Intra-Uterine Mortality in Morocco: Measures and Impact on Fertility

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Abstract

A recent universal public health problem, intrauterine mortality (IUM), is probably the least documented demographic and social phenomenon in Morocco caused by data scarcity. This study aims to measure the IUM's intensity and effect on women's fertility. IUM quotients and their components (early fetal and late fetal mortality) were estimated by constructing the mortality table. An empirical examination of IUM's impact on fertility was conducted using a direct method, the Bongaarts model (1978) and Leridon (2002) method. The data is from the 2009–2010 National Demographic Survey. The results show that in 2009–2010, the IUM quotient reached 272% pregnancies: 290% in urban areas versus 251% in rural areas. This IUM reduced potential fertility by 6% using the direct method. In particular, abortion reduced potential fertility by 5% versus 3.5% in 2009–2010, using the Bongaarts and Leridon methods. Given the importance of abortion, its impact on fertility, and its multidimensional consequences, it is interesting to research the determinants associated with the recourse to abortion as a significant public health issue.

Keywords

Bongaarts model; direct method; intrauterine mortality; Leridon method; Morocco; mortality table

Introduction

Reducing infant mortality represents a vital public health concern, while attention to fetal mortality remains negligible worldwide, particularly in developing countries (Woods, 2008). In addition, losing a baby in pregnancy through spontaneous abortion, induced abortion, or stillbirth is a taboo subject worldwide, linked to stigma and shame (World Health Organization, 2019d). Regarding late intrauterine mortality, defined as any intrauterine death that occurs after 28 weeks of pregnancy, one stillbirth occurs every 16 seconds, or nearly 2 million annually, according to the estimates developed by the United Nations Inter-agency Group for Child Mortality Estimation (UN IGME) (2020). While this number declined from 2.6 million in 2015 to 2.9 million in 2000, it continues to be a "neglected tragedy" and a "global burden."

While child mortality rates have reached the lowest levels in many developed countries, late intrauterine mortality is now higher than among infants (Woods, 2008). Still, most (98%) of stillbirths occur in low- and middle-income countries and 75% in sub-Saharan Africa and South Asia (Lawn et al., 2016). The risk is thus higher in sub-Saharan Africa (1 in 46 babies stillborn: 1/46) than elsewhere (1/72 worldwide, 1/321 in Europe/North America/Australia/Oceania, and 1/87 in North Africa and West Asia, for example) (UN IGME, 2020). Horton and Samarasekera (2016) stated that it is an urgent question and a genuine global health problem but has only been recognized as such since 2015 in the context of the SDGs.

The other components of fetal mortality named early intrauterine mortality: spontaneous abortion, and induced abortion, are defined as the intrauterine death of a fetus before 28 weeks. We note that, in the following, the terms "abortion" will be used for induced abortion and "miscarriage" for spontaneous abortion. Miscarriage is the most common reason for intrauterine nonviability of pregnancy and, in most cases, occurs during the first trimester of gestation (Dugas & Slane, 2021). An estimated 23 million miscarriages occur annually worldwide, constituting around 15% of clinically recognized pregnancies (Quenby et al., 2021).

Annually, from 2015 to 2019, there were 121 million unintended pregnancies globally, corresponding to a global rate of 64 unintended pregnancies per 1,000 women aged 15–49 years, whose 61% ended in abortion (Bearak et al., 2020). This translates to 73.3 million abortions per year, increasing compared to the period 2010 to 2014 and more so in countries with more restrictive abortion laws (Bearak et al., 2020). Unsafe abortions account for 45% of the total abortions each year. Almost all (97%) occur in developing countries in Africa, Asia, and Latin America, and one-third are performed in unsafe conditions (Ganatra et al., 2017). The World Health Organization (WHO) estimates that unsafe abortion is directly responsible for 4.7% to 13.2% of the annual maternal deaths worldwide. In addition to maternal mortality and morbidity, unsafe abortion accounts for 7 million complications admitted to hospitals in developing countries (World Health Organization, 2019a).

Various studies have revealed the impact on pregnancy outcomes. Stillbirths are due to multiple overlapping factors, including maternal age >35 years, maternal infections, non-communicable diseases, and nutrition and lifestyle factors. Stillbirths are also often associated with fetal growth restriction, preterm labor, post-term pregnancy, and suboptimum care. Few are due to congenital disorders (7.4% of stillbirths) (Lakshmi et al., 2017; Lawn et al., 2016;

Prasanna et al., 2015). In particular, genetic problems are identified main factors for miscarriages (Goddijn et al., 2004; Suzumori & Sugiura-Ogasawara, 2010), in addition to the parental characteristic (increased age of the mother, underweight, obesity, alcohol, and coffee consumption) (Larsen et al., 2013), immunological dysregulation, lifestyle, and infections (HIV, malaria, or bacterial vaginosis) (Giakoumelou et al., 2016). For abortion, the major associated factors identified are education, religion, age, knowledge about legal abortion, and safe places to practice abortions (Yogi et al., 2018), civil status, race or color, the prevalence of lower levels of education, and age less than 20 years (dos Santos et al., 2016). These factors can be classified into contextual and individual factors (Mundigo, 2006).

However, the neglect of intrauterine mortality until 2015 due to the scarcity of quality data and the availability of such information caused by the systematic non-recording of this type of event, even in developed countries (World Health Organization, 2019a). And there is a need for increased efforts to evaluate the IUM's intensity, identify its causes and implement preventive measures.

Indeed, while the availability of data on abortion depends on the legal, cultural, and religious context specific to each country (Guillaume & Rossier, 2018), the availability of data on stillbirths relies on the effectiveness of the system for recording this information, which remains very deficient and incomplete even in countries with a health information system (UN IGME, 2020). The civil registration information system, whose main prerogatives are to measure the intensity of the demographic phenomena underlying natural growth, i.e., mortality and natality and, secondarily, marriages and divorces, does not provide any information on intrauterine mortality practically worldwide regardless of the degree of development in the production of statistical data (UN IGME, 2020).

Given the importance of intrauterine mortality, it is interesting to analyze its impact on fertility. The various conceptual frameworks explaining fertility include intrauterine mortality among the proximate determinants, on the same level as age at marriage, contraception, post-partum infertility, and breastfeeding (Bongaarts, 1978, 1982; Bongaarts & Potter, 1983; Davis & Blake, 1956; Stover & Winfrey, 2017).

It is the same in Morocco regarding the availability and the quality of data related to intrauterine mortality and its components. Indeed, as a vital part of the national health information system, the information system relating to the mortality and deaths-causes statistics constitutes a unique tool for evaluating and appreciating mortality, including fetal mortality. It is noted that the threshold for reporting stillbirths into the civil status register, which corresponds to the threshold of fetal viability (World Health Organization, 1977), concerns all dead fetuses of 500 g or more at birth (or those who have completed 22 weeks of gestation or attainment of at least 25 cm crown-heel length if weight is not known) (World Health Organization, 2008).

Therefore, all other intrauterine deaths are not considered in Morocco (Ministry of Health, 2019). Yet, according to the United Nations (2015), vital events covered, among others, all events that occur at the level of individuals; live birth, death, and fetal death, including legal abortions.

