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Trends and geographical inequalities of the main health indicators for rural Iran†

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Background For more than three decades, the main health indicators of the rural population of Iran have been gathered using a 'vital horoscope'. In this study, we use information derived from the vital horoscope to assess trends over time and geographic patterns of inequality in these health indicators.

Methods Nine main health indicators were derived from official annual reports of the Ministry of Health & Medical Education from 1993 to 2005. Having plotted their temporal variations, we modelled their patterns and predicted their values for 2006 and 2007 using linear regression and fractional polynomial regression models. In order to illustrate spatial variations, we normalized the provincial indicators and mapped their geographical variations in two time bands: 1996–2000 and 2001–05.

Results Neonatal mortality rate (NMR), infant mortality rate (IMR) and under-5 mortality rate (U5MR) had a decreasing trend between 1993 and 2005. However, the slop for NMR ($\beta = -0.26$) was much smaller than the slopes for IMR ($\beta = -1.16$) and U5MR ($\beta = -1.60$), thus the rate of decline for NMR was less. The percentage of births attended by unskilled personnel declined from 27.2 to 7.5%, and the maternal mortality rate (MMR) declined from 47 to 34 deaths per 100 000 live births. At a provincial level, the heterogeneity in some indicators decreased (e.g. unskilled attendance at birth, IMR and total fertility rate), while we found no substantial changes in others.

Conclusion Our findings indicate a remarkable improvement in most of the health indicators in rural areas. On the other hand, there is still considerable inequality among the rural population at a provincial level.

Keywords Inequality, health indicator, vital horoscope, projection, rural, Iran

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KEY MESSAGES

- The vital horoscope is a rich source of information on the health status of the rural population in Iran, though the data derived from it have rarely been analysed systematically.
- Health status has improved in rural areas of Iran in recent years, although inequality between provinces remains an important health problem.
- Advanced statistical models can predict the future trends of health indicators and help the health system to set its targets rationally.

Introduction

After the Alma Ata conference in 1978, a new primary health care (PHC) system was implemented in Iran which has efficiently improved the national health indicators (Plan & Budget Organization and United Nations 1999; World Health Organization and Centre for Health Development 2003). The PHC Network in Iran is an integrated and stratified health care delivery system. In rural areas, rural heath centres are village-based facilities staffed by a general practitioner, several health technicians and administrative personnel, and each has 1–5 'health houses' under its supervision. The health house is the most peripheral rural facility in the network, covering an average of 1500 people. Each health house is staffed by a male and a female health worker, each known as a 'Behvarz' and each from the same village as the health house. Their principal duty is the provision of PHC services for the covered population. Every health house covers one or several villages (satellite villages), and is usually sited in a village on a route to an urban area, making it more easily accessible. By the end of 2003, more than 86% of the rural population had easy access to PHC services (Naghavi *et al*. 2005).

The information system of the rural health network mainly consists of data gathered from defined populations covered by health houses. Annual censuses are conducted by these houses to update their information on the population living within their catchment area. In addition to annual censuses, routine data are also gathered using special tools, including a 'vital horoscope', household folder, follow-up logbooks, and monthly report forms.

The 'vital horoscope' has been designed to display an up-to-the-hour account of births, deaths and family-planning activities. It consists of a sheet of paper (50 × 70cm) that is kept pinned to a wall in the health facility. The chart owes its name to the concentric coloured circles at its centre, which resemble the horoscope of ancient astrology. From the centre outwards, the circles represent live births, and mortality among infants, among children aged 1–5, and in those over 5 years of age. Each circle is divided into 12 parts, representing the months of the year. A number of small squares and circles, in turn, represent data from the main and satellite villages. Six other tables show the results of the census for that current year; more-detailed information about live births (including birth weight, type of birth attendant, sex and mother's age at delivery); maternal mortality; classification of all mortalities according to age and sex; under-5 mortalities by cause; and data on family planning activities. All data are recorded by village. A translated minimized sample of a vital horoscope, and the list of indicators extractable from it, is shown in Annex 1.

Based on the above information, the vital horoscope is a very rich source of information which can be used for the monitoring and evaluation of health system performance over time. However, the data derived from the vital horoscope have rarely been analysed systematically; there are few published academic documents in this regard.

The study reported here investigated the trends over time and patterns of inequality of health indicators in rural Iran using data from the vital horoscope. Further, some comprehensive statistical models are used to project these indicators for 2006 and 2007.

Methods

Nine indicators were analysed as the most important PHC indicators recorded in the vital horoscope between 1993 and 2005: crude birth rate (CBR; live births per 1000 population), total fertility rate (TFR; live births per woman), neonatal mortality rate (NMR), infant mortality rate (IMR), under-5 mortality rate (U5MR), maternal mortality rate (MMR), the percentage of low birth weight (LBW), prevalence of modern contraceptive use, and the percentage of births attended by unskilled personnel. The source of data was the formal national annual report of the Ministry of Health and Medical Education. The study protocol was approved by ethical committee and conformed to the principles embodied in the Declaration of Helsinki.

