■ Original article

Analysis of trends in birth outcomes and fertility measures in the rural population of east Azerbaijan province, Iran: 2001 - 2013

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Abstract

Background and Purpose: Birth outcomes and fertility measures are commonly evaluated in Maternal and Child Health Integrated Program (MCHIP) in the field of public health. Given the key role of time- trend study in the projection of current data to the future, this population-based study aimed to describe the significant changes of birth outcomes and fertility measures in the rural population of East Azerbaijan Province, Iran.

Methods: In this time-trend analysis, primary data of several birth outcomes and fertility measures were collected from the vital statistics of rural populations in the East Azerbaijan, recorded during 2001 - 2013. Data analysis was performed using simple linear regression to examine linear trends in these indicators.

Results: In this study, upward linear trends were observed in crude birth rate ($R^2 = 0.92$, P≤0.001), fertility rate of women aging> 35 years ($R^2 = 0.74$, P≤0.001), and low birth weight ($R^2 = 0.67$, P≤0.001). In addition, a downward linear trend was documented for neonatal mortality rate ($R^2 = 0.92$, P≤0.001).For other indicators such as stillbirth rate and adolescent fertility rate, non-linear trends were recorded.

Conclusion: Despite the noticeable reduction in the rates of neonatal mortality and stillbirth, maternal and child health is still at risk in the rural population of East Azerbaijan due to the pregnancies outside the typical childbearing age and increased rate of LBW.

Keywords: Birth outcomes, Fertility measures, Low Birth Weight, Maternal and Child Health, Trend Analysis

Introduction

Birth outcomes are defined as the significant factors that influence the mother, neonate or both at the time of birth. Among the most important variables associated with birth outcomes are maternal mortality, neonatal mortality, stillbirth rate, and low birth weight (LBW) (1).

According to target 5.A of the Millennium Development Goals (MDGs), maternal mortality rate has globally decreased by 1.4% per year during 1990 - 2000 and 3.5% during 2000 - 2013 (2).

In addition maternal mortality ratio (MMR) has dropped from 380 in 1990 to 210 per 100,000 live births in 2013 (2).

In Iran MMR has reduced from 40.1 in 1990 to 13.5 per 100,000 live births in 2013 with the annualized rate of -4.7% (-7% to -2.6%) (3). Although MMR has been on a downward trend within the past decade, this indicator may still serve as a significant sentinel of failures in the health care system (4).

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Today neonatal deaths account for 41% of the deaths under the age of five across the world (5); the global Neonatal Mortality Rate (NMR) has been estimated at 23.9 per 1,000 live births (1).In countries with low NMR, preterm birth complications such as LBW and congenital anomalies are the two main causes of neonatal deaths (6). In Iran NMR has plunged from 26 in 1990 to 11 per 1,000 live births in 2012 (2).

Stillbirth is generally defined in infants born without signs of life including breathing, movement, or heart rate (7). According to statistics, Stillbirth rate (SBR) has been calculated at 19 per 1,000 births across the world, and between 5-14.9 per 1,000 births in Iran (8).

As a surrogate measurement of prematurity, LBW has been shown to be one of the major risk factors associated with increased neonatal mortality and morbidity (2). According to a study conducted in Iran, vital statistics in rural areas have indicated that despite significant improvements in most of the health indicators in these regions within the past decades, LBW saw a gradual increase from 2.9% in 1994 to 5.1% in 2009 (9).

Fertility is a consequential parameter in the domains of public health, population change, and quality of life; changes in this parameter could remarkably influence the health of women and their offspring in a society (10). In a wide array of fertility measures, adolescent fertility rate (childbirth within the age range of 15-19 years) and fertility rate in women of the advanced reproductive age (childbirths at ≥35years) have been a major concern among medical experts due to the possibility of high-risk pregnancies (11).

Given the importance of adolescent fertility, the United Nations Funds for Population Activities (UNFPA) denominated the World Population Day to adolescent pregnancy in 2013 (12). The average Adolescent Fertility Rate (AFR) has been estimated at 49 births per 1,000 adolescent women around the world (2) while this rate accounts for 23 births per 1,000 adolescent women in Iran (13).

Birth outcomes and fertility measures play a pivotal role in the evaluation of Maternal and Child Health Integrated Program (MCHIP). Given the importance of time-trend analysis in the projection of the current childbirth data to the future, this population-based study aimed to investigate the significant changes in the birth outcomes and fertility measures in the rural population of East Azerbaijan (E.A) Province in Iran. Moreover, we attempted to encourage further studies in order to collect sufficient evidence to confirm possible correlations or causal relationships between these two health indicators.

