequently, the descriptive indicators in Table 1, albeit hinting at a decline in FGM risk, are not directly comparable and thus provide little information on how significant it is, and from when and where in the region it started. These are, however, key figures for programming and international coordination. If policymakers are to use existing data on FGM, they need to be translated into actionable and robust analytical results. Only by knowing where FGM is declining is it possible to deduce where policies and programs have been successful. Vice versa, by knowing where FGM risk remains high, policymakers know when and where adjustments may be required.

To address these issues, we propose a new methodology which is able to incorporate information on FGM from different survey years collected with varying periodicity and subject to heterogenous age-risk patterns at the national and subnational levels. While we build on the analysis by Weny et al. (2020), we adapt the approach to the subnational context and introduce formal statistical robustness tests. Our methodology is thus novel as it is adapted to the specific sparse data setting information on FGM is derived from while being able to incorporate its geographically clustered nature.

We apply survival analysis on data from direct reports of adult women and their proxy reporting about their daughters younger than 15 to the exemplary contiguous region of Ethiopia, Kenya, and Somalia. We do so, to avoid biases due to daughters who are represented in the surveys, but still at risk of FGM. In addition, we use a cohort approach, aligning temporal variations in data collection across countries. We further formally test the robustness of our statistical results, using formal statistical tests.

To date, most FGM analyses have been conducted at the national level with limited subnational disaggregation, without taking into account the age-specific pattern of FGM risk for daughters who are still at risk of experiencing FGM, and without aligning the variations in date and periodicity of data collection across countries. Therefore, they are not directly comparable between different countries. As such, our methodology has the potential to produce unbiased, subnational, and internationally comparable indicators and thus to inform policy and programming at the subnational and national and international levels. Subnational estimates are important to describe the clustered nature of FGM incidence and align with the "Leave no one behind" principle of the SDGs (UNFPA 2019; UNICEF 2013; United Nations 2015). Our specification of formal statistical tests formalizes the assessment of measurable change in FGM risk, in line with statistical methodology on robustness checks.

DATA

The data sources for this analysis are the 2011 MICS in Somalia's Northeast Zone (UNICEF 2014a), covering the areas of Bari, Nugal, and Mudug, and the 2011 MICS in Somaliland (UNICEF 2014b), covering Maroodijeex/Saaxil, Awdal, Togdheer, Sool, and Sanaag, the 2008–2009 and 2014 DHS in Kenya (KNBS 2009 and 2014), and the 2016 DHS in Ethiopia (CSA 2016). We limit our analysis to these surveys as our methodological approach depends on information on FGM status as well as age at FGM either for all survey respondents and/or

for all their living daughters. We include data from the FGM survey modules administered to survey respondents directly and data from the module which asks survey respondents about their living daughters younger than 15.

As we merged all survey data, we denormalized survey weights by obtaining population estimates and projections for the respective survey years and age groups from the United Nations Department of Economic and Social Affairs (UNDESA 2019). To estimate the female population in Somaliland and Somalia's Northeastern Zone, the closest approximation for up-to-date subnational population estimates that allow us to distinguish between the two regions comes from the Population Estimation Survey for the 18 prewar regions of Somalia carried out from October 2013 to March 2014 (UNFPA 2018). The estimated population shares of the two regions were applied to population estimates from the United Nations for the survey year. Consequently, all estimates are adjusted for sampling probabilities and population size and divided by the number of observations in the relevant survey (Rukundo, Schmale, and Namaste 2014).

For the maps, we merge the survey boundaries provided by the DHS program for Ethiopia and Kenya (DHS 2020) and the administrative boundaries published by OCHA Somalia (OCHA 2014).

METHODOLOGY

Describing subnational risk of FGM statistically and comparatively across countries and time is challenging due to heterogeneous and inconsistent data coverage and quality of DHS and MICS. In addition, until 2010 most DHS and MICS included women aged 15–49 only. As a consequence, recent trends in FGM are not captured by estimates based on these data. Through the systematic collection of data on all living daughters of survey respondents since 2010 this has changed (Shell-Duncan 2016; Yoder and Wang 2013) alleviating the lag between the occurrence of FGM and its reporting. However, this results in a possible underestimation of FGM risk due to right censoring particularly in younger age cohorts still at risk of FGM at the time of the survey. In addition, age patterns of FGM and thus the severity of censoring vary across countries and regions and result in misleading cross-national comparisons (Weny et al. 2020).

Confronted with this sparse data environment, we apply survival analysis allowing the combination of both data on mothers and their daughters without risking biased estimates due to censoring. Further, we rely on five-year birth cohorts of women and girls born from 1970–1974 to 1995–1999 to estimate trends aligning evaluation periods across countries. By using birth cohorts, not age, data from surveys conducted at different points in time can be aligned and thus be compared. Our statistical analysis includes the calculation of confidence intervals based on complex survey analysis and heavily builds on the seminal work of Klein et al. (2007).

