Diffusion Test of Fertility Decline in Arab Countries of the Middle East and North Africa (MENA) Region

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Abstract

After a long period of resistance and indications reflecting a natural regime, with variable starting points and rhythms, fertility has finally transited in all Arab countries of the MENA region. This paper aims to analyze this fertility decline to identify precursors and laggards in the shift to conscious birth control and test whether this widespread and rapid decline results from a process of spatiotemporal diffusion. The data used are the United Nations estimates back to 1950. Two approaches are used for dating fertility decline: Schmertmann et al. (2010) is based on the total fertility rate, and Coale and Treadway's (1986) method is based on Coale's Ig marital fertility index. The Knox statistic was used for the diffusion theory test. According to the two methods, the clustering of countries does not show significant differences other than a few exceptions. However, the diffusion theory test yields different results for the two approaches used. For the first method, the test is significant at the 6% level, which indicates that birth control has occurred through a contagion process among countries. However, this diffusion process was not established using the second approach, which may result from social and intentional diffusion instead. The proximate and contextual characteristics analysis in the pioneer countries around the start-up shows that the settings were favorable. The new fertility behaviors emerged first from the elites and the cities.

Keywords

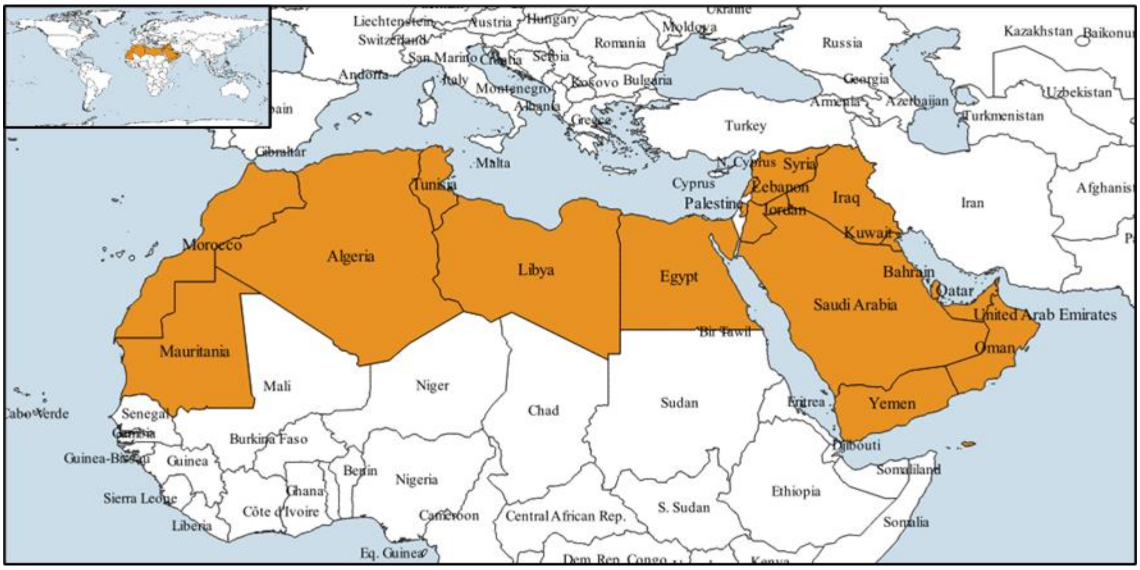
Arab countries; contraception; diffusion of innovation theory; fertility transition; MENA region; spatiotemporal interaction

Introduction

The MENA (Middle East and North Africa) region has no conventional definition. Even so, it often contains 21 countries, 18 of which are commonly referred to as Arab states due to their Arab League membership: Morocco, Algeria, Egypt, Tunisia, and Libya are all part of North Africa (to which we add Mauritania here which is also a member), and the Middle East which encompasses Jordan, Syria, Lebanon, Palestine, and Yemen in addition to the Gulf countries of Kuwait, Iraq, Bahrain, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE) (Figure 1). According to the most recent revisions of the United Nations World Population Prospects (United Nations, 2019b), the MENA region's total population is currently estimated to be 375.4 million, up from 64.2 million in 1950, an almost sixfold increase in 70 years (Appendix 1).

More than a quarter (27.3%) of the population live in Egypt, and three-quarters (76.8%) live in the six "demographic giants," which are Egypt, Algeria, Iraq, Morocco, Saudi Arabia, and Yemen in that order. Furthermore, more than half of the population lives in North Africa (54.7%), and most people are Muslims. However, there are considerable Christian minorities in Egypt and most Middle Eastern countries.

Figure 1: Arab Countries Composing the MENA Region



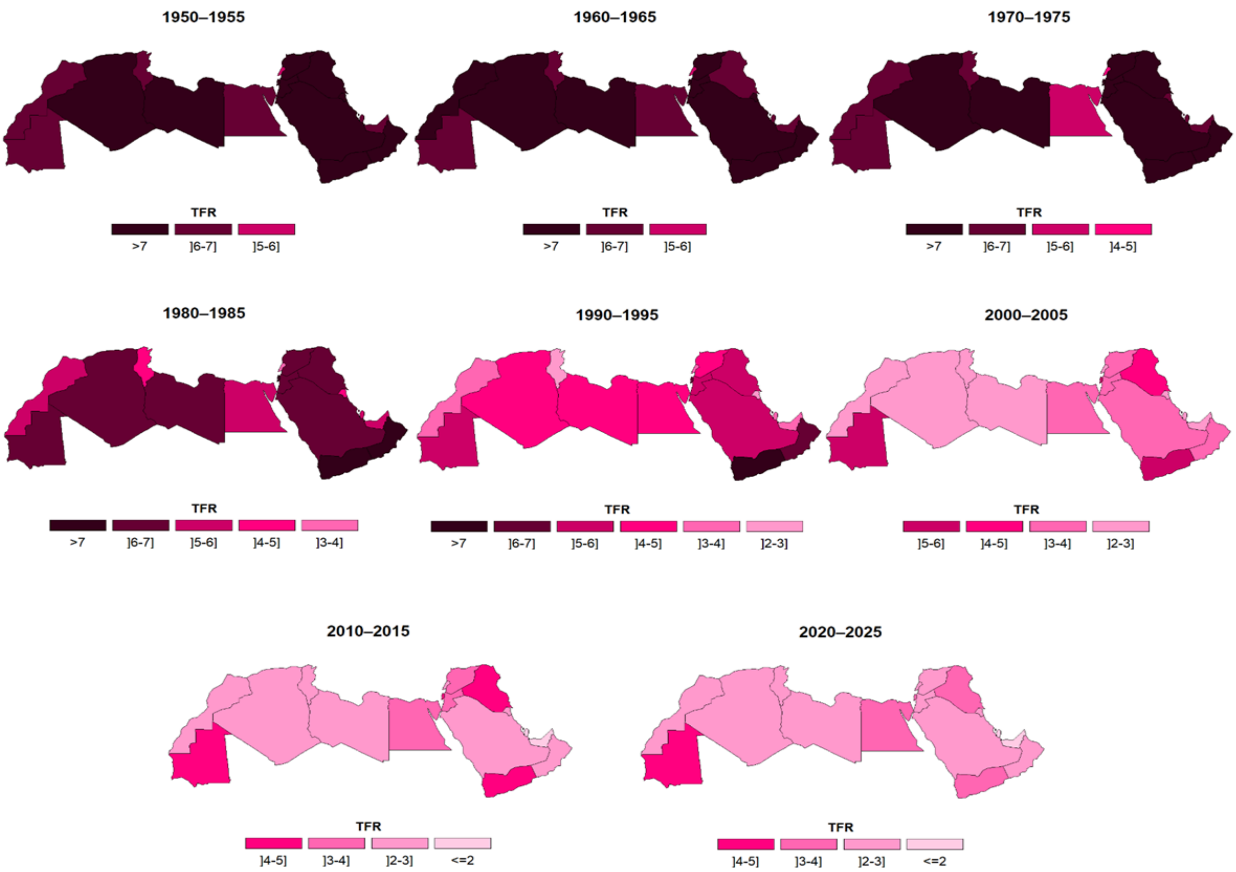
Note: Developed by the authors using QGIS software

This population explosion resulted from a high natural increase rate of 2.5%, which peaked at more than 3% for most countries between 1960–1965 and 1980–1985 (Appendix 2). Peaks vary by country and appear at different periods: 1950–1955 for Qatar (3,4%), 1965–1970 and 1975–1980 for the majority of countries, and 1985–1990 and 1990–1995 for Yemen (4.1%) and Palestine (4.1%). Despite decreased mortality across the region, the birth rate has been slow to adjust, especially in Libya, Jordan, Oman, Palestine, Kuwait, and Yemen.

In terms of fertility, representations in the regions have long resisted the facts (Fargues, 1988; Rashad, 2000). "… the region has, rightly or wrongly, a reputation for opposition to change- here in the shape of an unbridled birthrate. Up to the 1970s, Arab demographics seemed isolationist, a bastion of natural fertilities and resistance to family change" (Courbage, 1999, p. 353). "Dominated by Islamic Arab culture, the social structure in the Arab countries incorporates strong kinship bonds and strong pronatalist values" (Faour, 1989, p. 254). However, the fertility rate has begun its steady and irreversible decrease, albeit later than elsewhere, despite a notably significant time lag between the end of the first phase of the demographic transition and the start of the second (Fargues, 1986; Tabutin & Schoumaker, 2005). Fargues (1986) emphasized that statistics on births and deaths in the MENA region were incomplete or nonexistent until the middle of the twentieth century, making reliable chronology of the pre-transitional period difficult. Only Egypt and Algeria have data from the nineteenth century.

