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Levels and Trends of Child Mortality in Zaria Local Government Area of Kaduna State, Nigeria

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Abstract Information on child mortality at sub-national levels is scanty and where available, is fragmentary. The absence of universal, reliable and accurate vital registration system in the country generating sub-national level data on child mortality presents a challenge. This study is an attempt at responding to poor data on child mortality at sub-national level. Demographic inquiry was conducted in six political wards of Zaria between March and December 2014. Relevant demographic information was collected from women of reproductive age group using a questionnaire and indirect technique of estimating child mortality was applied to the data. The Palloni-Heligman version of the original Brass method was applied to estimate the level of child mortality. The estimated under-five and infant mortality rates of 186 and 122 per 1000 live births were recorded. Generally, infant mortality rate varied between 103 and 134 per 1000 live births while under-five mortality showed more stable estimates of between 170 and 176 per 1000 live births depending on the model life table in both situations. Child mortality estimates showed a gradual downward decline over past decades. Child mortality estimates in these communities are high even though there has been steady decline over the past years. Child mortality is still a public health challenge and more policies and programmes are urgently needed to address them as we to enter sustainable development goals era.

Keywords Child, Mortality, Residence, Zaria, North, Nigeria

1. Introduction

Worldwide, child mortality has declined by more than half from 12.7 million in 1990 to 5.9 million in 2015; with an annual average of 16, 000 deaths. The under-five mortality rate declined from 91 deaths per 1000 live births to 43 deaths per 1000 live births in the same period [1]. Similar rate of decline has been observed in sub-Saharan African region with under-five mortality rate decreasing from 180 deaths per 1000 live births to 83 deaths per 1000 live births [1].

In Nigeria, where child mortality remains a major public health challenge, such reduction has not been observed. The recent 2013 Nigeria Demographic and Health Survey (NDHS) indicates that the highest reduction in child mortality was seen among under-five rate falling 78% from 201 deaths per 1000 live births in 1999-2003 period to 128 deaths per 1000 live births in 2008-2013 period while the least reduction was among neonatal mortality rate falling from 48 deaths per 1000 live births to 37 deaths per 1000 live births [2]. Furthermore, while global child deaths burdens are on the decline, Nigeria's contribution to the global burden is on the increase. Nigeria's contribution to the global numbers of child deaths nearly doubled from around 6.7% in 1990 to 12.6% in 2015 [1]. This reversal of trend in child mortality corresponds to the period of global and national renewed efforts to address the issues of maternal and child health such as World Summit for Children in 1990 and MDGs [3, 4].

Information about child mortality at sub-national levels in Nigeria is scanty and fragmentary; in the absence of reliable, accurate and complete vital registration system it will be difficult to close the gap. While information on child mortality rates has been generated at national and in some instances at zonal levels by the DHS programme, there is need to generate such information beyond zonal level. In the past three decades a few researchers have generated child mortality rates at sub-national levels or community levels besides those generated by the DHS programme [5-9]. However, majority of these have also emphasized heavily on the determinants of child mortality except a few [8, 9]. Review of the available documented literature revealed only three earlier reports on child mortality were from northern Nigeria [9-11]. These estimates are more than three decades old and the need exist to generate recent estimates. This paucity of data on the levels and trends on child mortality as well their fragmentary nature at community level in Northern Nigeria prompted this investigation to document levels and trend in child mortality in the region.

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2. Materials and Methods

Background to the study area

Zaria is a major city in Kaduna State in Northwest geopolitical zone of Nigeria. This metropolitan city consists of two local government areas (LGAs), Zaria and Sabon Gari. Popularly and traditionally called Zazzau, it was one of the original seven Hausa city-states. According to the 2006 Census its population was 408,198 [12]. Zaria LGA is the study location bounded by Sabon Gari in the west, Soba LGA in the east and Igabi LGA in the south. The administrative headquarter is Zaria city and it has thirteen political wards seven in the northern and six in the southern division of the LGA namely Kufena, Tukur Tukur, Tudun Wada, Gyellesu, Dambo, Angwan Fatika and Kwarabai B in the north, and Angwan Juma, Angwan Limancin Kona, Kaura and Kwarbai A, Dutsen Abba and Wucicciri in the southern division of the LGA. There are thirty-six PHCs (primary health care centers) and four health clinics in the LGA. This study was conducted in five out of these wards with their estimated populations given: Angwa Juma (35,915), Angwan Limanci Kona (52,441), Dambo (41021), Kwarbai A (38,021) and Angwan Fatika (3307) wards. Each of these wards has a primary health center (PHC) run by the staff of Health Department of Zaria LGA. Data was collected in the five wards in March while data was collected in the last (Dutsen Abba) ward in December 2014 as part of the community health diagnosis of final year medical students.

