Denominator Adjusted PGE Fertility and Mortality Rates for Pakistan and Bangladesh: 1962 - 65

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Background of the Problem

The Population Growth Estimation (PGE) experiment of Pakistan, launched in 1961 to collect data on births and deaths through a sampling approach, yielded estimates of vital rates for the years 1962 through 1965. The statistics obtained through the PGE for each of the former two wings of the country namely West Pakistan (now Pakistan) and East Pakistan (now Bangladesh) were included in the two reports on PGE which also provided a description of the project design and some of the results [4, 5]. The overall aim of the PGE was to arrive at reliable estimates of birth and death rates through improved coverage by the simultaneous use of Longitudinal Registration (LR) and retrospective Cross-sectional Survey (CS), which were each independently carried out in the same sample areas. The purpose behind using the two systems was that either the registration or the survey when used alone would miss some events of births and deaths which had actually occurred, whereas under the dual system if one system failed to cover some events, the other was likely to pick these up and vice versa.

In order to arrive at an estimate which could utilize the data collected through both the systems, the events covered by both the LR and the CS systems corresponding to the overlapping time periods were matched (event to event) by comparing their related characteristics. Such matching provided three categories of events classified as (i) matched events (ii) un-matched events covered by LR only and (iii) un-matched events covered by CS only. Apart from these a fourth category of events, which were missed by both LR as well as CS, was obtained through an estimate known as Chandra-Deming (CD) estimate [2].

The PGE experiment therefore yielded the following three series of births and deaths estimates:

(i) the series based on Longitudinal Registration = LR series of estimates;

(ii) the estimates based on the Cross-sectional Survey = CS series of estimates;

(iii) the series obtained through the matching of LR and CS (and by adding all the four categories) = CD series of estimates.[1]

Among these the CD series of estimates, having been derived through the birth and death statistics based on the dual system of LR and CS, was the one which incorporated adjustments for underenumeration and underregistration. The CD estimates based on these adjustments were assumed to be more acceptable than the LR and CS estimates.

The number of vital events (the numerator in the calculation of vital rates) having been obtained through LR, CS and CD series of estimates, the corresponding mid-year population (to be used as denominator) was required for each of the calendar years over the period 1962-65 to calculate the vital rates.

In the PGE experiment the mid-year estimate of population was only obtained through the Cross-sectional Survey (CS). In other words no corresponding estimate of population was available for either LR or CD series and in working out the fertility and mortality rates for these series, the CS base population was used without any adjustments, as the denominator for the vital rates. This means that for the CS series of vital rates the numerator and the denominator came from the same source; for LR series the numerator was given by LR but the denominator came from CS; and for the CD series the numerator was adjusted (for underenumeration and underregistration) through the use of both LR and CS reported events, but the denominator remained the same as that used for LR and CS series.

The LR, CS and CD series of crude birth rates and death rates for Pakistan and Bangladesh, as given by PGE, are provided in Table 1. The table clearly shows that the CD rates are conspicuously higher than the LR and CS rates. However, in view of the fact that no corresponding adjustment for underregistration and underenumeration was made to the base population (which was used as the denominator) the CD rates must be higher than the actually prevailing rates. In other words, if the CD estimate of the number of births and deaths were assumed as accurate, then a correspondingly adjusted denominator (Population) would have given the actual prevailing rates. What was needed was to give the same importance to the adjustment of the base population size as had been given to the adjustment of vital events, and

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[1]The estimate of total number of events (N) is given by the formula

$$N = C + n_r + n_e + \frac{n_r \quad n_e}{C}$$

Where : C = matched events.
n_r = un-matched events covered by LR only.
n_e = un-matched events covered by CS only.
$\dfrac{n_r \quad n_e}{C}$ = estimate of events missed by LR as well as CS.