Our time variable indicates the years from birth until FGM occurs or until the observation is censored, which is the age of the woman or the girl at the time of the survey. We perform Kaplan–Meier estimates and calculate the cumulative probability of not experiencing FGM by age 20. We selected age 20 as cutoff for our assessment for two reasons. First, a

cutoff at age 20 will make the resulting indicator independent of different age patterns of FGM ranging from birth to late teens. Second, choosing a cutoff will allow us to include cohorts that are born up to 20 years ago, maintaining the validity of our results in terms of measuring trends across several decades. This statistic is comparable to the relative survival after five years in cancer trial follow-ups (Saadatman et al. 2015).

We estimate $S(t)$, the probability of not experiencing FGM at year (of age) t, as follows:

$$S(t) = \prod_{(t=0)}^{20} \left(1 - \frac{d_t}{n_t}\right), \tag{1}$$

where d_t is the number of FGM cases at a given t and n_t is the number of girls and women at risk at time t.

We stratify the survival function for each age cohort for the 27 first-level administrative regions in our analysis, 11 in Ethiopia (Addis Ababa, Affar, Amhara, Ben-Gumz, Dire Dawa, Gambela, Harari, Oromiya, southern nations, nationalities, and people's region (SNNP), Somali, and Tigray), eight in Kenya (Central, Coast, Eastern, Nairobi, North Eastern, Nyanza, Rift Valley, and Western), and eight in Somalia (Awdal, Bari, Mudug, Nugaal, Sanaag, Sool, Togdheer, and Woqooyi Galbeed) and include robust standard errors considering the complex survey design.

STATISTICAL ANALYSIS

As our analysis is disaggregated both by administrative levels and age cohorts, it is crucial to provide uncertainty estimates. We do so by providing confidence intervals for all five-year cohorts born between 1970–1974 and 1995–1999. In addition, we perform two-sample comparisons between the FGM risk by age 20 for the oldest cohort to the risk experienced by subsequent cohorts (H_0: $S_c\ (t = 20) = S_{c'}\ (t = 20)$). The comparison of FGM risk at a given age instead of the whole risk distribution is a conservative assessment as it does not rely on the proportionality assumption and thus remains valid even where age-at-FGM changes over time (Klein et al. 2007).

To ensure robust statistical results, we follow Klein et al. (2007) approach and perform extensive hypothesis testing. We calculate an untransformed and four transformed tests with asymptotic chi-squared distribution (see the Supporting Information). This is necessary, as Klein et al. (2007) show that the untransformed test statistic is only reliable when based on a large sample size and has a comparably large probability of type I error. In this context, this would lead to a high likelihood of mistakenly rejecting the null hypothesis that the FGM level across two different cohorts remained the same. Klein et al. (2007) also assess type II error which would in our case result in us incorrectly accepting the null hypothesis that the FGM levels across two cohorts remained the same and hence assume that there was no decline in FGM.

Klein et al. (2007) perform a Monte Carlo study to evaluate both type I and type II error rates for all versions of the test statistics and note that in particular the complementary log–log transformation offers the advantage of stability even with small sample sizes—a characteristic which is important as we disaggregated both geographically and by cohort. Based on our

observations in the present data as well as the results of Klein et al. (2007), we demonstrate our results with the complementary log–log transformed test statistic in the text of this analysis. Our full results for the untransformed and all four transformed tests can be retrieved from Table 2.

The complementary log-log transformation of the test statistic is given as

$$\chi_3^2 = \frac{\left(\log\left(-\log \hat{S}_c\,(t=20)\right)\ \log\left(-\log \hat{S}_{c'}\,(t=20)\right)\right)^2}{\frac{\hat{\sigma}_c(t=20)^2}{\left(\log \hat{S}_c(t=20)\right)^2} + \frac{\hat{\sigma}_{c'}(t=20)^2}{\left(\log \hat{S}_{c'}(t=20)\right)^2}}. \quad (2)$$

IMPLEMENTATION

To account for the complex survey design in all five surveys, we apply functions from Thomas Lumley's "survey" package version 3.37 (Lumley 2021). To implement this package, we create unique primary sampling units (cluster), secondary sampling units (households), and strata (rural/urban) across surveys allowing us to account for both clustering and stratification (Vanderelst and Speybroeck 2014).

To obtain standard errors, our code was executed on an external server powered by Amazon Web Services. This became necessary as the standard error calculations required computational power proportional to the product of the number of FGM events and the sample size (Lumley 2021).