Statistical analysis

We illustrate the temporal variations of the selected indicators between 1993–2005 using line graphs. In addition, we predicted these indicators for 2005 and 2006. For this modelling we used linear regression. However, the linear regression model could not fit the observed data for some indicators appropriately. Therefore, we used fractional polynomial regression (FPR) models in these indicators. A short description and the rationale for using the FPR model are presented in Annex 2. In brief, FPR is a parametric regression model with extensive flexibility in catching variations.

The goodness of the models was checked by exploring the magnitude of residuals, i.e. the difference between observed and fitted values. Having used linear regression, we modelled all indicators and checked the patterns of residuals. Since we found considerable residuals in the models for MMR, LBW,

Table 1 The classification of provinces in geographic information system (GIS) maps based on their z-scores for the health indicators

Definition	Standard score range (Z score)
Highly adequate	<−2
Adequate	−2 to −1
Strong moderate	−1 to 0
Weak moderate	0 to +1
Inadequate	+1 to +2
Highly inadequate	>+2

Table 2 Correlation coefficients between health indicators and incremental year based on data derived from the vital horoscope, 1993–2005

Health indicator	Pearson correlation coefficient*
Percentage of births attended by unskilled personnel	−0.99
Under-5 mortality rate (U5MR)	−0.98
Infant mortality rate (IMR)	−0.97
Neonatal mortality rate (NMR)	−0.79
Total fertility rate (TFR)	−0.89
Crude birth rate (CBR)	−0.77
Maternal mortality rate (MMR)	−0.63
Modern contraceptive use	+0.86
Percentage of low birth weight (LBW)	+0.97

*All coefficients were significant ($P < 0.05$).

CBR, modern contraceptive use and unskilled attendance at birth, we used FPR to minimize residuals for these indicators.

Furthermore, to show whether the inequality between provinces has changed over time, we used a geographic information system (GIS) to map the spatial distributions of these indicators for two time periods, 1996–2000 and 2001–05. We used these two equal time bands to maximize our power in the comparisons; the average of the health indicator rates was used for the comparison. The data from 1993 to 1996 were not used in this part of the analysis because during this period the boundaries of some provinces were redrawn and hence their data were not comparable. The colours in the maps show the values of standardized indicators. For such standardization in each time period, we used the mean and the standard deviations of the corresponding indicators (Table 1). Therefore, the colours indicate the relative position of provinces to each other in that period of time. Thus a decreasing score of a province over time implies only that the speed of improvement in that province was slower than the average for the whole country in that particular indicator.

To show the heterogeneity of indicators across the country in each time period, we computed the standard deviations (SD). By comparing the corresponding SDs in the two time periods (1996–2000 and 2001–05), we can see if there is any change in heterogeneity between provinces.

The statistical software of STATA, version 8.0, and the Arc View program, version 3.2, were used to analyse and plot the data.