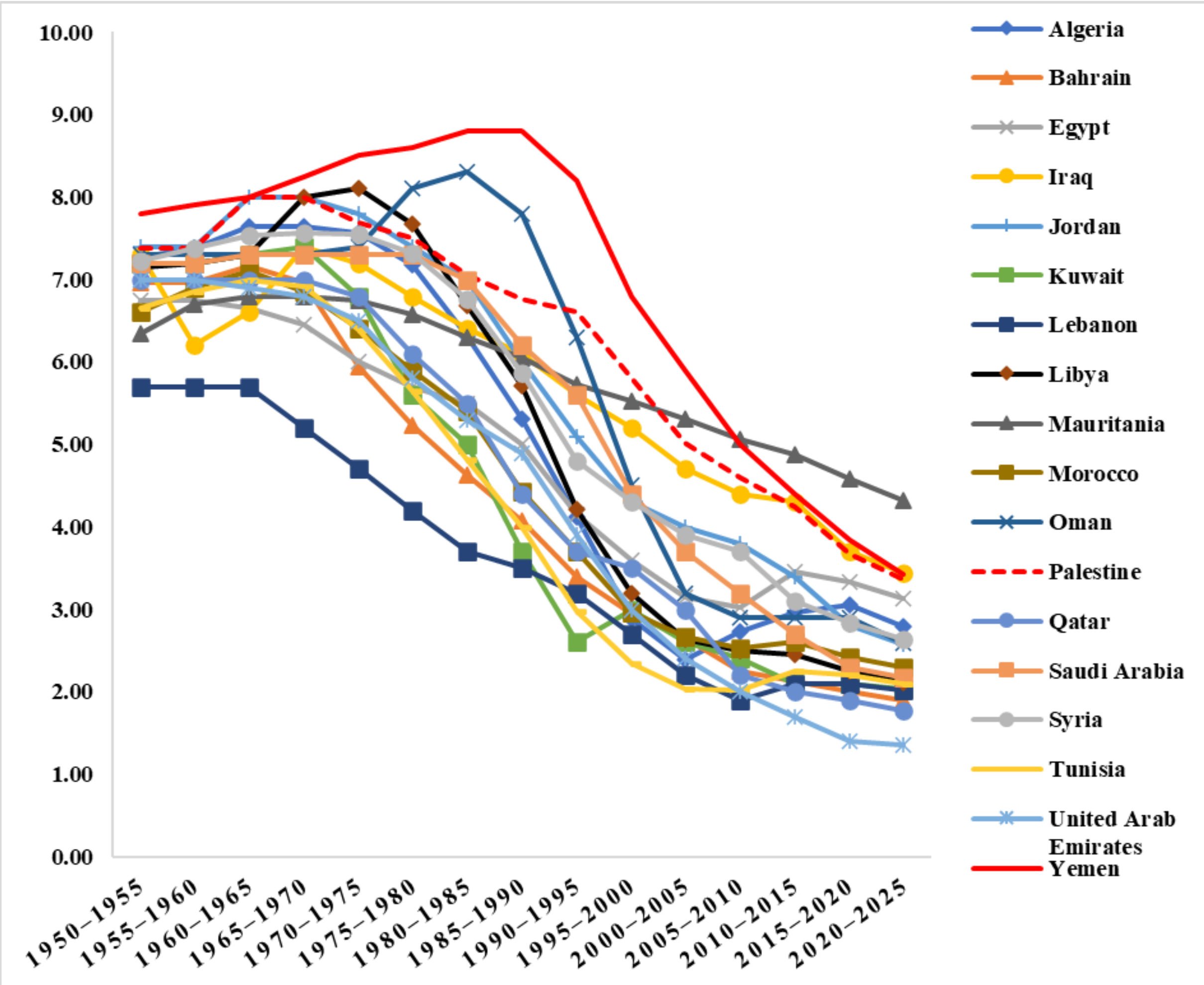
The mapping of fertility trends confirms the general convergence of the decline after more than 50 years of transitions with spatial disparities in the timing and the pace of decline (Figure 2). The MENA region includes countries where the fertility decline was surprisingly early, such as Lebanon, followed later by Morocco, Algeria, Egypt, and Tunisia in North Africa, Kuwait, and Bahrain in the Middle East, and others where it was late but rapid, such as Saudi Arabia and Libya, or exceptionally late and very rapid, such as Oman, Palestine, and Yemen. The region's average total fertility rate (TFR), which peaked at more than 7 children per woman in the 1950s–1970s, fell to half that level in the early 2000s to only 2.6 (Figure 3). Some countries, such as the UAE, Kuwait, Bahrain, Libya, Lebanon, and Qatar, have even reached below-replacement levels (estimated at 2.1 children per woman). Other countries have experienced a relative recovery in fertility, such as Algeria, Egypt, Tunisia, and Oman.

Figure 2: Mapping Fertility Trends in Arab Countries of the MENA Region, 1950–2025



Note: Developed by the authors using R software, United Nations data (2019a)

Figure 3: Evolution of the Total Fertility Rate (TFR) in Arab MENA Countries, 1950–2025



Note: Developed by the authors

In nations where universal marriage and the traditional family model were prevalent, this continuous and rapid decrease raises issues about the precise timing of the onset and the underlying variables.

Contributing factors to the fertility transition in the MENA region

While the decline in mortality appears to be mainly due to factors external to individuals, it is generally accepted that advances in medicine, hygiene and nutrition, and economic development explain the decline in mortality (Vallin, 2005). Fertility transitions are also seen as processes dependent on various initial conditions in this view. There is no single primary determinant but a series of conditions that encourage or discourage transitions or accelerate or retard their pace once initiated (Mason, 2001).

The proximate drivers of fertility are mortality, nuptiality, and birth control, which are impacted by contextual factors such as economic development, education, family systems, and gender relations (Balbo et al., 2013; Bongaarts, 1982; Caldwell, 1982; Casterline, 2001; Chesnais, 1986; Cleland & Wilson, 1987; Goldscheider et al., 2015; Mason, 2001).

These conventional factors have also been discussed in the fertility analysis in Arab countries in the MENA region (Pourreza et al., 2021; Tabutin & Schoumaker, 2005). Indeed, after the continuous decline in infant and child mortality in this region (Appendix 3), late marriage among both men and women will be the impetus for the fertility transition (Appendix 4). Since this cannot be reversed indefinitely in societies that value marriage and family formation and prohibit extramarital reproduction, the spread of contraception has taken over as a means of birth control in most MENA countries (Appendix 4). Thanks to family planning initiatives that have made contraception more accessible, affordable, and acceptable to couples, this coverage has only been possible. This plan aligns with Coale’s (1973) third precondition, which states that efficient fertility-reduction methods must be available as a prerequisite for long-term fertility decline as less developed countries modernize.

Furthermore, Pourreza et al. (2021) conducted a systematic review on the factors contributing to fertility decline in MENA countries. Five drivers were discussed in the 18 articles selected in this study. The first is related to health, mainly improved health care services (such as increased beds/hospitals relative to population size) and increased access to family planning programs, as well as increased male participation in reproductive and sexual health practices (Mirkin, 2010, 2013; Roudi-Fahimi & Kent, 2007). These determinants have reduced infant and maternal mortality rates (Iqbal & Kiendrebeogo, 2014; United Nations, Population Division, 2002). The second factor is cultural changes. Indeed, some authors have emphasized the weakening of traditional values and norms in this region regarding child-raising and parenting and the emergence of new values and attitudes from Western cultures (Karim, 2004; Roudi-Fahimi & Kent, 2007). Thus, these new behaviors have led women to marry later and opt for smaller families (Crane et al., 2011; Mirkin, 2013). The third factor is economics, which emphasizes the high cost of marriage and children's education, inflation, housing and employment problems, and economic development and improvement of living standards (Mirkin, 2013; Pew Research Center, 2011; Yousef, 2004). Social factors have also been the subject of several studies on fertility analysis in MENA countries. These factors include urbanization, increasing education levels, especially among women, women's empowerment, increasing migration rates, and decreasing early marriage rates (Crane et al., 2011; Drioui & Bakass, 2021, 2022; Eberstadt & Shah, 2012; Matthiessen, 2005; Mirkin, 2010, 2013). The last factor is the policy one, where several authors have emphasized the crucial role of government policies that directly support family planning, elimination of restrictions to the achievement of women's rights (e.g., revision of divorce laws), the raising of the legal age of marriage, and the establishment of restrictions on polygamy (Crane et al., 2011; Matthiessen, 2005; Mirkin, 2013; Pew Research Center, 2011).

Fertility transition according to the diffusion theory

Cleland and Wilson (1987), Goldstein and Klüsener (2014), and Klüsener et al. (2019) argued that the emergence and adaptation of deliberate fertility control strategies in the context of demographic transition do not occur randomly across space and time, and instead favor the diffusionist perspective. This focus would be a global model of social change in which people's attitudes and ideas spread through informal face-to-face social interactions or the mass media at a distance (Brown, 1981; Casterline, 2001; Cleland & Wilson, 1987; Rogers, 1962; Valente & Rogers, 1995).

One of the most popular models in this area is that of Rogers (1962, 2003), who defined diffusion as “the process in which an innovation is communicated through certain channels over time among the members of a social system” (2003, p. 5). This theory has been applied to various areas as a theoretical framework (Dooley, 1999; Sahin, 2006; Stuart, 2000). However, it was not until the 1980s that the term "diffusion" began to appear more frequently in the literature on demographic change (Bocquet-Appel & Jakobi, 1998; Costa, 2015; Goldstein & Klüsener, 2014; Knodel & van de Walle, 1979; Tolnay, 1995; van Bavel, 2004; van de Walle & Knodel, 1967; Vitali & Billari, 2015; Watkins, 1986).

Different elements have been put forward as crucial factors in this diffusionist process to identify the main drivers of the diffusion of new ideas and behaviors regarding fertility. For Kohler et al. (2002), social interactions appeared essential in shaping the emergence of lower-level fertility. Other subsequent research has shown the relevance of social networks in shaping fertility choices, especially in advanced societies (Balbo & Barban, 2014; Bernardi et al., 2007). Bocquet-Appel and Jakobi (1998) distinguished two critical concepts: vertical diffusion, which occurs inside groups of the social hierarchy, and horizontal diffusion, which is geographic and oblique. Also, some authors have discussed the diffusion of modernized values from the West to poorer countries and African societies, from the elites to the middle classes and workers, or from the urban elite to rural families (Piché & Poirier, 1990; Tabutin, 2000). For their part, Retherford and Palmore (1983) referred to the "intentional" or "institutional" diffusion of birth control through public and private sector family planning programs.

In addition, the diffusion of other institutional practices has also been mentioned among the factors that can influence fertility and work-family balance, especially in modern societies (McDonald, 2006; Salles et al., 2010). Among the theories that support the central role of these institutional practices, McDonald's (2000) gender equity theory of low fertility focusing on both work and family is mainly cited. In this regard, empirical studies have shown the vital role of child care diffusion on reproductive behavior change (Hank & Kreyenfeld, 2003; Rindfuss et al., 2010).