Materials and Methods

In this time-trend analysis, primary data were extracted from the vital statistics of the rural population in E.A, recorded between 2001-2013 at the Health Informatics system (HIS) of the health care center of E.A. Primary data of birth outcomes included MMR, NMR, SBR, and LBW and the collected fertility measures were crude birth rate (CBR), general fertility rate (GFR), AFR, and fertility rate of women above 35 years. The required indicators were calculated using spreadsheet applications- designated for this purpose.

Due to the frequent verification of the registered data and high accuracy level, there were no inclusion or exclusion criteria for this study. The study protocol was approved by the Regional Ethics Committee of Tabriz University of Medical Sciences (No.5/4/7752).

Data analysis was performed using linear regression in SPSS V. 16.0 and trend direction indicator, statistical significance of linear trends, goodness-of- fit (R^2), and the mean of annual change were calculated for each indicator. In addition, Microsoft Excel 2007 was used to draw graphs and check the best Trend line options for each variable. In this study, all the P values were two- sided, and $P<0.05$ was considered as significant.

Results

General findings

In total, eight indices of birth outcomes and fertility measures were reviewed and analyzed in 253,706 births recorded in the vital statistics of E.A
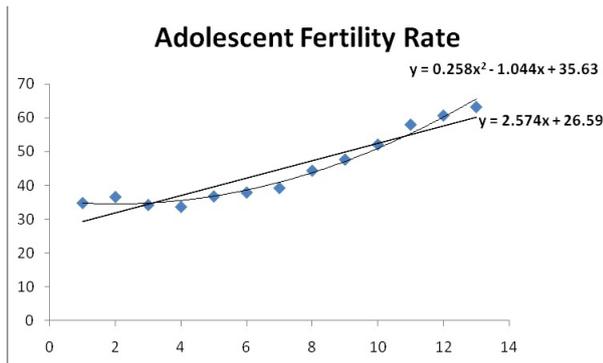
Figure 1. Comparision of Linear and Quadratic Terndlines for Adolescent Fertility Rate (AFR)

rural population during 2001 - 2013.

In this period, 4,875 deaths under five years of age were registered, 2,673 of which (about 55%) had occurred during the neonatal stage. It is also noteworthy that approximately 47% of the neonatal deaths were due to LBW and prematurity.

On the other hand, out of 52 maternal deaths which had occurred during the study period, 17 cases (one-third) were among the women at ages outside the typical child-bearing years (i.e., pregnancies at$\leq$ 20 and $\geq$35 years). Approximately one-fourth of the recorded pregnancies in the study population belonged to these two age groups.

During 2001-2013, the crude number of total and married populations of adolescent women and their live births changed from 73,232 to 42,715, 13,234 to 14,832 and 2,554 to 2,700 respectively. According

to the findings of the current analysis, while the changes in the crude numbers of married adolescent women and their live births were intangible (10% and 5%, respectively), the total number of adolescent women decreased significantly during this period (40%).

Changes in the birth outcomes and fertility measures in the rural population of E.A during 2001 - 2013 are shown in Table 1.

Trend analysis

The assumptions of linear regression including outliers, normality, linearity, constant variance, and independence (i.e.,autocorrelation) of the residuals were validated by inspecting the Normal Probability Plot (P-P) and the Scatter plot required as part of the analysis (14). In addition, to verify the normality and autocorrelation of the residuals, we performed a rigorous preliminary analysis by drawing a histogram with a best-fit normal distribution superimposed on it and calculating the Durbin-Watson statistic for each variable. The results of preliminary analyses are shown in Table 2.

Although residual analyses could verify the most significant assumption (i.e.,linearity), autocorrelation was violated in SBR, GFR and AFR. To resolve this problem we checked other Trend line options for these variables and concluded that a logarithmic scale could be an appropriate option

Table 1. Changes in Birth Outcomes and Fertility Measures in rural population of E.A (2001 – 2013)

Indicators	Initiation of trend	Termination of trend	Trend course Median (IQR)	Constant
CBR	16.6	18.9	17 (16-18)	per 1,000 Mid-year population
GFR	65	69	64 (61-66)	per 1,000 women (15-49 years)
AFR	35	63	39 (36-55)	per 1,000 women (15-19 years)
AMAFR	20	24	21 (19-22)	per 1,000 women ($\geq$35 years)
NMR	17	6	11 (7.5-14)	per 1,000 live births
MMR	21	19	20 (15-26)	per 100,000 live births
LBW	3.3	5.1	4.3 (3.9-4.6)	per 100 live births
SBR	12	7	9 (8-11.5)	per 1,000 births

