Fertility transition in sub-Saharan African countries by place of residence: Where do they stand and what has contributed most to the transition?

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Abstract

Fertility transition models predict that fertility declines first in urban areas and then in rural areas. However, several sub-Saharan African capitals have experienced fertility stalls, which may indicate that the transition will take time to reach other subnational areas. Using the DHS, we determine the phase of the fertility transition by place of residence in 33 sub-Saharan African countries and the change of the proximate determinants of fertility over the course of the transition. We find that most of the capitals are in an advanced phase of transition. Postpartum infecundability accounts for a higher than expected proportion of inhibited fertility in capitals in the final phase. Capitals that have made the most rapid progress in the transition are those with a sharp increase in contraceptive use. That postpartum infecundability still has a relevant effect in the final phase of transition may indicate that further fertility stalls or longer-lasting current stalls.

Introduction

Fertility transition consists in the decline in the total fertility rate (TFR) from high rates to replacement level. Fertility transition in sub-Saharan Africa (SSA) began in the early 1980s and by the mid-1990s it was underway (Garenne and Joseph 2002; Sánchez-Páez and Schoumaker 2022; Shapiro and Tambashe 2002). However, halts and reversals in fertility decline have been found in several SSA countries since the 2000s (Bongaarts 2008; Sánchez-Páez and Schoumaker 2022; Schoumaker 2019; Shapiro and Hinde 2017). Recent analyses suggest periods of stalled fertility are widespread among SSA capitals (Schoumaker and Sánchez-Páez 2020). In most cases, fertility has stalled at rates well above replacement levels. Moreover, in many SSA rural areas fertility transition has not yet began.

Stylized models of fertility transition predict that fertility declines first in urban areas and then in rural areas (Dyson 2011; Shapiro and Tambashe 2002), as urban dwellers have a higher standard of living and better access to education, health care and family planning services (Corker 2017; Lerch 2019). Moving beyond the urban/rural dichotomy, evidence shows that highly populated cities, usually the capitals, begin demographic transition earlier (Corker 2017). Although capital cities are at the forefront of a country's fertility transition, they have not been widely studied. On the other hand, the study of the fertility transition in rural areas is of great relevance since urbanization in SSA is low and, therefore, the fertility patterns of the largest population subgroup greatly affects the total population. Examining fertility trends in SSA by place of residence could shed some light on future fertility trends

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at the national level, and on the influence of capital cities on the fertility transition of the rest of the country's places of residence.

Phases of the fertility transition

Fertility changes over time can be explained by changes in proximate determinants. Four of them account for most of the variations of fertility: sexual exposure, contraception, postpartum infecundability and abortion (Bongaarts 1978, 2015; Bongaarts and Potter 1983). Each of these determinants has an inhibiting effect on fertility: fertility is reduced as a result of lower sexual exposure, greater use of contraception, more frequent abortion, and longer periods of breastfeeding and abstinence (Bongaarts 1982). Bongaarts (1982) and Bongaarts and Potter (1983) propose four phases of fertility transition based on ranges of the TFR. The role of the proximate determinants differs as the fertility transition progresses:

I. TFR over 6.0: Fertility-inhibiting effect of postpartum infecundability is the largest. Small effect of contraception.

II. TFR 4.5–6.0: Effect of postpartum infecundability decreases as the effect of contraception increases.

III. TFR 3.0–4.5: Fertility-inhibiting effect of contraception increases compared to Phase II. Small effect of abortion.

IV. TFR less than 3.0: Fertility-inhibiting effect of contraception is the largest while that of postpartum infecundability is the smallest. The effect of abortion increases compared to Phase III.

Our objective is to determine how proximate determinants of fertility change during the course of the fertility transition in capital cities, other urban areas and rural areas in SSA. We analyze capital cities separately from other urban areas as capitals pave the way for fertility transition, but the evidence suggests that fertility is stalled in most of them. As shown in previous studies (Bongaarts 1982; Bongaarts and Potter 1983), we expect that the fertility-inhibiting effects of the proximate determinants evolve with the fertility transition. However, we expect that postpartum infecundability still has a large effect on fertility at more advanced phases of fertility transition, reflecting long durations of breastfeeding and postpartum sexual abstinence in SSA (Page and Lesthaeghe 1981). The effect of postpartum infecundability is not taken over by an increase contraception, as contraceptive use remains low in many settings.

Data and methods

Data

We use data from the Demographic and Health Surveys (DHS). We include in our study all the countries with at least two surveys and where it is possible to identify the capital or the largest city of the country. Thus, we use 138 DHS from 33 SSA countries. These surveys were conducted between 1986 and 2019. These DHS include information on birth histories, marital status, sexual activity, contraceptive use, amenorrhea, and postpartum abstinence for

149,788 women aged 15–49 living in the capital or largest city, 371,424 in other urban areas, and 933,943 in rural areas. We analyze the largest city rather than the capital when there are significant differences in population. For instance, in Nigeria we examine Lagos instead of Abuja, in South Africa, Johannesburg instead of Pretoria, or in Tanzania, Dar es Salaam instead of Dodoma. Onwards, we refer to all cities as capital cities or capitals. Details are presented in Table 1.

Table 1: Capital cities and Demographic and Health Surveys (DHS) used in the study.

Country code	Country name	Capital or largest city	DHS used
CI	Cote d'Ivoire	Abidjan	1998-99, 2011-12
GH	Ghana	Accra	1988, 1993, 1998, 2003, 2008, 2014
ET	Ethiopia	Addis Ababa	2000, 2005, 2011, 2016
MD	Madagascar	Antananarivo	1992, 1997, 2003-04, 2008-09
ML	Mali	Bamako	1987, 1995-96, 2001, 2006, 2012-13, 2018
GM	Gambia	Banjul	2013, 2019-20
CG	Congo	Brazzaville	2005, 2011-12
BU	Burundi	Bujumbura	1987, 2010, 2016-17
GN	Guinea	Conakry	1999, 2005, 2012, 2018
BJ	Benin	Cotonou	1996, 2001, 2006, 2011-12, 2017-18
SN	Senegal	Dakar	1992-93, 1997, 2005, 2010-11, 2012-13, 2014, 2015, 2016, 2017, 2018, 2019
TZ	Tanzania	Dar es Salaam	1991-92, 1996, 1999, 2004-05, 2010, 2015-16
SL	Sierra Leone	Freetown	2008, 2013, 2019
ZW	Zimbabwe	Harare	1988, 1994, 1999, 2005-06, 2010-11, 2015
ZA	South Africa	Johannesburg	1998, 2016
UG	Uganda	Kampala	1988-89, 1995, 2006, 2011, 2016
RW	Rwanda	Kigali	1992, 2000, 2005, 2010, 2014-15, 2019-20
CD	Congo D.R.	Kinshasa	2007, 2013-14
NG	Nigeria	Lagos	1990, 2003, 2008, 2013, 2018
GA	Gabon	Libreville-Port Gentil	2000, 2012
MW	Malawi	Lilongwe	1992, 1992, 2000, 2004, 2010, 2015-16
TG	Togo	Lomé	1988, 1998, 2013-14
ZM	Zambia	Lusaka	1992, 1996, 2001-02, 2007, 2013-14, 2018
MZ	Mozambique	Maputo	1997, 2003, 2011
LS	Lesotho	Maseru	2004, 2009, 2014
LB	Liberia	Monrovia	1986, 2007, 2013, 2019-20
KM	Comoros	Moroni	1996, 2012
KE	Kenya	Nairobi	1989, 1993, 1998, 2003, 2008-09, 2014
TD	Chad	Ndjamena	1996-97, 2004, 2014-15
NI	Niger	Niamey	1992, 1998, 2006, 2012
BF	Burkina Faso	Ouagadougou	1993, 1998-99, 2003, 2010
NM	Namibia	Windhoek	1992, 2000, 2006-07, 2013
CM	Cameroon	Yaounde-Douala	1991, 1998, 2004, 2011, 2018

Methods

Proximate determinants of fertility

Proximate determinants of fertility are behavioral or biological factors that affect fertility. Changes in fertility can be accounted for by changes in four major proximate determinants (Bongaarts 1978, 2015; Bongaarts and Potter 1983). Each proximate determinant can be characterized by an index that varies between 0 and 1, where 0 indicates total fertility inhibition while 1 indicates no fertility inhibition. The TFR can be expressed as the product of the four indexes and total fecundity (TF), which represents the average maximum number of children a woman could have in her lifetime in the absence of fertility-inhibiting effects:

$$TFR = C_m \times C_c \times C_i \times C_a \times TF \quad \text{(Eq. 1)}$$

Where, C_m is the index of sexual exposure, C_c the index of contraception, C_i the index of postpartum infecundability, and C_a the index of abortion. The first three indexes can be computed with existing surveys; in contrast, data do not allow computing the fertility-inhibiting effect of abortion, and we assume $C_a = 1$. We compute the indexes following Bongaarts' revised model (Bongaarts 2015):

- C_m measures the exposure to childbearing. C_m includes in-union women and unmarried women who are pregnant, report sex in the last month, use contraception, or are postpartum infecundable.