Methodology

Five of the six wards were randomly selected while Dutsen Abba was purposively selected as a community for community health diagnosis posting for the final year medical students of Ahmadu Bello University, Zaria. An interviewer-administered questionnaire was used to collect relevant information for the purpose of estimating child mortality rates: age of respondent, children ever born, children still alive and children dead as well as other socio-demographic information about the respondent/ household: educational attainment, employment, marital status etc. The data required for this method are: (i) the number of children ever born, classified by five-year age group of mother; (ii) the number of children surviving (or the number dead) classified by five-year age group of mother; (iii) the total number of women (irrespective of marital status) classified by five-year age group. Since the purpose of this study was not to generalize the findings to the whole of Zaria LGA, sample size was not calculated; the aim was to estimate levels of child mortality cognizance of the fact that estimates available are over three decades old.

Statistical analysis

The analysis is based primarily on one of the two versions of the original Brass's indirect technique for indirect estimation of child mortality rates as described in the United Nations *Guide* [13]. The Trussell version [14] utilized the Trussell multipliers and adopted the Coale-Demeny model life tables (North, East, West and South) [15]. The second version is that developed by Palloni and Heligman [16], it uses the Palloni-Heligman multipliers but also requires mean age of child bearing among the women. Both these methods are based on the principle of converting the proportion of dead children among children ever born into probabilities of dying between birth and exact ages. The Palloni-Heligman version utilizes the UN model life tables (Latin America, Chilean, South Asia, Far East and General). The estimation procedure as proposed by Brass is of the form:

$$q(x) = D(i)K(i); \tag{1}$$

where $q(x)$ is the probability of dying between birth and exact age x, $D(i)$ is the proportion dead of children ever born to women in age group i and $K(i)$ is a multiplier that converts $D(i)$ into estimate of $q(x)$. The proportion of children dead is calculated from the ratio of children dead (D) and children ever born (CEB):

$$D(i) = \frac{CD(i)}{CEB(i)} \tag{2}$$

Average parity is derived in a similar manner, which is the ratio of children ever born to that of women in a given five-year age group:

$$P(i) = \frac{CEB(i)}{FP(i)} \tag{3}$$

where $P(i)$ is the average parity, and FP total number of women in a given five-year age group.

The multipliers, $K(i)$ are calculated from the Trussell regression equation:

$$K(i) = a(i) + b(i)\frac{P(1)}{P(2)} + c(i)\frac{P(2)}{P(3)} \tag{4}$$

In this study we chose the Palloni-Heligman version and therefore the coefficients $a(i)$, $b(i)$ *and* $c(i)$ are tabulated values from the Palloni-Heligman regression equation. In this exercise, we chose the General model life table of the United Nations since we believe it best suits Zaria mortality pattern [15]. In the case of Palloni-Heligman version and additional age at maternity or mean age at child bearing (MACB) was added to equation (4) above such that:

$$K(i) = a(i) + b(i)\frac{P(1)}{P(2)} + c(i)\frac{P(2)}{P(3)} + d(i)M \tag{5}$$

Where M is the mean age child bearing computed as follows:

$$M = \frac{\sum_{i=1}^{7}(B(i)mp(i))}{\sum_{i=1}^{7}B(i)} \tag{6}$$

In equation (6), *B(i)* is number of births to women in age group *i* and *mp(i)* is the mid-point in years of age group *i*. Time-dating of child mortality rates were estimated using the method developed by Brass but adopting separate coefficients for Palloni-Heligman equations [16]. The time-reference to which the estimates refer to are derived from, again Brass's equation using multipliers for Trussell and Palloni-Heligman separately:

$$t(i) = e(i) + f(i)\frac{P(1)}{P(2)} + g(i)\frac{P(2)}{P(3)} \qquad (7)$$

Where *t(i)* refers to time (in years) to which the estimate refer to before the survey, *e(i), f(i)* and *g(i)* are the coefficients from the tabulated values. Once the values of *t(i)* are obtained, they were converted into actual dates by subtracting them from the reference date of survey expressed in decimal terms. Finally, common indices of infant and child mortality $_1q_0$ and $_5q_0$, were derived from the estimates of $_nq_0$ by first converting $_nq_0$ into a value of α or the level of parameter of relational logit model life table. The calculated α is then used to estimate the corresponding probability of dying between birth and exact age 5, $_5q_0$. Each value of $_5q_0$ is converted into its logit $Y(n)$ by means of the relationship [17]:

$$Y(n) = 0.5\ln\left(\frac{_5q_0}{(1-{_5q_0})}\right) \qquad (8)$$

From this relationship, α is calculated for each $_5q_0$ using the following relationship:

$$\alpha = 0.5\left(\ln\left(\frac{_5q_0}{1-{_5q_0}}\right)\right) - Y^s(n) \qquad (9)$$

The $_5q_0$ are the estimated values obtained above and $Y^s(n)$ are the logit transformations of the standard life table selected, West Model Life Table at life expectancy of 60years. Series of α are then generated and for each, $_5q^c{}_0$ are calculated based on the relationship:

$$_5q^c{}_0 = \frac{e^{2(\alpha+Y^s(5))}}{1+e^{2(\alpha+Y^s(5))}} \qquad (10)$$

In this paper common indices for both $_1q_0$ and $_5q_0$ are calculated. Finally, *Mortpak* suite of programme was also used to generate child mortality estimates for all the families of model life tables used here; the output is here attached as Appendix I [18].

Assumptions

This indirect method is based on the following assumptions: 1) the age reporting by mothers does not show any digit preference or heaping; 2) the risk of child's death is independent of age of mother or any other associated factors such as socio-economic status; 3) information on children ever born and those surviving is accurate; 4) fertility and mortality patterns as well as levels remain constant; 5) the age pattern of mortality of the population is similar to the selected model life table. For the Palloni-Heligman version, MACB was assumed to be 29.80 years from the 2015 World Population Prospects [19].

3. Results

Table 1 shows information on the number of women interviewed, number of children ever born by these women as well as the number of children dead from those given birth by the cohort of women. Table 2 shows the results of the estimated child mortality using General model of the United Nations Model Life Tables (Palloni-Heligman version). It shows the average parity, the proportion of children dead among those ever born and the multiplying factors. It also shows the probability of dying between birth and exact age 1, 2, 3, 5, 10, 15 and 20; as well as the reference date to which these estimates refer. Importantly are the common indices of child mortality: $q^c{}_0$ and $_5q^c{}_0$ that where estimated to determine their trends over the previous 20years. For the six communities studied here, the corresponding infant and under-five mortality rates are 122 and 186 per 1000 live births respectively. Figures 1 and 2 show the trends in $_1q^c{}_0$ and $_5q^c{}_0$ by age group of women and reference dates for the six communities, both sexes combined. The results indicate downward trends in the levels of both $q^c{}_01$ and $_5q^c{}_0$; these probabilities of child death refer to period between June 2013 and September 2001. A dip in both $q^c{}_0$ and $_5q^c{}_0$ estimates corresponding to 2007 coinciding with women in the age group 35-39years in both versions are observed. This dip could possibly be due to under-reporting error by these women as has been reported elsewhere among older women as described in Manual X [20].

Table 1. Children ever born, children dead and age of mother Zaria, December 2014

Age of women	Number of women	Children ever born (CEB)	Children dead (CD)	Proportion dead (%)	Parity
1	2	3	4	5	6
15-19	83	102	19	0.1858	1.2321
20-24	151	388	39	0.1005	2.5698
25-29	138	572	86	0.1504	4.1429
30-34	100	422	76	0.1801	4.2200
35-39	82	465	67	0.1442	5.6667
40-44	56	357	99	0.2773	6.3750
45-49	28	254	62	0.2445	9.0556
Total	638	2559	448	0.1751	4.0113

Table 2. Estimates of infant and child mortality (both sexes) using indirect technique (Palloni-Heligman version), in six communities of Zaria, December 2014