CBR: Crude Birth Rate, GFR: General Fertility Rate, TFR: Total Fertility Rate, AFR: Adolescent Fertility Rate, AMAFR: Advanced Maternal Age Fertility Rate, NMR: Neonatal Mortality Rate, MMR: Maternal Mortality Ratio, LBW: Low birth weight, SBR: Stillbirth Rate, IQR: Inter-Quartile Range

Table2. Linear regression analysis of trends in birth outcomes and fertility Measures: (2001 – 2013)

Indicators	Violated assumption(s)	Goodness of fit (Adjusted R^2)	P-value	Trend type	Mean annual change
CBR	No	0.92	<0.001	Ascending Linear	0.25 per 1,000
GFR	-Independence of residuals -Normality of residuals	-	-	Quadratic	$Y=0.123X^2-1.142X+63.99$
AFR	Independence of residuals	-	-	Quadratic	$Y=0.258X^2-1.044X+35.63$
AMAFR	Normality of residuals	0.74	<0.001	Ascending Linear	0.4 per 1,000
NMR	Normality of residuals	0.92	<0.001	Descending Linear	0.9 per 1,000
MMR	No	0.005	0.32	Descending Linear	0.7 per 100,000
LBW	Normality of residuals	0.67	<0.001	Ascending Linear	0.1 per 100
SBR	-Independence of residuals -Normality of residuals	-	-	Logarithmic	$Y=-0.22In(X)+1.350$

CBR: Crude Birth Rate, GFR: General Fertility Rate, TFR: Total Fertility Rate, AFR: Adolescent Fertility Rate, AMAFR: Advanced Maternal Age Fertility Rate, NMR: Neonatal Mortality Rate, MMR: Maternal Mortality Ratio, LBW: Low birth weight, SBR: Stillbirth Rate

for SBR while curvilinear trend was considered as the most appropriate alternative for AFR and GFR. Figure 1 depicts this issue for AFR appropriately. It is noteworthy that the calculation of R square (R^2) for non-linear relationship could be misleading since Pearson product-moment correlation coefficient is not a proper statistic tool to evaluate non-linear relationships (15). Therefore, R^2 was not calculated for the aforementioned variables (SBR, GFR, and AFR) in this study. Moreover to interpret the mean of annual changes in SBR, GFR and AFR, we only noted the trend equations.

On the other hand, lack of other assumptions, such as normality and constant variance of the residuals was unlikely to significantly affect the estimations since the P value calculated for all the studied variables largely differed from the conventional value of 0.05 (16). Consequently, the linear trend was considered as the most appropriate option for most of the investigated variables, with the exception of SBR, GFR and AFR.

Discussion

In the present analysis, to avoid misleading interpretations of time series data when the variables were plotted over time (16), we performed rigorous preliminary analyses for the linear regression

assumptions. Accordingly, it was observed that with the exception of AFR, GFR, and SBR other indicators changed in a linear pattern during the study period. This finding could contribute to the accurate prediction of the changes in birth outcomes and fertility measures in the rural population of E.A region within the coming years.

Birth Outcomes

According to the results of this analysis, there was a weak linear trend in MMR in the rural population of E.A, and the insignificant per annum reduction could be disregarded. The high rate of maternal death could be prevented with access to adequate health care facilities (17). In the current study, the estimated absolute decline in MMR in the rural population of E.A was not correspondent with the national statistics; therefore, it is recommended that further research be conducted on the discovery of the root causes of maternal death among this population.

In the present study, statistically significant downward linear trend was observed in the NMR of E.A rural population. According to this linear trend, we concluded that with 0.9/1,000 live births, the per annum reduction of neonatal deaths among this population was higher than the national figure of 0.65/1,000 live births (2). The official annual reports by the Ministry of Health and Medical Education

in Iran show that the rate of NMR trends to reduce more slowly compared to other child death indices, such as Infant Mortality Rate (IMR) and Under-5 Mortality Rate (18). Similar to our findings, several sub-national studies have confirmed LBW and prematurity to be the most important risk factors for neonatal death (19-21).

In the present study, the frequency of LBW was found to be on rising trend in the rural population of E.A, accounting for 3.3% of neonates in 2001 and 5.1% in 2013. According to the literature, very young and advanced maternal ages could effectively predict the childbirths with LBW (22-25).Several studies have investigated the risk factors of LBW in Iran, stating that maternal weight gain during pregnancy could be one of the main causes of LBW in neonates (26-30). However, confirming the association between maternal weigh gain and maternal age at pregnancy requires further investigation. The overall prevalence of LBW is relatively high in Iran; nevertheless it is not regarded as a worthwhile public health interest in our country.

