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Article

A statistical assessment of healthcare and fertility rates in Saudi Arabia for 2022

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Abstract: An exhaustive analysis and evaluation of fertility indicators in a society including many ethnic groups might provide valuable insights into any discrepancies. This study aims to systematically analyse the fertility rates over specific periods and investigate the differences in levels and patterns between local and expatriate women in Saudi Arabia using the existing data. This analysis used data from credible sources published by the General Authority for Statistics in the Saudi census 2022. The calculation of period fertility indicators started with the most straightforward rates and advanced to more complex ones, followed by a comprehensive description of the advantages and disadvantages of each. The aim was to ascertain fluctuations in fertility rates and analyse temporal patterns. Multiple studies consistently show that the fertility rate among expats in Saudi Arabia is lower than that among Saudi native women. However, the reason for this discrepancy still needs to be discovered since the definitive effect of contraceptive techniques has yet to be confirmed. Moreover, the reproductive trends that have occurred since the early 1980s will persist, although with additional precautions in place.

Keywords: period fertility; fertility shift; fertility indicators; Household Health Survey; Saudi Arabia

1. Introduction and related work

In demography, the term ‘fertility’ refers to the total number of live births a woman has over her whole life (Burch, 2017). This process, particularly in Muslim nations, involves the establishment of matrimony. Fertility and fecundability are distinct concepts. Fecundability refers to a woman’s biological ability to conceive children, whereas fertility encompasses the ability to reproduce successfully. A woman may be physiologically capable of producing children (fecundable), but she may not be fertile and unable to conceive (Thomas, 2018). Therefore, it is of utmost importance to accurately estimate the duration of fertility for a given population, possibly up to two decimal places, before delving into the analysis of its determining factors (Carmichael, 2016). In Saudi Arabia, a variety of fertility indicators are available, each using distinct approaches and exhibiting varied levels of accuracy (Khraif, 2001). This work aims to comprehensively and precisely assess period fertility rates, with measurements provided to two decimal places.

Furthermore, we aim to elucidate the conceptual significance of these rates in an academically rigorous manner. This applies to both Saudi women living in the country and female residents who are not Saudi nationals, considering the rate at which fertility occurs during a specific period. The analysis not only examines the historical trend of

fertility rates over time but also delves into the differences in family planning practices between the two demographic groups, providing a comprehensive understanding of the subject.

The significance of fertility may be summarized as follows: It is widely regarded as a crucial factor in population increase and aids in comprehending population dynamics and formulating and assessing policies about population growth. Examining fertility patterns is a valuable method for forecasting future outcomes and aiding in formulating strategies and initiatives for healthcare and education (Mahgoub, 2022).

Fertility and fecundability are distinct concepts. Fertility refers to a woman's biological ability to conceive and bear children, whereas fecundability refers explicitly to a woman's capability to get pregnant despite being physiologically capable of reproduction. In other words, fecundability denotes the fertility potential but not always the actual capacity to conceive (Burch, 2003). Based on historical data, the average maximum number of children per woman is about 17 births when no fertility control measures are used. Nevertheless, there has yet to be a documented instance of any population reaching this level, and the highest recorded number of children has never exceeded 15 or fallen below 0.83. Therefore, accurately measuring the fertility rate over a certain period is paramount for any community.

Demographers make a conceptual distinction between a ratio and a rate. Newell (1990) states that a ratio results from dividing one integer by another. The dependence ratio is calculated by dividing the combined number of young and elderly individuals by the working population and multiplying the result by 100. A rate, however, is similar to how a particular event takes place within a specific time frame, requiring the measurement of exposure years to the influences of that event. Understanding the concept of a period rate requires a certain level of imagination since it is a synthetic rather than a tangible measure. As we will discuss later in this article, the total fertility rate is a conceptual measure of the reproductive behaviour of a group of women. It represents the number of children they would have during their lifetime if they lived and adhered to the same patterns of childbearing as seen historically (Shryock and Seigel, 1980).

A term widely used by demographers is the notion of 'person-years', which exhibits even more creativity. As women progress through life and give birth, a portion of them unfortunately die during the process. Since these women contribute to fertility at different ages, it is necessary to consider their specific years of survival within their age group. This is where the concept of 'person-years' comes into play, as it allows demographers to account for the contribution of these women to fertility at different ages. For a more comprehensive understanding of the 'person-years' notion, refer to Smith's (2013) publication.

The growth reproduction rate (GRR) and net reproduction rate (NNR) are additional composite indicators that exhibit more creativity than total fertility. These two indicators indicate the concept known as "reproductivity" in demography. This word pertains to substitution when considering only female births rather than all births. Two crucial concepts associated with these metrics are the average age of fertility distribution and the average age of childbirth, which are distinct.

An often-used notion is that of fecundability. This idea pertains to the physiological capacity to get pregnant, explicitly referring to the statistical likelihood

of being pregnant during a menstrual cycle. The concept of fecundability is essential in the statistical modelling of the family-building process and in estimating the success of family planning programs (Newell, 1986).