Table 1

PGE Crude Birth and Death Rates for Pakistan and Bangladesh: 1962—65

Series	Pakistan					Bangladesh				
	1962	1963	1964	1965	Total	1962	1963	1964	1965	Total
Crude Birth Rate (per thousand)										
CD	52	53	55	49	52	57	55	50	49	53
LR	45	42	41	39	42	47	48	43	40	44
CS	37	38	42	37	38	42	48	43	38	43
Crude Death Rate (per thousand)										
CD	19	19	20	16	18	20	19	21	20	20
LR	17	16	15	12	15	17	16	16	16	16
CS	12	11	13	9	11	13	15	17	10	14
Rate of Natural Increase (per hundred)										
CD	3.3	3.4	3.5	3.3	2.4	3.7	3.6	2.9	2.9	3.3
LR	2.8	2.6	2.6	2.7	2.7	3.0	3.2	2.7	2.6	2.8
CS	2.5	2.7	2.9	2.8	2.7	2.9	3.5	2.6	2.8	2.9

Source: [4]

* Rates are in round figures.

then to work out vital rates which were correspondingly adjusted in both the numerator and the denominator.[2]

Recognizing the error introduced in the Chandra-Deming estimate of vital rates in the First Report on PGE, it was stated that the "application of Chandra-Deming technique probably enables one to approximate more closely the number of births and deaths, but may overstate the birth and death rates some what" [5]. It was further stated in this report that this technique does not provide any solution to the errors (presumably underenumeration) of the base population. While emphasis was on estimating complete birth and death statistics, not much consideration could be given to measuring the extent of coverage of enumeration of the base population.[3]

With a view to providing a realistic perspective on the levels of fertility and mortality which might have been actually existing during the years 1962-65, an attempt has been made in this study to work out CS, LR and CD estimates of vital rates that incorporate adjustments in the denominator which correspond with the estimated number of births and deaths given by the respective series.

Methodology of Present Study

The PGE experiment having been carried out during the years 1962-65, the question does not arise, of making any effort to correct the base population from the actual sample areas. The only alternative left in order to achieve the desired objective of adjusting the denominator population is to follow some indirect approach.

We know that the population estimates given by CS were used as such to work out the LR, CS and even the Chandra-Deming (CD) series of vital rates. The same estimates of population for each of the calendar years 1962 through 1965 yield independently an average (geometric) annual rate of population growth. This rate of growth could not be affected by the extent of undercount in population, assuming that the percentage of such undercounting was the same in the population estimation for the years in question. This assumption has the following basis:

(a) The population counts were taken every time through the same (CS) system by the same organization, as such the percentage of under-enumeration should have been almost the same.

(b) The average annual geometric rate of population growth implies the balancing out of any year to year variation.

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[2]The upward bias in CD estimates of PGE was also recognized during the preparation of the fourth five-year plan projections for Pakistan Planning Commission, and some ad-hoc adjustments for the undercoverage were made in the set of fertility rates used in the projections [9].

[3]In a discussion provided on the sources of errors and problems experienced in the PGE experiment, the First Report stressed the need to keep "identity in the definitions, particularly those concerned with coverage, actually used in the field by the two independent systems and perfection in matching the two sets of events" to get the least possible estimates of births and deaths [5]. These conditions were not entirely fulfilled in PGE and as such the estimates of births and deaths were also subject to some limitations. For a detailed discussion on this aspect, reference may be made to the First and the Final Reports on PGE [4, 5].

(*c*) The same estimates of population were used as denominator in the PGE to determine the vital rates for each year, inspite of the fact that the degree of coverage in the numerator was definitely different than that of the denominator. The use of the same estimates provides a basis for estimating the rate of growth which is not dependent on the estimates of the vital events.

Knowing the fact that the population growth rate is practically equal to the rate of natural increase when migration is negligible, a comparison of the average annual growth rates with average rates of natural increase given by LR, CS and CD series should provide a basis to examine the vital rates given by the three series.