There is a variety of sub national data on the prevalence of LBW. For instance, the prevalence rate of LBW has been reported to be 2.9% in Mazandaran region (North of Iran) (31) 4% in Hamadan (western part of Iran) (32), 6.3% in Ardabil (Northwest of Iran) (33), 6.5% in Razavi Khorasan (Northeast of Iran) (34), and 8.8% in Yazd (central part of Iran) (35).

Fertility measures

CBR, GFR and Age-Specific Fertility Rate (ASFR) are among the basic fertility measures and CBR is considered as the most significant indicator in this regard (10). In the present study, CBR observed to have a definitive linear upward trend changing from 0.25 per 1,000 population per annum to the equal national value (19 per 1,000 population) (36) and close to the global value of 19.6 per 1,000 population (2). Ideally changes of CBR should be interpreted in accordance with SBR since reduced stillbirths will result in increased crude number of live births, eventually leading to increased CBR.

One of the prominent findings in the current study was the reduction observed in SBR trends among the rural population of E.A within the past decades. Accordingly SBR reduced to 7 per 1,000 births, while the average global rate has been estimated at 19 cases per 1,000 births (8). Similarly, another study conducted based on the national data extracted from the Iranian vital statistics of rural population, analyzed the changes in 11 main health indicators during 2003 – 2007. According to the results, there was an acceptable improvement in several of these indicators, including SBR, which was reported to be one of the achievements obtained by the implementation of rural family physician program in Iran since 2005 (37).

In another retrospective study conducted in Babol located in the North of Iran, a significant reduction was observed in SBR, changing from 10.51 in 1999 to 8.57 per 1,000 births in 2008 (38).

GFR was another fertility measure recorded in our studied population as 69 births per 1,000 women within the age range of 15-49 years. This rate was higher than the national record of 63 births per 1,000 women within the age range of 15-49 years in 2013 (39). According to the findings of the current study, AFR upward trend was the main determinant of increased GFR.

Among different ASFRs, AFR has a key role in the domain of fertility investigation today. According to the definition of the World Health Organization (WHO), adolescent fertility is the annual number of births among women ageing between 15-19 years per 1,000 women in that age group (40).

According to the obtained results of this study, increased birth rate among adolescent women is normally accompanied by a significant decrease in the total population of these individuals. This concordance led us to the observation of significant upward trends in AFR. It is noteworthy that the reduction in the number of adolescent women population after 2003 was due to reestablishment of family planning and birth control in Iran after 1989 (41). Furthermore implementing this program resulted in the decreased value of Net Reproductive Rate, which changed from 2.49 - 2.74 during 1976-85 to its minimum level of 0.88 in 2010 (42).

As depicted in Figure 1, a dramatic increase was observed in AFR trends during 2001-2013 from

35 to 63 births per 1,000 adolescent women in the rural population of E.A. The latest rate of AFR was higher compared to the global average (49 births per 1,000 adolescent women) (2), as well as the national value (23 births per 1,000 adolescent women) (13).

After the increasing trends of AFR, upward trends in other fertility indices, such as pregnancy during advanced maternal age were found to have a significant effect on GFR.

In general, it could be concluded that MCHIP in the rural population of E.A has regressed substantially due to the pregnancies outside the typical childbearing age and about one-third of the maternal deaths occurring during the period of this study could be attributed to the pregnancies among these age groups.

Strengths and Limitations

Use of population-based data was one of the greatest advantages of the current analysis. Furthermore we conducted this trend analysis using the regression model, a subset of linear models which is the most prominent statistical analysis tool. This method could be beneficial to policy makers in the projection of the current findings and proper decision-making on the reproductive, familial and public health aspects.

Additionally, trend data could be used to qualitatively evaluate the effectiveness of prevention activities, as well as to use evidence for public health policies in a certain framework. Trend data could be the key element in bringing urgent health issues to light (43).

On the other hand, the short-course trends (13 years in this study) have resulted in limitations in the external validity of our findings. It is necessary to interpret the concordance of trends carefully, because if all the variables are time-related there will be the risk of ecological fallacy (16).

Conclusion

Despite the substantial improvements in NMR and SBR, MCHIP has regressed in the rural population of E.A due to high ASFRs in pregnancies outside

the typical childbearing age as well as the growing rate of LBW. Therefore, broad trends and multiple time series are required to explore the root causes of these health issues and investigate the correlations between them.

Conflicts of interest

None declared

Author's contributions

MA developed the study concept, prepared the first draft and revised it for intellectual content. HJ was resposible for data collection and the revision for intellectual concept. SM was responsible for study concept and design, worked in data collection, statisitcal analysis, interpretration of the data, and preparatiopn of draft manuscript.

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