RESULTS

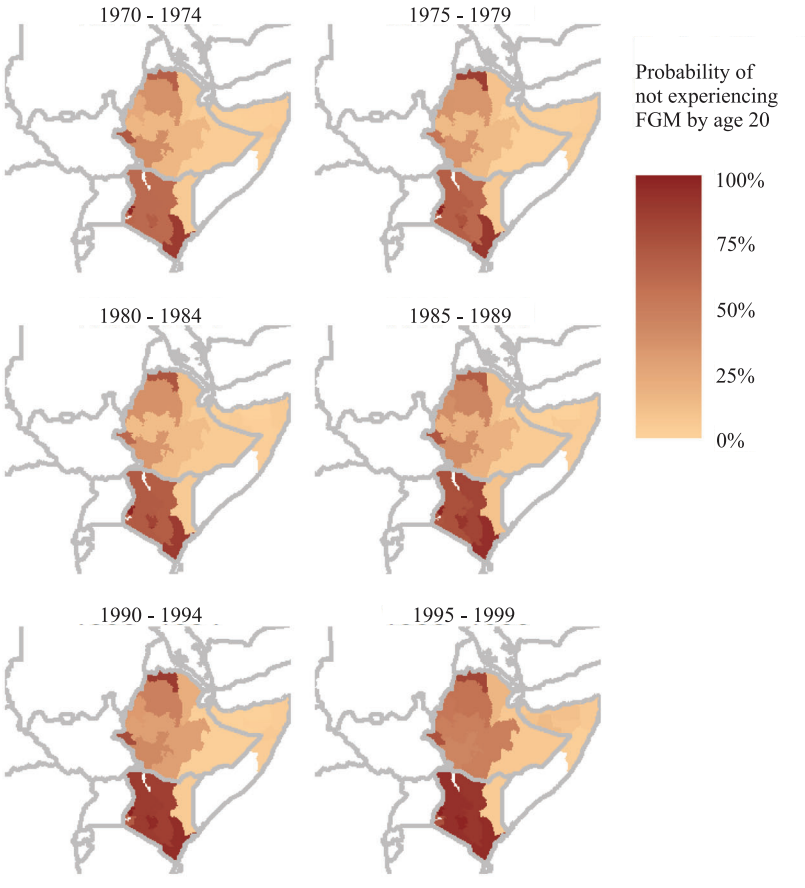
Subnational differences in overall FGM risk were evident in the earliest cohort and have been increasing over time (Figure 1).

The upper left panel shows the probability of not experiencing FGM by age 20 for women born between 1970 and 1974 demonstrating low FGM risk in Southern and Western areas of Kenya, except its North Eastern province, and in Western and Northern Ethiopia. By contrast, FGM was nearly universal in all areas in Somalia with available data, the Somali and Affar region in Ethiopia, and Kenya's North Eastern province.

This remains virtually unchanged until we observe cohorts born in the late 1980s for which the figure shows a decrease in FGM risk in Kenya's Central, Rift Valley, and Eastern regions as well as in Oromoia in central Ethiopia. These trends persist and extend for all regions in Ethiopia, except Affar and Somali, and all regions in Kenya, except the North Eastern Province.

As a result of these decade-long developments, the map of FGM incidence has significantly changed leading to larger heterogeneity for women born in the late 1990s than those born two decades earlier. Regions experiencing a decline in FGM risk are adjacent to one another, spreading across Ethiopia's and Kenya's Central and Western regions while regions without decline equally span adjacent regions across Kenya's Northeast, Ethiopia's East, and Somalia.

FIGURE 1 Cumulative probability of not experiencing FGM by age 20 by 5-year birth cohorts and administrative level 1



UNCERTAINTY ESTIMATES

We provide confidence intervals for the point estimates (Figure 2a–c) and perform two sample tests comparing the FGM risk of cohorts born in 1970–1974 to all later cohorts (1975–1979, 1980–1984, 1985–1989, 1990–1994, and 1995–1999) for all 27 first-level administrative units, displayed in Figure 3. By displaying our results using different underlying transformations and in conjunction with the confidence intervals, we seek to provide a comprehensive interpretation of FGM point estimates and their underlying uncertainty.

The confidence intervals indicate that the decline of FGM risk is not only a product of sampling design but reflects true changes in the underlying population, but mostly only from the 1990–1994 and the 1995–1999 cohorts in at least three regions of Ethiopia: Oromoiya, Dire Dawa, Addis Ababa, and possibly Ben-Gumz; four regions of Kenya: Eastern, Central, Nairobi, Rift Valley, Western, and possibly Coast; and two regions of Somalia: Togdheer and Woqooyi Galbeed.

FIGURE 2 Confidence intervals, log-survival scale, administrative level 1. (a) Ethiopia. (b) Kenya. (c) Somalia