Despite Morocco's efforts to ensure its completeness and quality, civil registration is still deficient in most countries, where live births and stillbirths are not systematically registered, and stillbirths are often underestimated (Woods, 2008; World Health Organization, 2019b). The World Health Organization (2019b) report indicated a coverage rate of death in Morocco of around 62% in 2015–2018 and low-quality knowledge of causes of death in 90% of reported cases. Likewise, the other components of intrauterine mortality are affected by the scarcity and quality of data, often based on hospital statistics and household surveys. This makes intrauterine mortality the least studied demographic phenomenon in Morocco.

Indeed, despite the surveys conducted by the Ministry of Health and High Commission for Planning (HCP), since the 1980s, the approach to this phenomenon has often persisted in the phase of quantitative analysis, marked by many limitations and irregularities; the investigations carried out by these official public institutions have always focused on unmarried women, which omit a large fringe of the population at risk, whose pregnancy occurs outside the context of the religious marriage. Moreover, apart from the 1995 Population and Health Panel Survey (PHPS 1995), realized by the Ministry of Health, these surveys do not permit the dissociation between abortions and miscarriages. According to the PHPS 1995 data, the abortion rate has reached 7.4% and the miscarriage rate 4.8%. In this regard, it should be noted that abortion represents an integral part of early fetal mortality.

The study realized by Bakass et al. (2009) indicated that in the 1990s, the percentage of aborted pregnancies varied between 3.6% and 4.4%, depending on the methods used (direct or indirect). In a few qualitative studies, such as the one carried out by Moroccan Family Planning Association (Moroccan Family Planning Association, 2016) or by a few doctors (Belhouss et al., 2011), this field has been left almost completely abandoned. However, although there are no official figures, Moroccan Association for the Fight Against Clandestine Abortion states that 600 to 800 clandestine abortions are performed every day in Morocco (Moroccan Association for the Fight Against Clandestine Abortion, 2022), and the Moroccan Family Planning Association (2016) advances numbers oscillating between 150 and 200 abortions per day.

This urgent public health question also interests the medical profession to explore its epidemiological aspects. Laghzaoui (2016) showed, according to a retrospective study from 2009 to 2014, based on 451 cases of patients victims of unsafe abortion among 12,040 pregnancies treated in the gynecology-obstetrics department of a hospital in Meknes, that the frequency of unsafe abortion reached 3.74%. Also, Remani (2020), according to the prospective study, in 2018–2019, based on 234 patients treated for stopped pregnancies or miscarriages at the Mohammed VI University Hospital in Marrakech, showed, concerning the risk factors, that 82% of the population affected had a Body Mass Index (BMI) ≥ 25 kg/m^2, 34% consumed caffeine every day excessively (> 100mg/ day of caffeine), and 11% had consumed abortive substances.

Regarding stillbirth, Ouakrim and Azelmat (2005), based on the National Family Planning and Health Survey data (NFPHS-2003–2004), indicated that the stillbirth rate, which is estimated at 16.5%, is higher in rural than in urban areas (18.7% versus 14.5%) and among women with no education (18.7%) compared to those with secondary school or higher (9.3%). Clinical studies have highlighted that the risk of this mortality is related to the health status of the newborn fetal monitoring during pregnancy and labor, and finally, the health system organization (Bourfoune, 2009; Ouahid et al., 2019).

Given the few studies that have been allocated to the intrauterine mortality issue in Morocco, we propose to estimate the level of this phenomenon and construct a mortality table relating to this specific mortality. We will then measure its effect on fertility levels.

Key terms

Intra-Uterine Mortality (IUM) refers to all fetal death. These deaths are defined by the WHO as the intrauterine death of a fetus at any time during pregnancy (World Health Organization, 2021); for international comparison, the WHO recommends defining stillbirth as a baby with no signs of life at or after 28 weeks of gestation (World Health Organization, 2019c).

Abortion, otherwise known as "Early Fetal Mortality (EFM)," is medically defined as the expulsion or extraction from the uterus of a product of conception that is presumed to be non-viable, i.e., that has not reached a certain period of gestation or, in some cases, a certain weight 500 grams (less than 22 weeks or less than 500 grams) (World Health Organization, 1977). These norms vary depending on the definition used in each country, and the criteria defining viability can also vary between countries depending on progress in medical technology (Pignotti, 2009).

Types of abortion

- **Spontaneous abortions** (miscarriages) are cases where the fetus is expelled without any deliberate action on the part of the woman or another person. This definition generally applies up to 7 months of pregnancy (beyond which it is considered a "stillbirth").

- **Induced or voluntary abortions** follow a deliberate action performed by the woman or another person to end the pregnancy. These include therapeutic abortions performed for medical reasons, often due to an anomaly, an illness that threatens the life of the fetus, a risk of severe sequelae after birth, or danger to the mother's life or health.

Stillbirth (SB), otherwise known as "late intrauterine mortality," is defined as a baby born with no signs of life after a given threshold, usually related to the gestational age or weight of the baby. Stillbirths are reported inconsistently across countries due to different criteria or combinations of criteria and varying thresholds in areas such as gestational age and/or birth weight.

For international comparison, we refer to the "late gestation fetal deaths" as deaths occurring at or after 28 weeks of gestation, which is in line with the International Classification of Diseases (World Health Organization, 2021).

Gestational age is defined as the duration of pregnancy, measured from the first day of the last normal menstrual period. Therefore, gestational age at birth is the duration measured from the first day of the previous menstruation period to the day of birth.

Live birth refers to the complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of the pregnancy, which, after such separation, breathes or shows any other evidence of life - e.g., beating of the heart, pulsation of the umbilical cord or definite movement of voluntary muscles - whether or not the umbilical cord has been cut or the placenta is attached.

Data and methods

Data sources

This paper used the 2009–2010 National Demographic Surveys (NDS 2009–2010) (High Commission for Planning, 2011) to construct the mortality table and the aggregate indicators from the NDS 1986–1988 (High Commission for Planning, 1993) to compare the intrauterine mortality levels in Morocco. This combination of data from the 2000s with those from the 1980s is explained by the fact that only two follow-up surveys have been carried out in Morocco.

Also, we used the 1995 Population and Health Panel Survey (PHPS 1995) (Ministry of Health, 1996) and the 2011 National Population and Family Health Survey (NPFHS 2011) (Ministry of Health, 2012). These investigations are representative sample surveys at the national, regional, and residence levels (urban or rural).

In the PHPS 1995 and the NPFHS 2011, the sample was 2,917 and 15,343 households, and in terms of women aged 15–49, it was 4,753 and 11,069, respectively. Based on retrospective observation, these surveys allow collecting information about fertility, marital status, contraceptive practice, and postpartum behaviors of unmarried women aged 15–49.

In the NDS 2009–2010, our primary data source, the sample, which is not self-weighted, comprised 105,000 households and 143,391 women aged 15–49, including 13,941 pregnant women. To ensure the representativeness of the results at the national and regional levels, we resorted to a weighting procedure using the weights, which means the reciprocal of the likelihood of being sampled, are available in the data file, accessible at the Centre d'Etudes et de Recherches Démographiques [Center of Demographic Studies and Research] in Morocco.

For this study, using SPSS software (version 25), we created a file, through the NDS 2009–2010 file, containing the fertility module of unmarried women aged 15–49, with other key variables such as demographic and socioeconomic and housing characteristics.