Age of women	Average parity, P*(i)*	Proportion dead, D*(i)*	K*(i)*	Age *(x)*	*q(x)*	logit Y(n)	Standard logit $Y^s(n)$ [UN General]	α	$_1q_0$	$_5q_0$	Time reference *t(i)*	Reference date	Approximate Calendar Date
1	2	3	4	5	6	7	8	9	10	11	12	13	14
15-19	1.2321	0.1858	0.6564	1	0.1219	-0.9871	-1.2757	0.2886	0.1219	0.1684	1.36	2013.6	June 2013
20-24	2.5698	0.1005	0.8956	2	0.0900	-1.1568	-1.1793	0.0225	0.0754	0.1063	3.62	2011.3	March 2011
25-29	4.1429	0.1504	0.9774	3	0.1470	-0.8790	-1.1339	0.2549	0.1149	0.1592	5.39	2009.5	June 2009
30-34	4.2200	0.1801	1.0345	5	0.1863	-0.7371	-1.0870	0.3500	0.1357	0.1863	6.62	2008.3	March 2008
35-39	5.6667	0.1442	1.0794	10	0.1556	-0.8455	-1.0401	0.1946	0.1032	0.1437	7.53	2007.4	April 2007
40-44	6.3750	0.2773	1.0456	15	0.2900	-0.4478	-1.0122	0.5644	0.1943	0.2601	8.96	2006.0	November 2005
45-49	9.0556	0.1751	1.0579	20	0.2587	-0.5264	-0.9723	0.4459	0.1598	0.2172	12.27	2002.6	July 2002

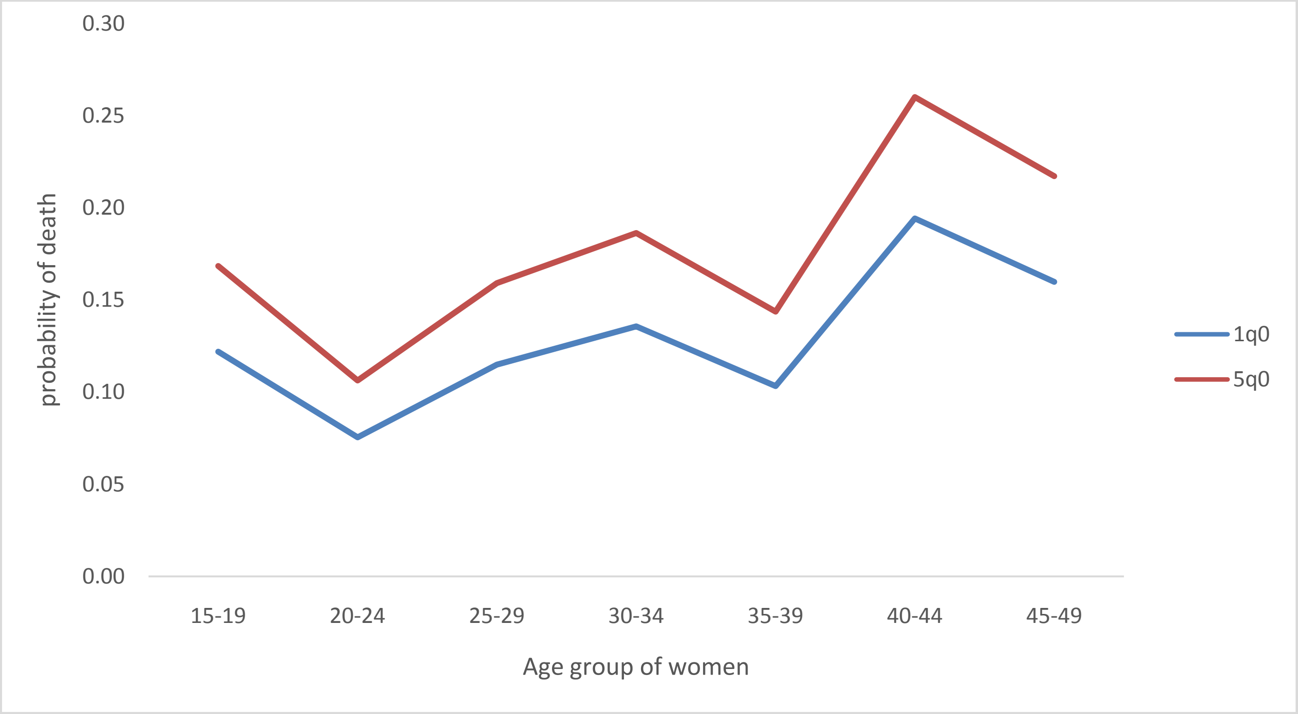

Figure 1. Trends in child mortality rates for both sexes by age group of women in six Zaria communities (Palloni-Heligman version), December 2014