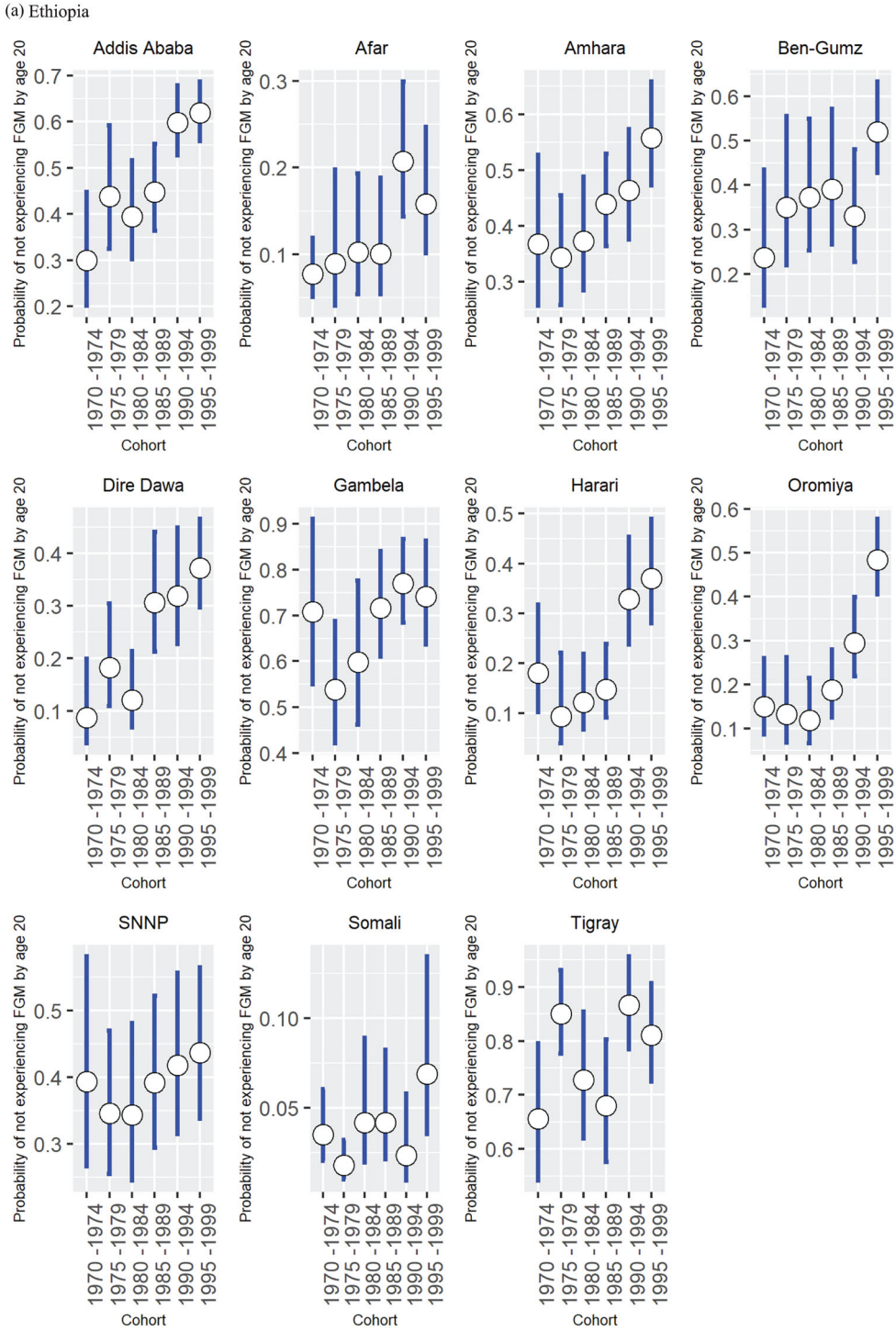
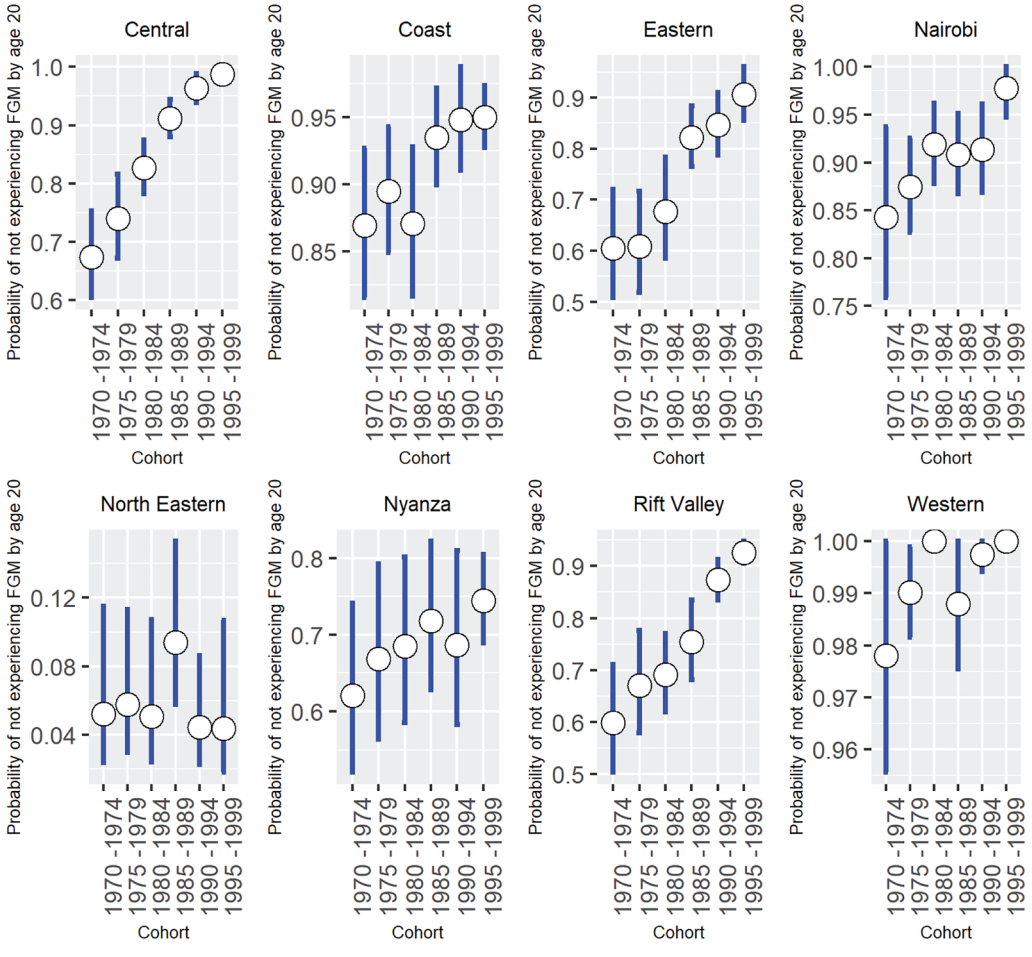