To our knowledge, fertility analysis using this approach has never been conducted in the context of Arab MENA countries. Thus, this paper aims to fill this gap by first determining when these countries transitioned from natural fertility to deliberate birth control and then seeing whether this fertility decline results from spatiotemporal diffusion in the sense of contagion. By studying the contexts at the time of the transition, it will be possible to determine the factors that allow the adoption of new behaviors.

Data and methods

The data used in this analysis are the estimates of demographic indicators produced by the United Nations, which are comparable and allow data to be available for many periods (United Nations, 2018, 2019a, 2019b, 2020a, 2020b). The data are provided by the quinquennial period from 1950 to 1955 for births, fertility, and mortality, and 1970 to 1975 for nuptiality and modern contraceptive prevalence.

For nuptiality, we also supplemented with other data from Chamie and Weller (1983), Weinberger (1987), and Yaukey (1963).

To examine the transition from natural fertility to fertility based on deliberate birth control, two approaches are used for comparison: Schmertmann et al. (2010) and Coale and Treadway (1986), abbreviated as SA and CT, respectively.

The first method is based on the total fertility rate (TFR). According to Schmertmann et al. (2010), one of two conditions must be met: a TFR below 4.5 or when the TFR decreases by at least 20% during the previous intercensal period.

The second method is based on Coale's Ig marital fertility index (Coale & Treadway, 1986; Coale, 1970):

$$Ig = B_L / \sum M_i * H_i = B_L / B^H{}_L$$

B_L = total observed legitimate births
$B^H{}_L = \sum M_i * H_i$, where:
M_i : number of married women in the age group [x, x+5[
H_i = fertility rate of Hutterites in the age group [x, x+5[
i = 1, 2, 3, 4, 5, 6 and 7 and refers to the 7 five-year age groups ([15–19[…, [45–49[)

The Ig index thus measures the ratio between the legitimate births actually observed among a group of married women of reproductive age at a given time and the births they could have had if they had the standard level of fertility. This is in reference to a kind of maximum which is the remarkably high fertility of Hutterite women observed in the American Middle-West during the 1930s; a population deemed to have natural fertility (Vilquin, 1989). The index makes it possible to indirectly assess the intensity of birth limitation for married couples through the introduction of contraception. It varies between 0 and 1. The reference level is 1 by definition.

Thus, according to Coale and Treadway (1986), a 10% drop in Ig after the pre-transitional period, with no return to a high ceiling, marks the beginning of conscious birth limitation in marriage and the introduction of contraception.

Lesthaeghe (1977) and van de Walle (1974) argued that an Ig of more than 0.7 indicates natural fertility, characteristic of the pre-transitional period.

The test of the hypothesis of the spatiotemporal diffusion of a decline in fertility due to contraception (the innovation) as a contagion process was based on the Knox statistic (Knox, 1964), although there are other techniques (Diggle et al., 1995; Mantel, 1967).

The Knox statistic has two parameters, one spatial (s_{ij}) and the other temporal (t_{ij}), which determine the proximity or distance between each pair of zones, which are N(N-1)/2 with N the number of areas.

$$X = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} s_{ij} t_{ij}$$

Proximity in terms of space and time must be defined according to the context of the study (Schmertmann et al., 2010).

The geographical distances between the Arab countries of the MENA region were calculated using the R software by the Haversine formula, which generates the shortest distance between two points based on the geographical coordinates of the countries provided by the QGIS software (Sinnott, 1984).

It turns out that the average distance is 2,544 km, and the first quartile is 1,130 km. The distances also show heterogeneity between country pairs, ranging from longer distances in North Africa to shorter distances in the Middle East.

Thus, a pair of countries is considered geographically close if they share common borders or if the distance between the centroids is less than a minimum, here the first quartile.
For temporal proximities, a pair of countries is close in time if their transition occurs in the same five-year period, according to the two adopted approaches of SA and CT.

Results

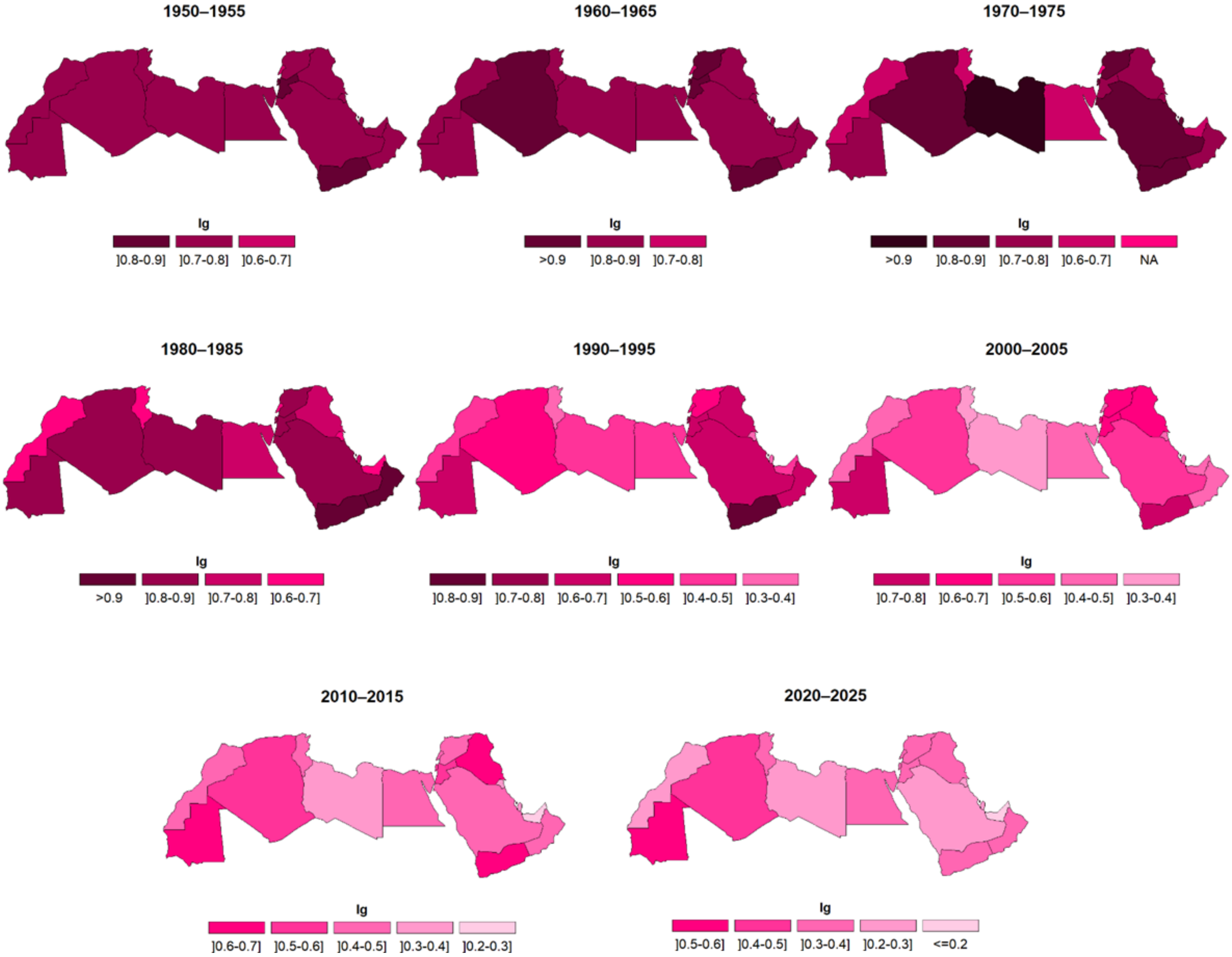
Estimation of the Ig index and determination of the pre-transitional period

The data from the United Nations provides global births, not legitimate births. Therefore, it is assumed that the two indicators are close in the countries studied, which will not significantly influence the value of Ig. This presumption is due to two reasons: a) most population registration or data gathering methods do not register or account for illegitimate births (Négadi & Vallin, 1974), and b) the rarity of out-of-union births compared to legitimate births in societies where reproduction is only legally permitted within marriage (Barraud, 2010; Department of Statistics and National Accounts, 1984; Fargues, 1988; Négadi & Vallin, 1974).

As the published data on the number of married women does not cover the period before 1970, and to complete the Ig series up to 1950–1955, the Ig index for the four missing five-year periods is measured by the relationship between Ig and the TFR during the period 1970–2020. This relationship was estimated by a Panel regression model (Appendix 5), the most appropriate model for estimating a temporal model, based on 180 observations (18 countries and 10 five-year periods (from 1970–1975 to 2015–2020). Since we wanted to estimate a parameter (Ig) with only one predictor (here, the TFR), a size of 10 to 15 observations may be sufficient. Panel models generally do not require many observations (Sheytanova, 2014). Specification tests (Fisher and Hausman) confirmed the choice of the random-effects panel model.

We finally had a matrix (18*14) of the Ig index by country (18) and by five-year period (14), which showed that the index verified the condition Ig > 0.7 for the periods before 1960–1965 (Appendix 6). In addition, we noted a recovery in fertility for some countries with fluctuations, but this is on a low level: for example, Algeria in the two periods 2000–2005 and 2005–2010, Egypt and Lebanon in 2005–2010, Oman and Tunisia from 2000–2005 to 2010–2015. The evolution of Ig by country from 1950–1955 to 2020–2025 is illustrated below (Figure 4).

Figure 4: Mapping of the Ig Index in Arab Countries of the MENA Region, from 1950–1955 to 2020–2025



Note: Developed by the authors using R software

This mapping shows differences between countries regarding the timing of deliberate birth control and the pace of its adoption. There is Lebanon, where the timing of the decline of fertility due to contraception was earlier, with an Ig of about 0.7. Still, the pace was not fast enough, as is the case for Bahrain, where the decline began in 1965–1970 with an accelerated rate, or the UAE, where the Ig index is now below 0.2. Other countries seemed to be precursors in the fertility transition, such as Morocco and Tunisia in North Africa and Kuwait in the Middle East. Others have experienced many later transitions in contraceptive adoption timing and pace. This finding is the case for Mauritania and Yemen, where the Ig value was above 0.7 until 1995–2000 and 2005–2010, respectively.

