

Research Report No. 76

POPULATION GROWTH ESTIMATION: STUDIES IN METHODOLOGY II  
SAMPLE DESIGN, ESTIMATION PROCEDURES AND  
RELIABILITY OF ESTIMATES

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## INTRODUCTION

1. This is the second of a series of reports on the methodological aspects of the Population Growth Estimation (PGE) Project. In the first report some details of the two systems of data collection, viz. the longitudinal registration system (LR) and the cross sectional surveys (CS), were given along with the detailed methodology of the matching procedures used in comparing the LR and CS reports of vital events [6]. The object of this report is to present the sample design, estimation procedures and some measures of reliability of the various demographic parameters estimated from the PGE data.

## SAMPLE DESIGN

2. For drawing the PGE sample the universe was defined as the defacto population of the whole geographic area of Pakistan less the Chittagong Hill Tracts District in East Pakistan and Frontier Regions and Quetta and Kalat Divisions in West Pakistan. These areas were excluded because of their difficult terrain, very low density of population and certain other field problems [1]. In terms of population the excluded areas accounted for less than 1 per cent and about 11 per cent of the total population of East and West Pakistan respectively [1].

3. The rural areas of the four administrative divisions of East Pakistan were treated as 4 strata. Contiguous thanas in each stratum were combined to form groups of about 140,000 population each according to the 1951 Census count. There were 28 such groups in the 4 strata, from which 10 groups were selected randomly (see Appendix Table 1). The selected groups

had a total of 1,423 union councils (U.C.) One U.C. was selected from each group in the sample (see Appendix Table 2). From each selected U.C. a contiguous area inhabited by about 5,000 persons was taken as the PGE sample area.

4. The urban areas of the four administrative divisions of East Pakistan were grouped into 2 strata. These strata in all had 58 urban areas. One urban area was selected randomly from each stratum with probability proportional to its population size (see Appendix Table 3). The two selected urban areas (the cities of Mymensingh and Khulna) had 17 union committees (U.Ct). One U.Ct was selected randomly from each of these cities. From the area under the jurisdiction of the selected U.Ct. a cluster of about 5,000 population was selected as the PGE sample area.

5. The rural areas of the ten administrative divisions of West Pakistan were grouped into 8 strata (see Appendix Table 4). Contiguous tehsils in each stratum were combined to form groups of about 800,000 population according to the 1951 Census count. There were 28 such groups, from which 10 were selected randomly (see Appendix Table 5). The selected groups had a total of 67 tehsils. One tehsil was randomly selected from each group in the sample. One union council (U.C) was selected from each of the 10 selected tehsils. Contiguous areas inhabited by about 5,000 persons were selected from each of the 10 selected U.Cs.

6. The urban areas of the ten administrative divisions of West Pakistan were grouped into 2 strata (see Appendix Table 6). These strata had a total of 212 urban areas. One urban area was selected randomly from each stratum with probability of selection

proportional to the population of the area. The 2 selected areas (cities of Rawalpindi and Hyderabad) had 29 Union Committees (U.Ct). One U.Ct was selected randomly from each of these cities. A cluster of about 5,000 population was chosen from each of the selected U.Cts (see Appendix Table 6).

7. Maps and household listings were prepared for each of the 24 sample areas and the field work was started in January 1962. During the field work it was noted that the population of half of the sample areas was substantially less than the originally anticipated 5,000 persons (Tables 1A and 1B). Thus in mid 1962 the boundaries of these 12 sample areas were arbitrarily extended so as to bring them at par with the other sample areas.

8. As pointed out in a previous research report [6], two systems of data collection (viz. the LR and CS systems) were being used in PGE. In the LR system, full time registrars were stationed in 20 out of the total 24 sample areas (see Tables 1A and 1B). The registrars were expected to register all vital events occurring within the boundaries of their sample areas. In the CS system specially trained interviewers were sent to enumerate all households in the 20 sample areas, of which 16 areas were common with the LR system. The interviewers were expected to visit each sample area four times a year and to record information about the household composition and occurrence

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1. As the wards (Union Committees) in Hyderabad city were too large, they were subdivided into subwards. One subward was selected randomly and from the selected subward a cluster of about 5,000 population was selected.

TABLE 1A: SOME DETAILS OF THE EAST PAKISTAN SAMPLE FOR THE PGE PROJECT

| Name of the stratum<br>(Division) | Stratum<br>number | Estimated<br>mid 1962<br>population<br>of the<br>stratum* | Name of the<br>sample area | Area<br>code | System<br>of data<br>collection<br>used | Type of<br>area | Mid 1962<br>population<br>of the sample<br>area |                         |
|-----------------------------------|-------------------|-----------------------------------------------------------|----------------------------|--------------|-----------------------------------------|-----------------|-------------------------------------------------|-------------------------|
|                                   |                   |                                                           |                            |              |                                         |                 | before<br>exten-<br>sion                        | after<br>exten-<br>sion |
| EAST PAKISTAN                     |                   |                                                           |                            |              |                                         |                 |                                                 |                         |
| Rajshahi                          | 1                 | 11,783,468                                                | Barasanglashi              | 110          | LR and CS                               | Rural           | 4,100                                           | 4,550                   |
| Khulna                            | 2                 | 10,002,670                                                | Dighapatia                 | 111          | LR and CS                               | Rural           | 5,500                                           | 5,500                   |
|                                   |                   |                                                           | Dhalbaria                  | 122          | LR and CS                               | Rural           | 5,350                                           | 5,350                   |
| Chittagong                        | 3                 | 13,107,709                                                | Padrisibpur                | 123          | LR and CS                               | Rural           | 4,700                                           | 4,700                   |
|                                   |                   |                                                           | Kulaura                    | 134          | LR and CS                               | Rural           | 4,400                                           | 5,200                   |
| Dacca                             | 4                 | 14,761,201                                                | Belghar                    | 135          | LR and CS                               | Rural           | 4,900                                           | 4,900                   |
|                                   |                   |                                                           | Patabhog                   | 146          | LR only                                 | Rural           | 4,550                                           | 4,550                   |
|                                   |                   |                                                           | Jafarabad                  | 147          | LR only                                 | Rural           | 2,500                                           | 3,200                   |
|                                   |                   |                                                           | Paratali                   | 148          | CS only                                 | Rural           | 5,100                                           | 5,100                   |
|                                   |                   |                                                           | Itail                      | 149          | CS only                                 | Rural           | 4,400                                           | 5,100                   |
| Dacca and Chittagong              | +-5               | 1,753,707                                                 | Mymensingh                 | 150          | LR and CS                               | Urban           | 3,600                                           | 5,750                   |
| Rajshahi and Khulna               | +-6               | 963,696                                                   | Khulna                     | 161          | LR and CS                               | Urban           | 5,000                                           | 5,500                   |

\*Estimated by inflating the 1961 Census population by a growth rate of 2.6 percent per annum.

+- Strata 5 and 6 were the urban strata.

TABLE 1B: SOME DETAILS OF THE WEST PAKISTAN SAMPLE FOR THE PGE PROJECT

| Name of the stratum<br>(Division)                                 | Stratum<br>number | Estimated<br>mid 1962<br>population<br>of the<br>stratum* | Name of the<br>sample area | Area<br>code | System<br>of data<br>collection<br>used | Type of<br>area | Mid 1962<br>population<br>of the sample<br>area |                         |
|-------------------------------------------------------------------|-------------------|-----------------------------------------------------------|----------------------------|--------------|-----------------------------------------|-----------------|-------------------------------------------------|-------------------------|
|                                                                   |                   |                                                           |                            |              |                                         |                 | before<br>exten-<br>sion                        | after<br>exten-<br>sion |
| WEST PAKISTAN                                                     |                   |                                                           |                            |              |                                         |                 |                                                 |                         |
| Peshawar and<br>D.I.Khan                                          | 1                 | 3,526,762                                                 | Karak                      | 200          | LR and CS                               | Rural           | 5,150                                           | 5,150                   |
| Rawalpindi                                                        | 2                 | 3,343,102                                                 | Simbli                     | 211          | LR and CS                               | Rural           | 4,500                                           | 4,500                   |
| Lahore                                                            | 3                 | 4,408,781                                                 | Bhedian                    | 222          | LR and CS                               | Rural           | 6,350                                           | 6,350                   |
| Multan                                                            | 4                 | 5,829,648                                                 | Aliwah                     | 233          | LR and CS                               | Rural           | 4,150                                           | 4,950                   |
| Bahawalpur                                                        | 5                 | 2,301,120                                                 | Ramma                      | 244          | LR and CS                               | Rural           | 5,250                                           | 5,250                   |
| Hyderabad and Karachi                                             | 6                 | 2,860,545                                                 | Khudadad                   | 255          | LR and CS                               | Rural           | 4,900                                           | 4,900                   |
| Sargodha                                                          | 7                 | 4,987,087                                                 | Mocch<br>82/G.B.           | 266<br>269   | LR only<br>CS only                      | Rural           | 2,350<br>4,100                                  | 4,050<br>4,100          |
| Khairpur                                                          | 8                 | 2,728,610                                                 | Wazirabad<br>Laghari       | 277<br>278   | LR only<br>CS only                      | Rural           | 3,100<br>3,900                                  | 5,000<br>5,100          |
| Peshawar, D.I.Khan,<br>Rawalpindi, Lahore,<br>Multan and Sargodha | 9 +               | 6,084,062                                                 | Rawalpindi                 | 280          | LR and CS                               | Urban           | 2,800                                           | 4,750                   |
| Bahawalpur, Khairpur<br>Hyderabad and Karachi                     | 10 +              | 3,666,405                                                 | Hyderabad                  | 291          | LR and CS                               | Urban           | 4,150                                           | 6,450                   |

\*Estimated by inflating the 1961 Census population by a growth rate of 2.6 percent per annum.

of vital events during the 12 months prior to the interview.<sup>1</sup>  
 The vital events data collected through the LR and CS systems were coded and punched on IBM cards. The LR and CS vital events' cards for the 16 common areas were then matched by using an elaborate matching procedure.<sup>2</sup> As a result of matching, all the vital events' cards from the 16 common areas were divided into the following three categories:

- i) the matched vital events' cards i.e. cards for events reported by both the LR and CS systems,
- ii) the non matched LR vital events cards, i.e. cards for events reported by the LR but not the CS system, and
- iii) the non matched CS vital events cards, i.e. cards for events reported by the CS but not the LR system.