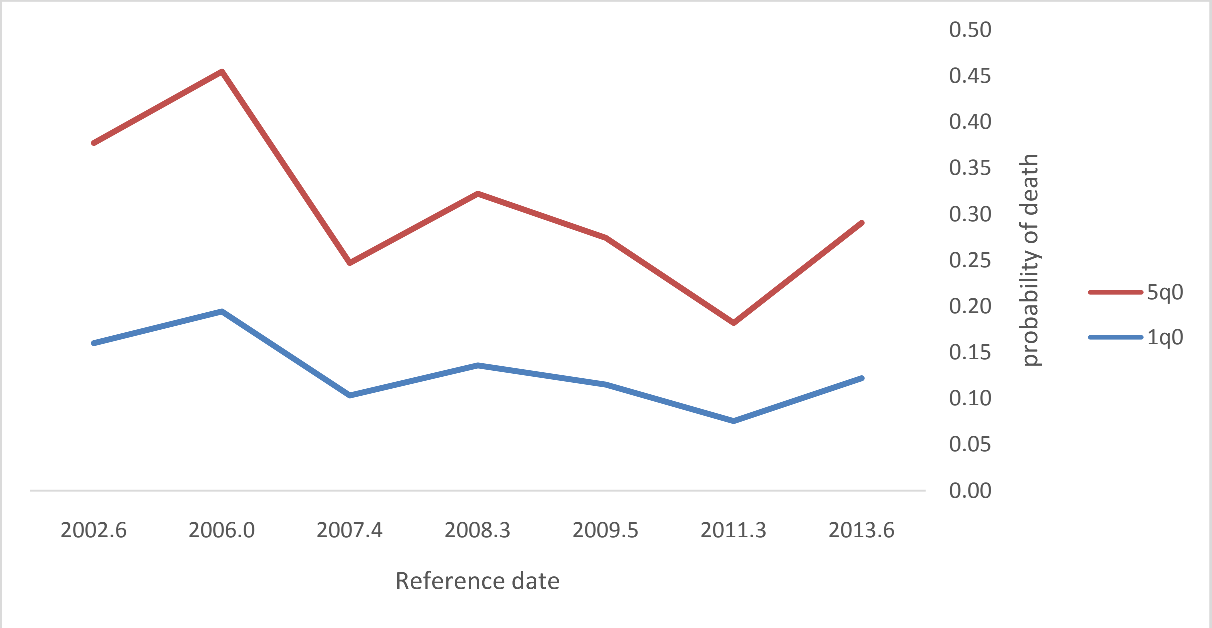

Figure 2. Trends in child mortality rates for both sexes by reference date in six Zaria communities (Palloni-Heligman version), December 2014