- C_c measures the impact of contraception, accounting for the average effectiveness of the method used and the overlap with postpartum infecundability. We use the average effectiveness proposed in Stover (1998), as it includes a more comprehensive list of contraceptive effectiveness measures than the one used in Bongaarts (2015) and Bongaarts and Potter (1983).

- C_i captures the extent to which postpartum abstinence and lactational amenorrhea inhibit fertility.

Following Bongaarts' approach (Bongaarts 1978, 2015; Bongaarts and Potter 1983), TF (total fecundity) can be computed from TFR and proximate determinants as

$$TF = \frac{TFR}{C_m \times C_c \times C_i \times C_a} \quad \text{(Eq.2)}$$

Bongaarts (2015) estimated the TF for each country and then averaged without weighting all of the TFs from surveys included in his study. Thus, the average TF was 15.4. We followed the same approach using equation 2 to calculate the TF by place of residence. We first estimated the TF of each of the three subnational areas by country and then calculated the unweighted average of all TFs by area. Our estimate of the average TF is 12.1 for capital cities, 13.4 for other urban areas, and 15.5 for rural areas. To check robustness, we calculated the TF at the national level for each country as the unweighted average of the three subnational TFs. Then, we averaged without weighting the TF of all the surveys used in our study. As a result, TF at the national level in our sample is 13.7. This value is close to that

presented by Bongaarts (2015) once abortion is considered, that is, $TF \times C_a = 13.9$, where Bongaarts' estimate of C_a is 0.9. That the TF is lower in the capital cities could be related to the effect of abortion that we are not measuring. If we had a measure for C_a, which would be less than 1, by mathematical relationship the TF would be higher. Evidence shows that abortion is more frequent in urban areas, especially in capital cities, such as in Abidjan or Ouagadougou (Guillaume 2003; Lauro 2011; Rossier et al. 2006).

Fertility inhibition of proximate determinants

The number of children avoided due to the fertility-inhibiting effect of proximate determinants can be estimated from TFR (equation 1), TF (equation 2), and proximate determinants (Bongaarts 1982):

- Exposure to childbearing: $\frac{TFR}{C_m} - TFR = TF \times C_c \times C_a \times C_i - TFR$
- Contraception and abortion: $\frac{TFR}{C_m \times C_c \times C_a} - \frac{TFR}{C_m} = TF \times C_i - \frac{TFR}{C_m}$

The inhibiting effect of abortion on fertility is estimated simultaneously with that of contraception. In a context of limited access to contraceptives, abortion is used to some extent as a substitute (Guillaume 2003). Particularly in capital cities, we note that assuming $C_a = 1$ would underestimate the effect of abortion in some cities, but the effect of contraception would be overestimated.

- Postpartum infecundability: $\frac{TFR}{C_m \times C_c \times C_a \times C_i} - \frac{TFR}{C_m \times C_c \times C_a} = TF - \frac{TFR}{C_m \times C_c \times C_a}$

Preliminary results

For the purposes of this extended abstract, we limit our analyses to capital cities. Analyses for other urban areas and rural areas will be included in the full paper. However, we include preliminary results in Appendix 1 and Appendix 2.

Figure 1 presents the phase of fertility transition in which the SSA capitals are currently in. The classification has been made based on the TFR of the most recent survey. The color of the country represents the phase of the capital. No capital city is currently in Phase I. Three capitals are in Phase II, more than half of the capitals are in Phase III, and about one in three capitals is in Phase IV. We note that Maseru has already reached replacement level and that Addis Ababa is currently below it. We observe some geographic patterns. Capitals in Southern African countries are mostly in Phase IV. Capitals in Sahelian countries are in Phase II. Capitals in Middle African countries are in Phase III. Capitals in Western and Eastern African countries are between Phase III and Phase IV.

Fertility trends correspond to the yellow area in Figure 2.1, Figure 2.2 and Figure 2.3. We observe fertility stalls well above the replacement rate in about two-thirds of the capitals included in this study. Most of the stalls began in the early 2000s and are still ongoing. In these figures we also present trends in fertility inhibited due to the effect of proximate determinants according to phases of fertility transition in the most recent survey in SSA capitals. For instance, in Bamako and Ndjamena, capitals in Phase II, postpartum

infecundability has the greatest fertility-inhibiting effect, while contraception has a small effect, as can be seen in the size of the areas. Fertility inhibited by pospartum infecundability decreases as fertility transition progresses in Dar es Salaam and Yaounde-Douala, capitals in Phase III, while fertility inhibited by contraception increases. Despite its decline, fertility inhibited by postpartum infecundability remains as the greatest in these cities (largest area in the graph). In Lilongwe and Nairobi, capitals in Phase IV, contraception has the greatest inhibiting effect on fertility. However, in Accra, Harare and Monrovia, capitals also in Phase IV, postpartum infecundability still has the greatest inhibiting effect on fertility. In some cases, the increase in fertility-inhibiting effect of contraception is offset by a decrease in the effect of postpartum infecundability. In all phases, fertility inhibited by sexual exposure remains fairly constant over time.

Indexes of proximate determinants according to phases of fertility transition are presented in Figure 3. Boxplots show the changes in proximate determinants for cities at different phases of fertility transition. Phase of fertility transition corresponds to the TFR at the time of the survey. As expected, the product of the indexes, $C_m \times C_c \times C_i$, predicts lower fertility in more advanced phases of the fertility transition.

Index of sexual exposure is highest in Phase I of the fertility transition, then decreases and remains at similar values during Phases II and III. The index is slightly lower in Phase IV than in the previous phases. The decrease in C_m corresponds to the increase in the median age of first sexual intercourse and first union for women aged 25–49 (see panel A of Figure 4). Age at first sex increases on average by two years from Phase I to Phase IV. Similarly, age at first union increases on average by almost four years.

Figure 3 shows no clear differences in C_i between phases. This can be explained by the average duration of amenorrhea and postpartum abstinence (see panel C of Figure 4). Except for Phase I, the average duration of amenorrhea is approximately 10 months. The average duration of postpartum abstinence varies from 7 to 9 months between Phases II and IV. Duration of postpartum abstinence presents a U-shaped pattern by phase of fertility transition. The duration is short at the beginning of the transition, which implies a greater exposure to a new pregnancy, therefore to high fertility rates. Then, the duration lengthens until Phase III. The duration of postpartum abstinence is lower in cities in phase IV, as increased contraceptive use compensates for the increased exposure to pregnancy by resuming sexual intercourse in a shorter period after delivery.

Figure 1: Phase of fertility transition in capital cities from the most recent survey.

Figure 2.1: Sub-Saharan African capitals in the Phase II of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants.

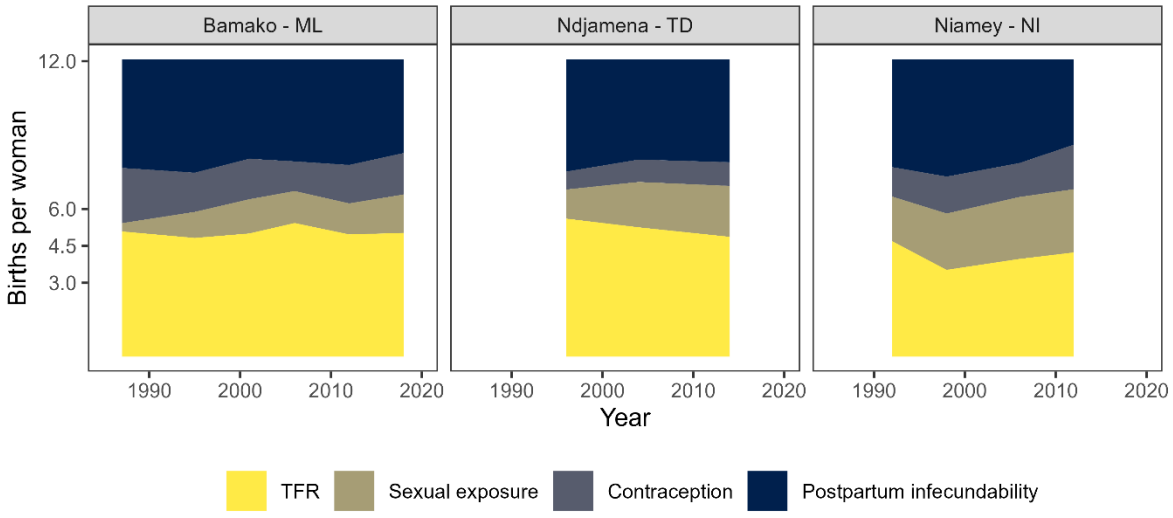


Figure 2.2: Sub-Saharan African capitals in the Phase III of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants.