In addition to these there were two more categories of vital events cards:

- iv) LR vital event's cards for the 4 LR only areas, and
- v) CS vital event's cards for the 4 CS only areas.

From these five categories three decks of vital events cards, namely the LR, CS and AN decks, were prepared. The LR deck consisted of cards in categories (i), (ii) and (iv), the CS deck consisted of cards in categories (i), (iii) and (v), and the AN deck consisted of cards in all the five categories.

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- 1. For methodological details of PGE see [1,5].
  - 2. For details of the matching procedures see [6].

It may be noted that both the LR and CS decks consisted of vital events' cards for 20 sample areas each, while the AN deck contained the vital events' cards for all the 24 sample areas. For the base population only one deck of cards, namely the PC deck, was prepared which consisted of the base population cards for the 20 CS areas, as these data were collected only through the CS system. Thus, in all we had four decks of data cards for each year from which we had to derive the provincial and national estimates for births, deaths and mid year populations.

#### ESTIMATION PROCEDURES

9. Although the PGE sample was selected through multistage stratified sampling procedure, for estimation purposes it was assumed that each stratum was divided into clusters of about 5,000 population, from which one, two or more clusters were selected randomly. On this basis the raising factors for each sample area were computed by using the formula  $P/n \cdot p$  where P was the estimated mid 1962 population of the stratum, n was the number of clusters (i.e. sample areas) selected from the stratum and p was the population of the sample area for which the raising factor was being computed.

10. Whenever there was a need to adjust the total number of vital events, for example to account for events missed by both the LR and CS systems, the raising factors were adjusted in the

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1. It may be noted that figures for p given in the last two columns of Tables 1A and 1B are not the enumerated mid 1962 populations but are some sort of a compromise between various population estimates for the sample areas.



following manner. Let  $Y_1$  be the total number of events reported in a sample area,  $Y_2$  be the estimated number of events missed on some account and  $R$  be the raising factor for that area. Obviously  $Y_1 + Y_2$  was the adjusted total of vital events. At this stage we had two alternatives:

- i) to multiply  $Y_1 + Y_2$  by  $R$  to get the sample estimate, and
- ii) to adjust the raising factor  $R$  by multiplying it with  $(Y_1 + Y_2) / (Y_1)$  and then to multiply the adjusted raising factor by  $Y_1$ .

To facilitate the processing of PGE data it was decided to adopt the second method, since by this method adjustments were made only in the raising factors and not in the number of vital events cards. However, algebraically both methods will yield identical results.

#### PC Decks of Base Population

11. Raising factors for the 20 CS areas from which the base population statistics were collected are presented in Table 2. These have been computed by using the formula given in para 9. While calculating these raising factors,  $p$  was taken as the estimated mid 1962 population of the sample areas after the extension of their boundaries. These raising factors were gang punched on the PC decks for all the 4 years (viz. 1962-1965) of PGE operations.

TABLE 2: RAISING FACTORS FOR THE PC DECKS OF BASE POPULATION

| Province/Area        | Raising factors for 1962-1965 |      |
|----------------------|-------------------------------|------|
| <b>EAST PAKISTAN</b> |                               |      |
|                      | 110                           | 1295 |
|                      | 111                           | 1071 |
|                      | 122                           | 935  |
|                      | 123                           | 1064 |
|                      | 134                           | 1260 |
|                      | 135                           | 1338 |
|                      | 148                           | 1447 |
|                      | 149                           | 1447 |
|                      | 150                           | 305  |
|                      | 161                           | 175  |
| <b>WEST PAKISTAN</b> |                               |      |
|                      | 200                           | 685  |
|                      | 211                           | 743  |
|                      | 222                           | 694  |
|                      | 233                           | 1178 |
|                      | 244                           | 438  |
|                      | 255                           | 584  |
|                      | 269                           | 1216 |
|                      | 278                           | 535  |
|                      | 280                           | 1281 |
|                      | 291                           | 568  |

### LR Decks of Vital Events

12. Since the boundaries of certain sample areas were extended in mid 1962, two sets of raising factors were prepared for the 20 LR areas from which the LR vital events statistics were collected (Table 3). The first set was computed by taking in denominator the estimated mid 1962 population of the sample areas before extension (given in last but one column of Table 1) while in the second set the population after extension (given in the last column of Table 1) were used. The first set of raising factors was gang punched on the LR cards for vital events which occurred between 1 January and 30 June 1962 while the second set was gang punched on the LR vital events' cards for the remaining 3½ years.

TABLE 3: RAISING FACTORS FOR THE LR DECKS OF VITAL EVENTS

| Province/Area        | Raising factors for   |                                      |
|----------------------|-----------------------|--------------------------------------|
|                      | first half<br>of 1962 | second half of<br>1962 and 1963-1965 |
| <b>EAST PAKISTAN</b> |                       |                                      |
| 110                  | 1437                  | 1295                                 |
| 111                  | 1071                  | 1071                                 |
| 122                  | 935                   | 935                                  |
| 123                  | 1064                  | 1064                                 |
| 134                  | 1490                  | 1260                                 |
| 135                  | 1338                  | 1338                                 |
| 146                  | 1622                  | 1622                                 |
| 147                  | 2952                  | 2306                                 |
| 150                  | 487                   | 305                                  |
| 161                  | 193                   | 175                                  |
| <b>WEST PAKISTAN</b> |                       |                                      |
| 200                  | 685                   | 685                                  |
| 211                  | 743                   | 743                                  |
| 222                  | 694                   | 694                                  |
| 233                  | 1405                  | 1178                                 |
| 244                  | 438                   | 438                                  |
| 255                  | 584                   | 584                                  |
| 266                  | 2122                  | 1231                                 |
| 277                  | 880                   | 546                                  |
| 280                  | 2173                  | 1281                                 |
| 291                  | 883                   | 568                                  |

CS Decks of Vital Events

13. As pointed out in [6], the reference period for obtaining the vital events in the CS enumeration visits was twelve months prior to the interview instead of a calendar year. Thus, for example, an interviewer visiting a sample area on 29 January 1963 was not expected to enumerate events which occurred between 1 and 28 January 1962 (say  $P_1$  events), but was required to report events occurring during the period 1-29 January 1963 (say  $P_2$  events). As the CS deck for 1962 contained only those events which occurred during 1962 and were reported in the

TABLE 4: RAISING FACTORS FOR THE CS DECKS OF VITAL EVENTS

| Province/Area | Births |      |      |      | Deaths |      |      |      |
|---------------|--------|------|------|------|--------|------|------|------|
|               | 1962   | 1963 | 1964 | 1965 | 1962   | 1963 | 1964 | 1965 |
| EAST PAKISTAN |        |      |      |      |        |      |      |      |
| 110           | 1353   | 1379 | 1295 | 1370 | 1321   | 1408 | 1295 | 1406 |
| 111           | 1071   | 1207 | 1071 | 1185 | 1071   | 1290 | 1071 | 1220 |
| 122           | 970    | 1000 | 935  | 1007 | 992    | 969  | 935  | 984  |
| 123           | 1401   | 1255 | 1064 | 1118 | 1234   | 1089 | 1064 | 1241 |
| 134           | 1288   | 1365 | 1260 | 1334 | 1359   | 1366 | 1260 | 1432 |
| 135           | 1391   | 1458 | 1338 | 1390 | 1404   | 1401 | 1338 | 1388 |
| 148           | 1502   | 1638 | 1447 | 1567 | 1545   | 1667 | 1447 | 1554 |
| 149           | 1514   | 1573 | 1447 | 1479 | 1547   | 1550 | 1447 | 1486 |
| 150           | 342    | 333  | 305  | 317  | 353    | 329  | 305  | 314  |
| 161           | 188    | 184  | 175  | 176  | 193    | 184  | 175  | 180  |
| WEST PAKISTAN |        |      |      |      |        |      |      |      |
| 200           | 723    | 755  | 685  | 727  | 712    | 712  | 685  | 724  |
| 211           | 774    | 794  | 743  | 762  | 812    | 838  | 743  | 807  |
| 222           | 705    | 750  | 694  | 740  | 704    | 725  | 694  | 771  |
| 233           | 1216   | 1218 | 1178 | 1255 | 1245   | 1228 | 1178 | 1365 |
| 244           | 469    | 459  | 438  | 448  | 458    | 473  | 438  | 454  |
| 255           | 601    | 604  | 584  | 593  | 659    | 667  | 584  | 597  |
| 269           | 1264   | 1318 | 1216 | 1232 | 1317   | 1415 | 1216 | 1278 |
| 278           | 618    | 596  | 535  | 574  | 963    | 555  | 535  | 544  |
| 280           | 1336   | 1406 | 1281 | 1340 | 1312   | 1452 | 1281 | 1405 |
| 291           | 598    | 596  | 568  | 635  | 792    | 568  | 568  | 591  |

January 1963 enumeration visit (say  $K$  events), the deck for the calendar year was short of number of events equal to  $P_1$ . To overcome this problem it was assumed that the number of  $P_1$  events was equal to the number of  $P_2$  events. Thus, following the reasoning given in para No. 10, the CS raising factors for each year were adjusted by multiplying them with a ratio  $(K+P_2)/K$ . These ratios were computed separately for births and deaths for each year and for each area. The adjusted raising factors given in Table 4 were gang punched on the relevant decks of CS vital events cards.

