Obtaining A More Refined Standardized Measure of Fertility

using Non-Reproductive Life Table

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1. The Purpose

It is welknown that, among the measures of fertility, only TFR (Total Fertility Rate) is the refined standardized measure. But, while TFR reflects well changes in fertility level, it does not reflect changes in age pattern of fertility (see Whelpton, 1946; Ryder, 1982; Feeney, 1983; Bhrolchain, 1987; Sivamurthy, 1987). The purpose of this paper is to present a summary measure named as the ICB (Intensity of Child Bearing) which is a more refined standardized measure, comparable to e(0), the expectation of life at birth for mortality measurement, that is capable of reflecting the changes in the level as well as in the age pattern of fertility. The Non-Reproductive Life Table (NRLT) is used for constructing this measure of fertility.

The NRLT will also yield Three more indexes – UPWNR (Ultimate Proportion of Women Not Reproducing , i.e. Childless Women), AFB (Average Age at First Birth), and ALB (Average Age at Last Birth) – which are also refined standardized indexes. These will provide more detailed understanding of the fertility situations in the populations.

Extending the concept of NRLT further, it is suggested to prepare a Supplementary Table which gives standardized measures of parity progression and closed birth intervals (see Sivamurthy, 1987; Bhrolchain, 1987; Feeney and Yu, 1987; Rashad, 1987). These measures are called here the Reproductive Life Table Parity Progression Ratio (RLT-PPR), and the Reproductive Life Table Closed Birth Interval (RLT-CBI), and will be very useful for comparing fertility behaviour in different populations.

Finally, numerical illustrations are given by selecting some countries around the World and a few time points.

2. The Construction of NRLT

The construction of NRLT essentially follows the construction of the Life Table for mortality measurement. For applying the life table technique, it is necessary to identify an event related to fertililty, which occurs only once in the life time of a person, like death. It is not difficult to see that the occurrence of the First birth (and of the last birth as well) is such an event. Sivamurthy has used this fact for constructing the NRLT.

Paper presented in the IUSSP International Population Conference held in Marrakech (Morocco) during 27 September to 2 October, 2009.

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Since ASFR (Age-specific Fertility Rate) by single year of age can be considered as the unconditional probability that a woman aged x years will have a birth before becoming aged

(x+1) years in completed years, it is easy to understand that the reproductive experience of a hypothetical cohort experiencing the fertility conditions represented by a set of ASFR, can be depicted in a life table format. The resulting Life Table is called the Non-Reproductive Life Table (NRLT). Suchindran and Horne (1984) have also suggested a similar approach for estimating the ages at First birth and Last birth. The NRLT suggested by Sivamurthy, however, yields more detailed information regarding the fertility conditions in a population.

In view of the fact that the gestation period for a human live birth is about 9 months and the ammenorrhea period following a live birth is at least 2 to 3 months, the probability of the occurrence of more than one live birth in one year of age of a woman, can be assumed to be negligible. It is implicitly assumed that the number of multiple births will not significantly affect the ASFR. For the same reason, it is suggested to use single year of age ASFR in the construction of NRLT. However, since the ASFR for Five year age groups will be less affected by age reporting errors and random errors, it is suggested to use always the Five year age group ASFR as the basic data and then obtain the single year of age ASFR for the construction of NRLT, by interpolating from the 5 year age group ASFR using a mathematical procedure.

Let GASFR(1), . . . ,GASFR(7) be the fertility rates for the age groups (15-19), . . . (45-49), respectively. Then, the ASFR by single year of age for ages 15, 16, . . . , 49 years can be obtained by linear interpolation as follows:

Assuming ASFR(17) = GASFR(1), ASFR(22) = GASFR(2), . . , ASFR(47) = GASFR(7),

we have : ASFR(15) = (0.5/2.5)*GASFR(1), ASFR(16) = (1.5/2.5)*GASFR(1),

ASFR(x) = K*GASFR(i)+(1–K)*GASFR(i+1) where i=1,2,…,6;

and K = (5–j +1)/5 for j=1,2, . . 5

and x = ({(i – 1) *5 +j +2} +14) for j = 1,2, …,5.

ASFR(48) = (1.5/2.5) * GASFR(7) ;

and ASFR(49) = (0.5/2.5) * GASFR(7).

Sivamurthy (1987) has shown that the use of log-linear procedure for interpolation did not make any substantial change in the results.

Now, let f(x) denote the ASFR for the age group (x, x+1), and x = a and x = b be the starting and the ending age of reproduction. In the numerical applications a = 15, & b = 50 are used. It should be noted that for comparison purposes it is necessary to keep the values of a & b the same for all the populations even if some of the f(x) values become zero at the beginning and/or at the end ages.