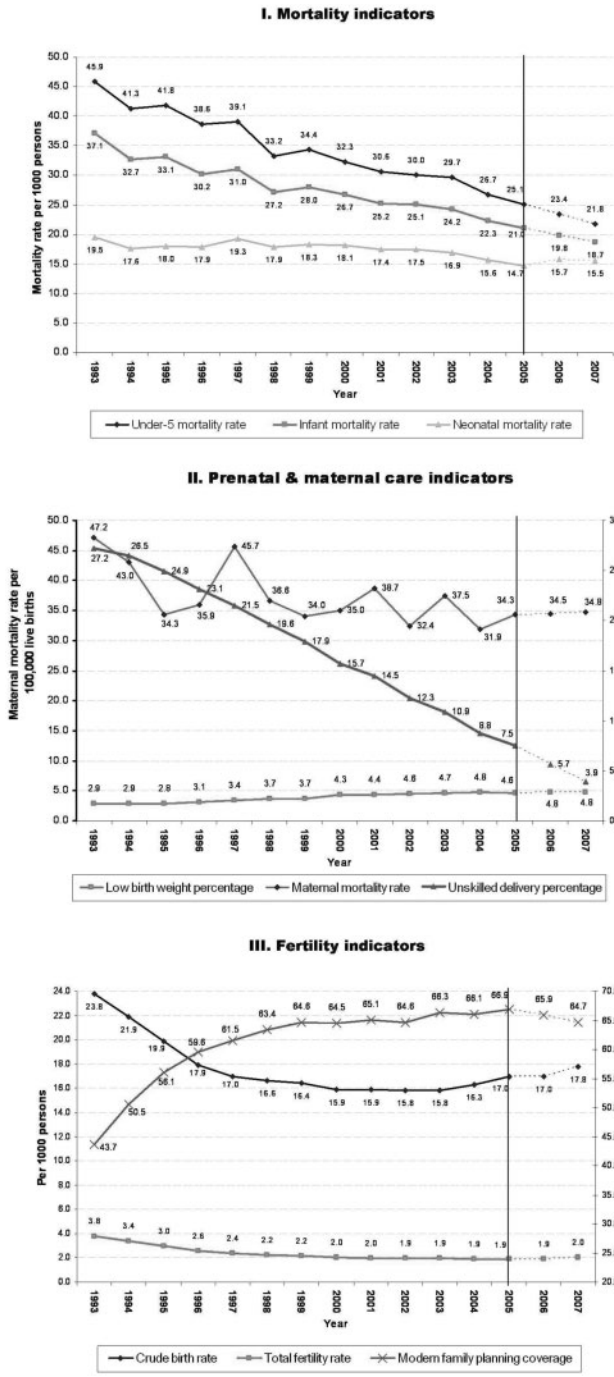

Figure 1 The trends of main health indicators for rural Iran from 1993 to 2005 and projection of the indicators for 2006 and 2007

Results

Child mortality indicators

The strongest negative correlation was found between incremental year and unskilled attendance at birth, U5MR and IMR, respectively, while the strongest positive correlation was observed between year and LBW (Table 2).

The trend of health indicators over time is shown in Figure 1. As shown in Figure 1-I, U5MR, IMR and NMR each showed

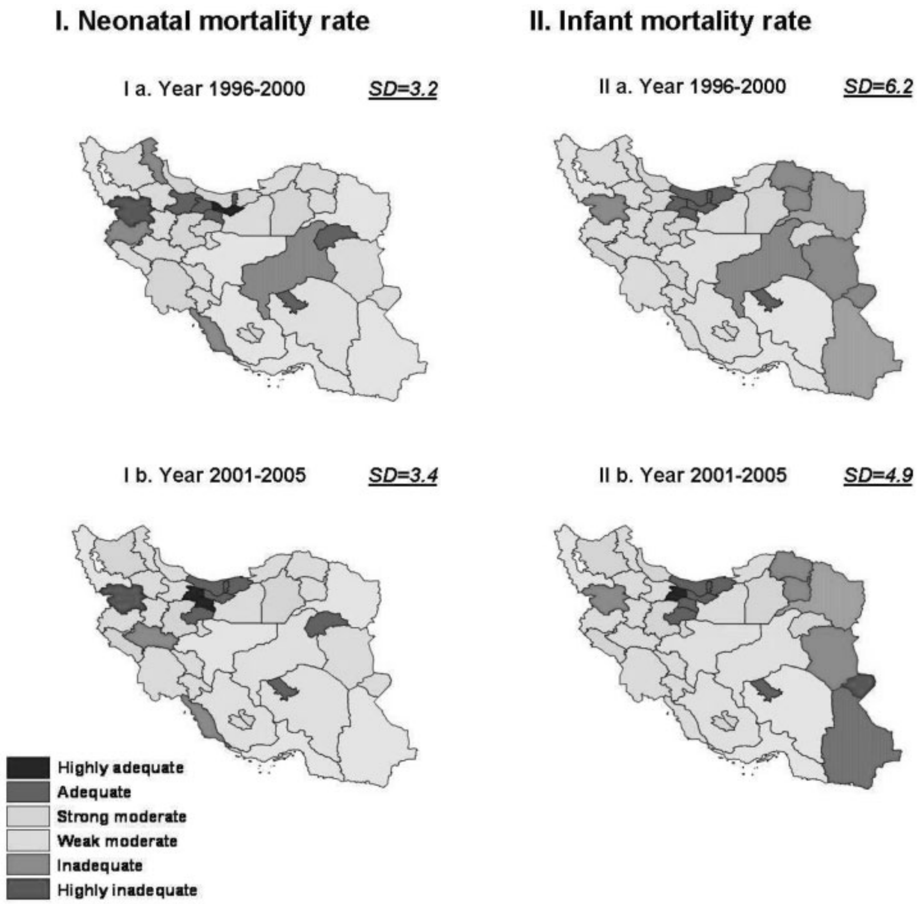

Figure 2 Geographical distribution of child mortality indicators for rural Iran, 1996–2000 and 2001–05 [standard deviation (SD) indicated at the top of each map shows the heterogeneity of that indicator across the country; increasing SD from the first time period to the second indicates increasing heterogeneity]

a decreasing trend over the 13-year period. However, the rate of decline in NMR was slower than for IMR and U5MR. The NMR declined from 19.5 per 1000 live births in 1993 to 14.7 in 2005, while the rate of decline in the U5MR was about twice this (from 45.9 to 25.1). The calculated linear regression coefficient for NMR was –0.26, while it was –1.16 and –1.60 for IMR and U5MR, respectively ($P < 0.001$ for all coefficients). This means that neonatal mortality was reduced by about only 0.26 per 1000 per year, whereas for infants and children under-5 the corresponding figure was over 1 per 1000.