Methods

Indicators

In this study, there are two IUM indicators: the first (Rate-1-IUM) is defined as the number of all fetal deaths per 1,000 total pregnancies, and the second (Rate-2-IUM) is defined as the number of all fetal deaths per 1,000 total births (live births + stillbirths). These rates are calculated as:

$$\text{Rate} - 1 - \text{IUM} = 1000 * \frac{\text{EFM} + \text{SB}}{\text{Pregnancies}}$$

$$\text{Rate} - 2 - \text{IUM} = 1000 * \frac{\text{EFM} + \text{SB}}{\text{Births}}$$

With: EFM: early fetal mortality (abortions +miscarriages), and SB refers to stillbirths.

Intra-uterine mortality table (IUM)

The NDS 2009–2010, carried out by the follow-up method, permits recording all pregnancies observed during 2009–2010, classifying them by gestational age at the month of observation, and registering their outcomes (live births, fetal deaths) by gestational age. Regarding the intrauterine mortality, the recording of the fetal deaths occurring month by month among the pregnancies concerned, i.e., the pregnancies subject to the risk of intrauterine mortality, makes it possible to construct the intrauterine mortality table. We note here that, contrary to the traditional mortality, it is impossible to constitute a "cohort" in the demographic sense of the term; our cohort of pregnancies is composed of 9 sub-cohorts according to the gestational age at the month of the observation (Figure 1).

The available NDS 2009–2010 data has permitted to measure the IUM, and its two components, using the quotient of the mortality by gestational age to construct the mortality table. To this effect, we need the elements as follows:

- G(x): pregnancies at the exact gestational age x (pregnancies subject to risk);
- E(x, x+1): events (EFM & SB) occurring between gestational age x and x+1;
- M(x, x+1): classical mortality rate between gestational age x and x+1;
- 1Qx: mortality quotient of the table between gestational age x and x+1 exact;
- S(x): table survivors at exact gestational age x;
- 1dx: table deaths between exact gestational age x and x+1.

Based on the Lexis diagram (Figure 1), which represents the statistical status data and events (EFM, SB) that occurred during the survey period NDS 2009–2010, all biometric elements of the table were calculated starting with the determination of pregnancies at risk G(x) and the events E(x, x+1).

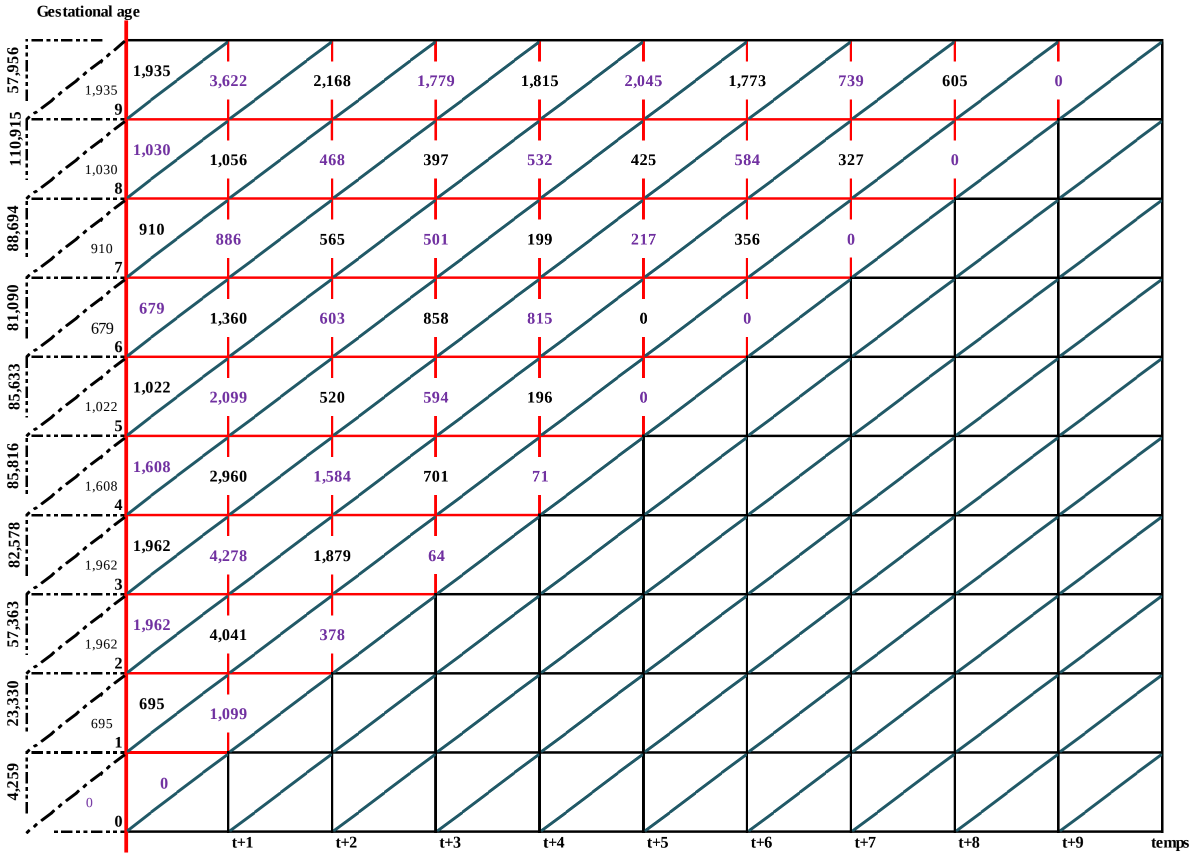
Indeed, the observation of each pregnancy cohort by month of gestation determines the period of exposure to the intrauterine mortality risk; this will be used to calculate the probability of interruption between gestational age x and x+1.

From the observation month to the next, the number of pregnancies at risk increases by gestational age as the pregnancy cohorts come into survey observation. At each gestational age (x), the number of pregnancies at risk is estimated by adding up the pregnancies up to gestational age (x) and subtracting the cumulative number of events up to gestational age (x-1). The number of pregnancies at risk at the exact age x is calculated as follows:

$$\mathrm{G(x) = G'(x) + E'(x, x+1)} + \sum_{\mathrm{i \leq x-1}} \mathrm{(G(i) - E(i, i+1))}$$

With G′(x) = the number of pregnancies in the cohort come into survey observation at its xth month of gestation, E′(x, x+1) = the events occurring in the pregnancy cohort come into survey observation at its xth month of gestation, G(i) = the number of pregnancies that have reached the exact gestational age i, and E(i, i+1) = the events occurring between the exact ages i and i+1, with (i<x).