Since no childbearing will have occurred before age ‘a’, the NRLT is started with a radix at age ‘a’ as CL(a) = 100,000. Then the respective columns of the NRLT table are :

CL(x+1) = Number of persons in the hypothetical cohort who had no birth by age (x+1)
= CL(x) [1-f(x)] . . . . . (1)
NFB(x) = Number of first births in the age interval (x, x+1)
= CL(x) – CL(x+1) . . . . . (2)
NLB(x) = Number of last births in the age interval (x, x+1)
= CL(x).f(x)*{(1-f(x+1)) . . . . (1-f(b))} . . . (3)

ECL(x) = Expectation of Non-Reproductive life time at age x

$= \sum \{ (CL(i) + CL(i+1))/2\}/CL(x)$ where $\sum$ denotes the summation over i values from i=x to b. . . (4)

E(xM) = Expectation of reproductive life time to be spent in motherhood status from age x to b.

= [Total reproductive life time at age x] minus [ECL(x)]

= (b-x) – ECL (x) . . . . . (5)

since mortality is assumed to be not affecting.

A numerical illustration of the construction of NRLT is given in Appendix Table A.1 taking the Five years age group ASFR schedule for India for 2003 from the Census and Vital Statistics Website (Registrar General of India).

3. The New Measure of Fertility

From the NRLT, the following summary indexes can be derived :

Total Fertility Rate = TFR = $\sum \{ f(x)\}$ . . . . (6)

where $\sum$ denotes summation for x=a to b.

Expectation of reproductive life time to be spent in motherhood status at age 'a '

= E(aM) . . . . (7)

Hence, the new measure of fertility, ICB (Intensity of Child Bearing) is defined as the Average number of Children born per year of motherhood status = ICB

= [TFR/E(aM)] . . . (8)

It may be noted that ICB may vary from 0.0 to 1.0 . But, in human populations it's value will not be more than 0.4 in view of the necessity of inter-birth interval.

Other Useful Summary Indexes :

The following Three more standardized Indexes can be obtained from NRLT which are very useful in comparing fertility situations in different populations and/or over time points.

Ultimate Proportion of Women Not Reproducing (i.e. Childless Women)

= UPWNR = CL(b)/CL(a) . . . . (9)

Mean age at first birth = AFB = $\sum \{ (x+0.5) * NFB(x) \} / \sum\{ NFB(x)\}$ . . . (10)

where $\sum$ denotes the summation for x=a to b.

Mean age at last birth = ALB = $\sum \{ (x+0.5) * NLB(x)\} / \sum \{NLB(x)\}$ . . . . (11)

It is not difficult to visualize that the changes in AFB will indicate the changes in the starting of reproduction which reflects the changes in education (especially higher education) and in work participation. Similarly, changes in ALB will indicate the control of fertility (especially the termination of reproduction) in the populations. This will reflect the practice of family planning.

4. Supplementary Table of Parity Distribution

Extending the life table technique further, we can use the increment – decrement life table procedure (Schoen, 1975) to obtain an expected parity distribution for the hypothetical cohort CL(a)=100,000. From that distribution it is possible to obtain Reproductive Life Table Parity Progression Ratios (RLT-PPR) and Reproductive Life Table Inter-live birth Intervals (RLT-CBI) which are standardized measures useful for comparing the fertility behavior in the populations.

Let N(1,x) = NFB(x), denote the number of first births in the age interval (x, x+1).

Then, it is easy to see that N(2, a) = 0 since there can not be two births at age x = a, and

N(2,a+1) = [N(1,a) – N(2,a)] * f(a+1).

Hence, in general we have : $N(2,x+1) = [\sum (N(1,i)) - \sum (N(2,i))] * f(x+1)$
where $\sum$ denotes summation over i = a, (a+1), . . . , x . . . . (12)

Similarly, we have : $N(3,a) = 0$; $N(3,a+1) = 0$; and
$N(3,a+2) = [N(2,a+1) - N(3,a+1)] * f(a + 2)$
Hence, in general we have : $N(3,x+1) = [\sum (N(2,i)) - \sum (N(3,i))] * f(x+1)$
where $\sum$ denotes summation over i = a, (a+1), . . . , x . . . . (13)

This procedure can easily be repeated for as many parities (i.e. the number of births) as we may decide to take into consideration. In the numerical illustrations given in this paper, we have taken only upto parity 6 (i.e. upto Six births only). It should be noted here that for comparison of fertility behaviour in different populations, it is necessary to keep the same maximum parity for calculating RLT-PPR and RLT-CBI.