A population that does not intentionally restrict the number of births is referred to as having "natural fertility." The topic in question, which has significant importance and is extensively used, was first recognized and designated by Louis Henry in 1972. The measure of fertility serves as a biological indication, and societal norms about family planning, nursing, and weaning habits influence its extent. No behaviour restricts fertility, which is influenced by the number of children a person has previously given birth to (Bongaarts, 2002).

Various authors, including González-Manteiga et al. (2010), Benavent and Morales (2016), and Pfeffermann (2002), have suggested modifications to the Fay-Herriot model for estimating small areas at the regional level.

Ahmed et al. (2024) performed an extensive literature analysis to investigate the correlation between fluctuations in birth rates and catastrophe occurrences. The study examined 73 primary publications published from 1990 to 2022, obtained from several databases such as Web of Science, Scopus, CINAHL, PubMed, and Google Scholar. Articles were chosen from many academic fields, including Demography, Family Studies, Environmental Studies, and Geography, without considering the specific nature or location of the tragedy.

The review's key results suggest that catastrophes impact fertility rates differently. Several studies indicate that interruptions in reproductive health care and the psychological effect of child death during catastrophes may lead to higher fertility rates. In contrast, another research emphasizes a decline in fertility rates that might be attributed to socioeconomic transformations and limited availability of healthcare services in regions devastated by disasters. The analysis highlights the intricate connection between catastrophes and fertility choices, emphasizing the need for policymakers and academics to consider these subtle impacts when developing solutions. Additional study is needed to enhance comprehension and develop strategies to promote reproductive health in communities prone to disasters.

Hailemariam (2024) examines the influence of income variations on fertility rates, particularly oil price shocks. The research used empirical methodologies to analyze changes in income levels to examine the impact of oil price shocks on reproductive practices across various socioeconomic categories. The study reveals that fluctuations in oil prices have diverse impacts on fertility rates, contingent upon wealth levels. Families with higher incomes may have their fertility rates shift due to income variations caused by oil price shocks. In contrast, lower-income families tend to have more consistent fertility patterns even during economic instability.

These results emphasize the intricate correlation between economic circumstances and reproductive choices. Gaining a comprehensive understanding of these processes is essential for formulating policies that promote reproductive health and provide financial stability in the face of external economic disruptions.

Peng (2024) offers a thorough investigation into demography using three articles that analyze methodological breakthroughs and their utilization in comprehending demographic patterns. The primary article is on methodological advancements, emphasizing sophisticated statistical approaches and computer tools in demography

research. The second article examines the impact of sociocultural changes on fertility choices and family dynamics across various generations, explicitly focusing on the role of gendered generational variations in demographic behaviors. The third article examines assortative mating patterns and their impact on reproduction rates, explicitly focusing on the desire for mates with comparable social and educational backgrounds.

Together, these pieces enhance our comprehension of demographic processes, highlighting the intricate interaction between rigorous methodology and sophisticated demographic studies. The authors emphasize the significance of multidisciplinary methods in demographic research and provide valuable insights that drive policy initiatives to tackle demographic concerns and foster sustainable population increase.

Fauser et al. (2024) have published a consensus paper for the International Federation of Fertility Societies (IFFS). This document summarizes the findings of a thorough narrative study of worldwide fertility trends and the difficulties that come with them. The paper examines the consequences of decreasing global fertility rates on approaches concerning family planning and family formation, focusing on various factors such as postponed childbirth, growing urbanization, contraceptive accessibility, socioeconomic inequalities, and changing social norms. Decreased fertility rates provide:

- Notable difficulties for family planning programs.
- Requiring modifications to tackle infertility.
- Assisting assisted reproductive technologies (ARTs).
- Guaranteeing fair access to reproductive healthcare services.

The statement supports the use of evidence-based approaches such as boosting fertility awareness, enhancing the availability of fertility treatments, and addressing socioeconomic obstacles that impact reproductive choices. Policy proposals emphasize the need to create supportive conditions for family planning, allocating resources to fertility research, and implementing global policies to tackle inequalities in access to reproductive healthcare. The report closes by urging ongoing research, policy formulation, and joint endeavors to tackle the intricate difficulties presented by the decreasing birth rates in modern nations.

In their work released by Cambridge Scholars Publishing, Salam and Mini (2024) analyze the changing demographic environment of Saudi Arabia. The authors examine many aspects of demographic change in the kingdom, such as population expansion, fertility rates, urbanization, and the influence of migratory trends. They emphasize the impact of socioeconomic variables and governmental policies on the demographic changes seen in recent decades. The book highlights the importance of these developments for Saudi Arabia's future progress, highlighting the difficulties and possibilities they bring regarding the economy, society, and culture. Salam and Mini's analysis offers vital insights into the intricate nature of demographic shifts in Saudi Arabia and its consequences for policy and planning.