The emergence of four groups of starter behaviors

According to the two methods of SA and CT, the start dates of marital fertility transitions in the countries are illustrated in Table 1 and Table 2 (see Appendices 7 and 8 for more details). The two methods did not provide the exact onset dates, with the CT method giving much earlier transitions than the SA approach. Thus, there are differences within countries ranging from 8 to 29 years. This variance can be attributed to differences in the methodology used by the two approaches. Indeed, the CT method, which is based on the rate of change of the Ig index, can generate misleading conclusions regarding the precise moment of fertility decline, especially for countries already at a low fertility level: the case of Lebanon. While the second method of SA, which is based on the value of the TFR, rather marks the moment of deliberate birth control, albeit with a slow pace of transition. However, the clustering by start-up phase does not change with a few exceptions.

The CT method identifies Bahrain, UAE, Morocco, Kuwait, Tunisia, and Lebanon as pioneer countries whose transition took place between 1965–1970 and 1975–1980. The early majority is reached with Egypt, Qatar, Palestine, Algeria, Jordan, and Libya, whose transition occurred in the early 1980s. Syria, Saudi Arabia, Iraq, and Oman constitute the late majority. Finally, Mauritania and Yemen, the late group, complete the table.

According to the SA method, the group of pioneer countries is made up of the same group as the CT method, in addition to Qatar, whose fertility decline occurred during the 1980s, except for Lebanon, where the transition was earlier, in 1974. An early majority occurred during the 1990s with Algeria, Egypt, Libya, Syria, Jordan, Saudi Arabia, and Oman. Iraq, Palestine, and Yemen constitute the late majority, whose transition took place in 2005–2015, while Mauritania is the last transiting country.

Table 1: Dates of Onset of Marital Fertility Decline Estimated by Country, CT Method

Countries	Date of decline (CT)	dt (Knox)	Classification
Bahrain	1969	1965–1970	**Pioneers/Precursors**
United Arab Emirates	1970	1970–1975	
Morocco	1970	1970–1975	
Kuwait	1972	1970–1975	
Tunisia	1973	1970–1975	
Lebanon	1977	1975–1980	
Egypt	1980	1980–1985	**Early majority**
Qatar	1980	1980–1985	
Palestine	1981	1980–1985	
Algeria	1982	1980–1985	
Jordan	1983	1980–1985	
Libya	1984	1980–1985	
Syria	1985	1985–1990	**Late majority**
Saudi Arabia	1986	1985–1990	
Iraq	1987	1985–1990	
Oman	1989	1985–1990	
Mauritania	1990	1990–1995	**Laggards**
Yemen	1995	1995–2000	

Table 2: Dates of Onset of Marital Fertility Decline Estimated by Country, SA Method

Countries	Date of decline (SA)	dt (Knox)	Classification
Lebanon	1974	1970–1975	**Pioneers/Precursors**
Bahrain	1983	1980–1985	
Kuwait	1984	1980–1985	
Tunisia	1984	1980–1985	
Morocco	1987	1985–1990	

Countries	Date of decline (SA)	dt (Knox)	Classification
Qatar	1987	1985–1990	
United Arab Emirates	1989	1985–1990	
Algeria	1990	1990–1995	
Egypt	1990	1990–1995	
Libya	1991	1990–1995	
Syria	1995	1995–2000	**Early majority**
Jordan	1996	1995–2000	
Saudi Arabia	1997	1995–2000	
Oman	1997	1995–2000	
Iraq	2005	2005–2010	
Palestine	2008	2005–2010	**Late majority**
Yemen	2011	2010–2015	
Mauritania	2019	2015–2020	**Laggard**

Testing the diffusion of innovation theory

Table 3 and Table 4 provide the results of the Knox statistic after 1,000 Monte Carlo simulations (Mantel, 1967) for the two temporal proximities of CT and SA, respectively.

Table 3: Knox Statistic for the Fertility Transition for the Pairs of Countries (I,j), CT Method

Close in Time	Close in Space	
	Yes (s_{ij}=1)	No (s_{ij}=0)
Yes (t_{ij} = 1)	9	18
No (t_{ij} = 0)	36	90
p-value = 0.3796		

Table 4: Knox Statistic for the Fertility Transition for the Pairs of Countries (i,j), SA Method

Close in Time	Close in Space	
	Yes (s_{ij}=1)	No (s_{ij}=0)
Yes (t_{ij} = 1)	8	8
No (t_{ij} = 0)	37	100
p-value = 0.0549		

The results obtained by the CT method (Table 3) indicate that the MENA transit countries are randomly distributed, and a spatiotemporal contagion process was not established. Thus, according to this method, the hypothesis of the presence of simultaneity of spatiotemporal proximities is rejected with a *p* value higher than 5% (*p*-value = 0.380).

However, with the results of the second method (Table 4), the fertility transition in the Arab countries of the MENA region can be considered as the result of a spatiotemporal diffusion process at the 6% level (*p*-value = 0.054).

On the whole, these results indicated either a contagious process of fertility decline in the Arab countries of the MENA region if we refer to the method of Schmertmann et al. (2010) or that a priori deliberate birth control occurred according to a process rather than endogenous to each country, in the framework of a social (elites or privileged classes) or vertical (institutional) diffusion if we adopt the Coale and Treadway (1986) approach. However, it should be considered that there are methodological differences between the two methods used, where the CT method provides dates based on the rate of change of the Ig index, which thus reflects the pace of contraceptive adoption. In contrast, the second method makes it possible to date the decline in fertility independently of the transition rate.

Nonetheless, it can be seen that there is a certain degree of synchrony between countries which may indicate a common ground of factors if we analyze the situation in the vicinity of the start of the transition.

Proximate determinants and favorable contexts for the onset of the fertility transition

We analyzed the situation of different countries that emerged from the SA method in the start-up period by limiting it to critical proximate determinants and contextual variables such as education, religion, and women's economic participation.

The first significant finding was that despite highly variable infant and child mortality rates (ICMR) in the region in 1950–1955 (between 80% in Lebanon and 417% in Yemen), there was a fairly significant decline that preceded the drop in fertility for all countries (Appendix 3). However, there is marked heterogeneity across countries regarding determinants regarding their level and concomitance.

In the group of precursors, there is the exception of Lebanon which stands out in all dimensions: lowest ICMR in the region from the early 1950s with 94%, the higher average age at marriage (23.2 years for women and 28.5 years for men in 1970) and a modern contraceptive prevalence which rises to 26% in the period 1970–1975. In Bahrain and Kuwait, marriage was early (20.2 years registered for women in Bahrain in 1971 and 19.5 years in Kuwait in 1970). Still, both countries showed a significant decline in infant and child mortality of 15% and 20%, respectively, between 1950–1955 and 1955–1960 and a high contraceptive prevalence (19.8% and 20.2%, respectively, in 1970).

In Tunisia, child mortality was very high in the 1950s (300% in 1950–1955 and 286% in 1955–1960) but declined significantly to 77% in 1980–1985. Moreover, the decline in marital fertility was preceded in particular by an increase in the age at marriage of women from 23.3 years in 1975 to 24.3 years in 1984 and a higher modern contraceptive practice (33% in the period 1980–1985), similarly for Morocco, which had average levels for all indicators that seem to have acted simultaneously. Thus, women's average age at marriage rose from 17.3 years in 1960 to 22.2 years in 1982, and modern contraceptive prevalence is continuously increasing (from 12.4% to 29.4% between 1970–1975 and 1985–1990).

In the UAE and Qatar, it was the significant reduction in the ICMR that played a critical role in the fertility transition (17.4% in the UAE and 17.1% in Qatar compared for examples of Morocco (7.7%) and Tunisia (5.3%) between the two periods 1950–1955 and 1955–1960).

In the early majority group, the ICMR continued its earlier decline, the variations between 1950–1955 and 1985–1990 being 74.3% in Algeria, 73.6% in Egypt, 85.5% in Libya, and 80.4% in Syria, 83.1% in Jordan, 81.7% in Saudi Arabia, and 84.1% in Oman. The age at marriage of women was 22.2 years in Algeria in 1985, 22.1 years in Egypt in 1988, 23 years in Libya in 1984, 21.5 years in Syria in 1981, 21.7 years in Saudi Arabia, 24 years in Jordan in 1990, while Oman recorded an earlier average age at marriage of women compared to the other countries with 20.7 years in 1993. Modern contraception was also present (35.1% in Algeria, 34.4% in Egypt, 19.5% in Libya, and 25.4% in Syria in 1985–1990, and 30.7% in Jordan, 20.7% in Saudi Arabia, and 14.3% in Oman in 1990–1995).

Again, there was a significant accumulation of ICMR decline for the late majority countries: 86.9% in Iraq, 86.6% in Palestine, and 80.4% in Yemen between 1950–1955 and 2000–2005. The fertility adjustment concerning the decline in child mortality was later than that of the precursor countries and the early majority. The modern contraceptive practice was more decisive in Palestine, which recorded 32.5% in 1995–2000, than in Iraq (23.8%) and especially Yemen, whose modern contraceptive prevalence was still negligible (10.2%).

The age of marriage for women has progressed well in Iraq, reaching 25.3 years for women in 2000, while it is still early in Palestine (21.7 years in 2004) and Yemen (22.6 years in 2006) compared to other Arab countries in the MENA region.

Mauritania, the lagging country, had, until 2005–2010, the highest ICMR in the region (105%) and is currently at 71%. The average age at marriage increased slightly from 19.7 years in 1977 to 21.8 years in 2000, while contraceptive practice was negligible, increasing from 0.1% to 9% between 1970–1975 and 2015–2020.

The duration of breastfeeding or abortion may also have contributed to initiating the fertility decline. Breastfeeding, for example, was widely practiced (more than 9 out of 10 women in 1977 for Syria, in 1976 for Jordan, and 1980 for Egypt) but for varying durations (7.2 months, 11.2 months, and 17 months, respectively).

With regard to contextual factors, the analysis of fertility by social groups implies an impetus provided by an educated and urban elite and certain religious confessions. For example, the prominent Egyptian cities, Cairo and Alexandria, had a lower TFR than the national level (5.9 vs. 6.7 in 1960, respectively) (Fargues, 1986). This is also the case in Syria and Jordan, where the fertility of urban women was lower than that of rural women (4.7 vs. 9 and 6.3 vs. 9.5, respectively, in the early 1980s). Muslim women had higher fertility in Lebanese cities and Jordan than Christian women. Whether in Jordan, Syria, or Yemen, educated women were less fertile than their illiterate peers (4.9 vs. 9.3, 4.1 vs. 8.8, and 5.4 vs. 8.6, respectively, in the early 1980s). The same is true for women whose husbands were teachers compared to farmers' wives (in the early 1980s, the TFR was 7.9 vs. 9.4 in Syria and 6.9 vs. 9.2 in Jordan, and 7.3 vs. 7.8 in Yemen) (Ashurst et al., 1984).