The average annual rates of population growth for the years 1962-65 obtained from the CS enumerated population for Pakistan and Bangladesh were 2.97 percent and 2.84 percent respectively. These rates when compared with the corresponding rates of natural increase for each country show that CD rates for Pakistan are on the higher side while LR and CS are on the lower side. For Bangladesh LR and CS rates are very close to the growth rate but the CD rate is higher. It must, however, be pointed out here that the same level of natural rate of increase can be obtained from different combinations of crude birth and death rates. For example if the crude birth rate is 45 per thousand and the crude death rate is 15 per thousand, the difference between the two gives the rate of natural increase as 30 per thousand or 3 percent. The same rate can, for example, be obtained from a crude birth rate of 40 and a crude death rate of 10. This means that a simple comparison of the growth rate and the rate of natural increase does not provide any basis of determining the actual levels of crude birth and death rates, even though the rates of natural increase yielded by LR and CS in Bangladesh are found to be almost equal to the population growth rate.

Adjustment of Crude Birth and Death Rates

In determining the actual levels of birth and death rates, the adjustment in the denominator has to be made in such a way that the difference in the crude birth rate and crude death rate becomes equal to the average rate of population growth given by PGE.[4]

The procedure followed to work out the denominator adjusted vital rates is explained below:

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[4]For the purpose of this study we have taken the average annual growth rate over the years 1962 and 1965, instead of the growth rates between two consecutive years, to obtain the denominator corrected PGE vital rates. The main reason behind this is that the year to year rates (are unrealistically different from each other). Such variations reflect upon the quality of enumeration of populations in the intermediate years. The issue as to which of the years provide realistic population counts has been examined in Appendix I. The exercise done in the Appendix suggests that the average annual rates of growth calculated from the population counts for 1962 and 1965 are closer to the rates which could be expected on the basis of increase and decrease in the population due to births and deaths occurring during the period between 1962 and 1965 population counts. Thus the average annual rate provides a more realistic index of the population growth during the period 1962-65 and hence the same has been used for the purposes of our study.

Given the following from the PGE results:

Number of births = B

Number of deaths = D

Average annual population growth rate = r (from the CS population enumerations)

Say, the adjusted denominator populations is P^l then the denominator corrected vital rates can be obtained as follows:

$$\text{Crude Birth Rate} = \frac{B}{P^l}$$

$$\text{Crude Death Rate} = \frac{D}{P^l}$$

The rate of natural increase being considered equal to the growth rate, we have the following equation:

$$\frac{B}{P^l} - \frac{D}{P^l} = r \quad \dots \quad \dots \quad \dots \quad (A)$$

Dividing both sides of the equation by $\dfrac{D}{P^l}$

$$\frac{B}{D} - 1 = \frac{rP^l}{D}$$

$$\text{or} \quad \frac{D}{P^l} = \left(\frac{r}{\dfrac{B}{D} - 1} \right)$$

which gives the denominator corrected crude death rate with the help of given values of B, D and r.

Now from equation "A" above, the crude birth rate can be easily obtained as follows:

Crude Birth Rate = r + Crude Death Rate

Having obtained the adjusted values of crude birth and death rates, the estimates of adjusted denominator population (P^l) can also be obtained by dividing the number of births or deaths by the corresponding vital rate.

Following this procedure the denominator adjusted vital rates obtained for CS, LR and CD series are given in Table 2.

Table 2

Estimation of Denominator Adjusted PGE Crude Birth Rates and Crude Death Rates for
Pakistan and Bangladesh : 1962—65

Type of Estimate	Pakistan			Bangladesh		
	CS	LR	CD	CS	LR	CD
1. Rate of Growth[1] (per thousand) r	29.7 (2.97 percent)	—	—	28.4 (2.84 percent)	—	—
2. Births during the years 1962-65[2] B	6,394,000	6,896,000	8,670,000	9,302,000	9,717,000	11,496,000
3. Deaths during the years 1962-65 D	1,820,400	2,500,000	3,068,300	2,999,400	3,594,700	4,382,000
4. Crude Death Rate (CDR) $r \div (\frac{B}{D} - 1)$	11.82	16.89	16.27	13.52	16.68	17.53
5. Crude Birth Rate (CBR) CDR+r	41.52	46.59	45.97	41.92	45.08	45.93