#### AN Decks of Vital Events

14. The AN decks of vital events consisted of matched, non matched LR and non matched CS events from the 16 LR-CS common areas along with the LR events from the 4 LR only and the CS events from the 4 CS only areas. The basic raising factors for

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1. Assuming that these events had the same match rates as the rest of the events in the 16 LR-CS common areas, 75 percent of  $P_2$  events were added to the CS matched category and 25 percent to the CS non matched category. Since the number of LR and CS matches must be equal, 75 percent of  $P_2$  events were transferred from the LR non matches to the matched category. This resulted in the diminution of the LR non matches. However, the total LR events (i.e. matched plus non matched) were not affected by this adjustment.

2. Matching in 1964 was done in such a manner that there was no need to make this adjustment, see 6.

3. The procedure for estimating the number of matched and non matched events in LR only and CS only areas is explained in para No. 18.

TABLE 5: BASIC RAISING FACTORS FOR THE AN DECKS OF VITAL EVENTS

| Province/Area | Raising factors | Stratum number |
|---------------|-----------------|----------------|
| EAST PAKISTAN |                 |                |
| 110           | 1294.9          | 1              |
| 111           | 1071.2          | 1              |
| 122           | 934.8           | 2              |
| 123           | 1064.1          | 2              |
| 134           | 1260.4          | 3              |
| 135           | 1337.5          | 3              |
| 146           | 811.1           | 4              |
| 147           | 1153.2          | 4              |
| 148           | 723.6           | 4              |
| 149           | 723.6           | 4              |
| 150           | 305.0           | 5              |
| 161           | 175.2           | 6              |
| WEST PAKISTAN |                 |                |
| 200           | 684.8           | 1              |
| 211           | 742.9           | 2              |
| 222           | 694.3           | 3              |
| 233           | 1177.7          | 4              |
| 244           | 438.3           | 5              |
| 255           | 583.8           | 6              |
| 266           | 615.7           | 7              |
| 269           | 608.2           | 7              |
| 277           | 272.9           | 8              |
| 278           | 267.5           | 8              |
| 280           | 1280.9          | 9              |
| 291           | 568.4           | 10             |

the 24 sample areas presented in Table 5 were adjusted to account for:

- i) the vital events not registered during the first half of 1962 in that portion of the sample that was first covered in July 1962,
- ii) the vital events not enumerated because time reference of the CS surveys did not correspond exactly to one calendar year,
- iii) the assumed excess of false non matches over matched events, and
- iv) the vital events missed by both the LR and CS systems.

The procedural details of the adjustment of the raising factors for the 24 sample areas are given in the following paragraphs.

15. Let us consider a sample area in which both the LR and CS systems were operating. On the basis of matching the vital events' reports we were able to classify the LR and CS vital events into:

- C = matched events
- R = non matched LR events, and
- E = non matched CS events.

This means that the AN deck consisted of C+R+E events of which C+R were the LR events while C+E were the CS events.

Further, let us suppose that we have also estimated the following categories of events:

- A = events missed by the LR system during the first

half of 1962 in that portion of the  $A_1$  sample area that was first covered in July 1962,

$A_1$  = matched events among A,

$A_2$  = non matched LR events among A,

B = events missed by the CS system because time reference  $t_2$  did not correspond exactly to a calendar year,  $t_2$

$B_1$  = assumed matched events among B = 75 percent of B

$B_2$  = assumed non matched CS events among B = 25 percent of B, and

D = assumed excess of non matched events to be transferred from the non matched LR and CS categories (viz R and E) to the matched category (viz C). <sup>3</sup>

16. After making the first three adjustments given in para 14,  $(A_1+B_1+D)$  events were added to the category C, while  $(A_2-B_1-D)$  were added to R and  $(A_1-B_2+D)$  events were subtracted from the category E. From these data the number of events missed by both the LR and CS systems was calculated by the expression:<sup>4</sup>

$$M = \frac{(R+A_2-B_1-D)(E-A_1+B_2-D)}{(C+A_1+B_1+D)}$$

1. These events were estimated in the following manner. Suppose if a sample area had a population of 4213 persons and after extension of its boundaries in mid 1962 it increased to 5010 persons, that is, an increase of about 25 per cent. This means that had the boundaries been extended on 1 January 1962 instead of July 1962 we would have registered 0.25 (C+R) more events. Thus,  $A_1$  was equal to 0.25C and  $A_2$  was equal to 0.25R. Since this adjustment did not affect the total CS events viz. (C+E), we had to decrease E by  $A_1$  so as to keep (C+E) unaffected. For more details of this adjustment see [ 6 ] para 20.

2. For details of this adjustment see para 13 of this report and particularly the footnote 1 on page 12.

3. This assumption was made on the basis of office and field investigation of non matched events. D was estimated by taking 5 per cent of the LR or CS non matches (which ever were less) and this number was transferred from both R and E to the category C. Thus, as a result of this adjustment the AN deck became:  $(C+D)+(R-D)+(E-D)$ .

4. This was the Chandra-Deming adjustment, see [ 2, 5 ].



It is evident that the C+R+E reported events after making all the four adjustments (listed in para 14) became K events, where:

$$K = (C+A_1+B_1+D) \quad (R+A_2-B_1-D) + (E-A_1+B_2-D) + (M).$$

Thus, instead of increasing the total number of cards of the vital events in the AN decks from C+R+E to K we in turn inflated the relevant raising factors (presented in Table 5) by the ratio  $I = K/(C+R+E)$ , and gang punched the adjusted raising factors on the relevant vital events' cards. This procedure was adopted in all the 16 LR-CS common areas and for all years except for the 7 LR-CS areas whose boundaries were extended in mid 1962. The adjustment procedure for the 7 LR-CS areas whose boundaries were extended in mid 1962 are presented in the following paragraph. It may be noted that while computing K, the values of  $A_1$  and  $A_2$  were taken as zero for vital events for the 9 LR-CS areas whose boundaries were not extended in mid 1962 and for the 1963 and 1965 vital events for all the 16 LR-CS areas, because the first adjustment was not applicable to these vital events. Similarly the values of  $A_1$ ,  $A_2$ ,  $B_1$  and  $B_2$  were taken as zero for the 1964 vital events, as both the first and second adjustments were not applicable to them.

17. As pointed out earlier, the boundaries of half of the sample areas were extended in mid 1962. Thus, it was only in the 1962 vital events data for these areas where we had to make the first adjustment listed in para 14. For this purpose the 1962 vital events for each area were divided into two parts, one containing the events during the first half of 1962 and the other consisting of vital events which occurred during the second half of 1962. Let us suppose the number of matched

and non matched events were:

|                                |                                                                                      |
|--------------------------------|--------------------------------------------------------------------------------------|
| $C_1$ = matched events,        | ) These were the events<br>which occurred between<br>1 January and 30 June 1962.     |
| $R_1$ = non matched LR events, |                                                                                      |
| $E_1$ = non matched CS events, |                                                                                      |
| $C_2$ = matched events,        | ) These were the events<br>which occurred between<br>1 July and 31 December<br>1962. |
| $R_2$ = non matched LR events, |                                                                                      |
| $E_2$ = non matched CS events, |                                                                                      |

Since we had estimated that during the first six months of 1962 the LR system would have registered  $A$  more events (of which  $A_1$  would have matched and  $A_2$  non matched), had the boundaries been extended on 1 January instead of 1 July 1962, thus, the matched events  $C_1$  became  $(C_1 + A_1)$ , the non matched LR events became  $(R_1 + A_2)$  and the non matched CS events became  $(E_1 - A_1)$ <sup>1</sup>. Thus, as a result of the first adjustment the total vital events reported during the first six months of 1962 had to be increased by a ratio  $K_1$  which was equal to  $\frac{(C_1 + A_1) + (R_1 + A_2) + (E_1 - A_1)}{C_1 + R_1 + E_1}$ . We then took the vital events for the second six months of 1962 and added them to the adjusted vital events for the first six months of 1962. Thus, we got  $K_2$  which was equal to  $(C_1 + A_1) + (R_1 + A_2) + (E_1 - A_1) + (C_2 + R_2 + E_2)$ . These  $K_2$  events were the total events after the first adjustment. It may be recalled from para 16 that  $K$  was the total events in which all the four adjustments had been incorporated. This means that as a result of the second, third and fourth adjustments the total vital events after first adjustment had to be increased by a ratio  $K_3$  which was equal to  $K/K_2$ . Thus, the basic raising factors for

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1. We subtracted  $A_1$  events from  $E_1$  so as to keep the number of matched and non matched CS events equal to  $C_1 + E_1$ .