Now we can compute the RLT-PPR and RLT-CBI as follows :
RLT-PPR(1,2) = Reproductive Life Table Parity Progression Ratio from First birth to Second birth = $[\sum (N(2,x))] / [\sum (N(1,x))]$ . . . (14)
where $\sum$ denotes summation from x=a to b.
The same procedure is continued to obtain other parity progression ratios.

In order to compute the closed birth intervals, we use the following easy procedure :
MAB(1) = AFB = Mean age at First birth = $\sum [(x+0.5) * N(1,x)] / \sum [N(1,x)]$
where $\sum$ denotes summation for x=a to b.
Similarly, MAB(2) = Mean age at Second birth = $\sum [(x+0.5) * N(2,x)] / \sum [N(2,x)]$

Then, RLT-CBI(1,2) = Hypothetical Closed Birth Interval between First & Second births
= MAB(2) – MAB(1) . . . . . (15)
Similarly, RLT-CBI(2,3) = MAB(3) – MAB(2) . . . . . (16)

It is easy to follow the same procedure for other parities.

A numerical illustration of constructing the Supplementary Table is given in Appendix Table A.2, taking the ASFR schedule for India, 2003 used for constructing the Non-Reproductive Life Table (NRLT) given in Appendix Table A.1 .

5. Comparison of the Fertility Situations in Selected Countries of the World

For illustrating the use of the summary measures obtained from the NRLT and the Supplementary Table for comparing the fertility situations in different populations, these summary measures were computed for Ten countries selected from different parts of the World (United Nations, 2006) and for Three selected time points for India and Australia. The results are presented in Table 1 and Table 2. While Table 1 presents the Level and Age Pattern of Fertility in the different countries, Table 2 shows the Indexes for fertility behaviour in these populations.

From Table 1, it may be seen that the new measure ICB distinguishes the countries almost in the same way as the TFR does. But there are some clear differences. For instance, Japan (2003) has the TFR of 1.22 and Puerto Rico (2003) has the TFR of 1.71, but the ICB for both is 0.78 . This is because of the difference in the expectation of number of years spent in mother-hood status in the two countries. While the value of E(15M) in the case of Japan is only 15.7 years, the same for Puerto Rico is 22.0 years.

Table 1 : Level and Age Pattern of Fertility : Selected Countries and Years

Country / Year		Level of Fertility			Age Pattern of Fertility			
		Common Measure	New Standardized Measures		Common Measure	New Standardized Measures		
		TFR	ICB	UPWNR (per 1000)	Mean Age of ASFR	E(aM)	AFB	ALB
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)
India :	2003	2.93	0.112	42.16	27.27	26.09	22.76	32.29
	1984	4.31	0.154	8.70	28.54	27.94	21.81	36.24
	1971	5.51	0.193	2.07	29.73	28.47	21.47	39.01
Egypt	1999	3.55	0.138	20.85	29.04	25.77	23.68	34.83
Morocco	2001	2.13	0.100	108.26	30.34	21.23	26.19	34.56
Venezuela	2002	2.23	0.092	96.20	27.14	24.29	23.12	31.37
Australia	2003	1.69	0.090	171.46	30.14	18.80	27.31	32.97
	1966	2.82	0.111	48.68	27.60	25.48	23.22	32.26
	1933	2.16	0.100	103.40	29.78	21.51	26.01	33.67
Azerbaijan	2003	1.58	0.075	191.18	26.42	21.03	24.00	28.91
Netherlands	2002	1.65	0.094	177.68	31.08	17.62	28.57	33.58
Japan	2003	1.22	0.078	282.98	30.01	15.68	28.13	31.90
Puerto Rico	2003	1.71	0.078	169.00	26.37	22.00	23.53	29.30
U.S.A.	2002	1.95	0.088	129.85	27.97	22.10	24.61	31.39

Similarly, other interesting differences may be noted from Table 1. Although Azerbaijan (2003) has higher TFR than Japan (2003), it has a lower ICB. This has happened inspite of the fact that E(15M) for Azerbaijan is much higher than for Japan. The observed difference must therefore be accounted for by the difference in fertility behaviour. From Table 1 itself we have an indication of this. The mean age at first birth (AFB) for Azerbaijan is lower than for Japan, but the mean age at last birth (ALB) for Japan is much higher than for Azerbaijan. It may also be noted that the Ultimate Proportion of Women Not Reproducing (UPWNR) is very high for Japan as compared to that for Azerbaijan. A similar picture may be seen if we compare the fertility situations in Morocco (2001) and in Venezuela (2002).