[1]r is the geometric rate of population growth obtained from the mid-year estimated population for 1962 (P_{1962}) and 1965 (P_{1965}) given by the Cross-sectional Survey with the help of the formula:

$$P_{1965} = P_{1962} (1 + \frac{r}{1000})^3,$$ where 3 is the number of years between mid-1962 and mid-1965

Or, $r = 1000 \times \sqrt[3]{\frac{P_{1965}}{P_{1962}}} - 1$, which gives the growth rate per 1000 [10].

[2]The actual population and the vital events enumerated in each PGE year and their respective rates are provided in the Appendix Table I.

A comparative picture of the unadjusted and adjusted LR and CD vital rates as given below clearly shows the extent of inflation in the PGE reported CD rates.

Type of Estimate	Pakistan				Bangladesh			
	CBR		CDR		CBR		CDR	
	LR	CD	LR	CD	LR	CD	LR	CD
Unadjusted	42	52	15	18	44	53	16	20
Adjusted	46.6	46	16.9	16.3	45.1	46	16.7	17.5
Difference	−4.6	6	−1.9	1.7	−1.1	7	−0.7	2.5

On the other hand the reported LR rates which did not incorporate adjustments, like the CD rates, for underenumerations in the numerator, increased due to the denominator adjustments carried out in this study, which required the use of the ratio of births and deaths rather than their absolute numbers as such.

A comparison of the adjusted vital rates given by CS, LR and CD from Table 2 shows that the adjusted CS rates remain considerably lower than the corresponding LR and CD vital rates. The main reason for the level of CS rates falling short of LR rates is the relatively larger extent of net underenumeration of vital events in the CS estimates than in the LR estimates [5].

In contrast to CS, the LR and CD adjusted rates are very close to each other for both Pakistan and Bangladesh. The LR rates for Pakistan are about 0.6 point higher than CD rates. For Bangladesh, however, the CD rates are 0.85 point higher than LR rates. Leaving aside these minor variations between LR and CD rates which can be attributed to different conditions of coverage and reporting in the two countries, these two series of estimates reinforce each other for both the countries.

Although the adjusted vital rates obtained for the LR and the CD series are fairly close to each other, a choice of one set of rates which more realistically represents the levels of fertility and mortality in Pakistan and Bangladesh, has to be made out of the two series. For this purpose it is to be kept in mind that in working out the adjusted vital rates for both the LR and the CD series, the same rate of growth has been used. Therefore the difference between the two can be attributed to difference in the ratios of births and deaths in the respective series. The CD estimates of births and deaths, having been obtained by pooling the data collected through LR and CS to compensate for the underreporting in both the series, was expected to approximate more closely the actual number of births and deaths [5]. Furthermore the methodology of this study required the use of the ratio of births and deaths (and not their absolute numbers), thereby minimizing to a large extent the effect of any possible overestimation of the number of vital events resulting from the use of Chandra-Deming technique

and due to matching problems. The denominator adjusted CD set of rates can therefore be considered as the ones which approximate more closely to the birth and death rates actually prevailing in the two countries during the period 1962-65.

It may be mentioned here that the estimates of vital rates obtained in this study are in close proximity to the results of an earlier study carried out by Shaw [11] which tried to adjust the denominator population for the CD rates by following a different approach than the one used in this study. Using a number of assumptions including the quasi-stability of the age structure of Pakistan, with constant fertility, declining mortality since 1921 and no under-enumeration above age 30, a correction factor was ultimately worked out which was then used to adjust the denominator population to compensate for the underenumeration. The average crude birth and death rates for the period 1961-1966 implied by this adjustment for Pakistan and Bangladesh were as follows:

	Pakistan	*Bangladesh*
Crude Birth Rate	46.3	48.2
Crude Death Rate	15.4	18.9

While the levels of vital rates suggested by Shaw's study are nearly of the same order as those worked out in this study, some of the assumptions used in his approach are very hypothetical and therefore may be considered questionable.[5]