The Kingdom of Saudi Arabia (KSA) has seen substantial changes in fertility patterns and levels during the last century. Historically, Saudi culture has placed significant importance on having prominent families as a cultural expectation and a source of family honor. The combination of this artistic milieu, together with the restricted availability of contemporary contraception and healthcare, had a role in the

elevated birth rates seen in the early to mid-20th century. According to Alwabari et al. (2023), large families were seen as a way to guarantee financial stability and social unity. From the second part of the 20th century forward, many circumstances triggered changes in reproductive patterns. Economic modernization and the rise of urbanization led to significant transformations in both lifestyle and family arrangements. The cities of Riyadh, Jeddah, and Dammam saw fast expansion, resulting in a migration of people from rural to urban regions. Urbanization facilitated enhanced educational and healthcare opportunities, empowering women and promoting the adoption of lower family sizes. Expanding educational possibilities for women has significantly increased their ability to seek higher education and join the workforce. As a result, women are now postponing marriage and motherhood (Aldegheishem, 2023).

Furthermore, implementing government programs that advocate for family planning and provide reproductive health education has been essential in decreasing fertility rates. The Saudi government implemented healthcare facilities and initiatives focused on improving mother and child health, providing family planning services, and advocating for the use of contraceptives. The combination of these initiatives, together with growing recognition of the advantages of having fewer children for economic stability and maternal well-being, had a significant role in the consistent decrease in fertility rates from the late 20th to the early 21st century (Götmark and Andersson, 2023). There is no text provided. In recent decades, Saudi Arabia has seen a decrease in fertility rates, aligning with the worldwide shift towards demographic transition. The government actively promotes family planning and reproductive health via various measures to balance population stability and economic growth objectives.

Nevertheless, there are ongoing geographical discrepancies, as rural regions and specific demographic groups have more excellent fertility rates than urban populations (Salam, 2023). Ultimately, the historical trajectory of reproduction in Saudi Arabia demonstrates an intricate interaction between cultural customs, socio-economic progress, and governmental strategies. The decline in fertility rates from high to lower levels reflects the kingdom's ability to adjust to worldwide population trends. It emphasizes the persistent difficulties in maintaining a demographic equilibrium while pursuing socio-economic goals (Elessawy, 2023).

In this study, we systematically used the available data to analyze fertility rates during specified periods. We examined the variations in levels and patterns between Saudi Arabian women born and raised there and expatriate women.

2. Materials and methods

This study is based on secondary data from the Saudi General Authority for Statistics, referring to the Household Health Survey 2022. The following data sets used for our analysis are framed as:

- The total population of Saudi Arabia.
- Age and gender distribution of both Saudi and non-Saudi individuals.
- Fertility rates in Saudi Arabia are categorized according to age categories.
- Fertility rates throughout administrative areas in Saudi Arabia.
- Incidence of contraceptive use among women of reproductive age.

In demographic environments, fertility pertains explicitly to the tangible act of producing kids, as opposed to the biological capacity to do so, referred to as fecundity. While fertility is quantifiable, fecundity is not. Demographers use many methodologies to assess the fertility rate, categorizing them into two main types: "period" measures and "cohort" measures. "Period" measurements pertain to a population snapshot during a single year. "Cohort" data, in contrast, involves tracking the same individuals for many decades. Both period and cohort metrics are extensively used.

Temporal metrics.

The crude birth rate (CBR) is the annual number of live births per 1,000 individuals alive at the midpoint of a particular year. This indicator's inherent drawback is its susceptibility to the population's age composition.

The general fertility rate (GFR) is calculated by dividing the number of births per year by the number of women aged 15–44 and multiplying the result by 1000. It explicitly targets prospective moms and considers the distribution of ages.

The Child-Woman Ratio (CWR) is calculated by multiplying the number of children under five by 1000 and dividing it by the number of women aged 15–49. Historical data is particularly advantageous since it obviates the need for birth enumeration. This statistic is a hybrid since it encompasses both mortality and natality. (Namely, the exclusion of births is due to infant mortality, while the omission of women who gave birth results from adult mortality.)

The Coale's Index of Fertility is a specialized tool used in historical research. Measures of a group of individuals that have a same characteristic or experience

The total fertility rate (TFR) measures the average number of children a woman would have in her lifetime based on the current fertility rates for women of different ages. The Total Fertility Rate (TFR) is calculated by summing the product of each Age-Specific Fertility Rate (ASFR) and a factor of 5 for all age groups.

The Gross Reproduction Rate (GRR) refers to the number of female infants that a hypothetical group of individuals would produce. It presupposes that every infant female will reach adulthood and survive until at least the age of 50.

The Net Reproduction Rate (NRR) is a measure that considers the General Reproduction Rate (GRR) and adjusts for the realistic expectation that some women will die before age 49. This adjustment accounts for these women's inability to carry part of the potential infants included in the GRR. The Net Reproduction Rate (NRR) is consistently lower than the Gross Reproduction Rate (GRR). However, in nations with meagre mortality rates, almost all female infants reach adulthood and have the potential to become mothers. As a result, the NRR is equivalent to the GRR in such cases. In nations with elevated mortality rates, the Net Reproduction Rate (NRR) may be as little as 70% of the Gross Reproduction Rate (GRR). When the net reproduction rate (NRR) is 1.0, each cohort of 1000 infant females reaches adulthood and produces precisely 1000 female offspring. When the net reproduction rate (NRR) falls below one, each successive generation is reduced in size compared to the preceding one. When the net reproduction rate (NRR) exceeds 1, each subsequent generation is larger than the preceding one. NRR, or Net Reproduction pace, is an indicator that assesses the potential for long-term increase in a population. However, it often differs from the present pace of population growth.