1962 for each area were multiplied by  $K_1$  for that area to adjust them for the extension of boundaries and were again multiplied by  $K_3$  for that area to incorporate the effect of the remaining three adjustments. The finally adjusted raising factors were gang punched on the vital events' cards for the first six months of 1962. Since the extension of boundaries did not affect the LR events for the last six months of 1962, the raising factors for each area were multiplied only by  $K_3$  for that area (which incorporated only the last three adjustments) and the adjusted raising factors were gang punched on the vital events cards for the second half of 1962.

18. As pointed out earlier there were 8 areas (4LR and 4CS) in which only one of the two systems of data collection were operating. Our problem was to compute the Chandra-Deming estimate of vital events for these areas. For this purpose two factors  $F_1$  and  $F_2$  were computed for each of the 12 rural LR-CS common areas. The factors  $F_1$  and  $F_2$  were in fact the ratios  $F_1 = K/(C+R)$  and  $F_2 = K/(C+E)$  where  $K$  was the Chandra-Deming estimate of vital events,  $(C+R)$  was the total LR events actually registered and  $(C+E)$  was the CS events enumerated in the field. These ratios were averaged separately for East and West Pakistan for each year to get  $Z_1$  and  $Z_2$ . The raising factors for the 4 LR only areas were then multiplied by  $Z_1$  and those for the 4 CS only areas were multiplied by  $Z_2$  and the adjusted raising factors were gang punched on the relevant vital events' cards. Since the boundaries of the 3 out of the 4 LR only areas were extended in mid 1962 the raising factors for these areas were adjusted by a modified procedure presented in the next paragraph.

19. Let us suppose that the 3 LR only areas whose boundaries were extended had:

- T = total LR events registered during 1962,  
 $T_1$  = total LR events registered during the first half of 1962,  
 $T_2$  = total LR events registered during the second half of 1962, and  
 A = events missed by the LR system during the first half of 1962 in that portion of the sample area that was first covered in July 1962.

Obviously  $T_1 + A$  represented the expected number of vital events, had the boundaries been extended from 1 January 1962 instead of July 1962, and hence the ratio  $N = (T_1 + A) / T_1$  gave us the adjustment factor which accounted for only the boundary extensions. Further, another factor  $M = (T \cdot Z_1) / (T + A)$  was calculated. In this factor as  $T \cdot Z_1$  gave us the Chandra-Deming estimate of T and  $T + A$  gave us the estimated T after making the boundary adjustments, so M was in fact the ratio which incorporated all the adjustments except that due to the extension of boundaries. Thus, we gang punched raising factors adjusted by the product of M times N on the first half of 1962 vital events' cards of the three areas whose boundaries were extended in mid 1962. As the problem of boundaries extension was not applicable to the second half of 1962, the raising factors were multiplied by M and were gang punched on the relevant vital events' cards for the second half of 1962.

20. Table 6 presents the adjusted raising factors for the AN decks of vital events.

21. The raising factors presented in Tables 2, 3, 4 and 6 were gang punched on the relevant decks and the sample figures

TABLE 6: ADJUSTED RAISING FACTORS FOR THE AN DECKS OF VITAL EVENTS

| Province/Area | Births   |          |        |        |        | Deaths   |          |        |        |        |
|---------------|----------|----------|--------|--------|--------|----------|----------|--------|--------|--------|
|               | 1962     | 1962     | 1963   | 1964   | 1965   | 1962     | 1962     | 1963   | 1964   | 1965   |
|               | 1st half | 2nd half |        |        |        | 1st half | 2nd half |        |        |        |
| EAST PAKISTAN |          |          |        |        |        |          |          |        |        |        |
| 110           | 1351.3   | 1309.3   | 1315.6 | 1301.1 | 1323.5 | 1407.8   | 1307.2   | 1322.1 | 1325.7 | 1392.0 |
| 111           | 1102.5   | 1102.5   | 1115.1 | 1074.4 | 1202.5 | 1091.2   | 1091.2   | 1139.7 | 1081.5 | 1303.5 |
| 122           | 951.6    | 951.6    | 949.7  | 938.4  | 957.2  | 966.9    | 966.9    | 945.1  | 934.8  | 1036.4 |
| 123           | 3719.0   | 3719.0   | 1147.8 | 1111.6 | 1106.1 | 4095.2   | 4095.2   | 1074.7 | 1203.5 | 1356.7 |
| 134           | 1368.6   | 1324.4   | 1296.9 | 1312.5 | 1354.9 | 1431.4   | 1356.1   | 1301.9 | 1311.3 | 1468.2 |
| 135           | 1354.5   | 1354.5   | 1366.4 | 1342.4 | 1366.8 | 1373.6   | 1373.6   | 1364.2 | 1350.7 | 1447.0 |
| 146           | 891.4    | 891.4    | 915.7  | 946.3  | 965.7  | 885.7    | 885.7    | 903.6  | 950.6  | 1038.0 |
| 147           | 1511.9   | 1266.0   | 1302.0 | 1345.6 | 1373.1 | 1638.1   | 1252.4   | 1284.7 | 1351.6 | 1475.9 |
| 148           | 921.9    | 921.9    | 950.1  | 809.3  | 963.2  | 1034.7   | 1034.7   | 1098.4 | 909.3  | 1294.3 |
| 149           | 921.9    | 921.9    | 950.1  | 809.3  | 963.2  | 1034.7   | 1034.7   | 1098.4 | 909.3  | 1294.3 |
| 150           | 344.6    | 317.4    | 327.8  | 343.0  | 338.9  | 388.0    | 320.5    | 331.2  | 366.0  | 355.1  |
| 161           | 186.0    | 181.6    | 192.7  | 188.2  | 211.8  | 200.7    | 195.3    | 196.2  | 204.1  | 224.5  |
| WEST PAKISTAN |          |          |        |        |        |          |          |        |        |        |
| 200           | 714.8    | 714.8    | 719.0  | 706.9  | 708.1  | 704.6    | 704.6    | 705.3  | 723.2  | 760.8  |
| 211           | 750.0    | 750.0    | 757.7  | 749.6  | 754.0  | 761.2    | 761.2    | 775.5  | 751.7  | 779.3  |
| 222           | 699.7    | 699.7    | 711.6  | 718.5  | 729.0  | 737.4    | 737.4    | 729.7  | 723.2  | 736.0  |
| 233           | 1224.7   | 1194.4   | 1196.8 | 1188.3 | 1222.5 | 1268.8   | 1209.8   | 1197.7 | 1194.1 | 1269.6 |
| 244           | 474.6    | 474.6    | 493.9  | 532.5  | 501.0  | 494.0    | 494.0    | 523.7  | 516.7  | 638.4  |
| 255           | 644.5    | 644.5    | 698.6  | 684.3  | 629.9  | 665.7    | 665.7    | 764.1  | 817.3  | 641.0  |
| 266           | 1280.9   | 722.6    | 809.6  | 896.3  | 766.5  | 1486.1   | 743.1    | 781.9  | 855.0  | 851.7  |
| 269           | 953.0    | 953.0    | 902.6  | 793.0  | 834.5  | 1061.9   | 1061.9   | 995.8  | 1007.9 | 1161.4 |
| 277           | 560.4    | 320.3    | 358.9  | 397.2  | 339.8  | 543.2    | 329.8    | 346.6  | 378.9  | 377.5  |
| 278           | 450.0    | 450.0    | 397.0  | 348.8  | 367.0  | 501.6    | 501.6    | 418.6  | 443.3  | 510.8  |
| 280           | 1421.2   | 1306.3   | 1380.8 | 1357.9 | 1419.1 | 1521.0   | 1303.7   | 1441.0 | 1413.3 | 1555.3 |
| 291           | 995.9    | 756.8    | 695.7  | 709.0  | 610.2  | 959.2    | 639.5    | 1063.4 | 891.6  | 686.8  |

were inflated to arrive at the LR, CS and Chandra-Deming provincial and national estimates.

#### RELIABILITY OF ESTIMATES

22. The provincial and national estimates derived from the PGE data were obviously subject to sampling and non sampling errors. Since some of the important non sampling errors and their probable effects have been described elsewhere [5], in this section we will limit ourselves to the procedures used for the computation of some measures of reliability for the various demographic parameters estimated from the PGE data.

23. As pointed out in para 9, for calculating the raising factors it was assumed that the PGE sample areas were selected through a one stage instead of the multistage stratified sampling procedure. Similarly, the measures of reliability presented in this report were also computed under the same assumption. Since we needed at least two sample areas per stratum in order to compute within stratum variances, we had to collapse the 6 strata in East and 10 in West Pakistan into 5 domains in each province (Table 7).