Adjustment of Age Specific Fertility Rates

Like the Crude Birth Rates, the Age Specific Fertility Rates given by the CD series of PGE were also inflated due to the unadjusted denominator population. For the adjustment of fertility rates it has been assumed that the under-coverage of the PGE population was uniform in each age and sex group. Following this assumption the PGE (CD) age specific fertility rates for Pakistan and Bangladesh have been divided by the adjustment factor for each country.[6] This procedure provided the age specific fertility rates which were adjusted by the corrected denominator population and were obviously lower than the CD rates given in the PGE reports [4, 10]. The unadjusted and adjusted age

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[5]Some of the questionable assumptions in Shaw's study are:
   (i) the age structure of population was considered unaltered after the great epidemics in the subcontinent and subsequently due to mortality associated with killings and other factors during the partition of the subcontinent.
   (ii) the estimates of CBR and CDR as given by Kingsley Davis for the period 1921-41 were taken as such. These rates were not based on reliable estimates of vital events, the vital registration system being grossly inadequate.
   (iii) Knowing very well that the CD estimates given in PGE reports were not adjusted for the underenumeration in the denominator, the life tables based on the same set of rates were used.
[6]The denominator adjustment factor was worked-out as follows:
From the number of births B given by CD, and the denominator adjusted Crude Birth Rate (CBR) the adjusted population P', for four years 1962-65 is given by the following:

$$P' = \frac{B}{CBR}$$

The adjustment factors for Pakistan and Bangladesh obtained by dividing P' with the unadjusted population P for the same period are 1.136 and 1.144 respectively.

specific fertility rates are given in Table 3. The table also provides the corresponding estimates of General Fertility Rates (GFR), Total Fertility Rates (TFR) and Gross Reproduction Rates (GRR) for the two countries.

Table 3

Denominator Adjusted PGE (Chandra-Deming) Age Specific Fertility Rates for Pakistan and Bangladesh: 1963—65

Age Group	Pakistan		Bangladesh	
	Unadjusted Rates	Adjusted Rates	Unadjusted Rates	Adjusted Rates
(1)	(2)	(3)	(4)	(5)
15—19	.130	.114	.276	.241
20—24	.303	.267	.359	.314
25—29	.373	.328	.356	.311
30—34	.353	.311	.260	.227
35—39	.250	.220	.150	.131
40—44	.114	.100	.056	.049
45—49	.067	.059	.022	.019
G.F.R.	249	219	245	214
T.F.R.	7.95	7.00	7.40	6.46
G.R.R.	3.86	3.39	3.59	3.09

Source: For columns 2 and 4 [4].

Summary and Conclusion

The Chandra-Deming estimates of birth and death rates given by the Pakistan PGE experiment were inflated because in working-out these rates the numerator had been adjusted for underregistration and underenumeration but the denominator remained correspondingly unadjusted. This meant that if the estimates of vital events, as obtained through the application of Chandra-Deming approach were accepted to be accurate then the levels of birth and death rates obtained by using a lower unadjusted denominator population, were biased and unrealistically high. The existence of this basic error was recognized (along with many other possible errors) in the First Report on PGE, where it was stated that the CD rates were somewhat high and the LR rates were somewhat lower than the actual rates [5]. The Final Report on PGE, while pointing towards the common biases suggested by almost constant relative difference of about 20 percent between the CD and LR estimates of vital rates, was unable to assess the direction of the bias in these two PGE series. Apparently it was probably assumed that the under-coverage in population would not significantly affect the vital rates.

Reservations about this basic shortcoming and the use of the unadjusted base population in the CD rates, continued to be expressed by individuals and on the official level. One such example was that during the preparation of the

Fourth Five-year Plan Population Projections for the Pakistan Planning Commission, the Inter-department Committee, applied an ad-hoc adjustment for lowering the CD age specific fertility rates [9].