The contexts prevailing at the onset of fertility decline for some pioneer or early majority countries during the 1970s and 1980s indicate some relevant similarities in one or other indicators that are worth highlighting (Ashurst et al., 1984; Chamie & Weller, 1983; United Nations, 2018). In Lebanon and Tunisia, more than half of the population was urban (60%), and more women participated in the economy, where the activity rate was 12.2% in Lebanon in 1970 and 19.5% in Tunisia in 1975. In Morocco and Algeria, which were also relatively urbanized (43% in 1982 and 51% in 1987, respectively), female illiteracy was widespread (over 90%), while the economic activity rate was very high in Morocco (12.6% in 1971) compared to other countries (3.7% in Algeria in 1977, 6.4% in Egypt in 1976, 6.2% in Bahrain in 1971, and 6.9% in Saudi Arabia). On the other hand, more women were literate in Egypt, Libya, Palestine and Bahrain, Kuwait, and Iraq, which are highly urbanized regions.

Discussion and conclusions

Including Lebanon, which appears to be a distinctive country with the lowest birth and death rates in the MENA region well before 1950—and the exceptionally high fertility rates of Arab couples around the middle of the last century had all the indications of a natural fertility regime. Dating the onset of the decline in marital fertility, which generally indicates the introduction of contraception as a means of deliberate birth control, allows us to distinguish four groups: the pioneers including Lebanon, Bahrain, Kuwait, Tunisia, Morocco, Qatar, and the UAE; the early majority including Algeria, Egypt, Libya, Syria, Jordan, Saudi Arabia, and Oman; the late majority with Iraq, Palestine, and Yemen; and one laggard (Mauritania). This transition was achieved over more than a quarter of a century.

When fertility started to decline in all less developed countries, mortality had already reached relatively low levels (Chesnais, 1986). The MENA region is not excluded from this rule, albeit with some nuances. Indeed, everything indicated that there was first an adjustment in the sense of Carlsson (1966) of general fertility to the increase in infant and child survival. Moreover, the decline in marital fertility was preceded by a more or less significant drop in the age at marriage, as is the case everywhere else when a population with universal natural fertility and early marriage transits to birth control fertility (Coale, 1992).

Furthermore, the test of the diffusion theory according to the Schmertmann et al. (2010) approach was significant at the 6% level, which indicated that birth control occurred through a process of spatial and temporal contagion. However, using the Coale and Treadway (1986) method, this diffusion process was not established between the Arab countries of the MENA region. This is the case in India (Balabdaoui et al., 2001; Bocquet-Appel et al., 2002).

The absence of contagion may have several explanations. The lack of data before 1950 does not allow sufficient hindsight to accurately determine the high ceiling of mortality and births, and their characteristics, primarily since the CT method is based on the rate of change of the Ig index, which is much more reflective of the pace of contraceptive adoption.

Moreover, in addition to the differences in the two approaches used, the notion of geographical proximity on which Knox's method is based is somewhat arbitrary and requires a more homogeneous context. The Arab countries of the MENA region, relatively homogeneous in cultural and religious terms, are very heterogeneous in terms of demographic weight, population density, and also socially and economically (Tabutin & Schoumaker, 2005). If the region constitutes a geographical continuum, it remains a vast expanse. Furthermore, demographic changes occur over long periods even when contagion is observed. Therefore, the spatiotemporal interaction in demographic events is only evidence if it is not explained by the spatiotemporal patterns of other relevant variables (Schmertmann et al., 2010).

However, suppose we do not accept the hypothesis of a spatiotemporal diffusion. In that case, we can then argue that the assumption of an 'intrinsic' diffusion in each country seems more relevant to explain the introduction of contraception as a means of birth control by couples. This process would have taken place according to a social diffusion initiated by the elites (Klüsener et al., 2019) and vertical or intentional, initiated or at least supported by the institutions of the public and private health sectors (Retherford & Palmore, 1983). Based on the available data, fertility decline was initiated among educated couples, socially privileged professions, and some religions and urban residents before spreading to other socio-professional classes and rural areas. The awareness of the Arab States of the negative impact of uncontrolled population growth from 1960, which was reflected in anti-natalist policies, supported this momentum.

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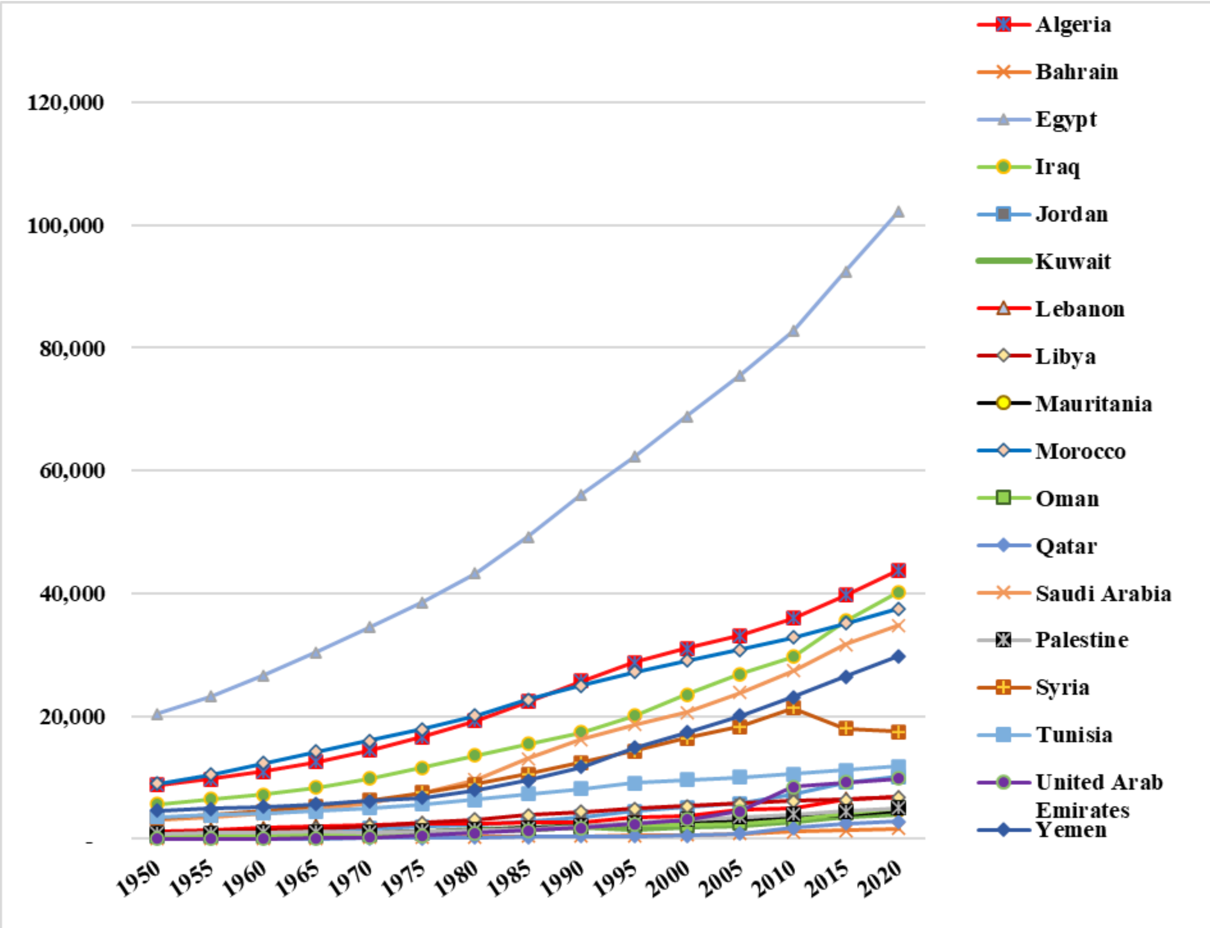
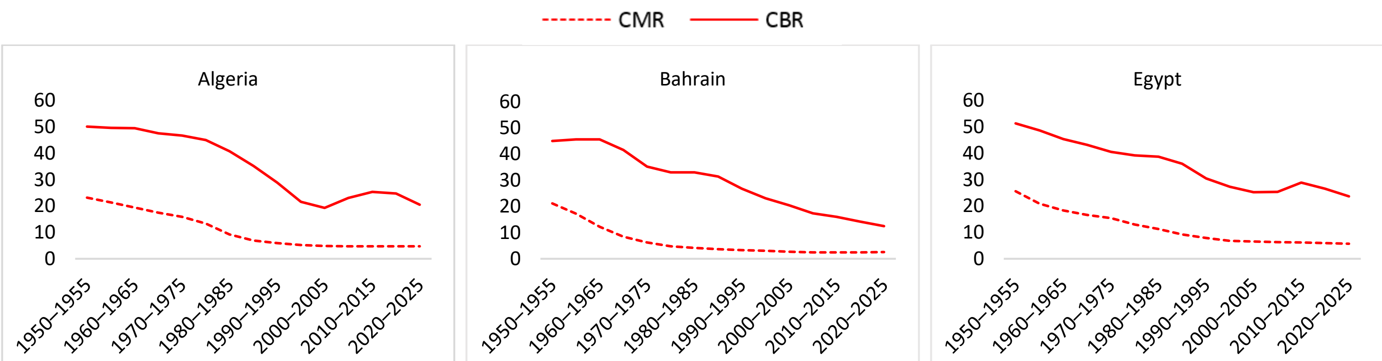
Appendix