There was also inequality in NMR across the country. The standard deviation of NMR differed little between the two time periods of 1996–2000 and 2001–05. The provinces of Kurdistan and Buhsher had the highest NMR, while Tehran province and the area under supervision of the Babol, Rafsanjan and Ghonabad universities had the lowest NMR (Figure 2). In addition, in some provinces, such as Ghazvin, Gilan and Khuzestan, the NMR was about 1 to 2 standard deviations lower than the country mean in the first time period, but rose to 1 standard deviation above the country mean in the second time period, i.e. their positions worsened. In terms of IMR, the heterogeneity tended to decrease between the two time periods in the country overall (Figure 2). However, the situation in some provinces, such as Sistan va Baluchestan, worsened in the second time period.

Prenatal and maternal care indicators

MMR decreased from 47 to 32 per 100 000 live births in the country as a whole between 1996–2000 and 2001–05 (Figure 1-II). Moreover, a positive but not very strong correlation was observed between MMR and unskilled attendance at birth ($r = +0.71$, $P = 0.003$). In 1996–2000, the MMR was lower in the central and northern provinces compared with provinces to the south, west and east. In the second period, this indicator was similar for most provinces, except, in particular, Sistan va Baluchestan (southeast) and Kohkilooye va Boyerahmad (southwest).

Between the first and the second period, there was a 3.5-fold decrease in births attended by unskilled personnel in the country overall (Figure 1-II). In terms of inequality, a remarkable homogeneity is observed in the latter period, except again for Sistan va Baluchestan (Figure 3).

Incidence of LBW was the only health indicator with an unexpected trend, increasing from 2.9 to 4.6% over the 13 years (1993–2005). Based on the FPR model prediction, it would not