In an attempt to work-out the denominator adjusted PGE birth and death rates the methodology of the present study involved the use of the ratio of births to deaths and not their absolute numbers to achieve the desired objective. Assuming that the CD estimates of the vital events provided a closer relative measure of the births and deaths, after adjustments for underenumeration, their ratio would have remained the same whatever the size of population in the denominator (the denominator being the same in the crude birth rate and the crude death rate). This ratio has been used to determine the levels of birth and death rates which correspond to the growth rate of population given only by the CS survey in the PGE. In doing so the rate of natural increase has been taken to be equal to the rate of population growth (net migration being considered as negligible).

Following the methodology adopted in the present study the denominator adjusted CS and LR vital rates have also been worked out along with the CD rates. This has been done to provide a comparative picture of similar adjustments in all the three series.

The denominator adjusted CD crude birth rates for both Pakistan and Bangladesh have come out to be about 46, as compared to the unadjusted CD rates of 52 and 53 respectively for the two countries. Similar adjustments in LR rates have also yielded the level of vital rates of almost the same order as the CD rates. The closeness of the results of the LR and CD estimates strengthens the validity of the denominator adjustments made in this study.

The vital rates estimated by Shaw's study are also very close to those of the present study, but his approach involved a number of assumptions, many of which were unrealistic. The approach used in the present study, having been based only on the criteria of internal consistency between the ratio of the estimated number of births and deaths and the average population growth rate given by CS, is much more simple and does not require the use of any other information (or assumption) than what is already available from within the PGE data.

The estimates of denominator adjusted PGE crude birth rates, crude death rates and age specific fertility rates, worked-out in this study have important policy implications by way of providing a more realistic basis for preparing population projections. By incorporating similar adjustments in the age specific mortality rates a revised set of life tables can be worked-out, which can further lead to a more realistic estimation of underenumeration in the 1961 census population. The age distribution of the 1972 census (or that given by the 1973 Housing, Economic and Demographic Survey) of Pakistan and the 1974 census of Bangladesh can be used together with the estimates of fertility and mortality given by the present study to project more closely the current levels of the birth rates and the death rates for the two countries.[7]

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[7]The estimated levels of birth rate and death rate for Pakistan have also been provided by the Population Growth Survey (PGS) for the years 1968, 1969 and 1971 [6, 7, 8]. These estimates are, however, not comparable with CD series of PGE, the PGS having been based on a single system of Cross-sectional Survey alone. For a detailed discussion on this issue reference may be made to [1].

The adjusted estimates of the crude birth rate and age specific fertility rates given by this study also provide more realistic benchmarks for the evaluation of the impact of the Population Planning Programme of Pakistan on fertility.

An important policy implication of the results obtained through the present study is that in carrying out any future PGE type project, it would be possible to get realistic estimates of fertility and mortality rates, if the following two conditions are met:

(a) The registration and enumeration of the vital events should be accurate enough to yield the correct ratio of the number of births and deaths.

(b) The population counts in at least the initial and the terminal years of the experiment are of the same degree of accuracy, so as to yield a correct average rate of population growth.

If the above two conditions are fulfilled, there would probably, be little need to worry about deriving the base population also through a dual system,[8] similar to the one used in the PGE for getting an accurate coverage of the number of vital events.

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[8]*If an attempt is made to obtain the base population also through two systems, the [number] of persons involved for matching purposes, would be many times more (sixteen times* [than] the number of births and deaths obtained through any single system. In view of [the] problems encountered in PGE, in matching of individuals one by one, the [. . .] for the estimation of a base population would be a huge task[5].