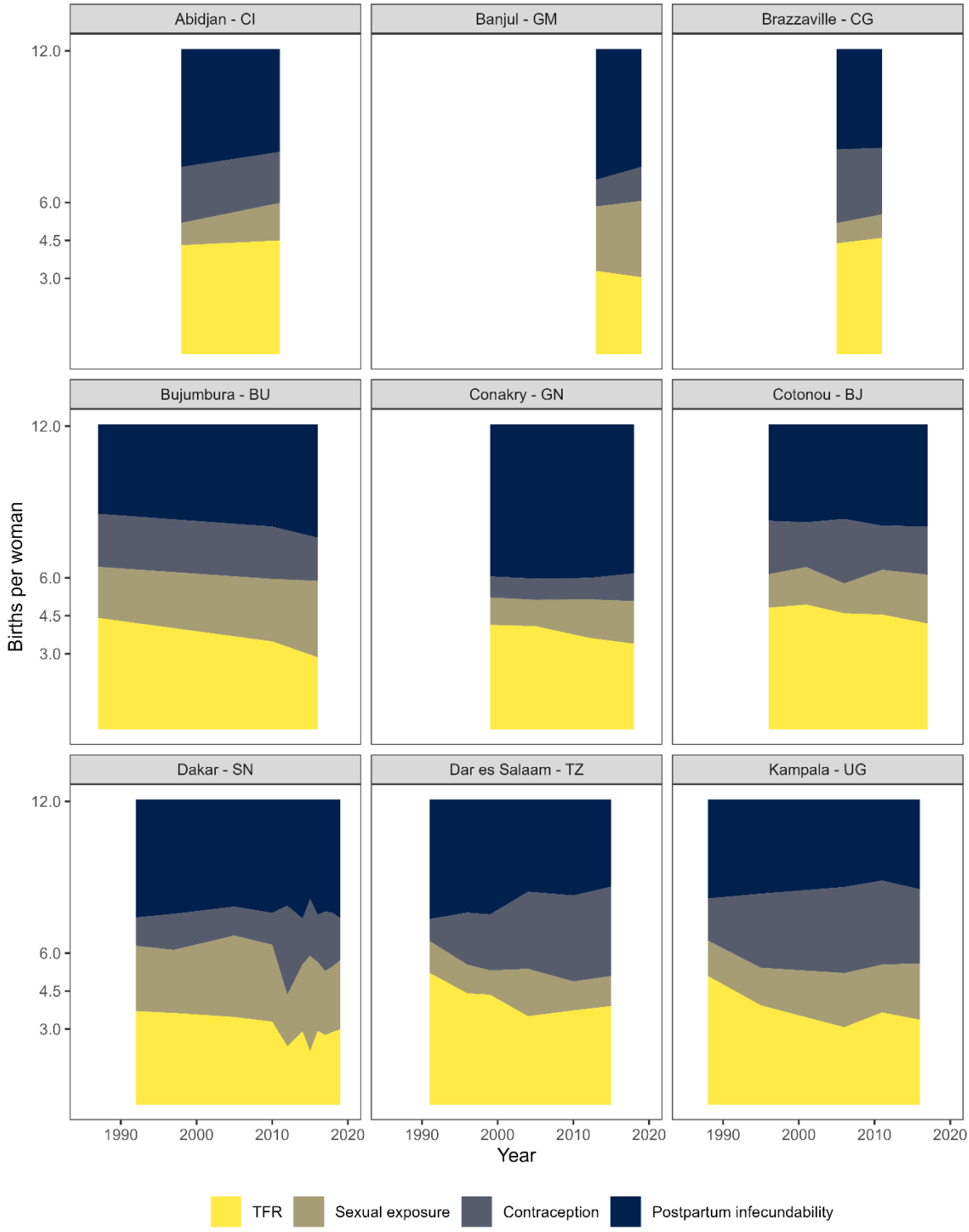


Figure 2.2: Sub-Saharan African capitals in the Phase III of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants. *(continued)*

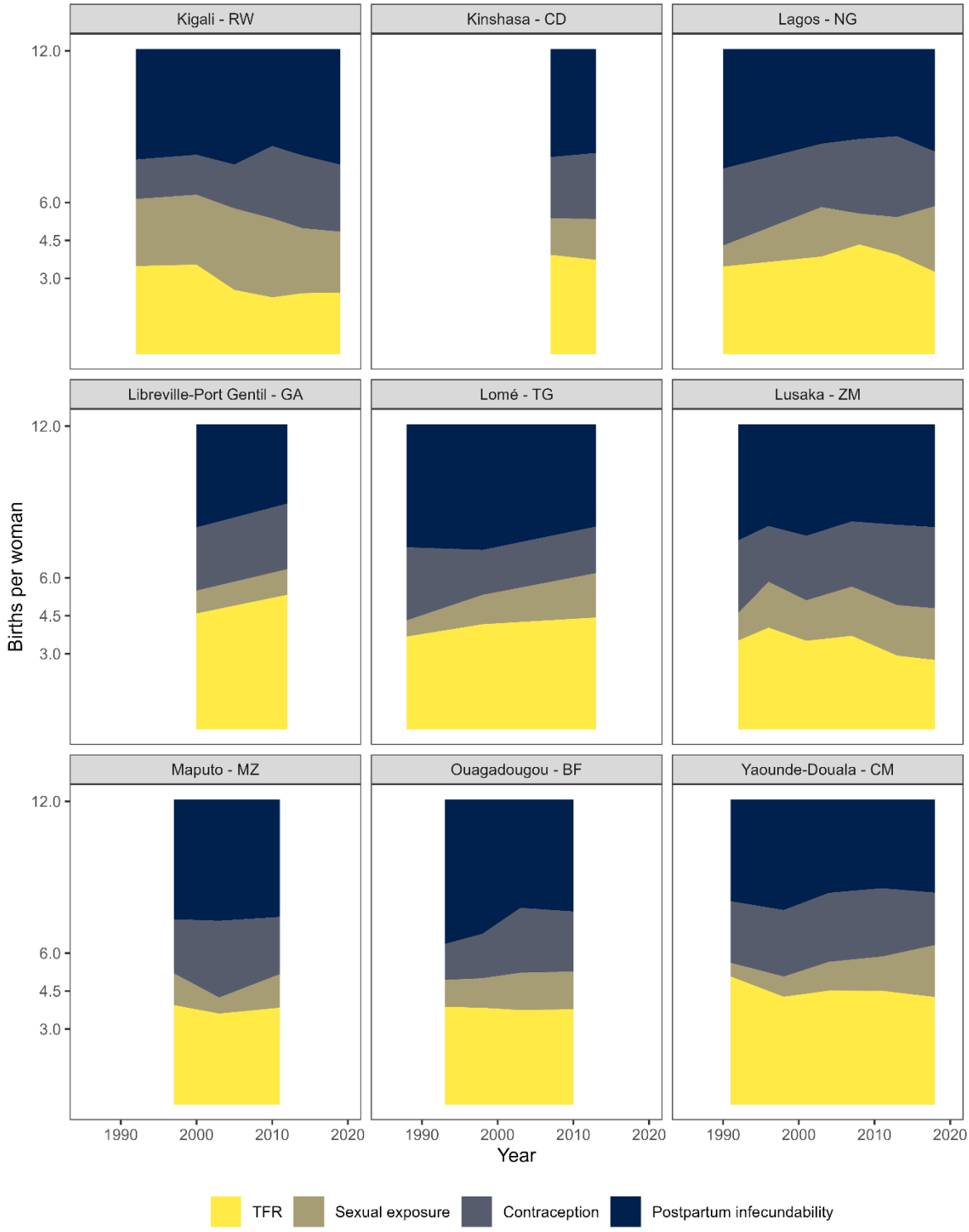


Figure 2.3: Sub-Saharan African capitals in the Phase IV of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants.