4. Discussion

This field survey was conducted to determine the levels and trends of child mortality in six communities in Zaria, northern Nigeria by utilizing the indirect method developed initially by Brass and further refined by Trussell and Palloni-Heligman. The DHS programme which started operation in Nigeria in mid-1980s has provided child mortality rate estimates at national levels but sub-national estimates has been very scanty. According to the recent report, the infant mortality and under-five mortality rates are 69 and 128 per 1000 respectively for the whole country; for the North West, North East and North Central zones are 89 and 185; 77 and 160; and 66 and 100 per 1000 live births [2]. The infant mortality rate estimated from our study is substantially higher than the regional and national average while under-five mortality rate virtually same with the regional average but much higher than the national average. Bradley has reported an infant and under-five mortality rates of 169 and 321 per 1000 from around two villages in Malumfashi area which is situated about 100km to the north of Zaria. However, Bradley's estimates refer to period around 1980 (35years ago). Considering the ecological, geopolitical and cultural similarities between Malumfashi and Zaria area it may be safe to infer that the infant and under-five mortality rates reported in our study is plausible considering that child mortality has declined both at national and global level; and that there has been a similar decline in child mortality over the same period. This shows that the rates of child mortality have gradually declined to current level in Zaria area over the past 35years if we use the Malumfashi mortality rates as our reference point [10]. Furthermore, child mortality rates were reported during a field posting of final year medical students of Ahmadu Bello University, Zaria during the period April/May 1985 in Yakawada area of present Giwa LGA of Kaduna State; Yakawada is around 40km to the North-West of Zaria along the major road to Sokoto. The infant and under-five mortality rates are 109 and 99 per 1000 respectively [11]. However, the Yakawada estimates indicates reversal between infant mortality and under-five rate; generally infant mortality rates are lower than under-five mortality rate except there are some events leading to excessive loss of life before the age of one year, notably measles epidemic. Udjo, in 1987 reported child mortality rates in some four villages surrounding Maiduguri area including some two wards in Maiduguri town, North Eastern Nigeria. The reported infant mortality rates ranged from 71 per 1000 in Maiduguri to an average of 123 per 1000 in the four villages around Maiduguri area. The under-five mortality rate ranged also from 132 per 1000 in Maiduguri to an average of 219 per 1000 in the four villages surveyed. Using the MDG targets for Nigeria from 213 per 1000 live births in 1990 it is reasonable that the estimates derived here are plausible; the under-five mortality rate was targeted to decline to 71 per 1000 live births by end of 2015 [9].

The fragmentary nature of these estimates from different parts of Northern Nigeria makes it difficult to make any reasonable conclusion on the levels and trends. However, from available literature, especially the serial Nigeria DHS reports it is possible to make a professional guestimate on the levels and trends of child mortality. Different components of child mortality rates have declined at varying rates; from 7.3 in under-five mortality rate to 3.1 in infant mortality rate annually. It is possible that child mortality rate has also declined in the past three decades or more drawing from decline at the national level.

The inability to make reasonable conclusion emanating from lack of data at community or sub-national level calls for the need to undertake a nation-wide vital registration system and systematic and organized surveys at sub-national levels to assess levels and trends in child mortality and other health indicators. This exercise will close the gap in lack of estimates of child mortality in the country and it will help in calibrating progress in reducing child mortality especially with the new SDGs [21]. Furthermore, the generation of child mortality rates estimates will serve as benchmark for both governmental and non-governmental agencies working in the area of improving child health [22].

5. Conclusions

Using one of the several indirect techniques of estimating child mortality, we estimated child mortality in some rural settlement in Zaria, northern Nigeria. Despite progress made in reducing mortality globally, estimates of child mortality from these communities indicate that child mortality is still high. Therefore, there is urgent need to accelerate reduction in child mortality especially in the light of achieving SDG 3.

Limitations of the Study

Estimating child mortality using the method applied here depends on the extent to which those assumptions have been met. Satisfying these assumptions is difficult in these communities where accurate reporting on age of the woman and children ever born is difficult. Fertility and mortality remaining constant or at least declining at steady rate cannot also be assumed to hold. However, it appears that model life table selected is similar to mortality pattern of these communities. Even though we have not reported here (but the results are in Appendix I just for purposes of comparison), using Mortpak to simulate child mortality show that whichever model life table chosen (either Coale-Demeny using Trussell equations or original Coale-Demeny), the estimate of child mortality are very similar. The differences are apparent using Coale-Demeny and Unite Nations model life table. As the study was not aimed at identifying the causes of child mortality, information on these causes were not captured. Finally, the social desirability poses some potential limitation on the study since the respondents' social expectation might not have aligned with that of the study.