Figure 1: Distribution of Fetal Deaths by Pregnancy Cohorts and Month of the Event



Note: Developed by the authors using NDS 2009–2010 data (High Commission for Planning, 2011)

The biometric elements (G(x) and E(x, x+1)) allow to calculate a classical mortality rates M(x,x+1). The mortality rate is converted to the mortality quotient Q(x, x+1) (Waltisperger, 1977), which means the probability of dying at gestational age x. In other words, it is the probability of dying at gestational age x before reaching the age x+ 1. See the formulas below:

$$M(x, x+1) = \frac{2 * E'(x, x+1) + \sum_{i \leq x-1} E(i, i+1)}{0{,}5 * (G(x) + G(x+1))}$$

With the quantity $(2 * E'(x, x+1) + \sum_{i \leq x-1} E(i, i+1) = xd1\ )$ corresponds to the number of fetal deaths observed between gestational age x and x+1.

$$Q(x, x+1) = \frac{2 * M(x, x+1)}{2 + M(x, x+1)}$$

The quotients Q(x, x+1) permits to estimate the other biometric elements of the mortality table, namely S(x) and d(x,x+1).

$$S(x+1) = \big(1 - Q(x, x+1)\big) * S(x)$$
$$d(x, x+1) = S(x) * Q(x, x+1)$$

Direct method, Bongaarts model and Leridon method

To estimate the impact of the IUM on fertility levels, we used three methods: the first is a direct method, based on women's self-reporting of pregnancy outcomes during 2009–2010. We calculate total fertility rates in the presence and the absence of EFM and/or SB. The difference between potential and observed total fertility rate permits us to estimate the impact of the phenomena in question on fertility for the 2009–2010 period.

$$\mathrm{N} = \mathrm{TFR_p} - \mathrm{TFR_o}$$

With:

N = the mean number of children avoided per woman per year.
TFRp = the total potential fertility rate.
$\mathrm{TFR_P} = \sum \mathrm{f'(a)}$, f′(a) = fertility rate by age group, calculated by adding fetal deaths (EFM and/or SB) to the live births.
and $\mathrm{TFR_o}$ = the total observed fertility rate.
$\mathrm{TFR_o} = \sum \mathrm{f(a)}$, f(a) = fertility rate by age group.

Furthermore, to estimate the impact of abortion on fertility, we combined two indirect methods to increase the results reliability and compensate for the bias or deficiencies of any single method (Johnston & Westoff, 2010). These are the Bongaarts method (Bongaarts, 1978, 1982; Bongaarts & Potter, 1983) and the Leridon method (Leridon, 2002).

We apply the Bongaarts proximate determinants model to calculate a residual abortion index C_a, which measures the inhibiting effect, by the following formula (Bongaarts, 1978, 1982; Bongaarts & Potter, 1983):

$$\mathrm{C_a} = \frac{\mathrm{TFR}}{(\mathrm{TF} * \mathrm{C_m} * \mathrm{C_c} * \mathrm{C_i})}$$

Where TFR = total fertility rate, TF = total fecundity, i.e., the potential maximum number of children per woman (15.3). C_m, C_c, and C_i are respectively the marriage index, the contraceptive index, and the postpartum infertility index. The values of all indices range from “0” to “1”, where “1” means no fertility-inhibiting effect by the given factor, and “0” means complete fertility-inhibiting effect. The model elements can be calculated using the formulae presented in Table 1 below.

Table 1: Formulae to Calculate the Indices of the Main Proximate Determinants of Fertility and Other Elements Required for the Bongaarts Method

Indices and rates	Formulae	Meaning of certain symbols
Marriage index C_m	$C_m = \frac{\sum f(a)}{\sum \frac{f(a)}{m(a)}}$	f(a) = fertility rate by age group. m(a) = proportion of ever-married women, by age group.
Contraceptive index C_c	$C_c = 1 - (1.08 \text{ x e x } \mu)$ avec $e = \frac{\sum (e(m) \text{x } \mu(m))}{\mu}$	µ: contraceptive prevalence. e: contraceptive efficacy. m: contraceptive method.
Postpartum infertility index C_i	$Ci = \frac{20}{18.5 + i}$ avec $i = 1.753 e^{[(0.1396\, a) - (0.001872\, a^2)]}$	i: mean duration of abstinence or amenorrhea (in months). a: mean duration of breastfeeding
Total fertility rate (TFR)	$TFR = \sum f(a)$	f(a) = fertility rate by age group.

Note: Bongaarts, 1982; Rossier, 2003

The variables needed for indirect calculation of abortion index (Ca) are:

- fertility rates by age group,
- the proportion of ever-married women by age group,
- contraceptive prevalence by method among sexually active women,
- efficacy rates for contraceptive methods,
- and the mean postpartum nonsusceptible period (postpartum period of sexual abstinence or amenorrhea).

With the exception of the efficacy rates, these variables were taken from the NPFHS 2011 and the NDS 2009–2010 data. To make up for the lack of efficacy rates, we chose the standard rates, with a more detailed breakdown by method, used in a study of African countries, where the method specific use-effectiveness used for Pill, injectable, implant, tubal sterilization, vasectomy, intrauterine device (IUD), condom, vaginal methods, periodic abstinence, withdrawal and other are 0.82, 0.96, 0.99, 0.99, 1.00, 0.90, 0.62, 0.80, 0.50, 0.38, and 0.10, respectively (Johnston & Hill, 1996).

After calculating all indices (Cm, Cc, Ci, Ca), we can estimate the proportion of the reduction in fertility from the biological maximum of the total fecundity due to each proximate determinant. The fertility-inhibiting effect of each of the four proximate determinants can be estimated to complement its index (Guillaume, 2003; Singh et al., 2022). For example, with an abortion index Ca, its inhibiting effect will be (1-Ca). This means that abortion reduces total fecundity, set at 15.3 children per woman, by (1-Ca) %.

The absolute effect of abortion on fertility (Frejka, 1985) is thus the difference between fertility in the absence of abortion and fertility in its presence:

$$\text{Absolute effect (abortion)} = \text{TFR(without abortion)} - \text{TFR(estimated))}$$

Where:

TFR(without abortion) = TF* (C_m * C_c * C_i) and TFR(estimated) = TF * (C_m * C_c* C_a * C_i).

The relative contribution of abortion can be estimated by assuming that the four proximate determinants independently and completely account for the reduction in fertility from total fecundity to the estimated TFR. The contribution of each determinant to fertility reduction is estimated as the ratio of the natural logarithm of the index for that determinant to the sum of the natural logarithm of the four indices multiplied by 100. For instance, the percentage contribution of abortion (Pa) to the reduction in fertility from total fecundity to total fertility rate will be (Rahman, 2002; Singh et al., 2022; Wang et al., 1987):

$$\mathrm{Pa} = 100 * \frac{\log(\mathrm{Ca})}{\log(\mathrm{Cm} * \mathrm{Cc} * \mathrm{Ci} * \mathrm{Ca})}$$

And the relative fertility inhibiting effect of abortion is the product of $\mathrm{Pa}/100$ and the total fertility reduction:

$$\text{Relative effect (abortion)} = (\mathrm{TF} - \mathrm{TFR(estimated)}) * \frac{\mathrm{Pa}}{100}$$

We note that abortion reduces the duration of pregnancy and the postpartum no susceptible period. However, an abortion does not prevent a birth since the number of abortions required depends on the mean time to conception, the duration of pregnancy, and postpartum infecundability. It can be calculated using the formula developed by Leridon (2002):

$$\mathrm{N} = \frac{\frac{1}{\mathrm{p}(1-\mathrm{E})} + \mathrm{G_m} + \mathrm{T_m}}{\frac{1}{\mathrm{P}(1-\mathrm{E})} + \mathrm{G_a} + \mathrm{T_a}}$$

where $1/\mathrm{p}$ = mean time to conception, estimated to be 4 months in the absence of contraception; E = the mean efficacy of contraception, equal to the weighted mean of efficacy rates for each method, the weights being the proportions of sexually active women who use contraception. The efficacy rates by the method used in this part are the same standard rates used in the study of African countries by Johnston and Hill (1996) as well as in our indirect estimations of abortion index; Gm = length of pregnancy, equal to 9 months; Tm = postpartum nonsusceptible period, equal to the mean duration of postpartum infecundability; Ga = length of pregnancy in case of abortion, equal to 3 months; Ta = post-abortion nonsusceptible period, equal to 1 month.