FIGURE 2 ***Continued***

(b) Kenya

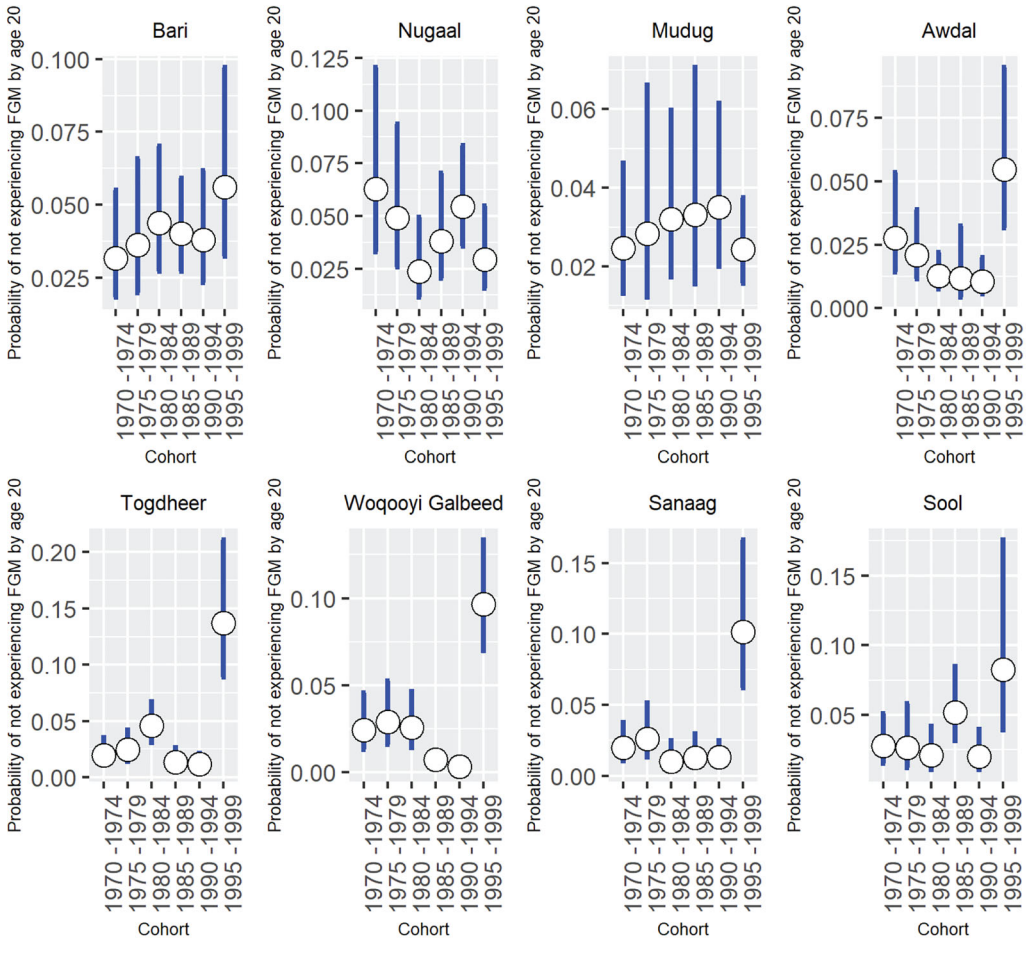


For ease of visual representation, we display the results of two-sample tests based on the complementary log–log transformed test statistic geographically in Figure 3.

These results are consistent with our visual inspection of confidence intervals. There is no statistically significant decline between the cohorts born in 1970/1974 and 1975/1979. The Central region in Kenya is the only region that hints towards a decrease in FGM risk for the 1980/1984 cohort. For the 1985/1989 cohort, more and more regions start to display reductions in FGM risk. Overall, reductions in FGM risk can be found for Addis Ababa, Dire Dawa, and Oromiya in Ethiopia; the Central, Eastern, Rift Valley, and Western regions in Kenya, and the Sanaag, Togdheer and Woqooyi Galbed regions in Somalia. Results for the Affar and Ben-Gumz regions in Ethiopia and Nairobi and the Coast region in Kenya point towards a decline in FGM risk.