The study explicitly investigates fertility rates over a certain period since there is a lack of data on fertility rates for specific birth cohorts in the Household Health Survey 2022. We aim to methodically include fertility measures over time by first using primary indications and gradually shifting to more advanced ones. In addition, we provide an overview of the different evaluation methods and analyse the pros and cons of each strategy. Moreover, we examine the disparities in rates between Saudi citizens and non-Saudi persons and investigate the influence of contraceptive usage on these disparities.

3. Result and discussion

3.1. Measures of period fertility in Saudi Arabia in 2022

3.1.1. The child/woman ratio

The following is an illustration of this ratio:

$$C/W\text{Ratio} = \frac{\text{Children age } 0-4}{\text{Women aged } 15-49} \quad (1)$$

The C/W ratios (1) are computed using the Saudi population by age group and sex data from the 2022 census, as shown in **Table 1** below.

Table 1. Child/Woman ratio.

Population	C/W
Saudi Women	0.5376
Non-Saudi Women	0.1856
Total population of women in Saudi Arabia	0.3597

Source: Saudi census, 2022.

The data indicates that the C/W ratio is superior among Saudi women to non-Saudi women. Nevertheless, the percentage for both categories remains relatively low compared to other Arab and Asian countries. The ratio's usefulness, however, is derived only from its dependence on statistics about the age and gender composition of the population. Statistical data on births is unnecessary. This particular characteristic enhances the significance of this calculation, mainly when using census data. This statistic is pretty straightforward. In general, when fertility rates are high, there will be a higher ratio of children to women; when fertility rates are low, the ratio will be lower. Nevertheless, it is crucial to acknowledge that the ratio is very vulnerable to reporting errors and the rate of infant death. Hence, it is not recommended to use the ratio as a method for comparing populations that exhibit substantial disparities in newborn and child mortality rates or in cases where there is a problem of inadequate reporting of young children.

3.1.2. The crude birth rate

This is a simple, well-known indicator that is derived from the following equation.

$$\text{CBR} = \frac{\text{Births in year}}{\text{Population at mid}-\text{year}} \times 1000 \quad (2)$$

The crude birth rates (2) are derived based on the Saudi population by age groups and gender data from the Saudi Census 2022, as shown in **Table 2** below.

Table 2. Crude birth rates

Population	CBR
Saudi Women	12.97
Non-Saudi Women	2.10
Total population of women in Saudi Arabia	15.06

Source: Saudi census, 2022.

There is a noticeable discrepancy in the outcomes for Saudi women who have citizenship in the nation and women who are expatriates. The observed range of cognitive ability, as evaluated by the Cognitive Behavioral Rating (CBR), in the human population is between 10 and 50. As a result, the fertility rate for Saudi women is somewhat higher than the global norm, while the fertility rate for non-Saudi women is lower than the worldwide average.

The measure's lack of inclusion across all age groups and genders makes it basic and unsophisticated. Comparisons lack logical consistency since there is no causal connection between births and females who are at risk. However, there are three often-cited reasons for the importance of this calculation. At first, it is easily understandable. Moreover, the data requirements and calculations must be more complete since they only need the population and birth statistics for a particular year.

Moreover, the natural growth rate may be determined by subtracting the crude death rate (CDR) from the crude birth rate (CBR). To evaluate the use of the CBR, it is necessary to analyze Saudi Arabia's position in the global fertility regimes shown in **Table 2,** as well as the suggested range for the CBR, which is a minimum of 10 and a maximum of 50. The crude birth rate (CBR) among non-Saudi women is much lower, nearing the lowest rate worldwide, while the CBR among Saudi women is closer to the highest global rate.

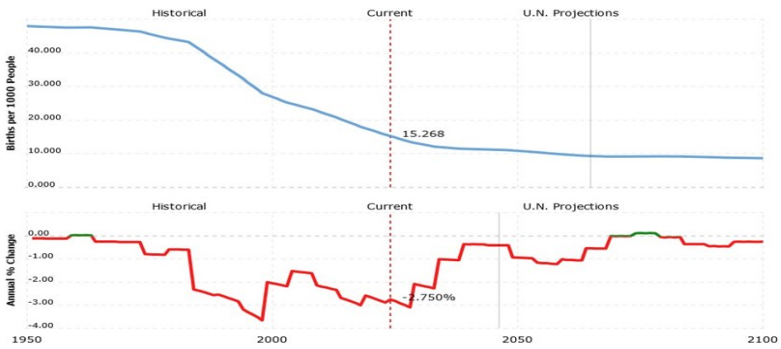

Figure 1. Saudi birthrate 1950–2024. UN estimates for 2100 are presented.
Source: United nations—World population prospects.