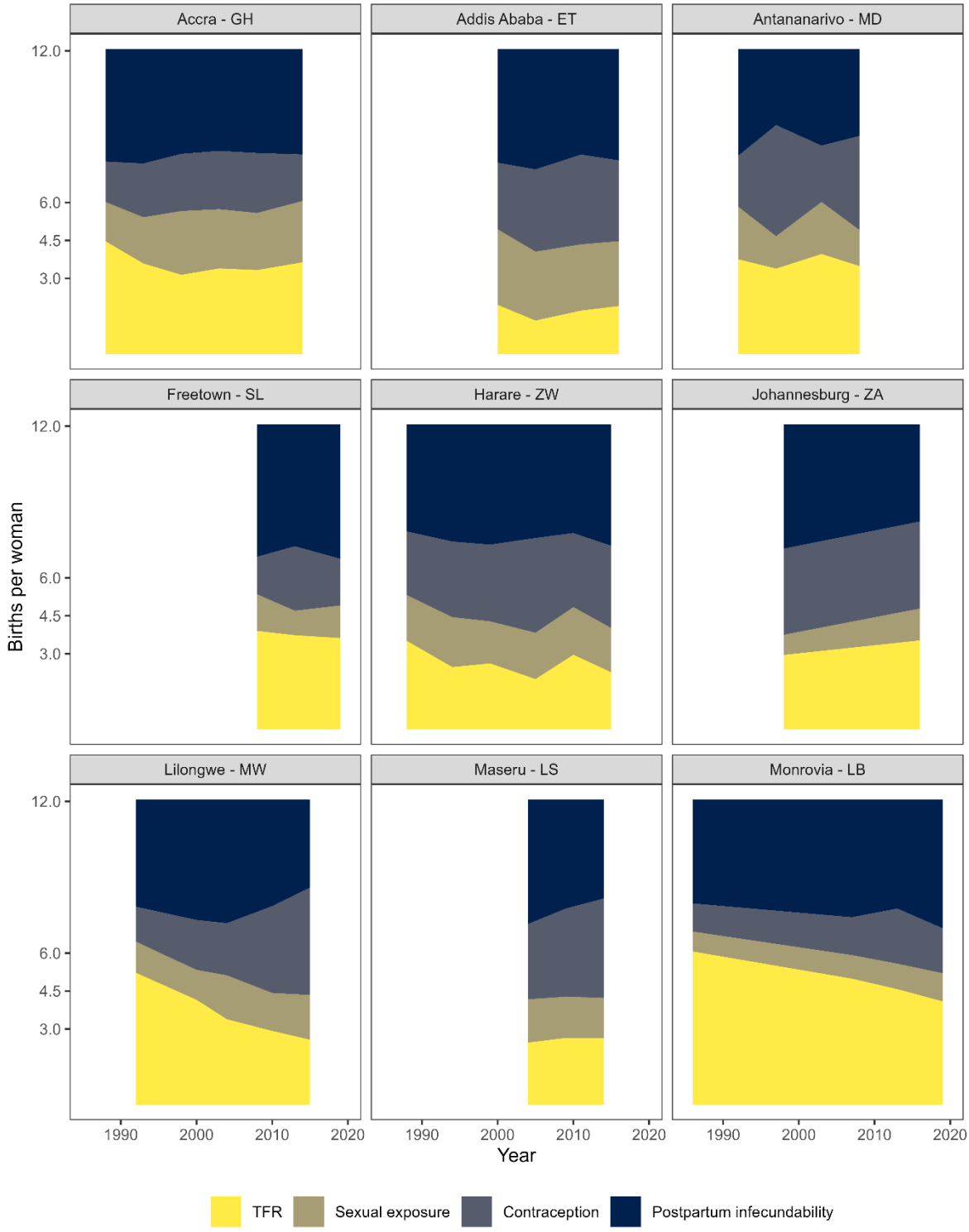


Figure 2.3: Sub-Saharan African capitals in the Phase IV of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants. *(continued)*

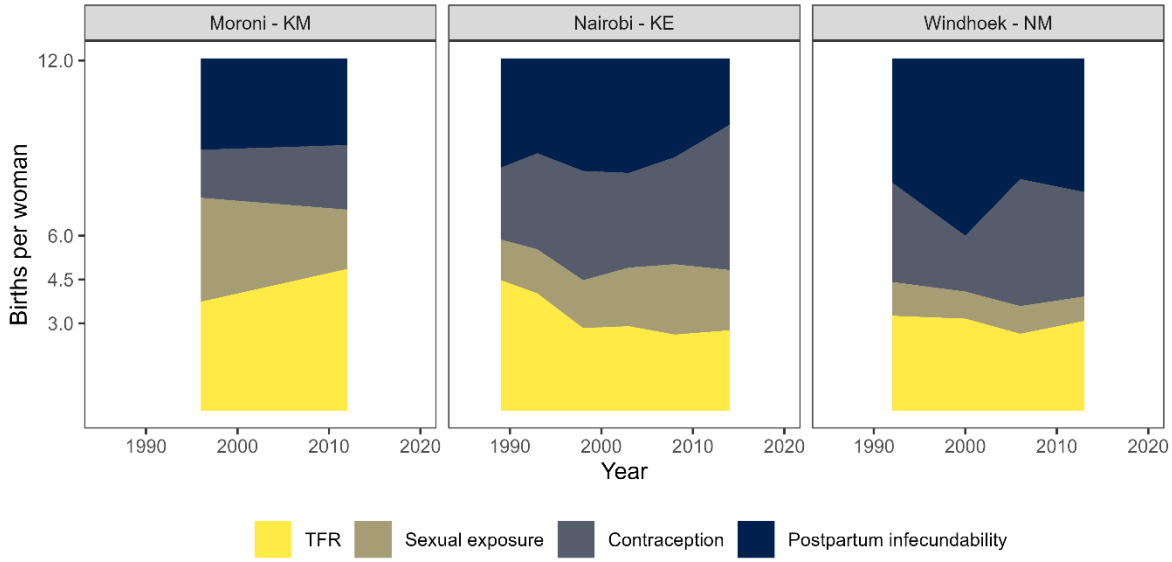
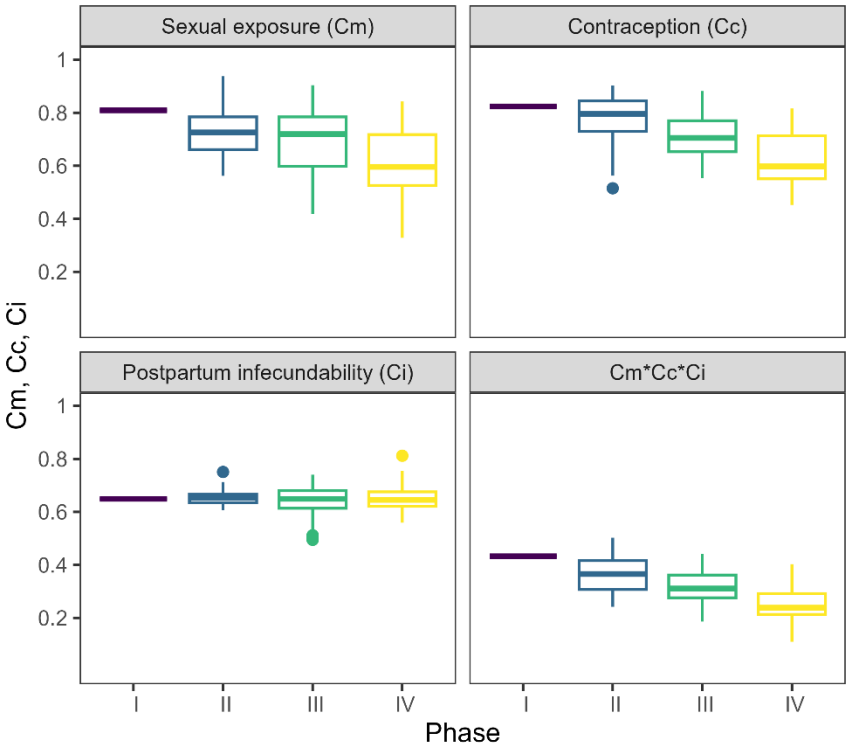


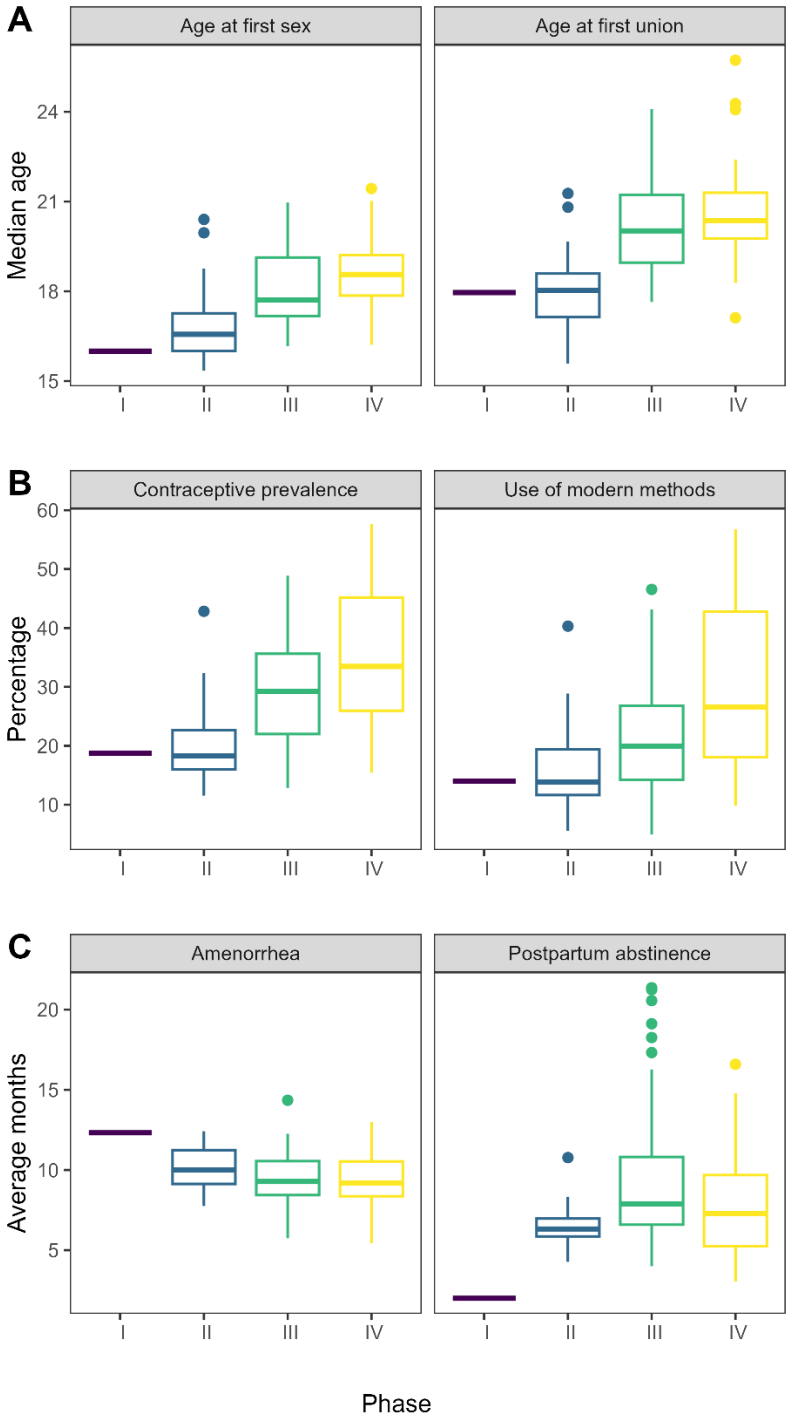
Figure 3: Proximate determinants of fertility in sub-Saharan African capitals according to the phase of fertility transition.