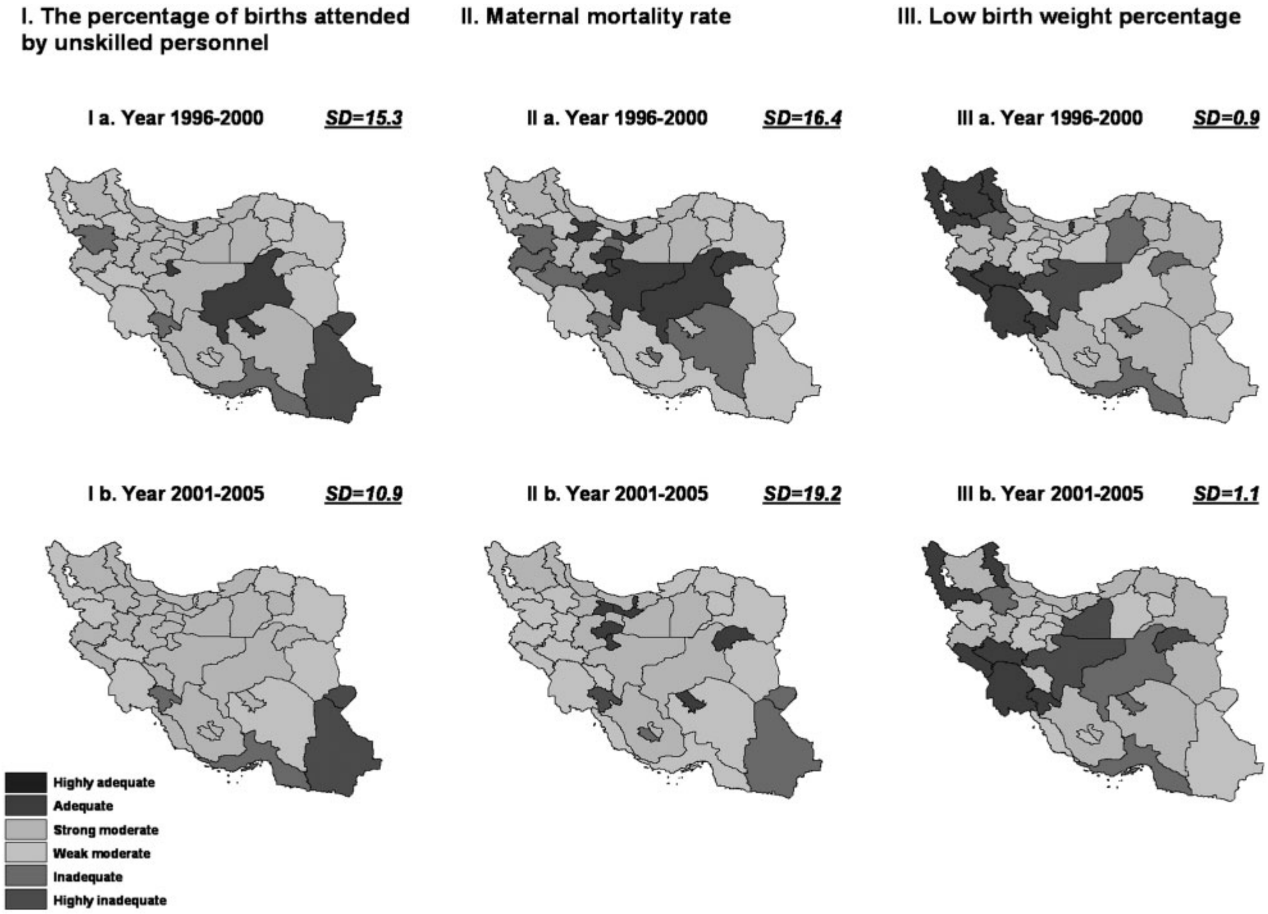

Figure 3 Geographical distribution of maternal care indicators and low birth weight for rural Iran, 1996–2000 and 2001–05 [standard deviation (SD) indicated at the top of each map shows the heterogeneity of that indicator across the country; increasing SD from the first time period to the second indicates increasing heterogeneity]

decrease in the following 2 years (Figure 1-II). Moreover, as shown by Figure 3, the pattern of inequality between provinces did not change between the two time periods. Surprisingly, incidence of LBW was high in central provinces, such as Yazd, Esfahan and Semnan, which scored highly on the other health indicators.

Fertility indicators

As expected, modern contraceptive use had a very strong negative correlation with TFR ($r = -0.99$, $P < 0.001$) and a very strong positive correlation with CBR ($r = +0.97$, $P < 0.001$). These findings, along with the strong positive correlation between TFR and CBR ($r = +0.97$, $P < 0.001$), all show appropriate consistency among the study data.

TFR decreased slightly until 2000, but it remained stable after 2000 and, according to the linear regression model prediction, would experience no significant changes in 2006 and 2007 (Figure 1-III). After a slight decrease from 1994 to 2000, CBR also increased from 15.8 per 1000 in 2002 to 17 in 2005, and we predict that this increase will have continued to 2007 based on the FPR model (Figure 1-III).

After a remarkable increase from 43.7% in 1994 to 65% in 1999, use of modern contraception remained stable until 2005. Further, the FPR model predicted that it would stay more or less constant in 2006–07 (Figure 1-III).

As Figure 4 shows, all fertility indicators other than TFR are more heterogeneous in the country in the second time period. In 1996–2000, most provinces were between 0 and 1 standard deviation lower than the country mean for TFR, whereas in 2001–05, the northern provinces and Tehran improved, but Sistan va Baluchestan, Hormozgan and Khuzestan are far from the country mean in this health indicator.

Discussion

Our findings suggest that most health indicators improved dramatically between 1993 and 2005, particularly births attended by unskilled personnel, U5MR and IMR. Other cross-sectional studies in Iran support these findings. For instance, in 1976 the NMR, IMR and U5MR were 32, 93 and 135 per 1000 live births, respectively, in Iran (Nahapetian and Khazaneh 1978), but they decreased to 18.3, 28.6 and 36 per 1000 live births, respectively, in 2000 (Ministry of Health & Medical Education and UNICEF 2000). A study in 1971 in Tehran showed that 60% of deaths occurring in children under-5 were due to upper respiratory tract infections and diarrhoea (Shanehchian 1972), while according to the country death