It is illustrated in **Figure 1** that the birth rate for Saudi Arabia in 2024 is 15.268 births per 1000 people, representing a decrease of 2.75% compared to 2023. In 2023, the birth rate for Saudi Arabia was 15.700 births per 1000 people, indicating a 2.88% decrease compared to 2022. In 2022, the birth rate in Saudi Arabia was 16.166 births per 1000 people, showing a 2.8% decrease compared to 2021. In 2021, the birth rate in Saudi Arabia was 16.631 births per 1000 people, indicating a 2.73% decrease compared to 2020.

3.1.3. Age-specific fertility rate (ASFR)

The term of ASFR is as stated below.

$$\text{ASFR} = \frac{\text{Births in year to women aged x}}{\text{Women aged x at mid} - \text{year}} \quad (3)$$

Frequently, the ASFR (age-specific fertility rate) is computed per thousand women, and rates are calculated for seven age groups, as shown in **Table 3**. However, it is also typical to calculate rates for individual years. Here, they are computed on a per-woman basis. It should be noted that there has been a significant increase in the need for data. The Household Health Survey of Saudi Arabia for 2018 provides specific fertility rates for both Saudi women and the total population of women. The lower end of the age-specific fertility rate (ASFR) range for the total population of Saudi women signifies a lower fertility rate among non-Saudi women. The age-specific fertility rates for all women, as shown by the child/woman ratio and the crude birth rate, are consistently lower at all ages compared to those of Saudi women. However, although the age-specific fertility distributions for Saudi and non-Saudi women vary in level, they exhibit comparable patterns. Both distributions have a delayed peak, suggesting that Saudi and non-Saudi women reach about 50% of their fertility by age 31, with a similar spread. Refer to **Figure 2.**

Table 3. ASFRs for the total population of women and Saudi women.

Age Groups	ASFR for Saudi Women	ASFR for Non-Saudi Women	ASFR for Total Population of Women
5–19	0.04	0.03	0.04
0–24	0.33	0.16	0.30
25–29	0.69	0.23	0.54
30–34	0.76	0.22	0.55
35–39	0.63	0.17	0.45
40–44	0.30	0.08	0.23
45–49	0.04	0.02	0.03
Total	2.80	0.90	2.14

Source: Saudi census, 2022.

According to the data shown in **Figure 2**, the age-specific fertility rate (ASFR) is lower for women in general compared to Saudi women in all age categories, except maybe for the younger age groups (15–19 and 20–24). However, it is worth noting that the two curves have very similar forms. They often exhibit consistent characteristics, namely a fast ascent to a maximum point in the early to mid-twenties and a slow decrease to deficient levels around 40. The regularities in age-specific fertility rates (ASFRs) allow for mathematical modelling.

The primary drawback of ASFRs is that they are not singular values but rather a collection of seven rates. Therefore, comparisons get very intricate. Fortunately, this issue may be resolved by condensing them using the total fertility rate.

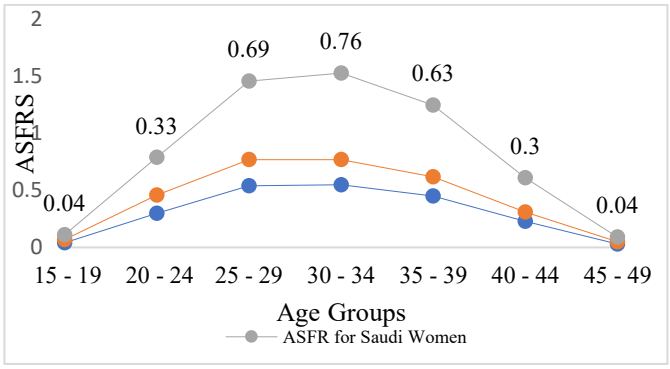

Figure 2. Comparisons of ASFRs for Saudi and non-Saudi women.
Source: Saudi census, 2022.

3.1.4. Total fertility rate (TFR)

The total period fertility rate (TPFR) is often referred to as the TFR, which is mathematically calculated by adding up the age-specific fertility rates (ASFRs). Nevertheless, there are several complexities associated with the average age range. Therefore, it is essential to double the rate of the five years by five. Furthermore, it is customary to represent the Total fertility rate (TFR) on a per-woman basis, whereas Age-Specific Fertility Rates (ASFRs) are often given per 1,000. If such is the situation, then it is imperative to perform the division operation by a factor of 1,000. As a result, the formula is as follows:

$$\text{TFR} = \frac{\text{Sum of ASFRs} \times 5}{1000} \tag{4}$$

Table 4. Total fertility rate (TFR).