24. Standard errors (SE) and coefficients of variation (CV) are the two measures of reliability presented in this report.  $\hat{Y}$ , the provincial total for a particular characteristic was obtained as the sum of the products of total of the same characteristic for the sample areas by their relevant raising factors. The standard error of  $\hat{Y}$  was calculated

TABLE 7: COMPOSITION OF DOMAINS IN EAST AND WEST PAKISTAN

| Province/Domain | Stratum  | Sample areas in the domain |
|-----------------|----------|----------------------------|
| EAST PAKISTAN   |          |                            |
| 1               | 1        | 110,111                    |
| 2               | 2        | 122,123                    |
| 3               | 3        | 134,135                    |
| 4               | 4        | 146,147,148,149            |
| 5               | 5 and 6  | 150,161                    |
| WEST PAKISTAN   |          |                            |
| 1               | 1 and 2  | 200,211                    |
| 2               | 3 and 7  | 222,266,269                |
| 3               | 4 and 5  | 233,244                    |
| 4               | 6 and 8  | 255,277,278                |
| 5               | 9 and 10 | 280,291                    |

- Note: 1. Areas 146,147,266,277 were LR and 148,149,269, 278 were CS only areas.
2. The domains were formed taking into account the geographical contiguity of the strata.

by the following formula:

$$SE(\hat{Y}) = \sqrt{\sum_{h=1}^{h=5} \frac{M_h(M_h - m_h)}{m_h} \cdot s_h^2}$$

where  $M_h$  was the total number of clusters of 5,000 population in the  $h^{th}$  domain,  $m_h$  was the number of clusters (sample areas) selected from the  $h^{th}$  domain, and  $s_h^2$  was calculated by the formula:

$$s_h^2 = \frac{\sum_{i=1}^{i=m_h} (y_{hi} - \bar{y}_h)^2}{m_h - 1}$$

1. For details of formulae presented in this paragraph see 3,47.
2. It may be noted that 5,000 persons was the approximate population of each sample area.

In the above formula,  $y_{hi}$  was the total for the characteristic in the  $i^{\text{th}}$  sample area of the  $h^{\text{th}}$  domain and  $\bar{y}_h = \sum_{i=1}^{m_h} y_{hi}/m_h$ . The relative variance (which is the same thing as the square of coefficient of variation) of a ratio  $\hat{R}$  of provincial totals  $\hat{X}$  and  $\hat{Y}$  (where  $\hat{R} = \hat{X}/\hat{Y}$ ) of two population characteristics was calculated by the following formula.

$$\text{Relative variance of } R = \frac{1}{\hat{X}^2} \sum_{h=1}^{h=5} \frac{M_h(M_h - m_h)}{m_h} \cdot s_h^2, \text{ where}$$

$$s_h^2 = \sum_{i=1}^{i=m_h} \left[ \frac{(x_{hi} - \bar{x}_h)^2}{m_h - 1} + \frac{\hat{R}^2 (y_{hi} - \bar{y}_h)^2}{m_h - 1} - \frac{2\hat{R}(x_{hi} - \bar{x}_h)(y_{hi} - \bar{y}_h)}{m_h - 1} \right]$$

In case of the LR and CS estimates where each domain consisted of two sample areas,  $s_h^2$  was calculated as:

$$s_h^2 = (x_{h1} - x_{h2})^2 + \hat{R}^2 (y_{h1} - y_{h2})^2 - 2\hat{R} (x_{h1} - x_{h2}) \cdot (y_{h1} - y_{h2}),$$

where  $x_{h1}$  and  $y_{h1}$  were the sample totals for two characteristics in one sample area of the  $h^{\text{th}}$  domain and  $x_{h2}$  and  $y_{h2}$  were their counterparts from the second sample area of the  $h^{\text{th}}$  domain. The coefficient of variation for the estimate of any parameter was calculated by dividing the standard error for that parameter by the estimate of the parameter.

25. Tables 8 through 10 give the standard errors and coefficients of variation for various demographic characteristics of East and West Pakistan derived from the 1964 and ~~1965~~ 1965 PGE data. The estimates presented in these tables were computed on an IBM 1401 computer.



TABLE 8: MEASURES OF RELIABILITY FOR VARIOUS DEMOGRAPHIC PARAMETERS: PGE 1964-1965

| Parameter                | Year/Province      | Registration |        |     | Survey   |        |       | Chandra Deming |        |     |
|--------------------------|--------------------|--------------|--------|-----|----------|--------|-------|----------------|--------|-----|
|                          |                    | Estimate     | CV     | SE  | Estimate | CV     | SE    | Estimate       | CV     | SE  |
| Total defacto births     | 1964 East Pakistan | 2,374        | .09521 | 226 | 2,403    | .09489 | 228   | 2,747          | .06137 | 169 |
|                          | 1964 West Pakistan | 1,717        | .11595 | 199 | 1,780    | .15132 | 269   | 2,333          | .07925 | 185 |
|                          | 1965 East Pakistan | 2,299        | .07235 | 166 | 2,132    | .05189 | 111   | 2,795          | .04335 | 122 |
|                          | 1965 West Pakistan | 1,694        | .15529 | 263 | 1,594    | .10062 | 160   | 2,155          | .09272 | 178 |
| Total defacto deaths     | 1964 East Pakistan | 959          | .03659 | 35  | 917      | .05651 | 52    | 1,153          | .05507 | 63  |
|                          | 1964 West Pakistan | 630          | .11543 | 73  | 532      | .10842 | 58    | 327            | .06264 | 52  |
|                          | 1965 East Pakistan | 891          | .07501 | 67  | 583      | .15869 | 93    | 1,143          | .05262 | 60  |
|                          | 1965 West Pakistan | 540          | .14061 | 76  | 376      | .11214 | 42    | 708            | .09014 | 64  |
| Total defacto population | 1964 East Pakistan | -            | -      | -   | 55,314   | .03417 | 1,890 | -              | -      | -   |
|                          | 1964 West Pakistan | -            | -      | -   | 42,390   | .06105 | 2,588 | -              | -      | -   |
|                          | 1965 East Pakistan | -            | -      | -   | 56,839   | .03534 | 2,009 | -              | -      | -   |
|                          | 1965 West Pakistan | -            | -      | -   | 43,605   | .06221 | 2,713 | -              | -      | -   |
| Total de jure births     | 1965 East Pakistan | -            | -      | -   | 2,214    | .05093 | 113   | -              | -      | -   |
|                          | 1965 West Pakistan | -            | -      | -   | 1,723    | .09576 | 165   | -              | -      | -   |
| Total de jure deaths     | 1965 East Pakistan | -            | -      | -   | 605      | .15570 | 94    | -              | -      | -   |
|                          | 1965 West Pakistan | -            | -      | -   | 405      | .11162 | 45    | -              | -      | -   |
| Total de jure population | 1965 East Pakistan | -            | -      | -   | 50,573   | .03447 | 1,950 | -              | -      | -   |
|                          | 1965 West Pakistan | -            | -      | -   | 43,619   | .03192 | 1,392 | -              | -      | -   |

\* The figures given in the Estimate and SE columns are expressed in thousands.

\*\* CV stands for coefficient of variation and SE for the standard error.

TABLE 9 - MEASURES OF RELIABILITY FOR VARIOUS DEMOGRAPHIC PARAMETERS: PGE 1964-1965

| Parameter                                 | Year/Province      | Registration |                 |                 | Survey   |                 |                 | Chandra Deming |                 |                 |
|-------------------------------------------|--------------------|--------------|-----------------|-----------------|----------|-----------------|-----------------|----------------|-----------------|-----------------|
|                                           |                    | Estimate     | CV <sup>1</sup> | SE <sup>2</sup> | Estimate | CV <sup>1</sup> | SE <sup>2</sup> | Estimate       | CV <sup>1</sup> | SE <sup>2</sup> |
| Defacto crude birth rate                  | 1964 East Pakistan | .042951      | .08485          | .003644         | .043293  | .04472          | .001936         | .049562        | .042720         | .002117         |
|                                           | 1964 West Pakistan | .039284      | .09165          | .003600         | .040988  | .07549          | .003094         | .054981        | .054534         | .002998         |
|                                           | 1965 East Pakistan | .040467      | .05099          | .002063         | .035391  | .07000          | .002477         | .049227        | .031177         | .001535         |
|                                           | 1965 West Pakistan | .038317      | .06324          | .002423         | .034759  | .07348          | .002554         | .049412        | .056285         | .002781         |
| Defacto crude death rate                  | 1964 East Pakistan | .017406      | .06782          | .001180         | .016575  | .07746          | .001284         | .020900        | .082795         | .001730         |
|                                           | 1964 West Pakistan | .014319      | .10392          | .001488         | .011905  | .12409          | .001477         | .019194        | .072877         | .001399         |
|                                           | 1965 East Pakistan | .015712      | .09643          | .001515         | .009493  | .19390          | .001841         | .020159        | .079051         | .001594         |
|                                           | 1965 West Pakistan | .012119      | .11090          | .001344         | .008005  | .07483          | .000599         | .016209        | .061976         | .001005         |
| Dejure crude birth rate                   | 1965 East Pakistan | -            | -               | -               | .036914  | .05744          | .002120         | -              | -               | -               |
|                                           | 1965 West Pakistan | -            | -               | -               | .037694  | .04899          | .001847         | -              | -               | -               |
| Dejure crude death rate                   | 1965 East Pakistan | -            | -               | -               | .009887  | .19000          | .001879         | -              | -               | -               |
|                                           | 1965 West Pakistan | -            | -               | -               | .008576  | .08366          | .000717         | -              | -               | -               |
| Fertility rate for women aged 15-19 years | 1964 East Pakistan | .235658      | .08062          | .018999         | .215045  | .06000          | .012903         | .276856        | .050210         | .013901         |
|                                           | 1964 West Pakistan | .111967      | .18574          | .020797         | .081652  | .14933          | .012193         | .138294        | .156863         | .021693         |
|                                           | 1965 East Pakistan | .217209      | .05477          | .011897         | .186830  | .06782          | .012671         | .264692        | .051798         | .013711         |
|                                           | 1965 West Pakistan | .089292      | .13928          | .012437         | .060617  | .25961          | .015737         | .106117        | .122752         | .013026         |
| Fertility rate for women aged 20-24 years | 1964 East Pakistan | .303104      | .11958          | .036245         | .283076  | .05656          | .016011         | .355103        | .065437         | .023237         |
|                                           | 1964 West Pakistan | .236949      | .11789          | .027934         | .253774  | .08944          | .022698         | .338724        | .066903         | .022662         |
|                                           | 1965 East Pakistan | .282682      | .02000          | .005654         | .219520  | .09899          | .021730         | .346606        | .034971         | .012121         |
|                                           | 1965 West Pakistan | .187755      | .10770          | .020221         | .211218  | .08306          | .017544         | .257032        | .092054         | .023661         |