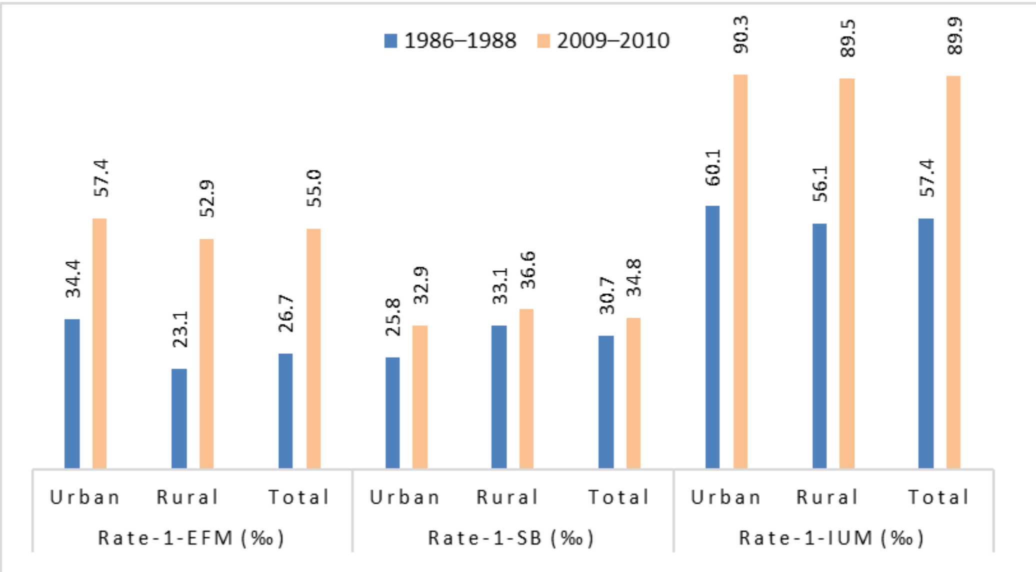
Results

The NDS 2009–2010 recorded 622,724 pregnancies, with 631,900 pregnancy outcomes, of which about 52% were among rural women. At the national level, 575,245 live births, 34,706 early fetal deaths, and 21,949 stillbirths were recorded, i.e., live births and intrauterine deaths represent 91.0% and 9.0% of pregnancy outcomes.

An urban EFM superiority versus a rural SB superiority

Figure 2 presents the EFM, SB, and IUM rates by place of residence based on NDS 1986–1988 and NDS 2009–2010 data. As the figure shows, the IUM rate (Rate-1-IUM), which estimates the phenomenon's intensity among pregnancies, increased from 57.4% to 89.9% during the inter-survey period. In other words, among 1000 pregnancies, more than 57 and nearly 90 pregnancies failed to reach their full terms in 1986–1988 and 2009–2010, respectively. In general, urban IUM was more than rural IUM, explained by the importance of the urban EFM. Indeed, the EFM rate (Rate-1-EFM)) has reached 34.4‰ in urban areas compared to 23.1% in rural areas in 1986–1988 and 57.4% compared to 52.9% in 2009–2010. On the other hand, SB was more present in rural areas than in urban areas, 33.1% versus 25.8% in 1986–1988 and 36.6% versus 32.9% in 2009–2010.

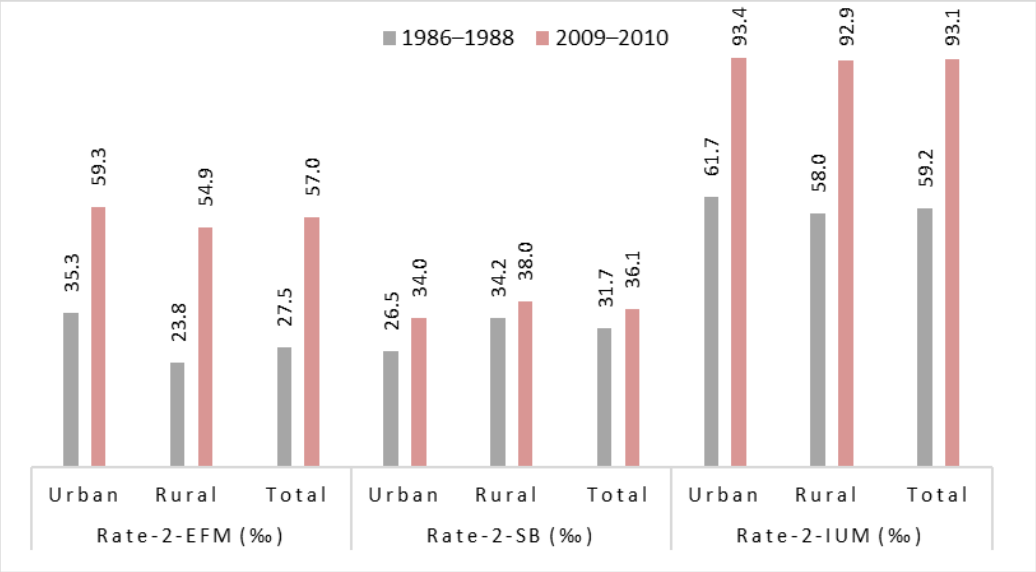
Figure 2: EFM, SB, and IUM Rates (% pregnancies) by Place of Residence in 1986–1988 and 2009–2010



Note: Calculated by the authors from NDS 1986–1988 and 2009–2010 data

According to the total births (live births + stillbirths), there was also an urban EFM superiority versus a rural SB superiority, with rates increasing between 1986–1988 and 2009–2010. For example, the SB rate increased between 1986–1988 and 2009–2010 from 31.7% to 36.1% (Figure 3). A recent report from the United Nations Inter-agency Group for Child Mortality Estimation (2020) stated that the SB rate in 2015, which is the number of fetal deaths at 28 weeks or more of pregnancy per 1,000 births, which has reached 15.0% in Morocco, was only 11.9% in Tunisia, 10.1% in Egypt, 9.7% in Algeria, and only 9.4% in Libya.