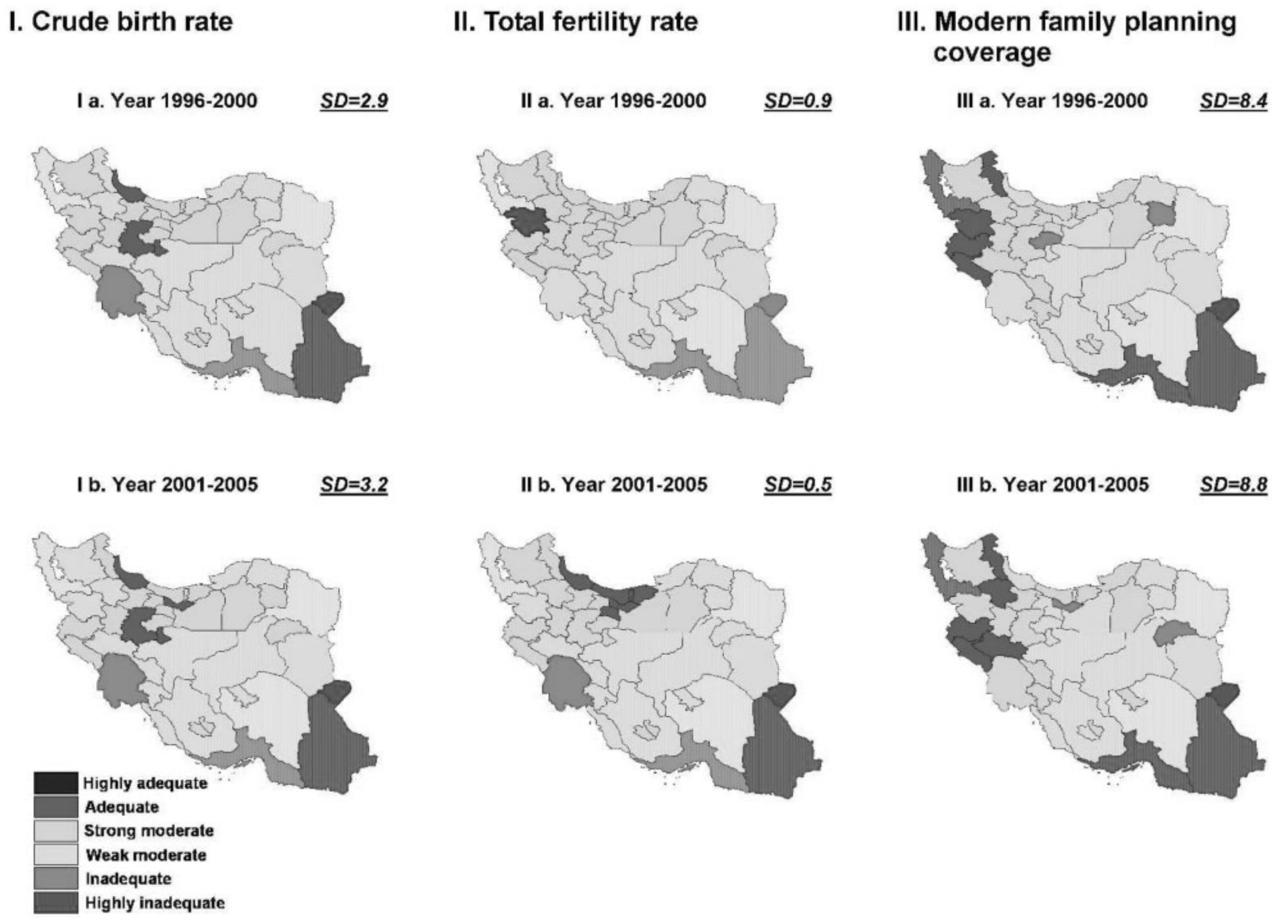

Figure 4 Geographical distribution of fertility indicators for rural Iran, 1996–2000 and 2001–05 [standard deviation (SD) indicated at the top of each map shows the heterogeneity of that indicator across the country; increasing SD from the first time period to the second indicates increasing heterogeneity]

registry in 2004, only 4.5% of deaths were due to parasitic and infectious diseases (Naghavi 2006). The reduction in child mortality is a result of the health system's success in controlling infectious diseases, previously the most common cause of death.

Our findings also show that health status improvement at national level was not comparable for all indicators, and there was inequality among the provinces for most indicators. However, for some indicators, such as births attended by unskilled personnel, TFR and IMR, the provinces have moved toward greater equality. One explanation for the move toward equality in unskilled attendance at birth might be the push by the government for student health workers and newly trained staff to work in deprived areas of the country.

There was wide variation in trends for MMR. This might be due random variation as the result of the few maternal deaths in recent years, which might explain the lack of strong positive correlation between this indicator and unskilled attendance at birth ($r = +0.71$). The fact that current maternal deaths are mostly due to high-risk pregnancies might be another explanation. Generally, high-risk pregnancies cannot be managed in rural health centres, requiring specialist care at secondary and tertiary levels. Thus, we may conclude that for further improvement in the MMR, we should pay more attention to these care levels and to the referral system.

Southeast Iran has the poorest status for the most of the indicators. The spatial patterns of the indicators are more or less comparable. Except for LBW, all of the indicators are better than the national average in northern and central provinces. The southeast province of Sistan va Baluchestan has the worst indicators. Further, the gap between it and other provinces increased in indicators such as IMR, MMR and TFR, while for other indicators the gap remained constant.

LBW was the only health indicator to increase over the time period. This increase may be explained by the limitations in prenatal care provision in the country. However, there are other possible alternative explanations. The increase could be due to better care of high-risk mothers; by reducing the risk of stillbirth and abortion as a result of better care, the risk of LBW could be increased. In addition, in 1994 around 87% of newborns were weighed, while in 2005 this had increased to 97.5%. Since this increase occurred mostly in remote areas, selection bias might have artificially distorted the true risk of LBW; i.e. in recent years, most of the LBW newborns in remote areas were weighed, but would have been missed in the past.