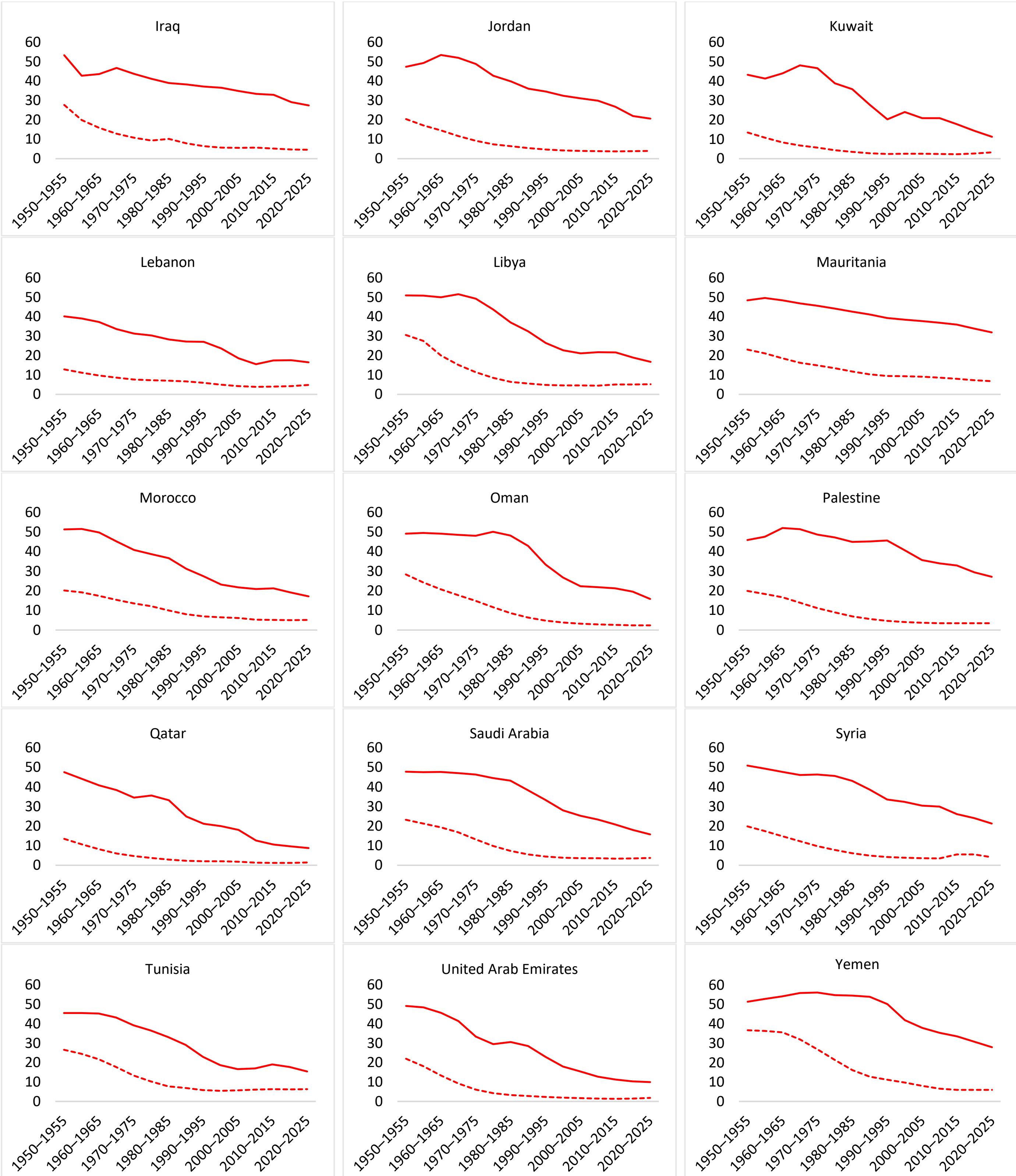
Appendix 1: Total Population of Arab Countries in the MENA Region Between 1950 and 2020



Note: Developed by the authors

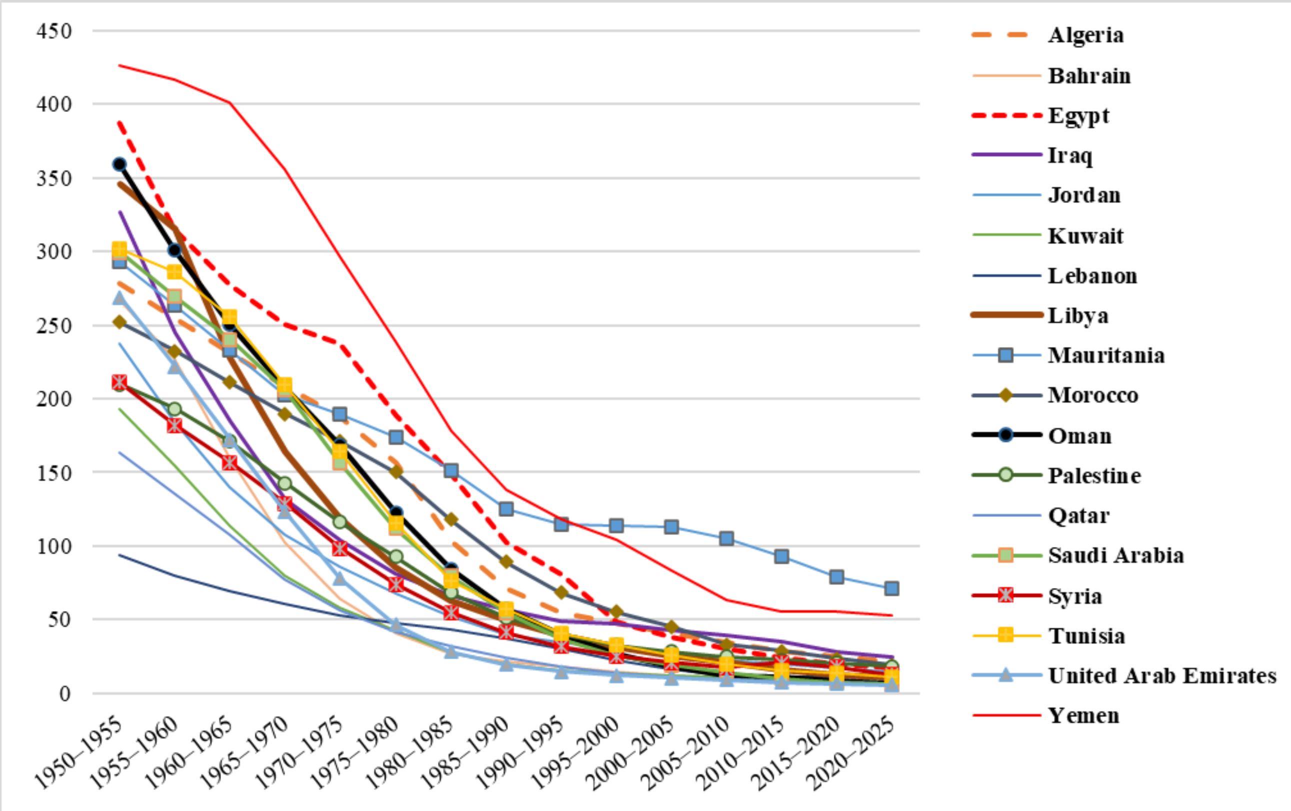
Appendix 2: Evolution of Crude Mortality Rate (CMR) and Crude Birth Rate (CBR) in the Arab Countries of the MENA Region Between 1950–1955 and 2020–2025