In contrast to C_m and C_i, C_c decreases from one phase to the next phase of the fertility transition (see Figure 3), which indicates that the fertility-inhibiting effect of contraception

increases. This corresponds with the increase in contraceptive prevalence (see panel B of Figure 4). There is no clear increase in prevalence between Phase I and Phase II, but an increase of approximately ten percentage points is observed between Phase II and Phase III, on average. The change between Phase III and Phase IV is mainly due to the increase in the use of modern contraceptive methods.

Figure 4: Measures of the indexes of proximate determinants in different phases of fertility transition in sub-Saharan African capitals.



Preliminary conclusions

Most SSA capitals included in our study are in an advanced phase of fertility transition. Thus, one would expect that replacement levels would be reached in the next few decades. However, we observe stalled fertility well above replacement level in most capitals, which could affect the transition not only in the capital cities, but also at the national level. Fertility stalls are a common feature among SSA capitals (Schoumaker and Sánchez-Páez 2020). Given that capital cities lead the fertility transition (Corker 2017; Dyson 2011) and that fertility is not declining there as fast as expected, declines toward replacement levels should not be anticipated to be observed in the other places of residence. Periods of stalled fertility suggest that the transition in SSA will take longer than expected, therefore the future trend of SSA's population remains unclear.

In accordance with previous research (Bongaarts 1982; Bongaarts and Potter 1983), the fertility-inhibiting effect of contraception increases throughout the phases of transition. We note that the rapid fall in fertility rates in certain capitals is often accompanied by an increase in the use of contraceptives, especially modern methods.

As Bongaarts (1982) proposed, the fertility-inhibiting effect of sexual exposure increases as the transition progresses, but the number of children inhibited by sexual exposure is quite similar across phases.

Fertility inhibited by postpartum infecundability is expected to decrease as transition progresses until it has the smallest fertility inhibitory effect in the last phase of the transition (Bongaarts 1982). While this is found in some capitals, in other cities that are already at an advanced phase of the transition, lower fertility rates can be attributed to longer periods of postpartum infecundability rather than to increased contraceptive use. All in all, we find that the index of postpartum infecundability varies little by phase of fertility transition in capital cities. This leaves open the possibility of further fertility stalls or longer-lasting current stalls. The increase in the fertility-inhibiting effect of contraception may indeed not compensate for the decline in the fertility-inhibiting effect of postpartum infecundability.

Regarding our limitations, we could not examine the effect of abortion in our study due to lack of information. We are assuming that this effect is constant across all capitals and phases; however, we are aware that the effect of abortion might become more relevant in capitals in more progressed phases of the transition.

We will present our conclusions for other urban areas and rural areas in the full paper.

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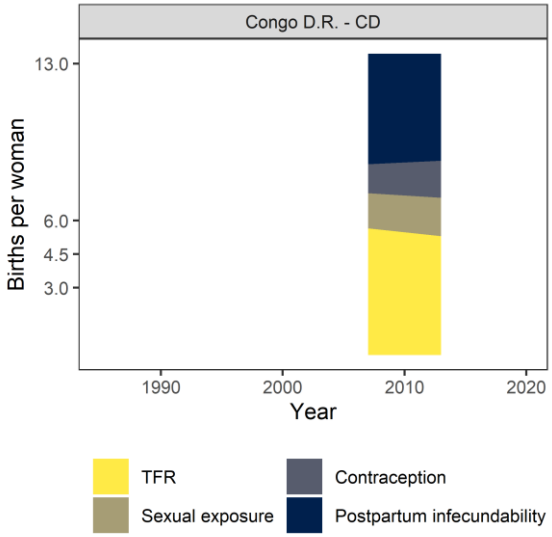
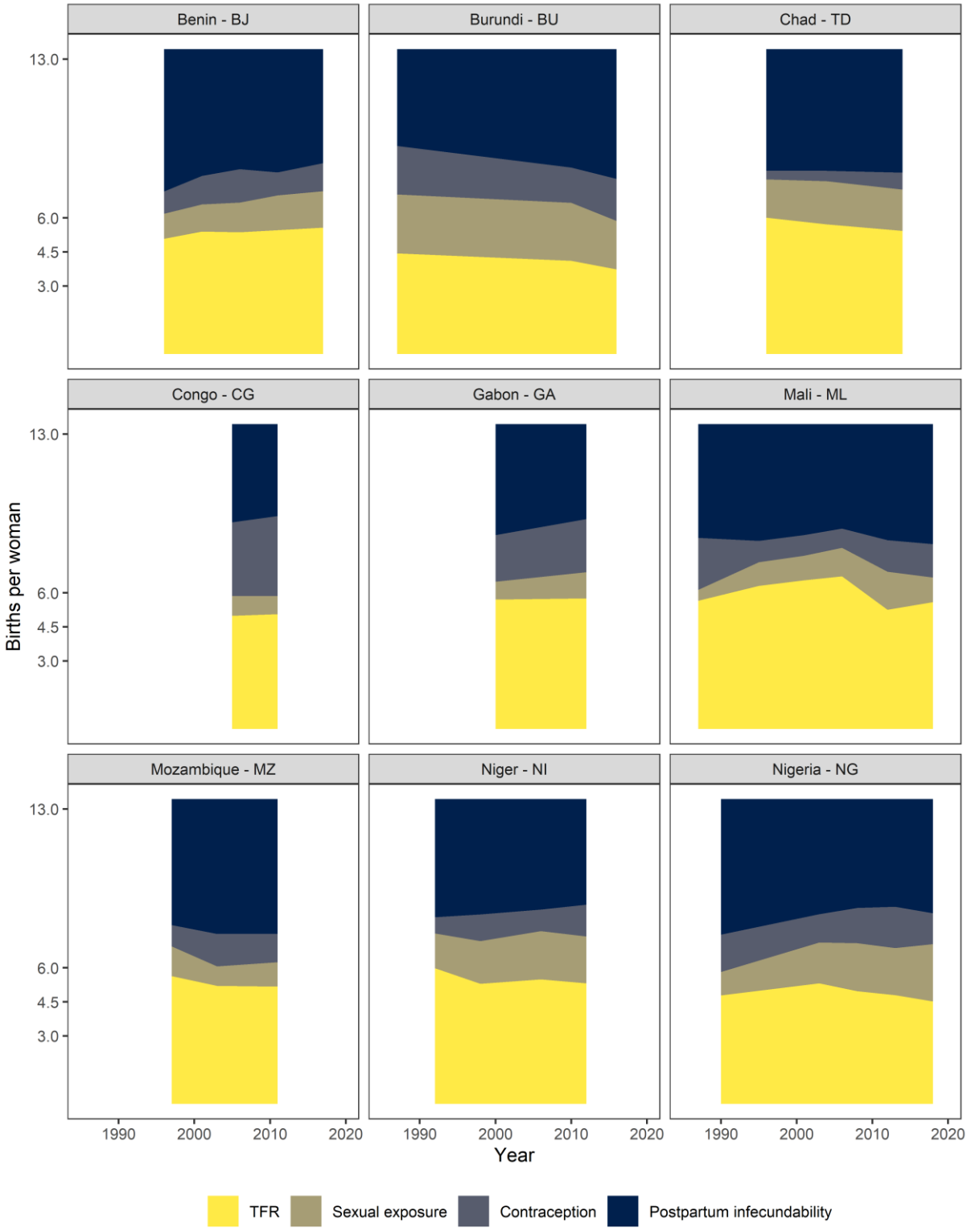
Appendix 1: Other urban areas by phase of the fertility transition