After a sharp decrease, TFR remained constant after 2000, while CBR showed an increasing trend in recent years. We propose two explanations for such an increase in CBR:

1. Less attention being given within the system to the family planning programme.
2. A surge in the number of young adult population as the result of the baby-boom in 1976–86, with this young and fertile population being of marriage age and mostly planning to have children early in their marriage. This change in the age-pyramid of the Iranian population could easily explain the increase in CBR, even with a constant TFR.

The remarkable decrease in child mortality is an important achievement for the health system in Iran. Nonetheless, the reduction in neonatal mortality is considerably less than that for infant and under-5 mortality. Although the IMR and U5MR include the NMR, the differences remained still considerable. The U5MR declined by more than 50% over the 13 year period, while the comparable figure for the NMR was less than 20% (Figure 1-I). This is consistent with findings of other studies of both the rural and urban population. For instance, the U5MR declined nearly four fold (from 135 to 36 per 1000) from 1976 to 2000 (Nahapetian and Khazaneh 1978; Ministry of Health & Medical Education and UNICEF 2000), whereas the NMR experienced a reduction of less than two fold (from 32 to 18 per 1000). A similar pattern has been reported in other developing countries such as Mexico (Vandale *et al*. 1997). However, Rutstein (2000) reviewed the mortality rates in 33 developing countries between 1990 and 2000 and did not report such a big difference in the rates of decline for NMR and IMR.

The more limited success in reducing the NMR might be due to weaknesses in prenatal care provision, particularly for high-risk pregnancies. The Iranian national death registry has shown that only around 17% of the NMR is due to chromosomal and congenital abnormalities, diagnosis and prevention of which are not easy in general. However, the registry statistics show that 65.5% of neonatal deaths are due to prenatal disorders such as pre-term labour, foetus growth retardation, respiratory disorders, intrauterine infection and neonatal infection (Naghavi 2006). Therefore, with close monitoring of high-risk pregnancies within a well-designed referral system, more neonates' lives could be saved and the NMR reduced.

We also found considerable heterogeneity in the mortality risks of children around the country. This heterogeneity was more or less constant during the study period. A recent study by Hosseinpoor *et al*. (2005), on the spatial distribution of the inequality of infant mortality in Iran, found a decreasing trend in IMR in relation to socio-economic quintiles. Overall, they showed that an infant in the lowest socio-economic quintile is more than twice as likely to die as an infant in the highest quintile.

Study limitations

Some part of the observed variation between provinces in the two time periods might be due to the regression to mean phenomena, particularly changes in extreme numbers. Hence we have emphasized the overall heterogeneity in the whole country. It is possible that a big improvement or deterioration in some provinces might be exaggerated due to the regression to mean effect.

We analysed only rural data in this study, which we consider to be the most important limitation. As explained in the methods section, data are collected by the health system in rural areas with an acceptable accuracy, and we therefore limited our analysis to these areas. We believe these data to be very rich, and their analysis provides important information on and for the health system.

Conclusions

The health status of the rural population of Iran has experienced an acceptable improvement in recent years. Although the inequality between provinces was found to decrease over the study period for some health indicators, we believe that inequality remains an important health problem. Advanced statistical models could be used to predict the trends of health indicators for future years and help the health system to set its targets more rationally.