Regions	Total Fertility Rate		
	Total	**Saudi**	**Non-Saudi**
Al Jawf	3.62	4.44	0.83
Northen Borders	3.17	3.90	1.04
Najran	3.11	3.79	1.29
Tabuk	2.71	3.16	0.92
Hail	2.51	3.11	0.65
Al Madinah Al Munawwarah	2.48	3.08	1.10
Aseer	2.46	2.90	0.67
Jazan	2.37	2.67	1.21
Al Bahah	2.31	2.71	0.79
Al Qaseem	2.28	2.81	0.74
Eastern Region	2.27	2.85	0.92
Riyadh	1.88	2.65	0.88
Makkah Al Mukarramah	1.79	2.45	0.91
Total	2.14	2.80	0.91

Source: Saudi census, 2022.

The overall fertility rates for Saudi women and the total population of women are derived from **Table 4** as 2.80 and 2.14, respectively. The reproduction rate of native Saudi women surpasses that of expatriate women by 0.66 children per woman. The

gap is significant since Saudi females have 660 more children per 1000 women compared to non-Saudi women. Before examining the causes for this significant discrepancy, let us first analyse the differences in total fertility rate (TFR) among different regions in Saudi Arabia.

As seen in **Table 4**, the total fertility rate (TFR) for all women continually remains lower than that of Saudi women, suggesting that expatriate women exhibit a lower level of total fertility. When using a TFR of 2 as a threshold, it is evident that the TFR of Saudi women exceeds 2.0 in all locations. However, the total fertility rate (TFR) for women in all areas, except for Riyadh and Makkah Al Mukarramah, is below 2.

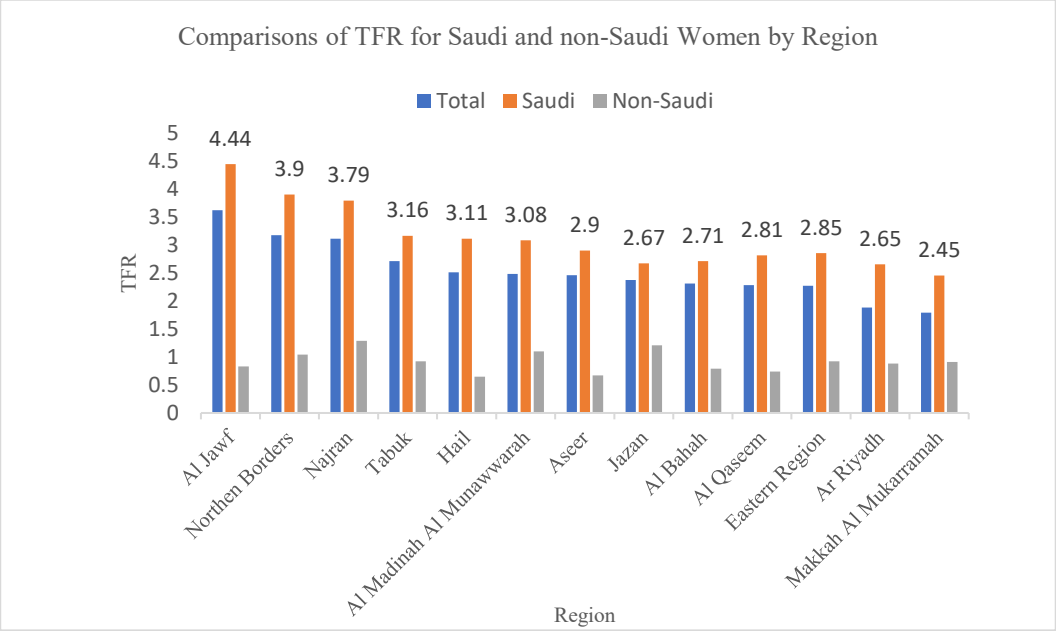

Figure 3. Comparisons of TFR for Saudi and non-Saudi women by region.
Source: Household Health Survey, Saudi Arabia, 2022.

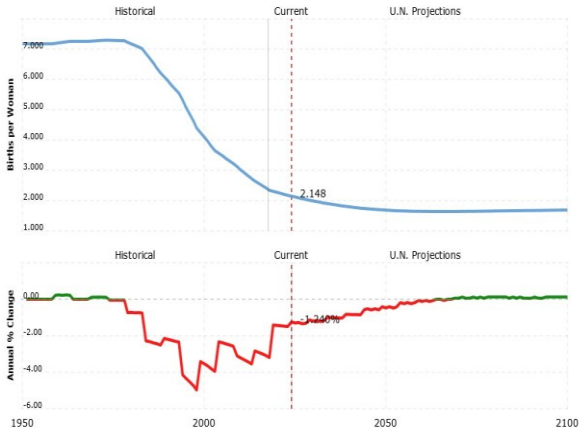

Figure 4. Saudi fertility rate 1950-2024. UN estimates for 2100 are presented.
Source: United Nations—World population prospects.

The study reveals in **Figure 3** and **Figure 4** that the fertility rate for Saudi Arabia in 2024 is 2.148 births per woman, indicating a decrease of 1.24% compared to 2023. In 2023, the fertility rate for Saudi Arabia was 2.175 births per woman, which is a

1.49% decrease compared to 2022. In 2022, the fertility rate for Saudi Arabia was 2.208 births per woman, which is a 1.47% decrease compared to 2021. In 2021, the fertility rate for Saudi Arabia was 2.241 births per woman, representing a decrease of 1.45% compared to 2020.