It may also be observed that in recent years, UPWNR has become very high in almost all the low fertility countries – Japan, Azerbaijan, Netherlands, Australia, Puerto Rico with Japan topping the list having a very high value compared to any other country. U.S.A. and Morocco have moderately high values of UPWNR.

If we look at the trend of fertility over time, in the case of India, all the indexes indicate that fertility has been continuously declining in India ; AFB has been increasing although only slightly, and ALB has been decreasing significantly; and UPWNR has increased substantially.

On the other hand , in the case of Australia the time trend is seen to be one of increasing and then decreasing fertility, and all the indexes indicate the same trend.

Table 2 : Reproductive Life Table Parity Progression Ratios (RLT-PPR) and Closed Birth Intervals (RLT-CBI) : Selected Countries and Years

Country / Year		Standardized PPR (RLT-PPR) (per 1000)					Standardized CBI (RLT-CBI) (in number of years)				weighted average (1-5)
		(0,1)	(1,2)	(2,3)	(3,4)	(4,5)	(1-2)	(2-3)	(3-4)	(4-5)	
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
India	2003	958	849	710	580	473	3.20	2.68	2.50	2.01	2.69
	1984	991	954	878	778	674	3.50	3.00	2.90	2.40	3.00
	1971	998	986	951	889	807	3.39	3.02	3.09	2.61	3.05
Egypt	1999	979	910	799	679	568	3.31	3.09	2.53	1.85	2.79
Morocco	2001	892	718	562	444	357	4.88	3.20	2.16	1.53	3.27
Venezuela	2002	904	738	581	460	369	4.28	2.98	2.29	1.75	3.07
Australia	2003	829	619	462	354	278	4.35	2.50	1.60	1.14	2.76
	1966	951	839	691	562	457	3.53	2.78	2.29	1.73	2.73
	1933	897	725	567	447	358	4.29	3.06	2.10	1.49	3.01
Azerbaijan	2003	809	591	433	327	255	3.13	2.35	1.97	1.53	2.43
Netherlands	2002	822	609	450	342	267	4.14	2.22	1.42	1.04	2.57
Japan	2003	717	485	344	256	198	3.94	2.18	1.39	1.01	2.51
Puerto Rico	2003	831	623	465	356	280	3.77	2.53	1.96	1.51	2.69
U.S.A.	2002	870	681	522	406	323	4.11	2.75	1.96	1.40	2.90

Note :- The weights used in computing the weighted averages given in Col.(11) of this Table, are respectively the RLT-PPRs given in Col. (3), (4), (5), & (6) of this Table.

Table 2 gives summary indexes which reflect the fertility behaviour in the populations. It shows that differences in RLT- PPR (0,1) are much less than those for higher parities. This indicates that to have at least One child is a more common desire than to have more number of children in all the countries considered here. Also, the parity progression ratios are seen to decrease fast with the increase of parity for the all countries, which indicates the same behaviour. Regarding the birth intervals, it may be noted that 2.5 to 3.0 years is more or less the universal average interval between births. However, there large differences between countries in the average interval between first and second births Also, countries which have large birth interval between first and second births, are seen to have substantially lower birth intervals for later parities.

The time trend in RLT-PPR in the case of India and Australlia, is seen to be the same as the time trend in fertility as observed from Table 1. However, it should be noted that although the RLT-PPRs of India have shown a decreasing trend over time, the values are still much higher than for all other countries compared here with the exception of Egypt .

It is apparent from these observations that the standardized summary indexes presented in Table 1 and Table 2 are very useful in understanding and comparing fertility situations in the populations.,

6. Concluding Remarks and Suggestions :

From the presentation given in this paper it may be concluded that it is worthwhile for all the countries to prepare the Non-Reproductive Life Tables (NRLT) and the Supplementary Tables as a routine practice, in the same manner as the Life Tables are constructed to represent the mortality situations. Since the construction of NRLT and the Supplementary Table , requires only the ASFR, it is obviously not difficult to prepare these Tables which would yield many standardized indexes useful for understanding and comparing the fertility conditions within the countries and accross the countries. Also, it would be better to use the ASFR in Five year age groups as basic data and apply the linear interpolation to obtain ASFR by single years of age required for the construction of these reproductive life tables.