1. Coefficient of variation

2. Standard error

TABLE 9 (CONTINUED)

| Parameter                                 | Year/Province      | Registration |        |         | Survey   |        |         | Chandra Deming |         |         |
|-------------------------------------------|--------------------|--------------|--------|---------|----------|--------|---------|----------------|---------|---------|
|                                           |                    | Estimate     | CV     | SE      | Estimate | CV     | SE      | Estimate       | CV      | SE      |
| Fertility rate for women aged 25-29 years | 1964 East Pakistan | .315618      | .09110 | .028753 | .261671  | .07000 | .018317 | .343817        | .096778 | .033274 |
|                                           | 1964 West Pakistan | .280665      | .06782 | .019035 | .281979  | .08602 | .024256 | .380774        | .061033 | .023240 |
|                                           | 1965 East Pakistan | .290795      | .03162 | .009195 | .225468  | .03741 | .008435 | .364409        | .086695 | .031592 |
|                                           | 1965 West Pakistan | .272981      | .08544 | .023323 | .238676  | .08544 | .020392 | .354753        | .067713 | .024021 |
| Fertility rate for women aged 30-34 years | 1964 East Pakistan | .185643      | .11874 | .022043 | .244444  | .10630 | .025984 | .219847        | .081123 | .017835 |
|                                           | 1964 West Pakistan | .269620      | .10816 | .029162 | .255493  | .10000 | .025549 | .362247        | .076217 | .027609 |
|                                           | 1965 East Pakistan | .208381      | .07810 | .016275 | .194616  | .07141 | .013898 | .249218        | .071421 | .017799 |
|                                           | 1965 West Pakistan | .292773      | .12806 | .037493 | .247109  | .12165 | .030061 | .362986        | .119892 | .043519 |
| Fertility rate for women aged 35-39 years | 1964 East Pakistan | .138004      | .19026 | .026257 | .161042  | .12530 | .020179 | .158731        | .094884 | .015061 |
|                                           | 1964 West Pakistan | .159546      | .15874 | .025326 | .197039  | .07211 | .014208 | .242969        | .069678 | .016930 |
|                                           | 1965 East Pakistan | .100034      | .22956 | .022964 | .126928  | .09380 | .011906 | .123563        | .149362 | .018456 |
|                                           | 1965 West Pakistan | .204154      | .08366 | .017080 | .169539  | .08544 | .014485 | .258163        | .051147 | .013204 |
| Fertility rate for women aged 40-44 years | 1964 East Pakistan | .046581      | .33708 | .015702 | .084122  | .18275 | .015373 | .060372        | .156480 | .009447 |
|                                           | 1964 West Pakistan | .057086      | .24269 | .013854 | .106498  | .13892 | .014795 | .105965        | .094795 | .010045 |
|                                           | 1965 East Pakistan | .048830      | .46881 | .022892 | .054930  | .35707 | .019614 | .049788        | .272255 | .013555 |
|                                           | 1965 West Pakistan | .085506      | .13784 | .011786 | .076574  | .10583 | .008104 | .112779        | .111369 | .012560 |
| Fertility rate for women aged 45-49 years | 1964 East Pakistan | .007395      | .46889 | .003467 | .042914  | .31192 | .013386 | .013658        | .184713 | .002523 |
|                                           | 1964 West Pakistan | .052718      | .33180 | .017492 | .091966  | .18681 | .017180 | .087742        | .219477 | .019257 |
|                                           | 1965 East Pakistan | .010754      | .56262 | .006050 | .049415  | .61704 | .030180 | .015101        | .491912 | .007428 |
|                                           | 1965 West Pakistan | .035077      | .40427 | .014181 | .059833  | .19493 | .011663 | .049847        | .166514 | .008300 |
| Infant mortality rate for both sexes      | 1964 East Pakistan | .135129      | .08062 | .010894 | .143114  | .09273 | .013271 | .166008        | .078294 | .012997 |
|                                           | 1964 West Pakistan | .138470      | .09000 | .012462 | .110136  | .11916 | .013124 | .149625        | .076942 | .011512 |
|                                           | 1965 East Pakistan | .140343      | .10392 | .014584 | .097186  | .18220 | .017707 | .176975        | .108844 | .019263 |
|                                           | 1965 West Pakistan | .114423      | .11090 | .012690 | .076288  | .08306 | .006336 | .128160        | .076046 | .009746 |

TABLE 9 (CONTINUED)

| Parameter                                  | Year/Province      | Registration |        |         | Survey   |        |         | Chandra Deming |         |         |
|--------------------------------------------|--------------------|--------------|--------|---------|----------|--------|---------|----------------|---------|---------|
|                                            |                    | Estimate     | CV     | SE      | Estimate | CV     | SE      | Estimate       | CV      | SE      |
| Infant mortality rate for male babies      | 1964 East Pakistan | .160405      | .07483 | .012003 | .164905  | .08485 | .013992 | .194601        | .086418 | .016817 |
|                                            | 1964 West Pakistan | .126463      | .06324 | .007998 | .098760  | .06245 | .006168 | .138263        | .052593 | .007272 |
|                                            | 1965 East Pakistan | .151601      | .09643 | .014619 | .109442  | .16309 | .017849 | .198184        | .094673 | .018763 |
|                                            | 1965 West Pakistan | .107596      | .11532 | .012408 | .084192  | .09539 | .008031 | .129986        | .069843 | .009079 |
| Infant mortality rate for female babies    | 1964 East Pakistan | .109728      | .12961 | .014222 | .133416  | .11000 | .014676 | .137148        | .103446 | .014187 |
|                                            | 1964 West Pakistan | .152248      | .11874 | .018078 | .122775  | .18520 | .022627 | .162306        | .104288 | .016927 |
|                                            | 1965 East Pakistan | .128818      | .11789 | .015186 | .084998  | .21213 | .018031 | .155551        | .126380 | .019659 |
|                                            | 1965 West Pakistan | .121883      | .15779 | .019232 | .068080  | .19131 | .013024 | .126265        | .124788 | .015756 |
| Mortality rate for males 1-14 years        | 1964 East Pakistan | .010089      | .18330 | .001849 | .008678  | .19621 | .001703 | .011649        | .180078 | .002098 |
|                                            | 1964 West Pakistan | .007750      | .18574 | .001439 | .007661  | .14000 | .001073 | .011759        | .082656 | .000972 |
|                                            | 1965 East Pakistan | .006846      | .31840 | .002180 | .005860  | .24576 | .001440 | .009648        | .231598 | .002269 |
|                                            | 1965 West Pakistan | .004749      | .21794 | .001035 | .003768  | .09695 | .000365 | .007044        | .106626 | .000751 |
| Mortality rate for females aged 1-14 years | 1964 East Pakistan | .012984      | .17233 | .002238 | .010864  | .19849 | .002156 | .014484        | .173124 | .002508 |
|                                            | 1964 West Pakistan | .012203      | .17406 | .002124 | .011362  | .16643 | .001891 | .016709        | .120079 | .002006 |
|                                            | 1965 East Pakistan | .010053      | .16062 | .001615 | .006104  | .34697 | .002118 | .012529        | .160823 | .002015 |
|                                            | 1965 West Pakistan | .008817      | .26776 | .002361 | .005967  | .20124 | .001201 | .012097        | .144409 | .001747 |
| Mortality rate for males aged 15-44 years  | 1964 East Pakistan | .005574      | .14000 | .000780 | .004813  | .18303 | .000881 | .006047        | .113917 | .000689 |
|                                            | 1964 West Pakistan | .002908      | .18520 | .000539 | .002932  | .13266 | .000389 | .004365        | .091011 | .000397 |
|                                            | 1965 East Pakistan | .002898      | .34651 | .001004 | .001678  | .34566 | .000580 | .003675        | .259598 | .000954 |
|                                            | 1965 West Pakistan | .004065      | .19131 | .000778 | .002504  | .11357 | .000284 | .004970        | .119800 | .000595 |