3.2. Measures of reproductivity

Reproductivity measures a female generation's ability to reproduce and continue its existence. This research investigates two crucial measures of period fertility: the gross and net reproduction rates. In addition, it examines two temporal indicators of period fertility: the mean age-specific fertility distribution and the mean age of births.

3.2.1. The gross reproduction rate (GRR)

This statistic closely resembles the total fertility rate (TFR), with the distinction that it only considers births among females. The calculation method for this indicator is identical to that of the Total Fertility Rate (TFR), but it utilizes explicitly age-specific fertility rates for females (Keyfitz, 2005). According to the data in **Table 5**, the General Fertility Rate (GRR) for Saudi women is calculated to be 1.37 (0.274583296 multiplied by 5) children per woman.

Table 5. Gross and net reproduction rates for Saudi females.

Age Group	Saudi Females ASFRs	Exact Age	l_x	$_5L_x$	Female Births in the Stationary Population	Midpoint of Age Group	Average Female Births	Average Female Births in the Stationary Population
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6) = (2) × (5)**	**(7)**	**(8) = (2) × (7)**	**(9) = (6) × (7)**
15–19	0.004263241	15	0.9991	4.995	0.021294887	17.5	0.074606711	0.372660524
20–24	0.032729965	20	0.9989	4.965	0.162504278	22.5	0.736424222	3.656346265
25–29	0.067238538	25	0.9871	4.911	0.330208458	27.5	1.849059783	9.080732594
30–34	0.074634638	30	0.9774	4.867	0.363246781	32.5	2.425625723	11.8055204
35–39	0.061827523	35	0.9695	4.967	0.307097306	37.5	2.318532109	11.51614899
40–44	0.02998689	40	0.9091	4.318	0.129483392	42.5	1.274442832	5.50304415
45–49	0.003902502	45	0.8183	-	-	47.5	0.185368833	-
Total	0.274583296				1.313835103		8.864060215	41.93445292

Source: Saudi census, 2022.

Moreover, the gross reproduction rate refers to the mean number of female births per woman who has reached the age of fifty, assuming constant age-specific fertility rates (ASFRs). It is important to note that the GRR, like the TFR, is a rate calculated over a certain period and is not associated with any specific group of individuals. Alternatively, it considers a theoretical, artificial group, as previously shown. A Generalized Replacement Rate (GRR) of 1.0 indicates that the female population is about to maintain its size. At the same time, a GRR of 2.0 suggests that the population is growing exponentially, with each woman giving birth to an average of two daughters.

Nevertheless, caution must be used when interpreting the GRR since it measures period fertility and does not account for mortality during the 15 to 50 age range. Therefore, a GRR (Gross Reproduction Rate) greater than 1.0 is necessary for a

woman to replace herself, but this is contingent upon the level of mortality. Similarly, the Total Fertility Rate (TFR) must exceed 2.0 to guarantee the population's long-term stability.

Similarly, the gross reproduction rate (GRR) for all women in Saudi Arabia is 1.37 children. The findings indicate that for every 100 Saudi women, there is an average of 137 daughters replacing them. Still, every 100 non-Saudi women has an average of just 90 daughters replacing them. This elucidates the disparity between the two groups in an inherent manner.

Not every daughter will survive to replace their moms, and not every mother will live to the end of their reproductive years. The influence of death is accounted for in the subsequent metric, known as the net reproduction rate.

3.2.2. The net reproduction rate (NRR)

The net reproduction rate (NRR) is calculated by adjusting the gross reproduction rate (GRR) for mortality. The adjustment is performed by multiplying each Age-Specific Fertility Rate (ASFR) for daughters by the chance of living to that age, calculating the aggregate, and multiplying it by five (Alho and Spencer, 2006). The Net Reproduction Rate (NRR) is consistently somewhat lower than the Gross Reproduction Rate (GRR), with the disparity being influenced by death rates. The likelihood of reaching a certain age, denoted as x, is often known as lx. Therefore, in order to calculate the Net Reproduction Rate (NRR), it is necessary to have access to both female Age-certain Fertility Rates (ASFRs) and a life table (Skiadas and Skiadas, 2018).

The NRR (Net Reproduction Rate) for Saudi females is 1.31, as shown by the total of column 6 in **Table 4**. The discrepancy of 0.06 children may be attributed to the death rate among females in 2022. The NRR for the whole population of women, including non-Saudi women, is 2.04, calculated using the same method. The fertility timing of Saudi and non-Saudi women was almost identical. The average childbearing duration, as determined from **Table 4**, was around 31 years for Saudi women and 32 years for non-Saudi women. This is because, as previously mentioned, the age-specific fertility curves for both groups exhibit comparable forms with a considerable degree of skewness and kurtosis.