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Appendix Table A.1
Non-Reproductive Life Table for India: 2003

Age	ASFR	CL(x)	NFB(x)	NLB(x)	ECL(x)	ELSPR(x)
15	9.22	100000	922	39	8.91	26.09
16	27.66	99078	2740	121	7.99	26.01
17	46.10	96338	4441	211	7.20	25.80
18	79.76	91896	7330	398	6.53	25.47
19	113.42	84567	9592	638	6.05	24.95
20	147.08	74975	11027	970	5.76	24.24
21	180.74	63948	11558	1454	5.66	23.34
22	214.40	52390	11232	2196	5.80	22.20
23	205.78	41157	8469	2654	6.25	20.75
24	197.16	32688	6445	3167	6.74	19.26
25	205.78	26243	5400	4162	7.27	17.73
26	197.16	20843	4109	4967	8.03	15.97
27	171.30	16734	2866	5208	8.88	14.12
28	155.16	13867	2152	5584	9.61	12.39
29	139.02	11715	1629	5811	18.78	2.22
30	122.88	10087	1239	5855	10.86	9.14
31	106.74	8847	944	5694	11.32	7.68
32	90.60	7903	716	5315	11.61	6.39
33	81.30	7187	584	5191	11.71	5.29
34	72.00	6603	475	4954	11.71	4.29
35	62.70	6127	384	4603	11.58	3.42
36	53.40	5743	307	4141	11.32	2.68
37	44.10	5436	240	3578	10.93	2.07
38	38.98	5197	203	3291	10.41	1.59
39	33.86	4994	169	2959	9.81	1.19
40	28.74	4825	139	2585	9.14	0.86
41	23.62	4686	111	2176	8.39	0.61
42	18.50	4576	85	1737	7.58	0.42
43	16.16	4491	73	1542	6.72	0.28
44	13.82	4418	61	1337	5.82	0.18
45	11.48	4357	50	1124	4.89	0.11
46	9.14	4307	39	903	3.94	0.06
47	6.80	4268	29	676	2.98	0.02
48	4.08	4239	17	407	1.99	0.01
49	1.36	4222	6	136	1.00	0.00
50		4216				
Total	2930		95784	95784	-	-
Mean-Age	27.27		22.76	32.29		

Note: Basic Date of ASFR in 5 Year Age Groups are taken from.
Registrar General of India, Census and Vital Statistics Website..

Appendix Table A.2
Supplementary Table of Parity Distribution for Computing RLT-PPR and RLT-CBI

Age	ASFR	First Births	Second Births	Third Births	Fourth Births	Fifth Birhs	Sixth Birhs
15	9.22	922	0	0	0	0	0
16	27.66	2740	26	0	0	0	0
17	46.10	4441	168	1	0	0	0
18	79.76	7330	631	15	0	0	0
19	113.42	9592	1657	92	0	0	0
20	147.08	11027	3316	349	16	0	0
21	180.74	11558	5468	965	80	3	0
22	214.40	11232	7792	2110	284	20	1
23	205.78	8469	8187	3195	649	74	5
24	197.16	6445	7900	4045	1124	184	18
25	205.78	5400	7946	5015	1774	385	58
26	197.16	4109	7111	5383	2339	643	115
27	171.30	2866	5664	4973	2553	849	191
28	155.16	2152	4696	4612	2688	1033	275
29	139.02	1629	3854	4144	2676	1156	352
30	122.88	1239	3133	3627	2546	1209	410
31	106.74	944	2519	3098	2327	1193	441
32	90.60	716	1996	2577	2045	1115	443
33	81.30	584	1687	2265	1878	1076	452
34	72.00	475	1415	1965	1691	1011	445
35	62.70	384	1173	1676	1490	923	423
36	53.40	307	957	1401	1279	816	387
37	44.10	240	762	1137	1061	695	339
38	38.98	203	653	991	941	628	313
39	33.86	169	552	849	819	556	283
40	28.74	139	457	712	696	480	248
41	23.62	111	368	579	573	399	209
42	18.50	85	284	450	449	316	167
43	16.16	73	245	390	392	278	149
44	13.82	61	207	332	335	239	129
45	11.48	50	170	274	278	200	108
46	9.14	39	134	217	222	160	87
47	6.80	29	99	161	165	119	65
48	4.08	17	59	96	99	72	39
49	1.36	6	20	32	33	24	13
Total	2930	95784	81305	57728	33500	15856	6162
RLT-PPR	TFR=2.93	0.958	0.849	0.710	0.580	0.473	0.389
MeanAge	27.27	23.32	26.52	29.20	31.71	33.72	35.28
RLT-CBI	-	-	3.20	2.68	2.50	2.01	1.56