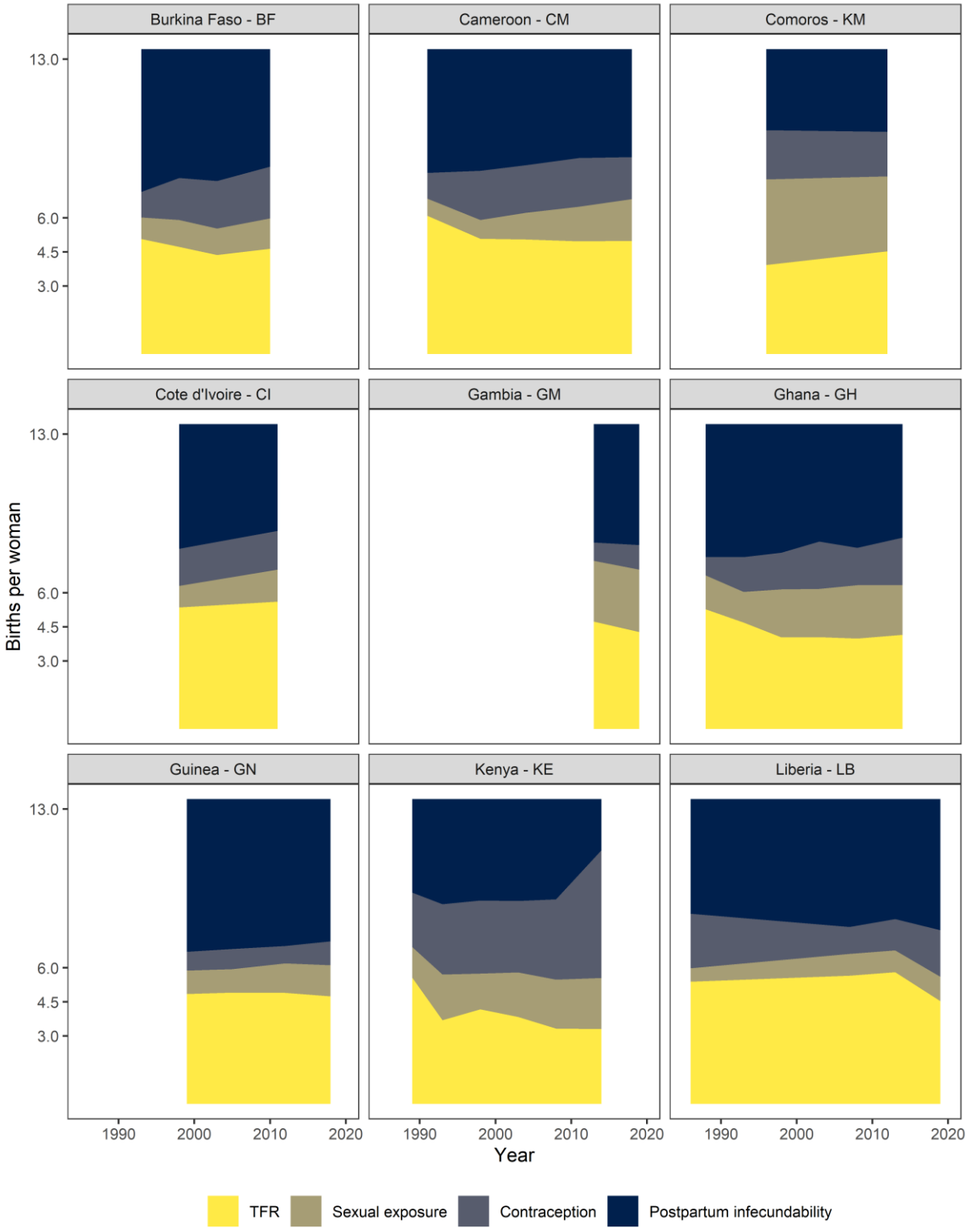
Appendix figure 1.1: Other urban areas of Sub-Saharan African in the Phase I of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants.



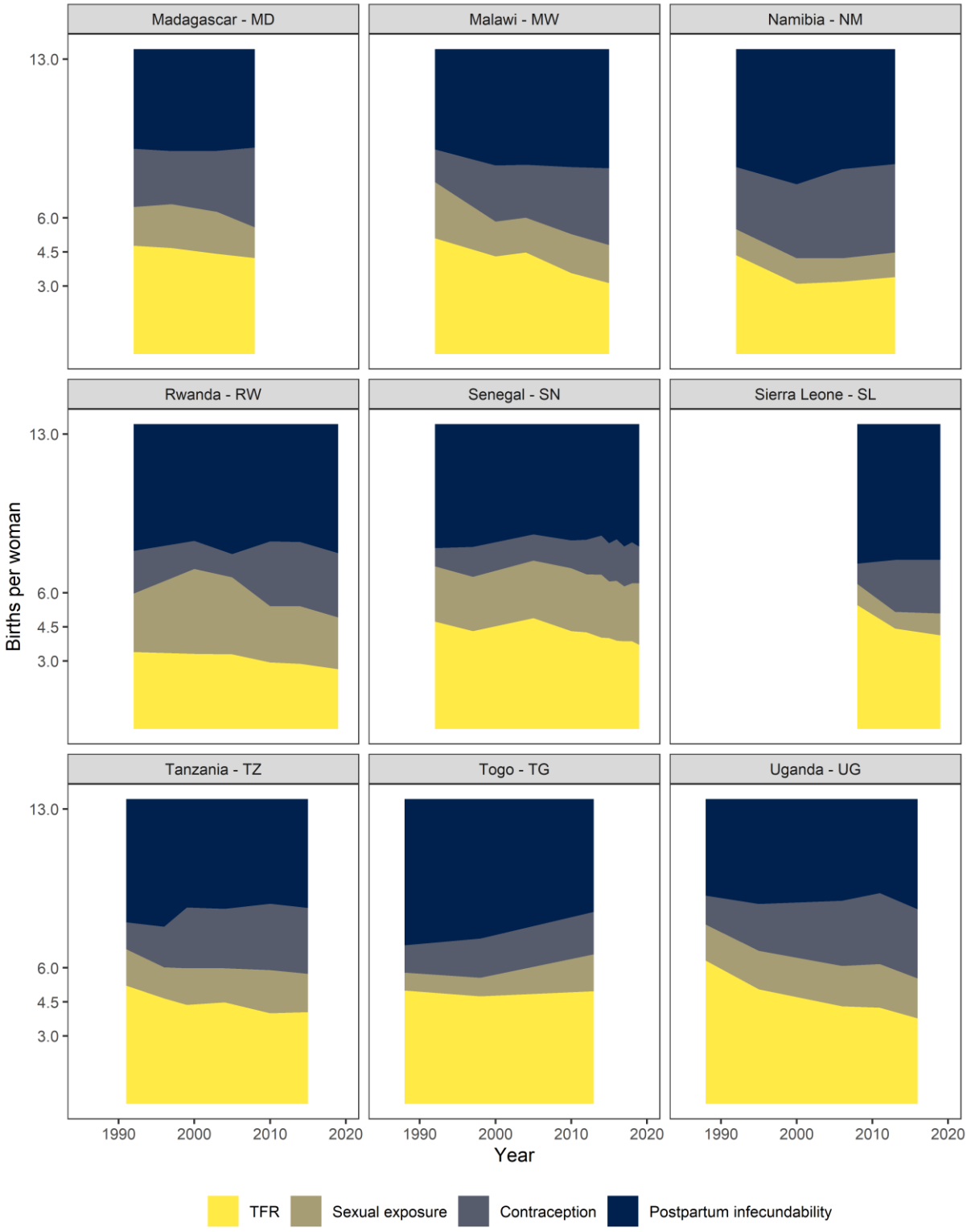
Appendix figure 1.2: Other urban areas of Sub-Saharan African in the Phase II of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants.



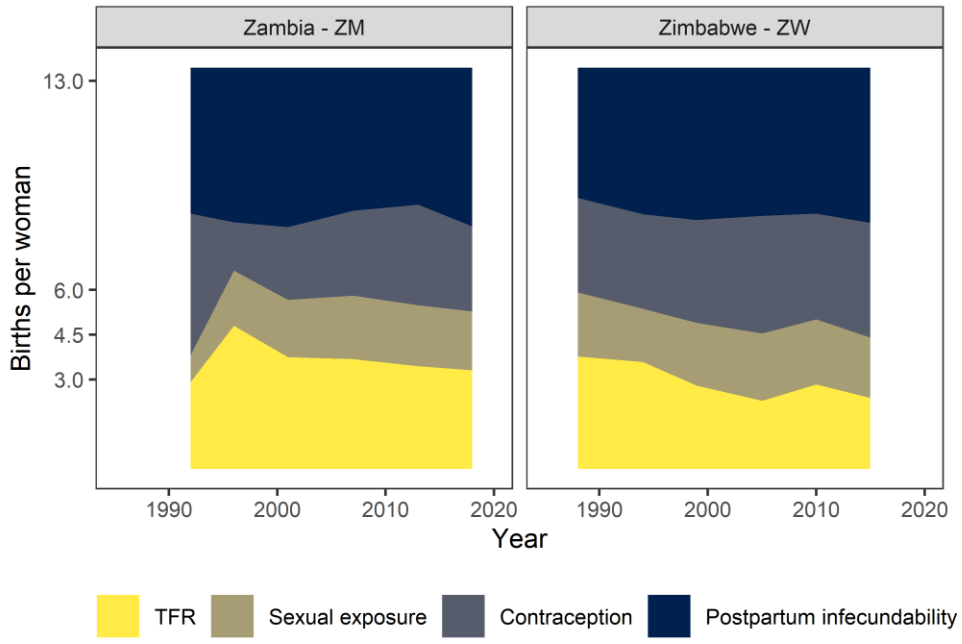
Appendix figure 1.3: Other urban areas of Sub-Saharan African in the Phase III of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants.