Yearwise Growth Rates of Population Expected (Under CS Natural Increase) and of Population Actually Enumerated, Compared to Average Annual Growth Rates : 1962-65

Under the assumption of negligible migration in effect, the population in any subsequent year beyond 1962 should be equal to the population (P) in 1962 plus the net balance of the number of births (B) and deaths (D) occurring during the intervening period. Since the population was enumerated in the middle of the year, only half the number of births and deaths for the initial and terminal years are to be taken into account. For example the expected population in mid-1963 (P_{1963}) should be given by the following:

$$P_{1963} = P_{1962} + \tfrac{1}{2}\ (B_{1962} + B_{1963} - D_{1962} - D_{1963})$$

and the population for mid-1964 (P_{1964}) should be provided by:

$$P_{1964} = P_{1962} + \tfrac{1}{2}\ (B_{1962} + B_{1964} - D_{1962} - D_{1964}) + B_{1963} - D_{1963}$$

and for mid-1965 the population should be as follows:

$$P_{1965} = P_{1962} + \tfrac{1}{2}\ (B_{1962} + B_{1965} - D_{1962} - D_{1965}) + B_{1963} + B_{1964} - D_{1963} - D_{1964}$$

The expected population estimates for each year worked-out through the above procedure and the corresponding populations enumerated through CS, are provided in Appendix Table I. The annual growth rates implied by these two estimates of population are shown in parentheses.

Since the enumerated population for the years 1963, 1964 and 1965 should be nearly the same as the population expected with increase and decrease due to births and deaths occurring during the intervening period, their respective growth rates should also be comparable.[9] Similarly the yearly growth rates should also not be much different from the average annual growth rates. Such a comparison would not only indicate consistency and reliability of the actual population counts during the intervening years 1963 and 1964 but also indicate the appropriateness of the average annual geometric rate of growth over the years 1962-65, for use in our methodology to work-out the denominator adjusted vital rates.

From Appendix Table I it is observed that for both Pakistan and Bangladesh the annual growth rates of the CS enumerated actual population, are unrealistically different from each other. These rates are also different from the annual growth rates implied by expected population; the latter rates showing only slight variations from year to year (the average of the years' rates are 2.85 percent for Pakistan and 2.96 percent for Bangladesh). Since the average annual geometric rates of growth over 1962-65 for Pakistan and Bangladesh (2.97 and 2.84 respectively for the two countries) are close to the expected rates for the individual years (as well as their average), we are justified in using only these rates to work-out the denominator adjusted average vital rates for the period 1962-65.

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[9]Ideally the two estimates should be the same, but due to variation in the quality of population coverage and enumeration of vital events within the same (CS) system, the population expected under natural increase could be slightly different but not very much different.

Appendix Table I

Yearwise Enumerated and Expected CS Populations and Estimates of CS, LR and CD Vital Events for Pakistan and Bangladesh:1962—65

(in thousand)

Factor of Growth	Pakistan					Bangladesh				
	1962	1963	1964	1965	Total	1962	1963	1964	1965	Total
CS Survey										
Actual Population	39,942	40,156 (0.54)	42,390 (5.56)	43,605 (2.87)*	166,093	52,263	54,324 (3.94)	55,314 (1.82)	56,839 (2.76)*	218,740
Births	1,480	1,540	1,780	1,594	6,394	2,178	2,589	2,403	2,132	9,302
Deaths	464.2	448.4	531.7	376.1	1820.4	687.4	811.9	916.7	583.4	2999.4
Expected Population	—	40,995 (2.64)	42,165 (2.85)	43,449 (3.05)*	—	—	53,896 (3.12)	55,528 (3.03)	57,045 (2.73)*	—
LR Registration										
Births	1,791	1,694	1,717	1,694	6,896	2,458	2,586	2,374	2,299	9,717
Deaths	683.6	647.2	629.6	539.6	2500.0	876.9	867.6	958.9	891.3	3594.7
Chandra-Deming										
Births	2,064	2,118	2,333	2,155	8,670	2,969	2,985	2,747	2,795	11,496
Deaths	757.1	775.7	827.4	708.1	3068.3	1063.3	1023.5	1152.6	1142.7	4382.0

*Figures in parenthesis are growth rates from the previous year. The average annual geometric rates of growth between 1962 and 1965 for Pakistan and Bangladesh are 2.97 percent and 2.84 percent respectively.