FIGURE 2 ***Continued***

(c) Somalia

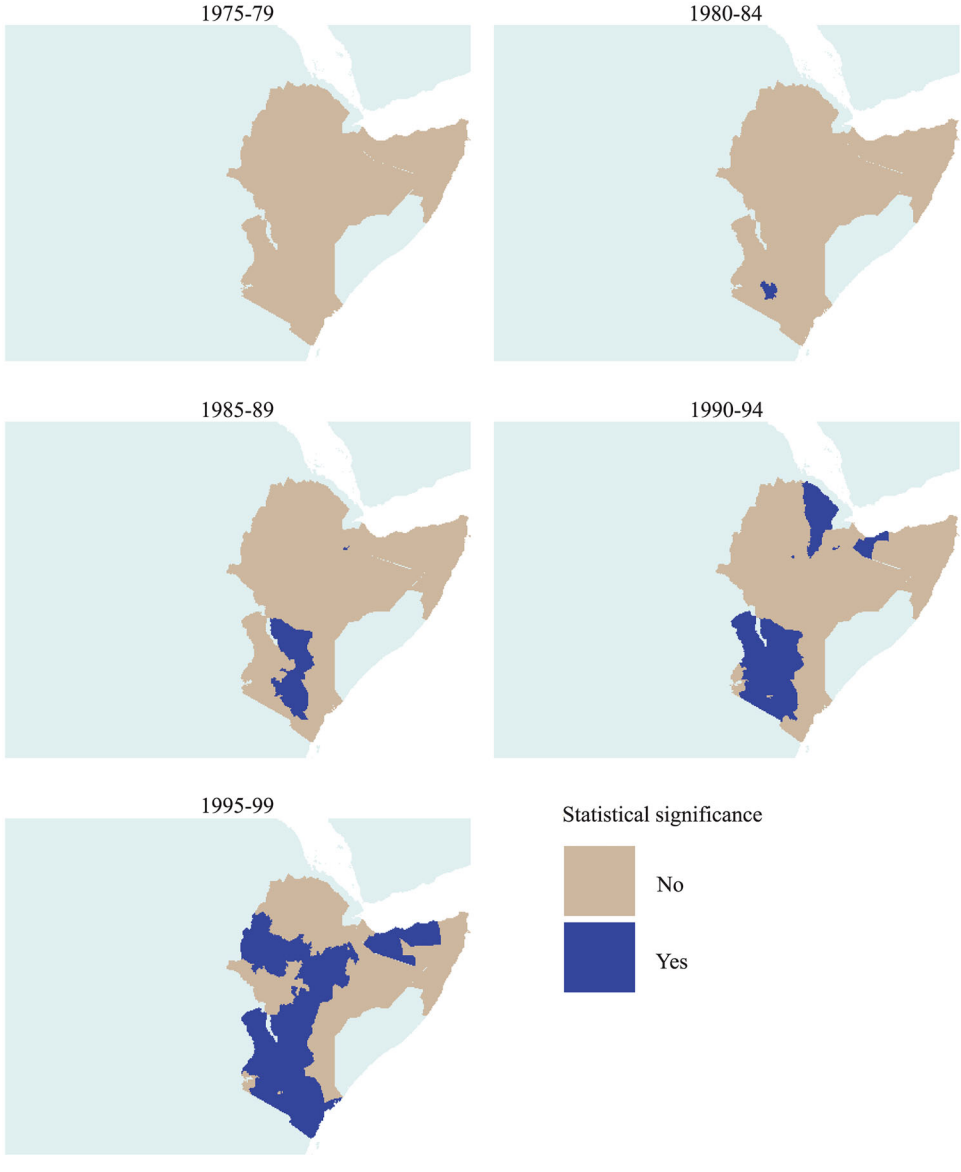


LIMITATIONS

Our analysis is limited by the varying degrees of missing data, and the possibility of non-sampling bias that is yet to be fully studied.

Firstly, no full geographical coverage could be achieved in Somalia with two surveys taking place in Somaliland and in the Northeastern Zone of Somalia separately omitting all other parts of the country. In addition, several enumeration areas selected for the survey could not be accessed due to population movements or civil conflict (UNICEF 2014a, 2014b). In general, due to sample design and size limitations, DHS and MICS surveys do not offer unbiased estimates beyond the first administrative level. Therefore, our analysis cannot be disaggregated further.

FIGURE 3 Areas with p values < 0.05 comparing cohorts born in 1970/1974 to younger cohorts, by administrative level 1, complementary log–log transformed test statistic



Further, our dataset uses both proxy data from mothers providing information on the status of FGM, and the age at which FGM occurs for their daughters, as well as direct information on mothers themselves. These two sources of information can both contain different types of non-sampling errors and biases. Mothers may be reluctant to provide information with respect to their daughters where the practice is banned and may suffer from recall bias on their own FGM experience. Future quantitative analysis needs to assess if these biases are problematic in terms of interpretability of the achieved results.