TABLE 9 (CONTINUED)

| Parameter                                         | Year/Province      | Registration |        |         | Survey   |        |         | Chandra Deming |         |         |
|---------------------------------------------------|--------------------|--------------|--------|---------|----------|--------|---------|----------------|---------|---------|
|                                                   |                    | Estimate     | CV     | SE      | Estimate | CV     | SE      | Estimate       | CV      | SE      |
| Mortality rate<br>for females aged<br>15-44 years | 1964 East Pakistan | .007586      | .10392 | .000788 | .006832  | .14035 | .000959 | .008574        | .099066 | .000849 |
|                                                   | 1964 West Pakistan | .004792      | .05099 | .000244 | .003220  | .15716 | .000506 | .006202        | .053160 | .000330 |
|                                                   | 1965 East Pakistan | .004816      | .13784 | .000664 | .003204  | .25298 | .000811 | .006393        | .069448 | .000444 |
|                                                   | 1965 West Pakistan | .004648      | .17663 | .000821 | .003195  | .21563 | .000689 | .006610        | .110086 | .000728 |
| Mortality rate<br>for males aged<br>45 +          | 1964 East Pakistan | .028085      | .12165 | .003417 | .028012  | .12206 | .003419 | .033368        | .104690 | .003493 |
|                                                   | 1964 West Pakistan | .021725      | .16000 | .003476 | .016603  | .21189 | .003518 | .027535        | .125587 | .003458 |
|                                                   | 1965 East Pakistan | .034816      | .12124 | .004221 | .021313  | .16462 | .003509 | .042522        | .099423 | .004228 |
|                                                   | 1965 West Pakistan | .023396      | .16941 | .003964 | .016152  | .15394 | .002486 | .030546        | .142000 | .004338 |
| Mortality rate<br>for females aged<br>45 +        | 1964 East Pakistan | .029276      | .15524 | .004545 | .027125  | .13638 | .003699 | .034777        | .149990 | .005216 |
|                                                   | 1964 West Pakistan | .020564      | .13416 | .002759 | .014581  | .11789 | .001719 | .024688        | .104250 | .002574 |
|                                                   | 1965 East Pakistan | .032762      | .09000 | .002949 | .013128  | .21377 | .002806 | .036874        | .102655 | .003785 |
|                                                   | 1965 West Pakistan | .017079      | .11832 | .002021 | .012610  | .13892 | .001752 | .023571        | .085200 | .002008 |
| Proportion of births<br>of parity 4 +             | 1964 East Pakistan | .583615      | .02828 | .016505 | .600170  | .02000 | .012003 | .595715        | .025479 | .015176 |
|                                                   | 1964 West Pakistan | .600827      | .03162 | .018998 | .635996  | .02645 | .016822 | .611375        | .020025 | .012243 |
|                                                   | 1965 East Pakistan | .602672      | .03000 | .018080 | .626524  | .02828 | .017718 | .608709        | .032680 | .019893 |
|                                                   | 1965 West Pakistan | .589705      | .04690 | .027657 | .640769  | .02000 | .012815 | .609007        | .026665 | .016239 |
| Proportion of<br>population 0 - 14<br>males       | 1964 East Pakistan | -            | -      | -       | .465590  | .01414 | .006583 | -              | -       | -       |
|                                                   | 1964 West Pakistan | -            | -      | -       | .425692  | .02645 | .011260 | -              | -       | -       |
|                                                   | 1965 East Pakistan | -            | -      | -       | .472020  | .01732 | .008175 | -              | -       | -       |
|                                                   | 1965 West Pakistan | -            | -      | -       | .436896  | .02000 | .008738 | -              | -       | -       |
| Proportion of<br>population 0 - 14<br>females     | 1964 East Pakistan | -            | -      | -       | .468733  | .01414 | .006628 | -              | -       | -       |
|                                                   | 1964 West Pakistan | -            | -      | -       | .437164  | .01000 | .004372 | -              | -       | -       |
|                                                   | 1965 East Pakistan | -            | -      | -       | .471840  | .01414 | .006672 | -              | -       | -       |
|                                                   | 1965 West Pakistan | -            | -      | -       | .438287  | .01414 | .006197 | -              | -       | -       |

TABLE 9 (CONTINUED)

| Parameter                                                      | Province      | Registration |    |    | Survey   |        |         | Chandra Deming |    |    |
|----------------------------------------------------------------|---------------|--------------|----|----|----------|--------|---------|----------------|----|----|
|                                                                |               | Estimate     | CV | SE | Estimate | CV     | SE      | Estimate       | CV | SE |
| Proportional<br>increase in<br>population between<br>1962-1965 | East Pakistan | -            | -  | -  | 1.087727 | .01414 | .015380 | -              | -  | -  |
|                                                                | West Pakistan | -            | -  | -  | 1.085287 | .02828 | .030692 | -              | -  | -  |

fy/k.a.

TABLE 10 - MEASURES OF RELIABILITY FOR AGE - SEX SPECIFIC  
DEATH RATES BASED ON CHANDRA-DEMING ESTIMATES,  
PGE: 1964-1965

| Age at death | Year/Province      | Male                   |         |         | Female                 |         |         |
|--------------|--------------------|------------------------|---------|---------|------------------------|---------|---------|
|              |                    | Estimate of death rate | CV      | SE      | Estimate of death rate | CV      | SE      |
| 0            | 1964 East Pakistan | .194601                | .086418 | .016817 | .137148                | .103446 | .014187 |
|              | 1964 West Pakistan | .138263                | .052593 | .007272 | .162306                | .104288 | .016927 |
|              | 1965 East Pakistan | .198184                | .094673 | .018763 | .155551                | .126380 | .019659 |
|              | 1965 West Pakistan | .129986                | .069843 | .009079 | .126265                | .124788 | .015756 |
| 1 - 4        | 1964 East Pakistan | .025353                | .211073 | .005351 | .033522                | .182647 | .006123 |
|              | 1964 West Pakistan | .026712                | .108083 | .002887 | .038987                | .130461 | .005086 |
|              | 1965 East Pakistan | .022829                | .270841 | .006183 | .028230                | .182291 | .005146 |
|              | 1965 West Pakistan | .015790                | .145911 | .002304 | .029574                | .158855 | .004698 |
| 5 - 9        | 1964 East Pakistan | .008145                | .170581 | .001389 | .007131                | .227462 | .001622 |
|              | 1964 West Pakistan | .005864                | .245071 | .001437 | .005648                | .202383 | .001143 |
|              | 1965 East Pakistan | .004489                | .188048 | .000844 | .006133                | .256408 | .001573 |
|              | 1965 West Pakistan | .003854                | .126281 | .000487 | .003265                | .227181 | .000742 |
| 10-14        | 1964 East Pakistan | .003087                | .293397 | .000906 | .003020                | .266631 | .000805 |
|              | 1964 West Pakistan | .002092                | .243857 | .000510 | .004716                | .234679 | .001107 |
|              | 1965 East Pakistan | .002494                | .283544 | .000707 | .001621                | .379770 | .000616 |
|              | 1965 West Pakistan | .001685                | .266631 | .000449 | .003539                | .136989 | .000485 |
| 15-19        | 1964 East Pakistan | .002645                | .356107 | .000942 | .011022                | .267983 | .002954 |
|              | 1964 West Pakistan | .002811                | .363956 | .001023 | .004272                | .354999 | .001517 |
|              | 1965 East Pakistan | .004290                | .351902 | .001510 | .006441                | .294717 | .001898 |
|              | 1965 West Pakistan | .003451                | .207215 | .000715 | .006531                | .368516 | .002407 |
| 20-24        | 1964 East Pakistan | .005578                | .242211 | .001351 | .006235                | .146458 | .000913 |
|              | 1964 West Pakistan | .003175                | .413267 | .001312 | .008105                | .092309 | .000748 |
|              | 1965 East Pakistan | .002509                | .306646 | .000769 | .007193                | .163686 | .001177 |
|              | 1965 West Pakistan | .005438                | .168523 | .000916 | .004165                | .167708 | .000699 |
| 25-29        | 1964 East Pakistan | .002623                | .231359 | .000607 | .008699                | .098798 | .000859 |
|              | 1964 West Pakistan | .004330                | .286751 | .001242 | .004624                | .194720 | .000900 |
|              | 1965 East Pakistan | .002637                | .294314 | .000776 | .007340                | .358200 | .002629 |
|              | 1965 West Pakistan | .004231                | .394853 | .001671 | .006196                | .171526 | .001063 |
| 30-34        | 1964 East Pakistan | .009306                | .214033 | .001992 | .008548                | .181271 | .001550 |
|              | 1964 West Pakistan | .003803                | .352966 | .001342 | .007730                | .190003 | .001469 |
|              | 1965 East Pakistan | .006537                | .176788 | .001156 | .006069                | .164116 | .000996 |
|              | 1965 West Pakistan | .006221                | .240554 | .001496 | .004980                | .286753 | .001428 |
| 35-39        | 1964 East Pakistan | .007363                | .139596 | .001028 | .012980                | .157934 | .002050 |
|              | 1964 West Pakistan | .005682                | .305044 | .001733 | .006925                | .322954 | .002236 |
|              | 1965 East Pakistan | .003740                | .506057 | .001893 | .005839                | .366734 | .002141 |
|              | 1965 West Pakistan | .003778                | .530289 | .002003 | .010191                | .207369 | .002113 |