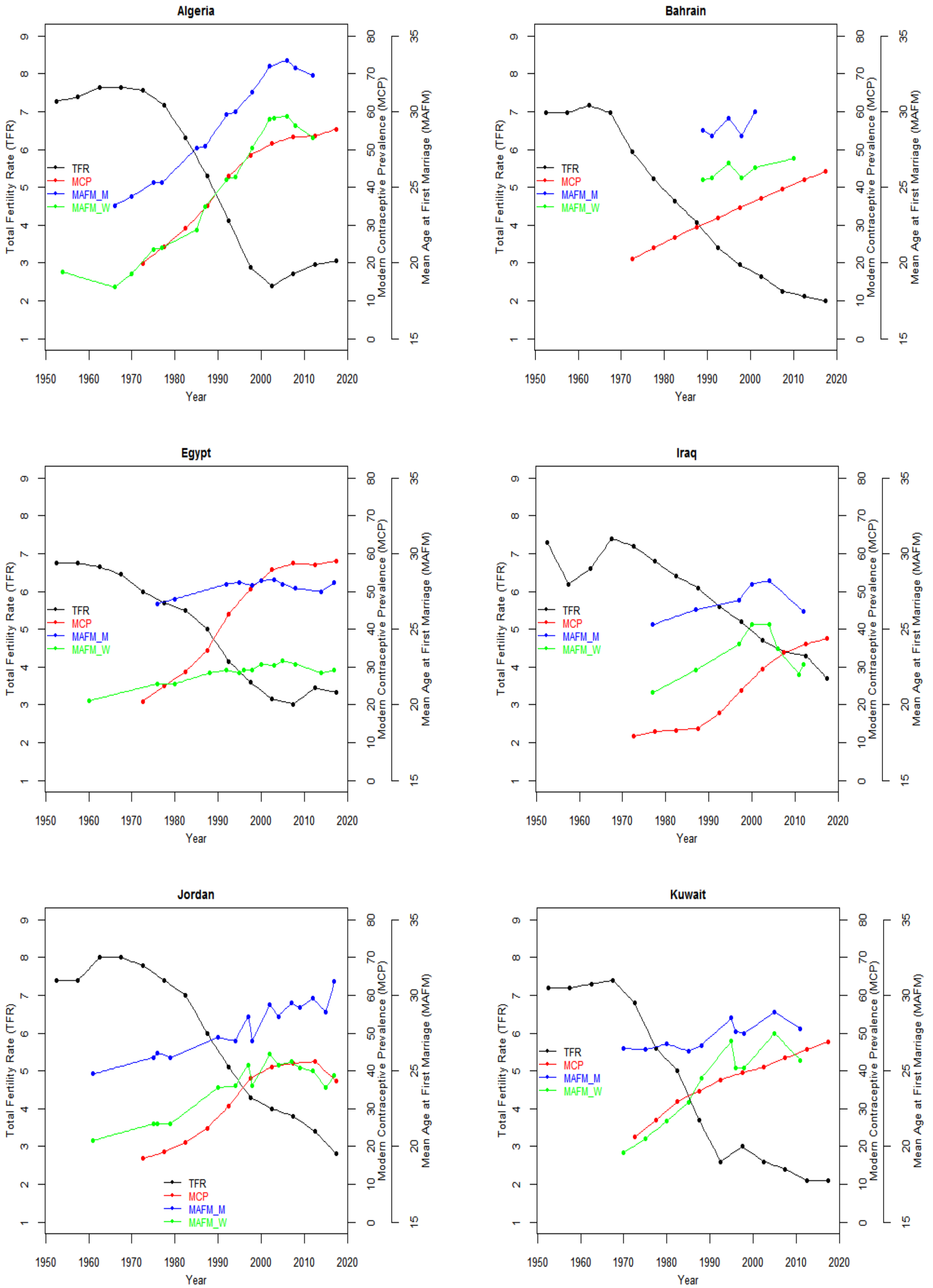
Note: Developed by the authors

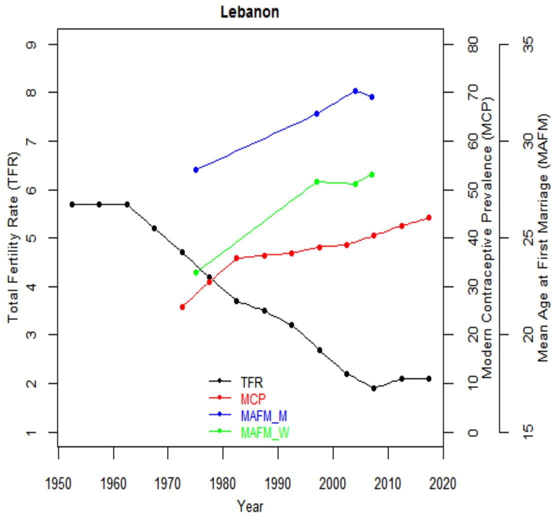
Appendix 3: Evolution of Infant and Child Mortality (%) in the Arab Countries of the MENA Region, 1950–2020

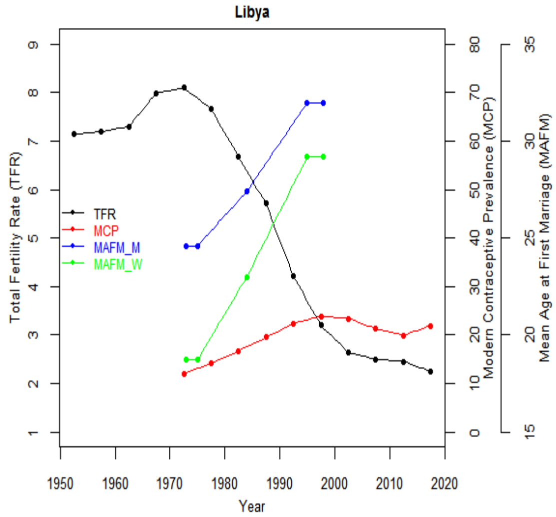


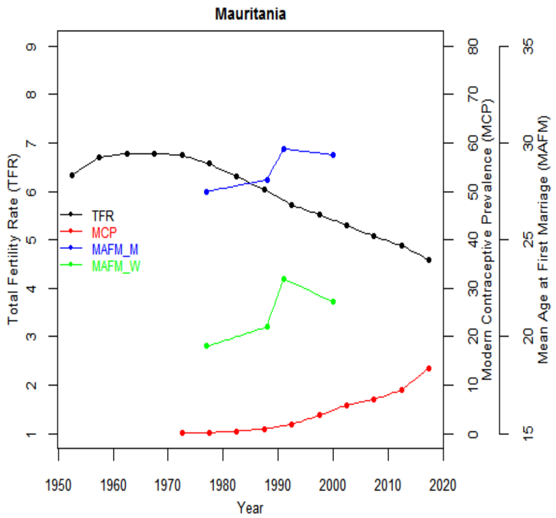
Note: Developed by the authors

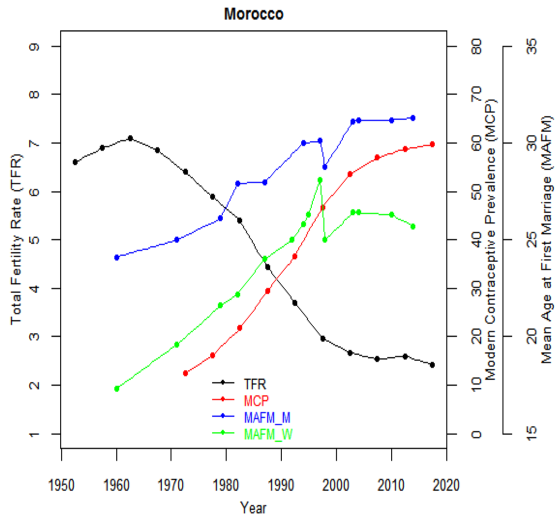
Appendix 4: Evolution of Total Fertility Rate (TFR), Mean Age at First Marriage (MAFM), and Modern Contraceptive Prevalence (MCP) in MENA Arab Countries, 1950–2020

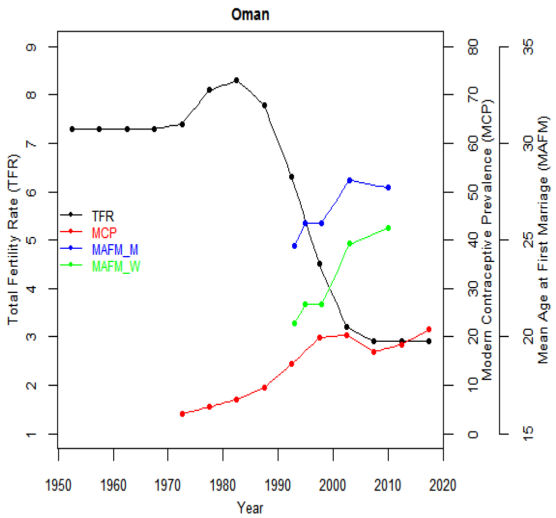


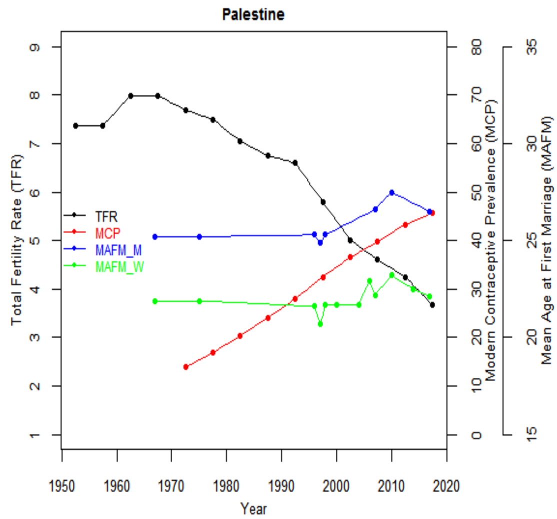

Lebanon
Total Fertility Rate (TFR)
Modern Contraceptive Prevalence (MCP)
Mean Age at First Marriage (MAFM)
Year
TFR
MCP
MAFM_M
MAFM_W

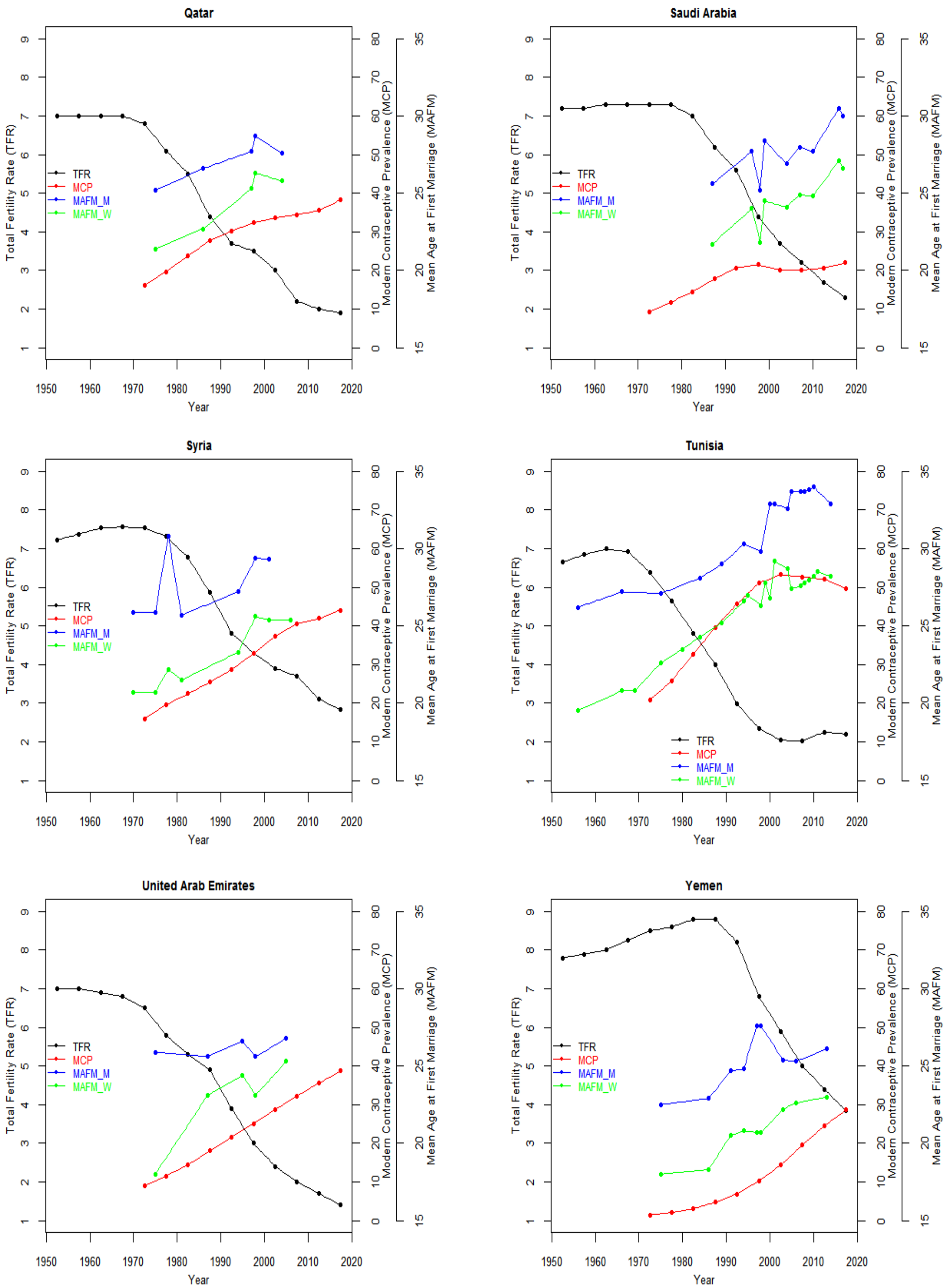

Libya
Total Fertility Rate (TFR)
Modern Contraceptive Prevalence (MCP)
Mean Age at First Marriage (MAFM)
Year
TFR
MCP
MAFM_M
MAFM_W