DISCUSSION

Our analysis proposes a new method to derive subnational and internationally comparable indicators in the wake of sparse data on FGM. Our goal is to provide a methodology that offers statistically reliable and disaggregated estimates even where data are collected at different times, with different periodicities and geographical coverage. In addition, our methods prove robust in the wake of structurally incomplete data due to right-censoring for more recent observations. This is especially important to measure progress towards the elimination of FGM. FGM demonstrates a unique geography of clustered hot spots across international boundaries and heavily relies on population-level household surveys such as DHS and MICS.

Using survival analysis, we calculate the probability of not experiencing FGM by age 20 and employ a cohort-based approach to align time and geographical dimensions for international comparability. We also provide uncertainty estimates in a complex survey design setting and several uncertainty measures to pinpoint when exactly a robust decline in FGM risk took place in the region under review. This is crucial as our indicators are calculated at the subnational level where sample sizes and thus statistical uncertainty are potentially crucial. As a consequence, we can pinpoint where there is a measurable change in FGM risk at localized levels. For the achievement of the 2030 Agenda, this is crucial as it allows policymakers to focus on areas where there is no or little decline in FGM risk and make true on the promise of leaving no one behind.

Our results allow us to assess levels and trends in FGM risk across different geographic areas for birth cohorts since 1970–1974 giving us a decade-long insight into the levels and trends of FGM in Ethiopia, Kenya, and Somalia. Our analysis provides support for the emergence of increasing differences within countries and rising similarities in neighboring border regions. While some regions in Ethiopia and Kenya have seen a consistent decline in FGM, Kenya's North Eastern region is in level and trend of FGM similar to Ethiopia's Somali regions and the surveyed areas in Somalia.

These findings highlight the importance of moving beyond coarse national-level estimates and analyses of FGM risk as national averages mask wide-ranging and increasing subnational differences. They also draw attention to cross-border dynamics in neighboring regions separated by international borders, which can have decisive effects on programming, laws, and international cooperation. Taking these issues into account is crucial in identifying women and girls who continue to be at high risk of FGM and developing customized programmatic interventions specific to the local context.

DATA AVAILABILITY STATEMENT

The data on FGM that supports the findings of this analysis are available from the Demographic and Health Surveys (DHS) website (https://dhsprogram.com/Data/) as well as the Multiple Indicator Cluster Surveys (MICS) website (https://mics.unicef.org/). Population data are publicly available from the United Nations Population Division's website (https://population.un.org/wpp/). In the case of Somalia, the report on the 2014 population estimates is equally publicly available (https://somalia.unfpa.org/sites/default/files/pub-pdf/Population-Estimation-Survey-of-Somalia-PESS-2013-2014.pdf).

REFERENCES

Ashford, Lori S., Reshma Naik, and Charlotte Greenbaum. 2020. "Reflections from Five Years of Research on FGM/C, Evidence to End FGM/C: Research to Help Girls and Women Thrive." Washington, DC: Population Reference Bureau.

Central Statistical Authority (CSA) [Ethiopia] and ORC Macro. 2001. "Ethiopia Demographic and Health Survey 2000." Addis Ababa and Calverton, MD: CSA and ORC Macro.

Central Statistical Agency (CSA) [Ethiopia] and ORC Macro. 2006. "Ethiopia Demographic and Health Survey 2005." Addis Ababa and Calverton, MD: CSA and ORC Macro.

Central Statistical Agency (CSA) [Ethiopia] and ICF. 2016. "Ethiopia Demographic and Health Survey 2016." Addis Ababa and Rockville, MD: CSA and ICF.

Diop, Nafissatou J., Zakari Congo, Aina Ouedraogo, Alphosine Sawadogo, Lydia Saloucou, and Ida Tamini. 2006. "Analyse de l'évolution de la pratique de l'excision au Burkina Faso: L'environnement institutionnel, politique et programmatique de la lutte contre la pratique de l'excision." Ouagadougou: Population Council.

Kenya National Bureau of Statistics (KNBS) and ICF Macro. 2010. "Kenya Demographic and Health Survey 2008–09." Nairobi and Calverton, MD: KNBS and ICF Macro.

Kenya National Bureau of Statistics (KNBS), Kenya Ministry of Health, Kenya National AIDS Control Council (NACC), Kenya National Council for Population and Development (NCPD), Kenya Medical Research Institute (KEMRI) and ICF Macro. 2015. "Kenya Demographic and Health Survey 2014." Nairobi: KNBS, NACC, NCPD, KEMRI and ICF Macro.

Klein, John P., Brent Logan, Mette Harhoff, and Per Kragh Andersen. 2007. "Analyzing Survival Curves at a Fixed Point in Time." *Statistics in Medicine* 26(24): 4505–4519. https://doi.org/10.1002/sim.2864

Lumley, Thomas. 2021. "Package 'Survey', Analysis of Complex Survey Samples." CRAN. Accessed June 24, 2022. https://cran.r-project.org/web/packages/survey/survey.pdf.