TABLE 10 (CONTINUED)

| Age at death | Year/Province      | Male                   |         |         | Female                 |         |         |
|--------------|--------------------|------------------------|---------|---------|------------------------|---------|---------|
|              |                    | Estimate of death rate | CV      | SE      | Estimate of death rate | CV      | SE      |
| 40-44        | 1964 East Pakistan | .010799                | .205063 | .002214 | .004117                | .560770 | .002309 |
|              | 1964 West Pakistan | .008067                | .257577 | .002078 | .006302                | .253756 | .001599 |
|              | 1965 East Pakistan | .003502                | .428503 | .001501 | .005335                | .433690 | .002314 |
|              | 1965 West Pakistan | .008972                | .192252 | .001725 | .010364                | .192582 | .001996 |
| 45-49        | 1964 East Pakistan | .011575                | .406562 | .004706 | .007858                | .213654 | .001679 |
|              | 1964 West Pakistan | .010745                | .253716 | .002726 | .008718                | .444203 | .003873 |
|              | 1965 East Pakistan | .013545                | .407378 | .005518 | .009979                | .222090 | .002216 |
|              | 1965 West Pakistan | .009284                | .440427 | .004089 | .005117                | .384488 | .001967 |
| 50-54        | 1964 East Pakistan | .017497                | .119264 | .002087 | .019181                | .279152 | .005354 |
|              | 1964 West Pakistan | .006483                | .242532 | .001572 | .013589                | .201896 | .002744 |
|              | 1965 East Pakistan | .017456                | .352986 | .006162 | .010251                | .229247 | .002350 |
|              | 1965 West Pakistan | .019471                | .137706 | .002681 | .007109                | .312149 | .002219 |
| 55-59        | 1964 East Pakistan | .014207                | .245695 | .003491 | .014503                | .456367 | .006619 |
|              | 1964 West Pakistan | .025418                | .126123 | .003206 | .004494                | .102728 | .000462 |
|              | 1965 East Pakistan | .026938                | .296891 | .007998 | .028825                | .254547 | .007337 |
|              | 1965 West Pakistan | .024460                | .319515 | .007815 | .010325                | .296562 | .003062 |
| 60-64        | 1964 East Pakistan | .040452                | .202571 | .008194 | .034066                | .311764 | .010621 |
|              | 1964 West Pakistan | .025898                | .108591 | .002812 | .023400                | .215912 | .005052 |
|              | 1965 East Pakistan | .040693                | .304979 | .012411 | .052685                | .141887 | .007475 |
|              | 1965 West Pakistan | .024480                | .246885 | .006044 | .028815                | .231283 | .006664 |
| 65 +         | 1964 East Pakistan | .092157                | .170129 | .015679 | .125602                | .164578 | .020671 |
|              | 1964 West Pakistan | .067727                | .158436 | .010730 | .065593                | .133064 | .008728 |
|              | 1965 East Pakistan | .124569                | .096969 | .012079 | .119088                | .189005 | .022508 |
|              | 1965 West Pakistan | .075165                | .127824 | .009608 | .063825                | .086510 | .005522 |



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APPENDIX TABLE 1: THE FIRST STAGE OF THE PGE EAST PAKISTAN  
RURAL SAMPLE

| Division   | Stratum | Total No.<br>of groups | No. of groups<br>in the sample |
|------------|---------|------------------------|--------------------------------|
| Rajshahi   | 1       | 6                      | 2                              |
| Khulna     | 2       | 6                      | 2                              |
| Chittagong | 3       | 8                      | 2                              |
| Dacca      | 4       | 8                      | 4                              |

APPENDIX TABLE 1: THE FIRST STAGE OF THE PGE EAST PAKISTAN RURAL SAMPLE

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| Division   | Stratum | Total No.<br>of groups | No. of groups<br>in the sample |
|------------|---------|------------------------|--------------------------------|
| Rajshahi   | 1       | 6                      | 2                              |
| Khulna     | 2       | 6                      | 2                              |
| Chittagong | 3       | 8                      | 2                              |
| Dacca      | 4       | 8                      | 4                              |

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APPENDIX TABLE 2: THE SECOND AND THIRD STAGES OF THE PGE EAST PAKISTAN RURAL SAMPLE

| Stratum | Group No. | Total No. of U.Cs | No. of U.Cs in the sample | 1961 population of the U.C. | Area code |
|---------|-----------|-------------------|---------------------------|-----------------------------|-----------|
| 1       | 1         | 221               | 1                         | Not available               | 110       |
|         | 2         | 176               | 1                         | Not available               | 111       |
| 2       | 1         | 133               | 1                         | Not available               | 122       |
|         | 2         | 102               | 1                         | Not available               | 123       |
| 3       | 1         | 93                | 1                         | Not available               | 134       |
|         | 2         | 133               | 1                         | Not available               | 135       |
| 4       | 1         | 128               | 1                         | Not available               | 146       |
|         | 2         | 152               | 1                         | Not available               | 147       |
|         | 3         | 127               | 1                         | Not available               | 148       |
|         | 4         | 158               | 1                         | Not available               | 149       |

APPENDIX TABLE 3: THREE STAGES OF THE PGE EAST PAKISTAN URBAN SAMPLE

| Divisions            | Stratum | Total No. of urban areas | No. of urban areas in the sample | Total No. of U.Cts. | No. of U.Cts in the sample | 1961 population of the U.Ct. | Area code |
|----------------------|---------|--------------------------|----------------------------------|---------------------|----------------------------|------------------------------|-----------|
| Rajshahi and Khulna  | 5       | 31                       | 1                                | 8                   | 1                          | Not available                | 150       |
| Dacca and Chittagong | 6       | 27                       | 1                                | 9                   | 1                          | Not available                | 161       |

APPENDIX TABLE 4: THE FIRST STAGE OF THE PGE WEST PAKISTAN  
RURAL SAMPLE

| Division                 | Stratum | Total No.<br>of groups | No. of groups<br>in the sample |
|--------------------------|---------|------------------------|--------------------------------|
| Peshawar and<br>D.I.Khan | 1       | 3                      | 1                              |
| Rawalpindi               | 2       | 3                      | 1                              |
| Lahore                   | 3       | 5                      | 1                              |
| Multan                   | 4       | 5                      | 1                              |
| Bahawalpur               | 5       | 2                      | 1                              |
| Hyderabad and Karachi    | 6       | 2                      | 1                              |
| Sargodha                 | 7       | 5                      | 2                              |
| Khairpur                 | 8       | 3                      | 2                              |

APPENDIX TABLE 5: THE SECOND, THIRD, AND FOURTH STAGES OF THE PGE WEST PAKISTAN RURAL SAMPLE

| Stratum | Group No. | Total No. of tehsils | No. of tehsils in the sample | Total No. of U.Cs. | No. of U.Cs in the sample | 1961 Population of the U.C. | Area code |
|---------|-----------|----------------------|------------------------------|--------------------|---------------------------|-----------------------------|-----------|
| 1       | 1         | 9                    | 1                            | 9                  | 1                         | Not available               | 200       |
| 2       | 1         | 3                    | 1                            | 40                 | 1                         | Not available               | 211       |
| 3       | 1         | 2                    | 1                            | 46                 | 1                         | Not available               | 222       |
| 4       | 1         | 4                    | 1                            | 22                 | 1                         | Not available               | 233       |
| 5       | 1         | 5                    | 1                            | 19                 | 1                         | Not available               | 244       |
| 6       | 1         | 15                   | 1                            | 4                  | 1                         | Not available               | 255       |
| 7       | 1         | 5                    | 1                            | 31                 | 1                         | Not available               | 266       |
|         | 2         | 2                    | 1                            | 57                 | 1                         | Not available               | 269       |
| 8       | 1         | 11                   | 1                            | 6                  | 1                         | Not available               | 278       |
|         | 2         | 11                   | 1                            | 8                  | 1                         | Not available               | 277       |

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APPENDIX TABLE 6: THREE STAGES OF THE PGE WEST PAKISTAN URBAN SAMPLE

| Divisions                                                   | Stratum | Total No. of urban areas | No. of urban areas in the sample | Total No. of U.Cts. | No. U.Cts in the sample | 1961 population of the U.Ct. | Area code |
|-------------------------------------------------------------|---------|--------------------------|----------------------------------|---------------------|-------------------------|------------------------------|-----------|
| Peshawar, D.I.Khan, Rawalpindi, Sargodha, Lahore and Multan | 9       | 158                      | 1                                | 19                  | 1                       | Not available                | 280       |
| Bahawalpur, Khairpur, Hyderabad and Karachi                 | 10      | 54                       | 1                                | 10                  | 1                       | Not available                | 291       |

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