A Brief Description of an Earlier Attempt to Solve the Problem

The first attempt to adjust the PGE denominator population for under-enumeration was made by Shaw [11]. This was done by him while carrying out an analysis of the age structure of Pakistan's population. The main objective of Shaw's study was to "set reconciled parameters that could serve as a starting point for the 1961 to 2000 projections".

Some of the assumptions used in the approach followed in Shaw's study were as follows:

(1) The age distributions of Pakistan's population given by 1961 census and the 1965 PGE, reverse survived to 1960 through PGE based life table [12] suggested the hypothesis that Pakistan had a quasi-stable age structure with constant fertility and declining mortality.

(2) The hypothesis of quasi-stability implied that there was no under-enumeration in the reported age structure above age 30.

(3) The CD birth and death rates were assumed to be accurate except for failure to adjust for underenumeration in the denominator population.

Taking the 1921 census age structure as a base, the age structure of population for the year 1961 was projected following the assumptions of mortality decline as estimated by Kingsley Davis from 1921 to 1941 [3] and then to the level indicated by the PGE for the years 1962-65 with a constant trend in fertility.

The method begins with a stable population age structure for the year 1921, holding constant the fertility measure consistent with this 1921 structure and decreasing mortality. Fertility was assumed to have been constant since 1921 and for a long period before that date [11]. The sets of life tables used for each of the five-year intervening periods were based on a schedule of mortality which gradually increased the life expectancy from the 1921 level as estimated by Davis, to the year 1961 as implied by the model life table which was consistent with that of a PGE life table constructed by using the CD estimates of age specific mortality. Once the 1961 age structure was projected for the model quasi-stable age distribution, the population of males with age 30 and over in the projected total population was worked-out. This population was then used to estimate the underenumeration of males in the 1961 census population. The corresponding estimate for females was obtained on the basis of an assumed estimate of sex ratio which was taken to remain unchanged throughout the period 1921-61. The estimates of average crude birth and death rates for the period 1961-65 implied by this adjustment in the population are provided in the text.

References

1. Afzal, Mohammad. *The Population of Pakistan.* Islamabad. The Pakistan Institute of Development Economics. 1974. (C.I.C.R.E.D. Series).

2. Chandra Sekar, C. and W. Edwards Deming. "On a Method of Estimating Birth and Death Rates and Extent of Registration". *Journal of the American Statistical Association.* Vol. 44. No. 249 March 1949.

3. Davis, Kingsley. *The Population of India and Pakistan.* Princeton University Press. 1951. (Reissued, 1968 by New York/Russell and Russell).

4. Farooqui, M. Naseem Iqbal and Ghazi Mumtaz Farooq (eds.). *Final Report of the Population Growth Estimation Experiment*: 1962-65. Dacca. The Pakistan Institute of Development Economics. 1971.

5. Pakistan Institute of Development Economics: *Report of the Population Growth Estimation Experiment: Description and Some Results for 1962 and 1963.* Karachi, 1968.

6. Pakistan. Statistics Division. *Population Growth Survey: 1968.* Karachi, 1973.

7. —————. *Population Growth Survey: 1969.* Karachi, 1975.

8. —————. *Population Growth Survey: 1971.* Karachi, 1974.

9. Pakistan. Technical Sub-Committee for the Planning Commission. "Population Projections for Pakistan". (Mimeographed). Islamabad. 1964.

10. Seltzer, W. "Benchmark Demographic Data for Pakistan: A Review of Summary Estimates Derived for the PGE Experiment". Research Report No. 66. Karachi. Pakistan Institute of Development Economics. 1968.

11. Shaw, David C. *An Analysis of the Age Structure of Pakistan.* Washington D.C. Bureau of the Census, International Demographic Center, (Research Document No. 3), 1970.

12. Yusuf, Farhat. "Abridged Life Tables for Pakistan and its Provinces, 1962-64". (International Union for the Scientific Study of Population). Contributed Papers: Sydney Conference, August 1967.