Meroka-Mutua, Agnes, Daniel Mwanga, Susan L. Ostermann, Joséphine Wouango. 2021. "Coercion versus facilitation: Context and the implementation of anti-FGM/C law." *Law & Society Review* 55 (4): 587–613. https://doi-org.eaccess.ub.tum.de/10.1111/lasr.12579.

National Council for Population and Development (NCPD), Central Bureau of Statistics (CBS) (Office of the Vice President and Ministry of Planning and National Development) [Kenya], and Macro International Inc. (MI). 1999. "Kenya Demographic and Health Survey 1998." Calverton, Maryland: NCPD, CBS and MI.

OCHA Somalia. 2014. "Somalia—Administrative Boundaries." Accessed June 24, 2022. https://data.humdata.org/dataset/somalia-administrative-boundaries.

Rukundo, Benedict K., Allison Schmale, and Sorrel Namaste. 2014. "Adolescent Nutrition 2000–2017: DHS Data on Adolescents Age 15–19." DHS Comparative Report No. 47. Rockville, MD: ICF

Saadatman, Sepideh, Reini Bretveld, Sabine Siesling, and Madeleine M. A. Tilanus-Llinthorts. 2015. "Influence of Tumor Stage at Breast Cancer Detection on Survival in Modern Times: Population-Based Study in 173 797 patients." *British Medical Journal* 351: h4901. https://doi.org/10.1136/bmj.h4901

Shell-Duncan, Bettina. 2016. "Considerations on the Use and Interpretation of Survey Data on FGM/C." Technical brief, Evidence to End FGM/C: Research to Help Women Thrive. New York: Population Council.

The DHS Program. 2020. "Spatial Data Repository." Accessed June 24, 2022. http://spatialdata.dhsprogram.com/home/.

UNFPA. 2020. "Tailoring Steps to End Female Genital Mutilation." New York: UNFPA.

UNFPA. 2019. "Beyond the Crossing – Female Genital Mutilation across Borders – Ethiopia, Kenya, Somalia, Tanzania and Uganda." New York: UNFPA.

UNFPA Somalia Country Office. 2018. "Population Estimation Survey for the 18 pre-war regions of Somalia." Nairobi: UNFPA.

UNICEF. 2013. "Female Genital Mutilation/Cutting: A Statistical Overview and Exploration of the Dynamics of Change." New York: UNICEF.

UNICEF. 2022. "Female Genital Mutilation (FGM)." Accessed June 24, 2022. https://data.unicef.org/topic/child-protection/female-genital-mutilation/.

UNICEF Somalia and Somalia Ministry of Planning and International Cooperation. 2014a. "Northeast Zone Multiple Indicator Cluster Survey 2011." Final Report. Nairobi: UNICEF Somalia and Somalia Ministry of Planning and International Cooperation.

UNICEF Somalia and Somaliland Ministry of Planning and National Development. 2014b. "Somaliland Multiple Indicator Cluster Survey 2011. Final Report." Nairobi: UNICEF Somalia and Somaliland Ministry of Planning and National Development.

United Nations Department of Economic and Social Affairs (UN DESA), Population Division. 2019. "World Population Prospects 2019." Accessed June 24, 2022). https://population.un.org/wpp/.

United Nations Statistics Division (UNSD). 2021. "SDG Indicator Metadata." Accessed January 11, 2023. . https://unstats.un.org/sdgs/metadata/files/Metadata-05-03-02.pdf.

United Nations. 2015. "Transforming Our World: the 2030 Agenda for Sustainable Development." A/RES/70/1, Resolution adopted by the General Assembly on September 25, 2015. New York: United Nations.

Vanderelst, Dieter, and Niko Speybroeck. 2014. "Loading, Merging and Analyzing Demographic and Health Surveys Using R." *International Journal of Public Health* 59: 415–422. https://doi.org/10.1007/s00038-013-0538-2

Weny, Kathrin, Romesh Silva, Rachel C. Snow, Berhanu Legesse, and Nafissatou Diop. 2020. "Towards the Elimination of FGM by 2030: A Statistical Assessment." *PLoS ONE* 15 (10): e0238782. https://doi.org/10.1371/journal.pone.0238782

World Health Organization (WHO). 2022. "Female Genital Mutilation." Accessed June 24, 2022. https://www.who.int/news-room/fact-sheets/detail/female-genital-mutilation#:~:text=Key%20facts,benefits%20for%20girls%20and%20women.

Wouango, Josephine, Susan L. Ostermann, and Daniel Mwanga. 2020. "When and How the Law is Effective in Reducing the Practice of FGM/C: A Cross-Border Study in Burkina Faso and Mali." Policy brief. Nairobi: Population Council.

Yoder, Stanely P., and Shanxiao Wang. 2013. "Female Genital Cutting: The Interpretation of Recent DHS Data." DHS Comparative Reports No. 33. Calverton, MD: ICF International.

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