Figure 3: EFM, SB, and IUM Rates (‰ births) by Place of Residence in 1986–1988 and 2009–2010

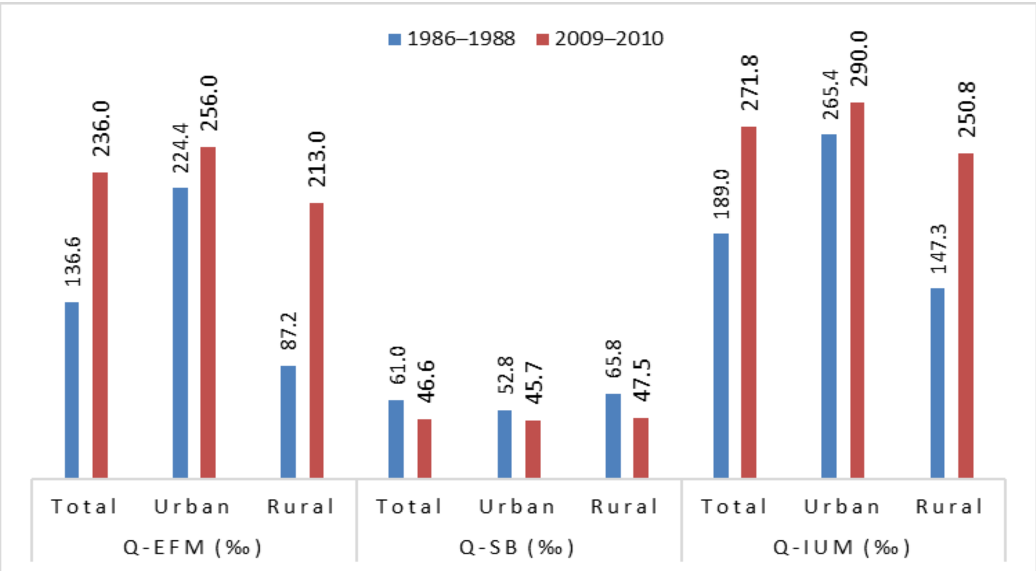


Note: Calculated by the authors from NDS 1986–1988 and 2009–2010 data

EFM is more important than SB

During the inter-survey period, Morocco recorded an increase in the EFM against a decrease in the SB. Indeed, the EFM and SB quotients that were estimated to be 136.6% and 61.0% respectively, in 1986–1988 were evaluated as 236.0% and 46.6% respectively, in 2009–2010 (Figure 4). This problem positively affects the level of IUM quotients (Q-IUM), which has risen, during the inter-survey period, at the national level, and in the two areas of residence, with an urban EFM superiority versus a rural SB superiority.

Figure 4: EFM, SB, and IUM Quotients (%) by Place of Residence in 1986–1988 and 2009–2010



Note: Calculated by the authors from NDS 1986–1988 and 2009–2010 data, HCP

Furthermore, these indicators do not permit comparing two populations with different fertility rates based on pregnancies or births. In fact, concerning the EFM rate per 1,000 women, the NDS 2009–2010 reveals that this indicator, which has reached 7.21% among unmarried women aged 15-49, was higher in rural areas (8.35%) than in urban areas (6.34%), with a slight disparity according to the place of residence. This situation is explained, perhaps, by the relative importance of rural repetitive EFM: 0.28% rural women against 0.24% urban women. According to the PHPS 1995 data, the opposite was constated, which estimated the EFM rate to be 12.2% in the year preceding the survey; this rate differs significantly from urban to rural areas, 20.3% versus 4.2% respectively.

IUM peaked in the 2nd month of gestation

According to the NDS 2009–2010 data, an estimated 56,655 fetal deaths, whose 34.4% occurring in the first trimester of gestation (26.9% and 38.7% in the 2nd and 3rd trimester, respectively). As the IUM table (Table 2) shows, which presents the IUM quotients by gestational age, the risk of fetal mortality increases by gestational age until it peaks in the 2nd month. At this age, the risk is, in fact, very high with over 110%. Then it declines at an accelerated rate during the 3rd month by more than half (50.2%) and finally has reduced gradually to 30.6% at the 4th month and about 11.5% at the 6th month.

The same trends can be observed according to the place of residence, but with different levels. The rural EFM in the first trimester is lower than the urban EFM. After the 4th month, this situation was reversed with a slight excess of rural mortality. This superiority of urban EFM in the first trimester may be explained by the recourse to abortion in urban areas more than in rural areas to deal with family planning problems or others. According to Bankole et al. (1998), the most common reason for having an abortion, reported by around 50% of women, was spacing or limiting births. Also, Chae et al. (2017) stated that the most frequently cited main reasons for having an abortion were socioeconomic concerns (27% to 40% in six of 13 countries) or limiting childbearing (20% to 64% in five countries).

Table 2: Moroccan IUM Table 2009–2010

Gestational age	Pregnancy cohorts come into survey observation	G(x)	E(x,x+1)	M(x,x+1)	Table parameters		
					Q(x,x+1)	S(x)	d(x,x+1)
			Total Morocco				
0 month	4,259	-	-	-	-	-	-
1 month	23,330	28,284	2,489	0.0428	0.0419	1,000	42
2 months	57,363	88,144	14,391	0.1168	0.1103	958	106
3 months	82,578	158,293	10,145	0.0515	0.0502	852	43
4 months	85,816	235,572	8,532	0.0311	0.0306	810	25
5 months	85,633	313,695	5,453	0.0155	0.0154	785	12
6 months	81,090	388,043	4,994	0.0116	0.0115	773	9
7 months	88,694	472,653	4,544	0.0086	0.0086	764	7
8 months	110,915	580,054	5,849	0.0096	0.0096	757	7
9 months	57,956	634,096	18,416	0.0295	0.0290	750	22
Total	677,634	-	74,813	-	-	-	272
			Urban Morocco				
0 month	2,631	-	-	-	-	-	-
1 month	13,512	16,661	1,878	0.0604	0.0586	1,000	59
2 months	28,147	45,567	8,040	0.1301	0.1222	941	115
3 months	39,552	77,995	5,147	0.0539	0.0525	826	43
4 months	39,425	112,933	3,897	0.0294	0.0289	783	23
5 months	43,207	152,549	2,228	0.0132	0.0131	760	10
6 months	36,820	186,257	1,781	0.0086	0.0086	750	6
7 months	41,613	226,663	2,573	0.0103	0.0102	744	8
8 months	50,237	274,610	2,030	0.0070	0.0070	736	5
9 months	31,012	304,900	8,851	0.0295	0.0290	731	21
Total	326,156	-	36,425	-	-	-	290
			Rural Morocco				
0 month	1,628	-	-	-	-	-	-
1 month	9,818	11,623	611	0.0225	0.0223	1,000	22
2 months	29,216	42,577	6,351	0.1034	0.0983	978	96
3 months	43,026	80,298	4,998	0.0493	0.0481	882	42
4 months	46,391	122,639	4,635	0.0327	0.0321	839	27
5 months	42,426	161,146	3,225	0.0178	0.0176	812	14
6 months	44,270	201,786	3,213	0.0144	0.0142	798	11
7 months	47,081	245,990	1,971	0.0071	0.0071	787	6
8 months	60,678	305,444	3,819	0.0120	0.0120	781	9
9 months	26,944	329,196	9,565	0.0295	0.0291	772	22
Total	351,478	-	38 388	-	-	-	251

Note: Compiled by the authors from the NDS 2009–2010 data, HCP

According to the NDS 2009–2010 data, about 40.0% of pregnancies were supervised (47.2% in the urban area against 33.4% in the rural area), and 87.1% of pregnant women received an assisted-events, including assisted childbirth and assisted fetal deaths, by qualified medical personnel (doctor, nurse, midwife); this proportion differs by place of residence: 92.6% in urban areas versus 82.0% in the rural area. This situation resulted in disparities in the medical coverage specific to each place of residence.