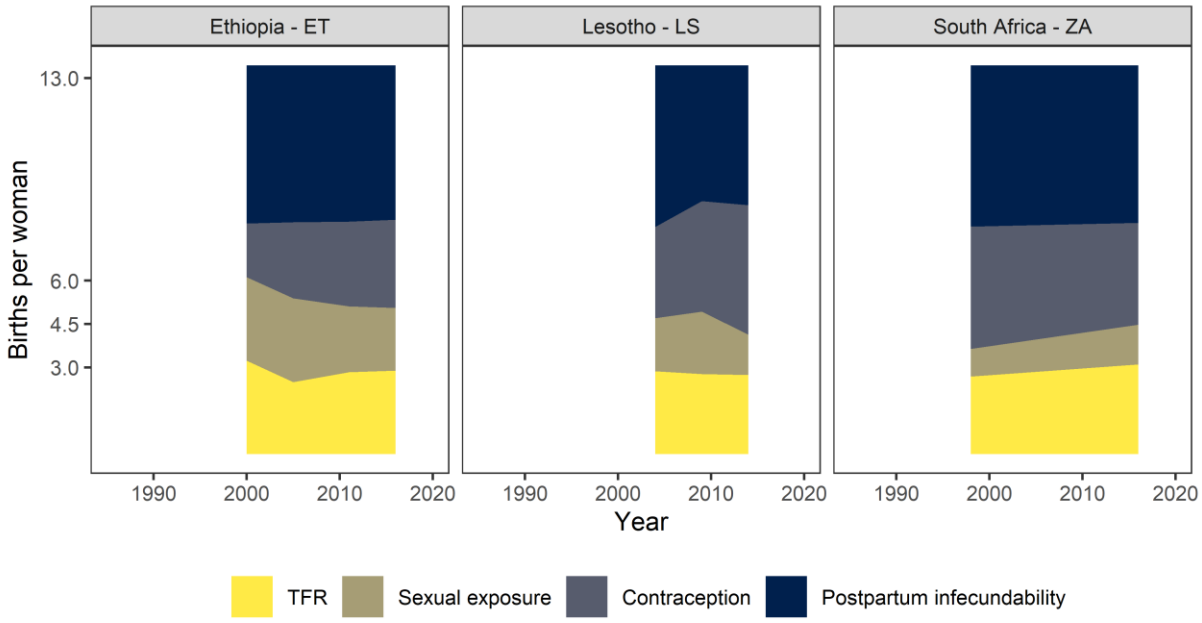
Appendix figure 1.3: Other urban areas of Sub-Saharan African in the Phase III of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants. *(continued)*



Appendix figure 1.3: Other urban areas of Sub-Saharan African in the Phase III of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants. *(continued)*

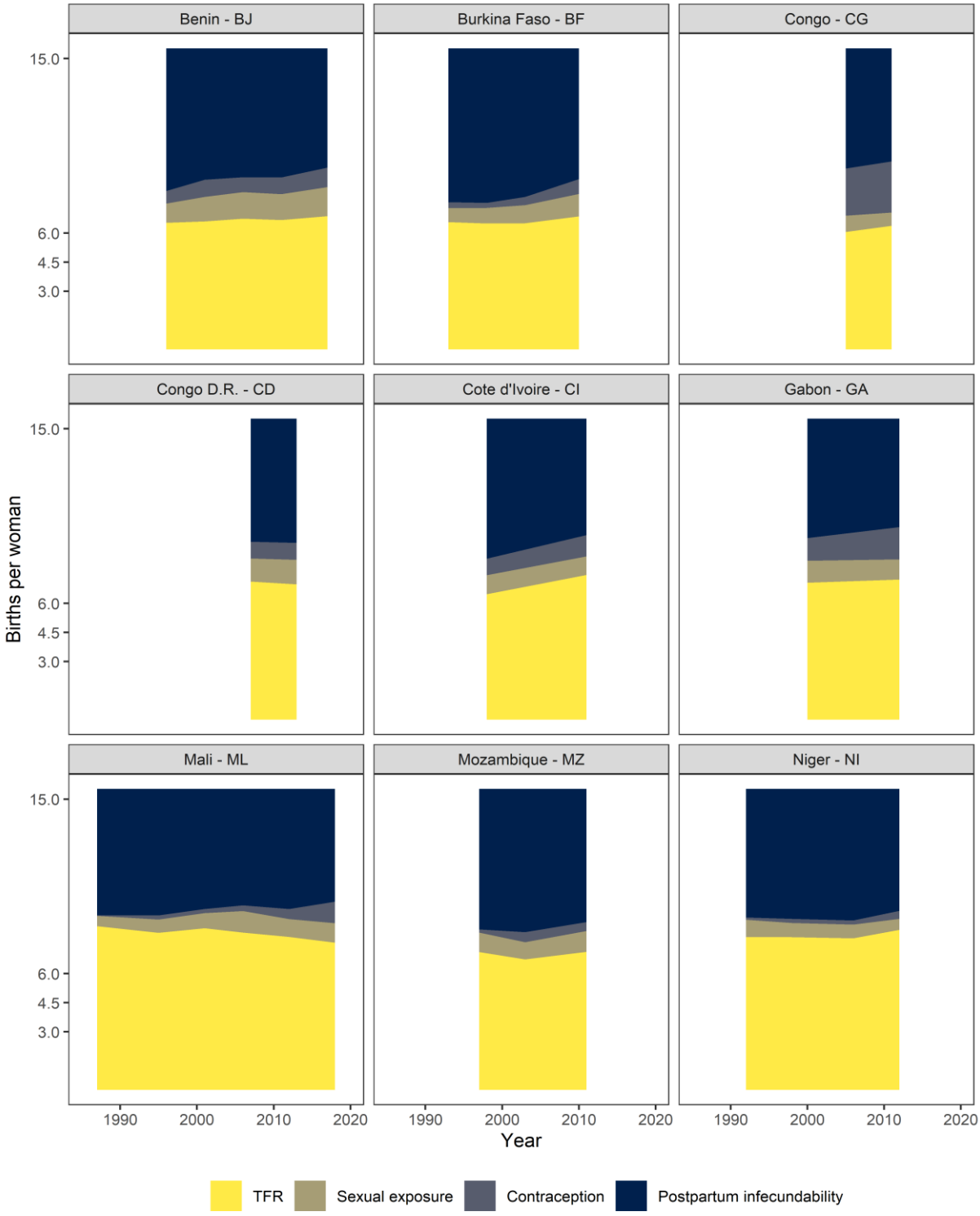


Appendix figure 1.4: Other urban areas of Sub-Saharan African in the Phase IV of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants.