Acknowledgements

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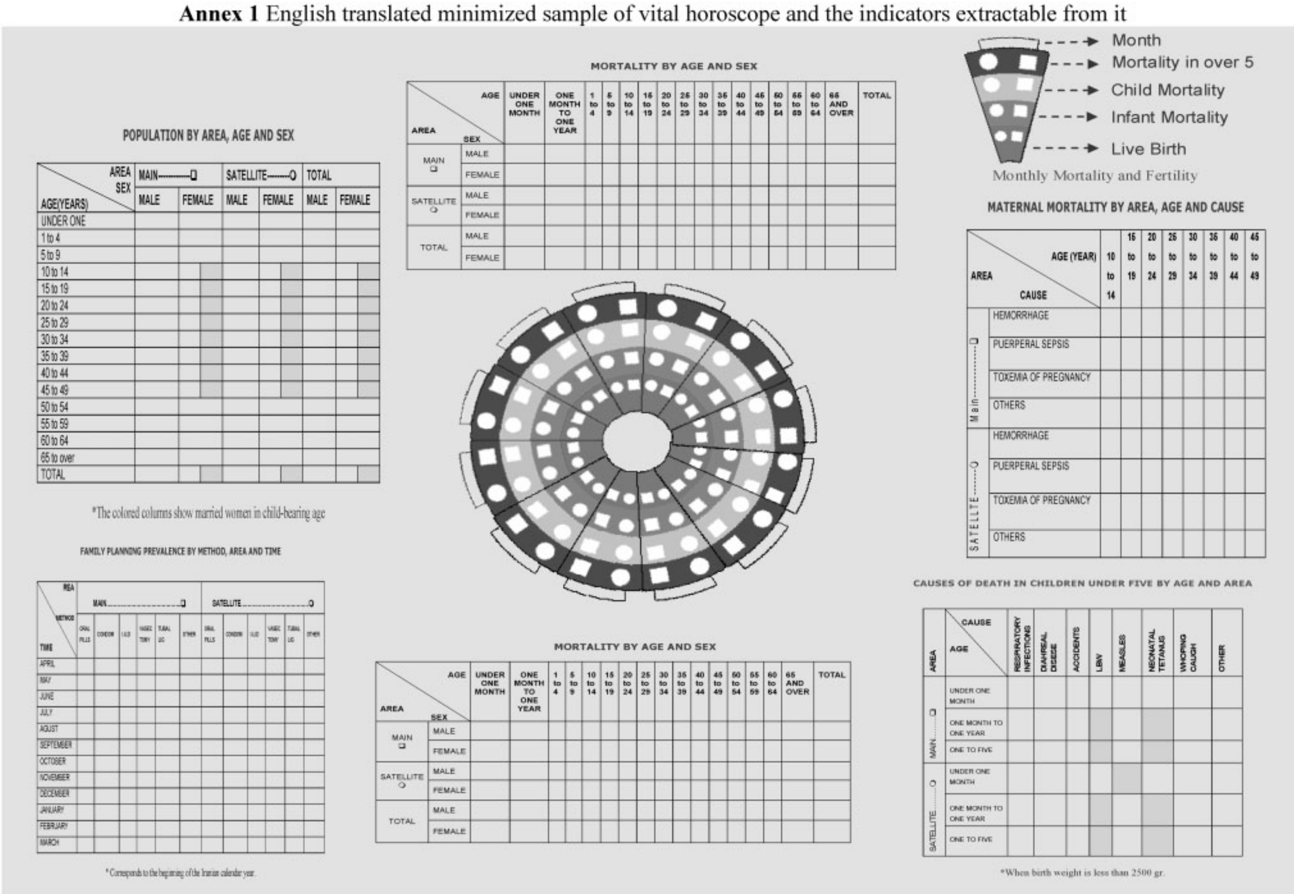
Appendix

Annex 1 English translated minimized sample of vital horoscope and the indicators extractable from it



- Population by age group
- Dependency ratio
- Crude birth rate
- Crude death rate
- Age- and sex-specific mortality rate
- Under-5 mortality rate
- Infant mortality rate
- Neonatal mortality rate by cause
- Maternal mortality rate
- General fertility rate
- Age-specific fertility rate
- Total fertility rate
- Population growth rate
- Sex ratio
- Percentage of deliveries at maternity facility or hospital
- Percentage of deliveries by trained birth attendant
- Percentage of low birth weight

Annex 2 Fractional polynomial regression

Polynomials are popular in analysis, but linear and quadratic functions are very limited in their range of curve shapes, and higher order curves may also generate undesirable artifacts, such as 'edge effects' and 'waves'. Fractional polynomial regression (Royston and Altman 1994a) is a parametric regression model which increases the flexibility afforded by the family of conventional polynomial models by using few parameters. It has a very high flexibility in catching variations by choosing the best powers for the independent variable (Royston and Altman 1994b; Royston *et al*. 1999).

By definition, a fractional polynomial model extends an ordinary polynomial model by including non-positive and fractional powers. A polynomial of degree m may be written as

$$\beta_0 + \beta_1 x + \beta_2 x^2 + \cdots + \beta_m x^m$$

Whereas a fractional polynomial of degree m has m integer and/or fractional powers $p_1 < \cdots < p_m$,

$$\beta_0 + \beta_1 x^{(p_1)} + \beta 2 x^{(p_2)} + \cdots + \beta_m x^{(p_m)}$$
$$x^{(p)} = \log x \quad \text{if } p = 0$$

The permitted powers are restricted to the set {−2, −1, −0.5, 0, 0.5, 1, 2, 3}. Experience shows that extra powers do not usually improve the goodness of fit of models considerably. Estimation involves a systematic search for the best power or combination of powers from the permitted set with the minimum corresponding deviance (defined as minus twice the log likelihood).

Since the temporal variations of health indicators do not usually follow a linear or quadratic trend, we should use more complicated formula to obtain an acceptable goodness of fit. To minimize the number of parameters and to catch the maximum temporal variations, fractional polynomial regression is an efficient alternative for the polynomial model which we use in our modelling.