As Table 3 shows, perinatal medical care and assisted events affect pregnancy outcomes. Indeed, nearly 80.0% of stillbirths and 86.0% of early fetal deaths in 2009–2010 occurred among pregnancies not supervised and/or not assisted at the event by qualified personnel; these proportions differ according to the place of residence; 45.7% of stillbirths and 45.6% early fetal deaths occurs in rural areas versus 33.9% stillbirths and 40.5% early fetal deaths in urban areas.

Table 3: Pregnancy Outcomes by Perinatal Medical Care and Assisted Events in 2009–2010

Perinatal medical care and assisted-events	Place of residence	Pregnancy outcomes			
		Live births	SB	EFM	Total
Pregnancies supervised and beneficed by the assisted events by qualified personnel	Urban	22.4	10.7	9.4	21.3
	Rural	16.2	9.7	4.6	15.3
	Total-1	**38.6**	**20.4**	**14.0**	**36.6**
Pregnancies not (supervised and beneficed by the assisted events by qualified personnel)	Urban	25.6	33.9	40.5	26.7
	Rural	35.9	45.7	45.6	36.7
	Total-2	**61.4**	**79.6**	**86.0**	**63.4**
	Total	100.0	100.0	100.0	100.0

Note: Compiled by the authors from the NDS 2009–2010 data, HCP

A non-negligible impact of IUM on fertility

According to the NDS 2009–2010 data, the total pregnancy rate (TPR) and the total fertility rate (TFR) reached 2.36 and 2.17 pregnancies per woman. By place of residence, the TPR was respectively 1.93 and 2.98 in urban and rural areas. However, the TFR reached only 1.78 and 2.73 pregnancies per urban and rural woman. This reduction is due to the combined inhibitory effects of EFM and SB.

Table 4: Contribution of IUM and Its Components to Fertility Reduction

Indicators	Urban	Rural	Total
Total pregnancy rate (TPR)*	1.93	2.98	2.36
Total fertility rate (TFR)	1.78	2.73	2.17
Total stillbirth rate (TSBR)	0.07	0.12	0.09
Total early fetal mortality rate (TEFMR)	0.12	0.17	0.14
TFR without early fetal mortality (TFR-EFM)	1.90	2.90	2.31
TFR without stillbirth (TFR-SB)	1.85	2.85	2.26
TFR without intrauterine mortality (TFR-IUM)*	1.96	3.02	2.40
% of reduction in fertility due to			
Early fetal mortality (EFM)	6.2	5.9	6.0
Stillbirth (SB)	3.5	4.1	3.8
Intrauterine mortality (IUM)	9.3	9.5	9.4

Note: Calculated by the authors from the NDS 2009–2010 data, HCP
**The difference between the TPR and the TFR-IUM is because a single pregnancy can result in more than one life birth*

Without IUM, the total fertility rate (TFR-IUM) would have been 2.4 children per woman instead of the 2.17 observed: 1.96 and 3.02 in urban and rural areas. Globally, IUM reduced potential fertility by about 9.4%: 9.3% and 9.5% in urban and rural areas, respectively (Table 4). Compared to the observed fertility, IUM prevented 0.23 children per woman in 2009–2010: 0.18 and 0.29 children per woman in urban and rural areas, respectively.

Also, the total fertility rate without stillbirth (TFR-SB) would have been 2.26 instead of the 2.17 children per woman: 1.85 and 2.85, respectively, in urban and rural areas. Thus, SB reduced potential fertility by 3.8%: 3.5% and 4.1% in urban and rural areas, respectively. Compared to the observed fertility, SB Prevented 0.09 children per woman in 2009–2010: 0.07 and 0.12 children per woman in urban and rural areas, respectively.

Early fetal mortality has a relatively more significant effect than SB. Indeed, TFR-EFM reached 2.31 instead of the 2.17 children per woman: 1.90 and 2.90 in urban and rural areas, respectively. In other terms, EFM reduced fertility by 6.0%: 6.2% and 5.9% in urban and rural areas, respectively. Compared to the observed fertility, EFM prevented 0.14 children per woman in 2009–2010: 0.12 and 0.17 children per woman in urban and rural areas, respectively.

A non-negligible impact of abortion on fertility

Bongaarts' model applied to the NDS 2009–2010 data, presented in Table 5, shows that the factors with the most significant impact on fertility are contraception (54.9%) and non-marriage (49.7%), and postpartum infecundability (30.7%). By comparison, although considerable (5.0%), the role played by abortion in this decrease is limited, with only 0.12 births per woman prevented. This is close to the 0.14 births avoided (6.0%) found by the direct method in the same period, which measures the impact of the EFM.

Moreover, since the Bongaarts model may overestimate the impact of abortion on fertility reduction (Johnston & Hill, 1996; Lara et al., 2004), it is more interesting to compare the relative impact of abortion with the other proximate determinants.

In Table 5, the values of the indices and the percent contribution of the four determinants show that contraception makes the largest relative contribution to the total fertility reduction: It has the smallest index (0.451) and accounts for around 42% of the decrease from total fecundity (TF) in 2009–2010. With 0.503 and 0.693 indexes, marriage and contraception contributed over 36,0% and 19.3%, respectively, to the reduction from TF; abortion has the largest index (0.950) and makes the smallest contribution (2.7%) to fertility reduction from TF. Indeed, of 13.02 births being inhibited, 5.45 births are due to contraception, 4.71 births to non-marriage, and 2.51 births to postpartum and infecund-ability. Abortion has the minimal effect, with 0.35 births.

The decline in fertility in Morocco is due, in fact, to marital changes and the use of contraceptive methods. This effect is mainly explained by the increase in the age at first marriage (between 2004 and 2014, the average age at first marriage was around 28.5 years) and the rise of the final celibacy rate (the celibacy rate at age 55 has risen from 3.0% in 2004 to 5.9% in 2014). This is in addition to the significant use of contraception, especially modern methods (67.4%, of which 56.7% are modern methods).

Table 5: Inhibitory Effects of Marriage, Contraception, Post-partum Infertility, and Abortion in Morocco in 2009–2010

Indices of proximate determinants	Effect of determinants	% Reduction in the total fertility	% Contribution to the total fertility reduction	Avoided fertility
Marriage index (Cm)	0.503	49.7	36.1	4.71
Contraception index (Cc)	0.451	54.9	41.9	5.45
Postpartum index of infecundability (Ci)	0.693	30.7	19.3	2.51
Abortion index (Ca)	0.95	5.0	2.7	0.35
Combined effect (Cm*Cc*Ci*Ca)	0.149	85.1	100.0	13.02
Fertility				
Total fertility (TF)				15.3
TFR in the presence of abortion (TFR=TF*Cm*Cc*Ci*Ca)				2.28
TFR in the absence of abortion (TFR*=TF*Cm*Cc*Ci)				2.40
Absolute abortion effet (TFR*-TFR)				0.12
Total inhibiting effect (TF-TFR (estimated))				13.02

Note: Calculated by the authors from the NDS 2009–2010 data, HCP and NPFHS 2011 data, Ministry of Health

Additionally, applying Leridon's formula estimates that 1.76 abortions were required to avoid birth in 2009–2010 (Table 6). By dividing the total abortion rate (TAR) of 0.14 by 1.76, we assume that abortions prevented 0.08 births per woman from 2009 to 2010. Without abortion, the total fertility rate (TFR) would have been 2.26 children per woman instead of the 2.18 observed. This difference represents a reduction of at least 3.5% in the potential fertility of women aged 15–49. This percentage reduction in fertility differs from that obtained with the Bongaarts model (5.0%).