Appendix I

1

INDIRECT ESTIMATION OF EARLY AGE MORTALITY FOR BOTH SEXES
ENUMERATION DATE: DEC 2014

AGE OF WOMAN	AVERAGE NO. CHILDREN BORN	SURVIVING	PROPORTION DEAD	AGE x	UNITED NATIONS MODELS (PALLONI-HELIGMAN EQUATIONS) LATIN AM q(x)	t(x)	CHILEAN q(x)	t(x)	SO ASIAN q(x)	t(x)	FAR EAST q(x)	t(x)	GENERAL q(x)	t(x)
15-20	1.232	1.000	.188	1	0.106	(1.2)	0.132	(1.7)	0.103	(1.2)	0.128	(1.6)	0.119	(1.4)
20-25	2.570	2.372	.077	2	0.069	(3.6)	0.074	(3.9)	0.069	(3.7)	0.070	(3.7)	0.070	(3.6)
25-30	4.143	3.190	.230	3	0.225	(5.4)	0.231	(5.6)	0.228	(5.5)	0.223	(5.4)	0.223	(5.4)
30-35	4.220	3.500	.171	5	0.174	(6.6)	0.173	(6.8)	0.176	(6.7)	0.170	(6.7)	0.171	(6.6)
35-40	5.667	4.806	.152	10	0.159	(7.5)	0.154	(7.7)	0.159	(7.6)	0.154	(7.6)	0.157	(7.5)
40-45	6.375	4.525	.290	15	0.288	(8.9)	0.290	(9.2)	0.298	(9.0)	0.288	(9.1)	0.288	(9.0)
45-50	9.056	6.444	.288	20	0.290	(12.2)	0.288	(12.6)	0.291	(12.3)	0.288	(12.4)	0.290	(12.3)

MEAN AGE AT MATERNITY = 28.90

AGE OF WOMAN	UNITED NATIONS: LATIN AM REFERENCE DATE	q	CHILEAN REFERENCE DATE	q	SO ASIAN REFERENCE DATE	q	FAR EAST REFERENCE DATE	q	GENERAL REFERENCE DATE	q
INFANT MORTALITY RATE: q(1)										
15-20	2013.8	.106	2013.2	.132	2013.7	.103	2013.4	.128	2013.6	.119
20-25	2011.4	.057	2011.1	.068	2011.3	.058	2011.2	.061	2011.3	.059
25-30	2009.6	.148	2009.4	.186	2009.5	.153	2009.5	.155	2009.6	.154
30-35	2008.4	.109	2008.2	.136	2008.3	.113	2008.3	.112	2008.4	.112
35-40	2007.5	.094	2007.3	.118	2007.3	.098	2007.4	.095	2007.4	.097
40-45	2006.1	.146	2005.8	.195	2006.0	.161	2005.9	.150	2006.0	.152
45-50	2002.8	.140	2002.3	.182	2002.7	.153	2002.5	.136	2002.7	.143

PROBABILITY OF DYING BETWEEN AGES 1 AND 5: $_{4}q_{1}$

15-20	2013.8	.070	2013.2	.040	2013.7	.060	2013.4	.081	2013.6	.073
20-25	2011.4	.025	2011.1	.013	2011.3	.023	2011.2	.023	2011.3	.023
25-30	2009.6	.123	2009.4	.075	2009.5	.117	2009.5	.112	2009.6	.114
30-35	2008.4	.073	2008.2	.043	2008.3	.071	2008.3	.065	2008.4	.067
35-40	2007.5	.057	2007.3	.033	2007.3	.056	2007.4	.049	2007.4	.052
40-45	2006.1	.120	2005.8	.082	2006.0	.127	2005.9	.106	2006.0	.111
45-50	2002.8	.112	2002.3	.073	2002.7	.117	2002.5	.090	2002.7	.101

PROBABILITY OF DYING BY AGE 5: q(5)

15-20	2013.8	.169	2013.2	.166	2013.7	.158	2013.4	.198	2013.6	.183
20-25	2011.4	.081	2011.1	.080	2011.3	.080	2011.2	.082	2011.3	.081
25-30	2009.6	.253	2009.4	.247	2009.5	.252	2009.5	.250	2009.6	.250
30-35	2008.4	.174	2008.2	.173	2008.3	.176	2008.3	.170	2008.4	.171
35-40	2007.5	.145	2007.3	.147	2007.3	.149	2007.4	.140	2007.4	.143
40-45	2006.1	.249	2005.8	.261	2006.0	.268	2005.9	.240	2006.0	.246
45-50	2002.8	.236	2002.3	.242	2002.7	.252	2002.5	.214	2002.7	.230

NOTE: A q VALUE OF .999 DENOTES VALUE FROM TABLE WITH LIFE EXPECTANCY LESS THAN 20
" .000 " GREATER THAN 100

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