3.3. Explaining the differential

Currently, the available research suggests a significant disparity in the fertility rates between Saudi and non-Saudi females, with Saudi women exhibiting more significant levels of fertility. The 2022 Saudi Household Survey did not provide predisposing characteristics that may be used to analyse the factors influencing the disparity, save for one such variable. This variable represents the statistics on the frequency of modern contraceptive usage among presently married Saudi women, as well as the entire population of women, categorized by age groups of women in their reproductive years (**Table 5**).

The **Table 6** suggests that family planning practices in Saudi Arabia have contributed significantly to the fertility transition that has been occurring since 1984. However, it also reveals that the use of contraceptive methods is slightly higher among

non-Saudi women (33%) compared to Saudi women (30%), which partially explains the difference in fertility rates (Salam, 2013).

In order to explore the underlying reasons for the difference, it is necessary to analyse the marriage patterns seen in both groups, specifically focusing on the age at which individuals get married. However, this topic is outside the scope of this research. However, the study has shown that the overall fertility rate for both Saudi and non-Saudi women has been decreasing over the last thirty years.

Table 6. Contraceptive prevalence rates by age group.

Age Group	Total Population of Women	Saudi Women
15–19	15.0	12.0
20–24	22.4	20.7
25–29	31.8	32.1
30–34	34.6	33.6
35–39	36.1	33.1
40–44	37.8	33.1
45–49	24.7	21.9
Total	32.9	30.4

In order to further the study, we examined the historical trend of the Total Fertility Rate (TFR) from 1960 to 2016, as documented in the Saudi Household Survey for 2018. Separate time series data for Saudi and non-Saudi women is not provided; instead, data is only available for the entire female population in Saudi Arabia. According to **Figure 5**, the total fertility rate in Saudi Arabia has shown a consistent downward trend since 1983.

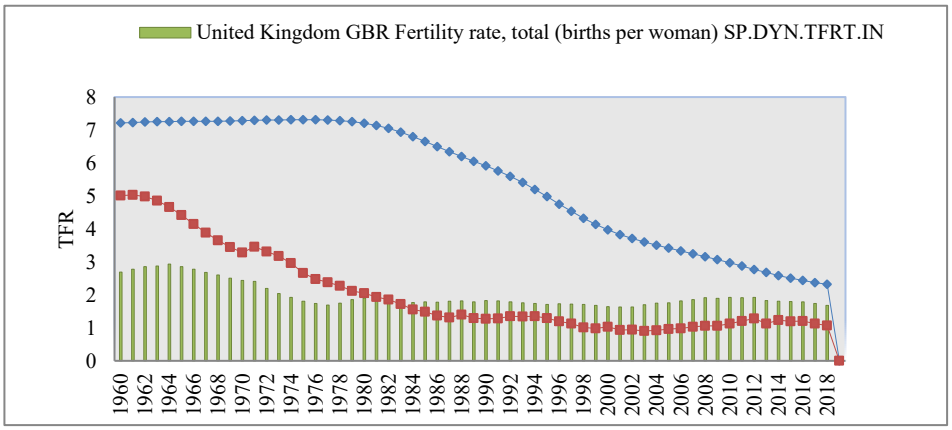

Figure 5. Fertility transition in Saudi Arabia, the UK and Hong Kong for the 1960–2018 period.

The fertility transition data from Saudi Arabia, the UK, and Hong Kong during the same era is significant, providing valuable insights into population trends.

- The fertility transition fall in Hong Kong and Saudi Arabia was already evident in the UK. When the UK TFR was less than 3.0 in 2018, Saudi Arabia had 2.3 children, down from slightly more than 7 in 1960.

- The change in Hong Kong began earlier than 1960 but accelerated, exceeding the UK transition and reaching replacement level in 2018.
- British and Hong Kong transitions had ups and downs, while Saudi Arabia's fertility rate continuously fell, suggesting that Saudi data has been graded or smoothed.
- Migrants have significantly influenced fertility transitions in Saudi Arabia and the UK, a factor that researchers and policymakers need to be cognizant of (Hazazy, 2018).
- In Saudi Arabia, non-Saudi women have a lower fertility rate than domestic women, indicating the potential for further decline or transition. These nations' populations would shrink during a second demographic shift (Caldwell, 2007).

4. Conclusion

This study did an empirical inquiry to analyze the fertility rate over a certain period in Saudi Arabia. Nevertheless, this research has prompted further queries rather than offering definitive solutions. Research consistently shows that the fertility rate among expats in Saudi Arabia is lower than that of Saudi native women. Nevertheless, the precise reason for this disparity remains elusive, given the substantial influence of contraceptive methods has yet to be confirmed. Based on the replacement level analysis, the expatriate population will shrink if this group's fertility rate continues to decline.

However, the current fertility transition in Saudi Arabia suggests a likely decline in fertility rates before the change is complete. The Saudi statistics authorities should provide crucial data about the determinants that impact the disparity in fertility rates between Saudi women and expatriate women. This is crucial due to the fact that the majority of expatriate women originate from nations with elevated fertility rates, and there is no indication of a decrease in fertility rates in these nations. Understanding these determinants could pave the way for future policies that could potentially reverse the declining trend.

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