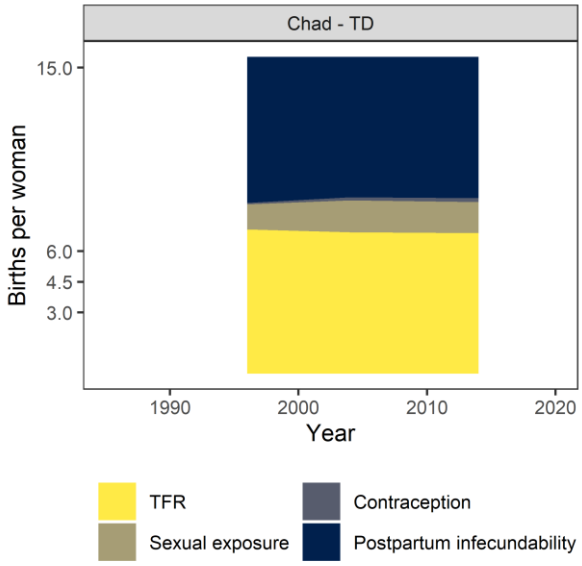


Appendix 2: Rural areas by phase of the fertility transition

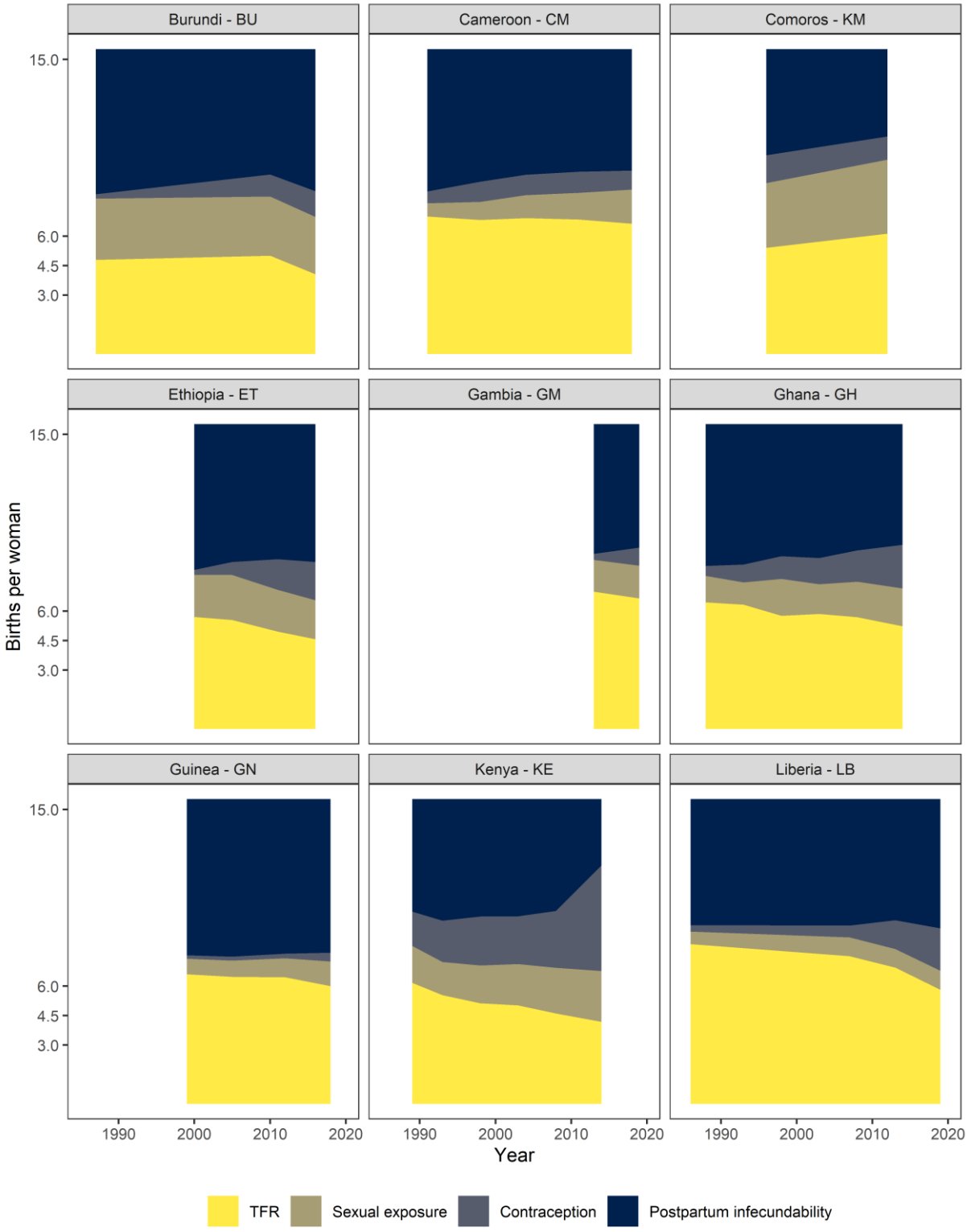
Appendix figure 2.1: Other urban areas of Sub-Saharan African in the Phase I of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants.



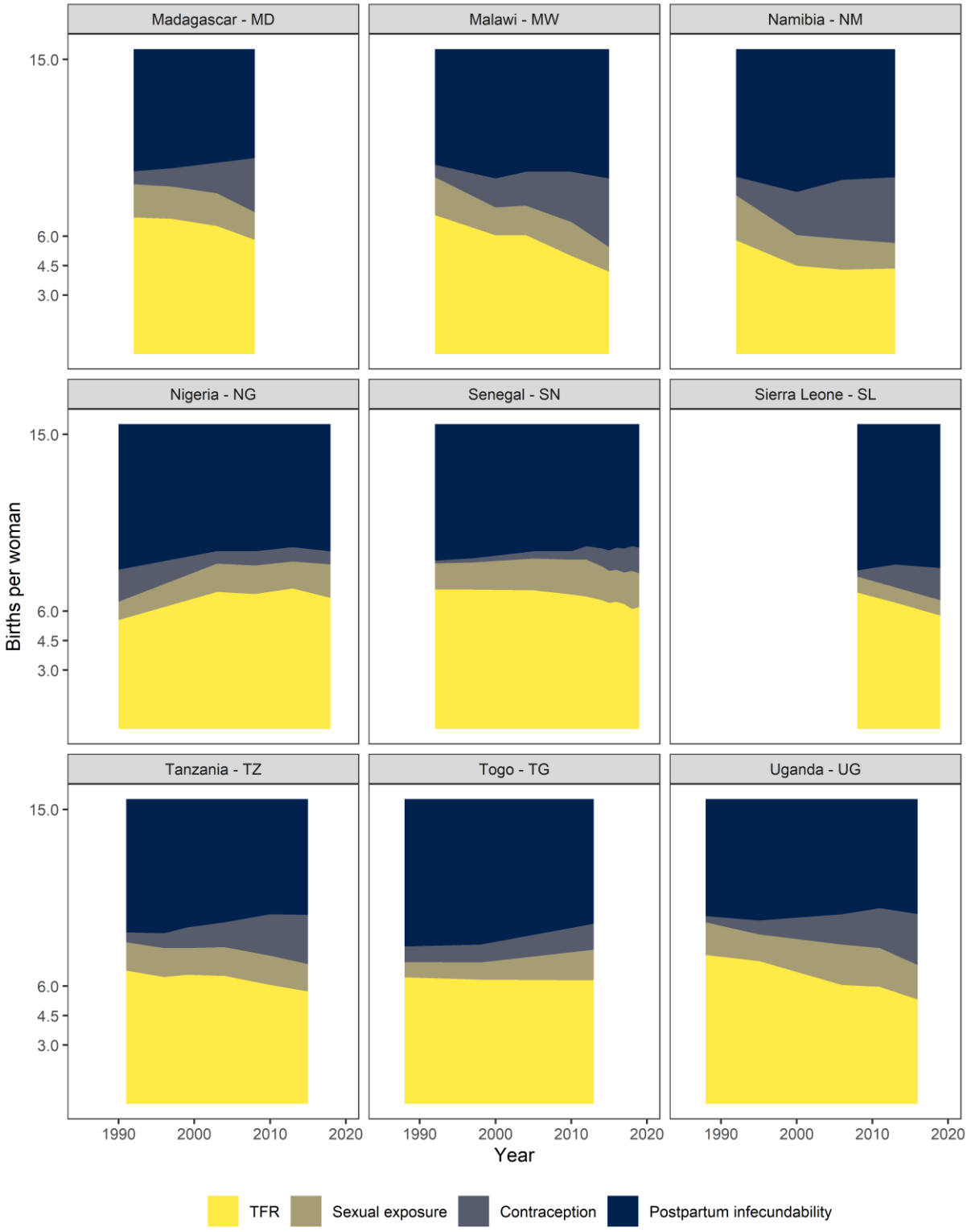
Appendix figure 2.1: Other urban areas of Sub-Saharan African in the Phase I of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants. *(continued)*



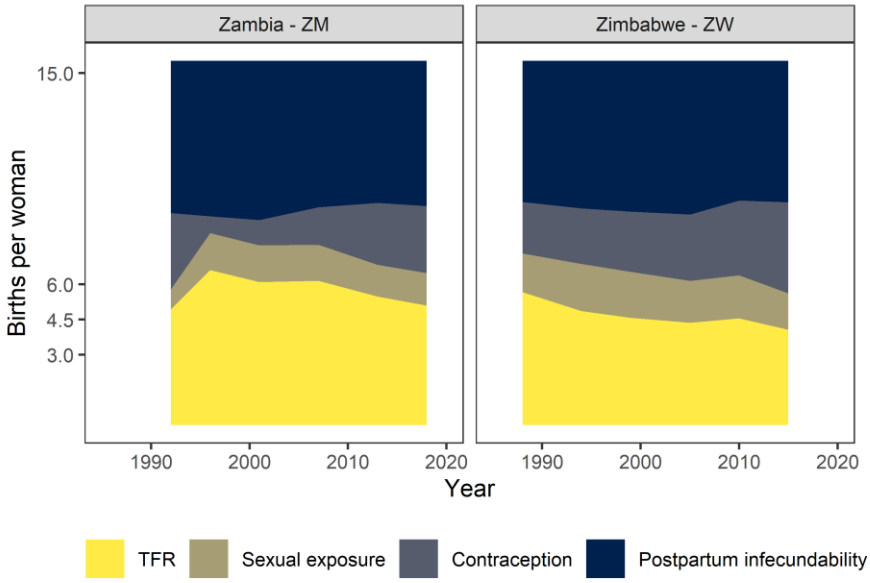
Appendix figure 2.2: Other urban areas of Sub-Saharan African in the Phase II of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants.



Appendix figure 2.2: Other urban areas of Sub-Saharan African in the Phase II of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants. *(continued)*



Appendix figure 2.2: Other urban areas of Sub-Saharan African in the Phase II of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants. *(continued)*



Appendix figure 2.3: Other urban areas of Sub-Saharan African in the Phase III of the fertility transition in the most recent survey. Total fertility rate (TFR) and inhibited fertility from proximate determinants.