Mauritania
Total Fertility Rate (TFR)
Modern Contraceptive Prevalence (MCP)
Mean Age at First Marriage (MAFM)
Year
TFR
MCP
MAFM_M
MAFM_W


Morocco
Total Fertility Rate (TFR)
Modern Contraceptive Prevalence (MCP)
Mean Age at First Marriage (MAFM)
Year
TFR
MCP
MAFM_M
MAFM_W


Oman
Total Fertility Rate (TFR)
Modern Contraceptive Prevalence (MCP)
Mean Age at First Marriage (MAFM)
Year
TFR
MCP
MAFM_M
MAFM_W


Palestine
Total Fertility Rate (TFR)
Modern Contraceptive Prevalence (MCP)
Mean Age at First Marriage (MAFM)
Year
TFR
MCP
MAFM_M
MAFM_W



Note: Developed by the authors

Appendix 5: Results of the Panel Model

	β parameter	Standard error	z-value	Pr(>|z|)
(Constant)	0.1430741	0.0106817	13.394	< 2.2e-16 ***
TFR	0.0961764	0.0016296	59.017	< 2.2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Total Sum of Squares: 4.6873
Residual Sum of Squares: 0.2279
R-Squared: 0.95138
Adj. R-Squared: 0.95111
Chisq: 3482.96 on 1 DF, *p*-value: < 2.22e-16

Note: Authors' calculations using R software

The equation that results is as follows:

$$Ig_{predicted} = 0{,}1430741 + 0{,}0961764 * TFR$$

Appendix 6: Calculated Values of the Coale Ig Index for Arab Countries in the MENA Region, 1950–2020

Countries	1950–1955	1955–1960	1960–1965	1965–1970	1970–1975	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000	2000–2005	2005–2010	2010–2015	2015–2020	2020–2025
Algeria	0.8	0.9	0.9	0.9	0.9	0.8	0.8	0.7	0.6	0.5	0.5	0.5	0.5	0.5	0.5
Bahrain	0.8	0.8	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
Egypt	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4
Iraq	0.8	0.7	0.8	0.9	0.8	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.4
Jordan	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.6	0.6	0.5	0.4	0.4
Kuwait	0.8	0.8	0.8	0.9	0.8	0.7	0.6	0.5	0.4	0.5	0.4	0.4	0.3	0.3	0.3
Lebanon	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.4	0.4	0.4	0.4	0.4
Libya	0.8	0.8	0.8	0.9	1.1	1.0	0.8	0.7	0.5	0.4	0.3	0.3	0.3	0.3	0.3
Mauritania	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6
Morocco	0.8	0.8	0.8	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3
Oman	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.8	0.7	0.5	0.4	0.4	0.4	0.5	0.4
Palestine	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.7	0.6	0.6	0.5	0.5	0.4
Qatar	0.8	0.8	0.8	0.8	0.9	0.8	0.7	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3
Saudi Arabia	0.8	0.8	0.8	0.8	0.9	0.9	0.8	0.7	0.7	0.5	0.5	0.4	0.4	0.3	0.3
Syria	0.8	0.9	0.9	0.9	0.9	0.9	0.8	0.7	0.6	0.6	0.6	0.5	0.4	0.4	0.4
Tunisia	0.8	0.8	0.8	0.8	0.7	0.7	0.6	0.6	0.4	0.4	0.3	0.4	0.4	0.4	0.4
United Arab Emirates	0.8	0.8	0.8	0.8	0.7	0.6	0.6	0.6	0.5	0.4	0.4	0.3	0.2	0.2	0.2
Yemen	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.4

Appendix 7: Rate of Change of the Ig Index (%), Dating of Fertility Decline by the CT Method

Countries	1965–1970	1970–1975	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000	2000–2005	2005–2010	2010–2015	2015–2020	2020–2025	Year of decline *
Algeria	0.0	1.9	6.5	10.0	17.7	28.8	43.3	47.0	42.8	41.1	42.1	48.6	1982
Bahrain	2.3	20.3	25.7	32.7	36.1	43.2	48.6	49.6	54.7	54.7	54.1	54.7	1969
Egypt	2.5	4.8	8.3	11.2	19.7	32.8	40.9	48.2	51.6	46.6	50.6	54.6	1980
Iraq	-9.9	-3.1	4.0	8.0	9.8	13.6	17.1	21.5	23.4	27.7	39.8	44.7	1987
Jordan	0.0	9.6	8.7	9.2	16.4	25.9	34.9	36.1	38.4	45.4	55.5	57.9	1983
Kuwait	-1.1	10.1	20.4	25.4	44.1	57.5	45.4	48.7	52.4	65.0	68.4	69.4	1972
Lebanon	7.0	6.9	10.2	14.2	14.2	19.6	32.7	41.3	45.9	39.1	39.3	41.8	1977
Libya	-7.9	-24.3	-15.5	1.8	18.6	39.9	54.1	61.4	62.7	62.5	64.7	66.2	1984
Mauritania	0.0	-2.1	0.8	4.3	7.5	11.6	13.7	15.8	18.8	21.1	25.2	28.3	1990
Morocco	2.9	14.7	16.8	21.6	33.6	41.5	49.1	50.6	53.2	53.7	58.5	61.5	1970
Oman	0.0	6.4	-3.2	-5.0	1.0	19.8	36.8	51.0	50.8	47.1	45.4	50.6	1989
Palestine	0.0	2.2	5.4	10.9	12.9	12.9	23.8	33.6	37.4	41.0	48.7	52.8	1981
Qatar	0.0	-10.4	-0.7	15.9	35.4	45.2	46.8	49.5	59.6	64.3	66.6	67.9	1980
Saudi Arabia	0.0	-3.2	-3.3	0.8	13.8	21.4	36.0	45.2	50.2	56.6	60.1	60.6	1986
Syria	-0.2	1.4	0.3	4.3	13.8	25.7	29.2	32.5	38.2	48.8	51.5	57.8	1985
Tunisia	0.8	8.2	14.6	22.1	31.9	46.6	56.0	59.7	57.0	48.9	48.5	51.0	1973
United Arab Emirates	1.2	17.6	26.0	28.1	28.9	37.3	50.1	56.2	64.6	71.9	76.0	76.3	1970
Yemen	-2.6	1.7	-0.5	-3.0	-4.2	1.5	13.9	22.1	31.3	39.1	46.2	50.9	1995

*Note: * The year of decline is calculated by linear interpolation to exactly specify the transition to the threshold defined by the CT method. i.e., a 10% drop in Ig after the pre-transitional period.*

Appendix 8: Total Fertility Rate, Dating the Fertility Decline by the SA Method

Countries	1950–1955	1955–1960	1960–1965	1965–1970	1970–1975	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000	2000–2005	2005–2010	2010–2015	2015–2020	2020–2025	Year of decline*
Algeria	7.28	7.38	7.65	7.65	7.57	7.18	6.32	5.30	4.12	2.89	2.38	2.72	2.96	3.05	2.79	1990
Bahrain	6.97	6.97	7.17	6.97	5.95	5.23	4.63	4.08	3.40	2.95	2.65	2.25	2.12	2.00	1.89	1983
Egypt	6.75	6.75	6.65	6.45	6.00	5.70	5.49	5.00	4.15	3.60	3.15	3.02	3.45	3.33	3.13	1990
Iraq	7.30	6.20	6.60	7.40	7.15	6.80	6.35	6.09	5.65	5.19	4.71	4.40	4.25	3.68	3.45	2005
Jordan	7.38	7.38	8.00	8.00	7.79	7.38	7.05	6.02	5.06	4.30	4.00	3.80	3.40	2.77	2.58	1996
Kuwait	7.20	7.20	7.30	7.40	6.75	5.60	5.00	3.65	2.55	3.00	2.60	2.40	2.10	2.10	2.03	1984
Lebanon	5.74	5.72	5.69	5.23	4.67	4.23	3.75	3.50	3.20	2.65	2.20	1.90	2.08	2.09	2.02	1974
Libya	7.14	7.20	7.30	7.99	8.10	7.67	6.68	5.71	4.22	3.20	2.64	2.50	2.45	2.25	2.11	1991
Mauritania	6.34	6.71	6.79	6.79	6.75	6.57	6.30	6.05	5.72	5.52	5.30	5.07	4.88	4.59	4.32	2019
Morocco	6.61	6.90	7.10	6.85	6.40	5.90	5.40	4.43	3.70	2.97	2.67	2.53	2.60	2.42	2.30	1987
Oman	7.25	7.25	7.25	7.31	7.41	8.10	8.32	7.85	6.27	4.46	3.20	2.90	2.90	2.93	2.60	1997
Palestine	7.38	7.38	8.00	8.00	7.69	7.50	7.05	6.76	6.60	5.81	5.02	4.60	4.25	3.67	3.36	2008
Qatar	6.97	6.97	6.97	6.97	6.75	6.10	5.45	4.40	3.74	3.46	2.95	2.23	2.00	1.88	1.78	1987
Saudi Arabia	7.18	7.18	7.26	7.26	7.30	7.28	7.02	6.22	5.55	4.40	3.65	3.23	2.73	2.34	2.17	1997
Syria	7.23	7.38	7.54	7.56	7.54	7.32	6.77	5.87	4.80	4.30	3.90	3.70	3.10	2.84	2.64	1995
Tunisia	6.65	6.85	6.99	6.92	6.39	5.65	4.82	4.00	2.98	2.34	2.04	2.02	2.25	2.20	2.10	1984
United Arab Emirates	6.97	6.97	6.87	6.77	6.45	5.75	5.30	4.90	3.93	2.97	2.40	1.97	1.70	1.42	1.35	1989
Yemen	7.80	7.90	8.00	8.25	8.50	8.60	8.80	8.80	8.20	6.80	5.90	5.00	4.40	3.84	3.43	2011

*Note: * The year of decline is calculated by linear interpolation to exactly specify the transition at the 4.5 children per woman threshold.*