Table 6: Impact of Abortion on Age-Specific and TFR in Morocco, 2009–2010

Age group	Abortion (1)	Avoided fertility. (2)= (1)/N	Observed fertility. (3)	Potential fertility (4)=(2)+(3)	Reduction in (%)
		Age-specific rates (per 1,000)			
15–24	2.9	1.6	49.1	50.7	3.2
25–34	5.5	3.1	87.7	90.8	3.4
35–44	4.7	2.6	40.4	43.0	6.2
45–49	1.8	1.0	2.8	3.8	27.0
		Total (per woman)			
15–49	**0.14**	**0.08**	**2.18**	**2.26**	**3.5**

*Note: Calculated by the authors from the NDS 2009–2010, HCP and NPFHS 2011 data, Ministry of Health, * N = 1.76; E = 0.755*

The scale of this reduction varies according to the age group: the fertility rate of women aged 15–24 is reduced by 3.2%, and that of women aged 25–34 by 3.4%. The fertility rate of women aged 35–44 is reduced by 6.2%, and that of women aged 45–49 is reduced by more than a quarter (27.0%). The role of abortion increases with the woman's age to limit the childbearing for these women in advanced age. Therefore, the practice of abortion is not constant in women's lives but occurs mainly at the end of their fertile lives.

Discussion and conclusion

A recent universal public health problem, IUM suffers from a severe crisis of availability and quality of statistical data that depends on the legal, cultural, and religious contexts in each society concerning induced abortion (Guillaume & Rossier, 2018) and the civil registration and health information system for the other components of the IUM. These contexts also determine the reliability and validity of the methods used to measure the real IUM level and components (EFM & SB) and, consequently, its impact on fertility. To overcome this problem, it is recommended that several approaches be used to enhance the reliability and consistency of the results obtained (Singh et al., 2010).

In the present study, we used the IUM table to measure the intensity of IUM and its components (EFM & SB). The impact of this mortality on fertility was estimated using the direct method. But the impact of abortion on fertility was evaluated via two indirect methods: Bongaarts (1978) and Leridon (2002). According to these methods, three different figures were found for the common period 2009–2010.

Regarding the levels of the IUM, the Q-IUM peaked at the 2nd month of gestation (over 110% in 2009–2010), which could be explained, in large part, by religious conviction against the tolerance of abortion practice and the risk of miscarriage at early ages of conception linked to the country's health system. In Morocco, where Islam is the state religion according to the Constitution (Ministry of Justice and Freedoms, 2011), two attitudes toward abortion coexist: one prohibits voluntary termination at the conception, is the case of the Malekite school, which constitutes the basis of religion in Morocco, and the other authorizes abortion during the first 40 days of pregnancy, or even up to 120 days. In this period, according to the Hadith, the process of 'ensoulment' occurs, i.e., the moment when the soul (rūḥ) enters the fetus after conception (Belhouss et al., 2011).

In addition, the IUM levels are correlated to the place of residence and the women's characteristics at reproductive age. Indeed, the urban areas being better equipped with infrastructure offers the advantage of improving women's social, economic, and health situation, which is not allowed, of the same quality, or non-existent in rural areas. This has been confirmed by the situation of prenatal care and the assisted events according to some women's characteristics in 2009–2010. Early Fetal Mortality was more prevalent in urban than rural areas, perhaps caused by the important recourse to abortion among urban women than rural women. Bakass et al. (2009) reported that in the 1990s, the percentage of pregnancies aborted was higher in urban areas than in rural areas. The authors also indicated that the risk was higher among urban women over 35 years old, with a higher education level, belonging to higher socioeconomic classes, and using a contraceptive method more recently.

Stillbirth was higher in rural areas than in urban areas; the recourse explains this to the antenatal care, the assisted events, and the women's characteristics, which determine their attitude towards medical care. According to the 2018 National Population and Family Health Survey data (NPFHS 2018), the percentage of women who received prenatal consultations by qualified personnel (doctor or nurse/midwife) is around 95.6% and 79.6% in urban and rural areas, respectively. It should be noted that recourse to prenatal care depends mainly on the number of children per woman and education level. In this regard, in 2018, 92.4% of women consulted for the first and second births, compared to 68.8% for the fifth or more births. It can also be seen that approximately 99.6% of women with a high education level benefited from prenatal consultations compared to 82.6% of those without a certificate. At the same time, it is noted that in 2018, 96.6% of urban women received assisted childbirth by qualified personnel compared to 74.2% in rural areas (Ministry of Health, 2020).

Regarding the impact of the IUM on fertility, although the direct method and the Bongaarts method provided almost the same estimates of the impact of the EFM on fertility, their limitations may raise questions about the accuracy of the results during data collection, which depends on the interview method used, as has been shown by several methodological studies (Lara et al., 2004; Tezcan & Omran, 1981).

As for the Bongaarts method, its validity remains closely linked to the quality of available data on proximate determinants of fertility (Johnston & Westoff, 2010) and the appropriateness of the efficacy rates for each method to the country context. In the absence of these conditions, the Bongaarts method produces such variable rates, which poses the problem of determining the true indirect estimates and hence the inhibitory effects of proximate determinants of fertility.

However, Leridon's method is limited because women who had clandestine abortions could suffer serious health consequences resulting in longer conception times, subsequent infertility, or even death. As a result, the abortion-induced reduction in births may be more significant. Indeed, the quality of the estimate of the IUM and its impact on fertility depends on the quality of the data collected related to all its components, especially abortion data. Given the importance of abortion, its impact on fertility, and its multidimensional consequences, it is interesting to research the determinants associated with the recourse to abortion as a significant public health problem.

The finding shows that IUM is more prevalent in urban areas than rural areas, with an urban EFM superiority versus a rural SB superiority. The results also indicate that IUM reduced potential fertility by 9.4%: 6% is attributed to the EFM and 3.8% to SB. Although it played the smallest role in reducing potential fertility, compared to the other key proximate determinants, the inhibitory effect on fertility by abortion was estimated at 5% and 3.5% for the 2009–2010 period, using the Bongaarts and Leridon methods, respectively. The recourse to abortion is higher in urban than in rural areas among women of advanced age and used a contraceptive method more recently (Bakass et al., 2009). it seems that abortion remedies the deficiencies of family planning.

In addition to the fertility loss, IUM is poised to cause havoc on women and children's health if these individuals are not timely and properly checked, while health and well-being are of paramount importance to any civilized society. One of the main reasons this issue has failed to gain global attention is the lack of formalized agendas and actions.

Although the results are relevant, the study has some data limitations. It is based on old data because, recently, no survey was conducted. The analysis is limited to the IUM of unmarried women with no disassociation between abortions and miscarriages, which is a limitation in terms of population-level conclusions. Based on this study's findings and their implications, we recommend a few critical strategies to improve access to family planning services, including access to safe abortion services. These will help couples exercise and achieve their sexual reproductive health and rights as outlined in Sustainable Development Goals. Finally, it is essential to conduct new studies to fill evidence gaps.

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