# Use of the Chandrasekar-Deming Technique in the Liberian Fertility Survey

JOHN C. RUMFORD, M.A.

THE FERTILITY survey is no longer a statistical freak. Born of necessity, it is perhaps the only inexpensive short-term and relatively accurate tool that countries without functional vital registration systems can use to estimate birth, death, and migration rates.

Implementation of fertility surveys is now worldwide. Brazil (*1*), India, (*2*, *3*), Morocco (*4*), Pakistan (*5*), Senegal (*6*), Thailand (*7*), Turkey (*8*), and the United Arab Republic (*9*), to name a few, have used these surveys to provide basic information on population growth. Currently, Liberia (*10*) and Ghana (*11*) are carrying out fertility studies, and there is evidence that several other African States will soon follow.

### Chandrasekar-Deming Technique

Although fertility surveys are relatively new on the statistical scene, most have adopted a similar pattern which is based on the Chandrasekar-Deming(C-D) technique (*12*). Basically, with the C-D technique vital event data are obtained by two separate data collection systems for the same population and the same time period.

One data collection system, usually a survey, seeks vital events through household enumerations taken at regular time intervals—generally monthly, quarterly, or annually. The other system, using a complementary enumeration device—a survey or some type of registration or informant system—also collects information on vital events but does it independently and usually on a continuing basis. The results obtained with the two systems are then compared, and differences in the records are reconciled through field verification or logic or both.

After reconciliation is completed, each event is categorized by the system in which the event was found. Three basic possibilities are (*a*) the same events recorded by both systems, $C$, (*b*) events recorded by the first system but missed by the second, $N_1$, or (*c*) events recorded by the second system but missed by the first, $N_2$. The total number of events that occurred is determined by adding the three possibilities, $N=C+N_1+N_2$. In addition, an estimate of the probable number of events missed by both systems can be made by application of a simple probability model $N=N_1\times N_2\div C$ (*12*,*13*). This estimate can then be added to the first to obtain the total number of events that probably occurred in a given area during a specified time.

Unfortunately, although the basic principles

*Mr. Rumford, with the U.S. Bureau of the Census working under a participating agency agreement with the U.S. Agency for International Development, is currently a demographic survey adviser to the Republic of Liberia, Department of Planning and Economic Affairs. He presented this paper at the Economic Commission for Africa's Working Group on Fertility Studies and Evaluation of Population Programs in Addis Ababa, Ethiopia, January 1970.*

of the dual collection system are generally accepted and relatively well documented (*14–16*), little has been said about actual field application of the method. As is often true in survey work, the translation of basic principles into operational procedures is a giant, complicated step. Often the field procedures, which are designed to protect the principles, result in modification or nullification or, in some situations, actually correct or reinterpret the principles.

### Field Application in Liberia

Some basic problems are being encountered with field application of the Chandrasekar-Deming technique. The Liberian Population Growth Survey is being conducted by the Department of Planning and Economic Affairs, Republic of Liberia, with technical and financial assistance from the U.S. Agency for International Development. The survey was started in May 1969 and, methodologically, it is totally committed to the C-D technique. The survey's purpose is to provide the Liberian Government with accurate and current estimates of births, deaths, migrations, and other demographic parameters needed by Government planners to evaluate the natality and mortality experience of the country's people.

The survey is conducted on a sample basis. Estimates are being generated for rural areas (2,000 or less persons) and for urban areas (2,001 or more persons). The rural sample consists of 100 villages located in 50 clans (counties). Every household in a sample village is included in the enumeration. In the urban areas, 100 sample "blocks," each containing about 200 people, have been selected. Again, every household within these blocks is included. The overall sample size is about 70,000 persons or roughly 5 percent of the current estimated population of Liberia.

The subject matter of the survey is based primarily on recommendations of the United Nations (*17*). The questionnaire currently being used is shown on pages 968 and 969.

### Data Collection Methods

The dual enumeration method used in Liberia is patterned after the Turkish model (*8*). The two methods used to collect the data are a monthly enumeration, conducted by a local resident called a registrar, and a semiannual enumeration, conducted by a nonresident staff enumerator called a supervisor. This model adapts well to the geographic, cultural, and social conditions of Liberia. Its tropical climate has two distinct seasons, a dry season beginning in late November and ending in May and a wet season during the balance of the year. During the rainy season, the roads are poor and many areas are not easily accessible. Thus, the semiannual enumerations are scheduled during the transition from wet to dry seasons in May and November. Not only does this schedule minimize travel during the wet season, but it also yields convenient recall time periods which are easily understood by respondents who are not oriented toward thinking in terms of specific months of the year.

Moreover, the resident registrar system lends itself to a culture which has varied language dialects and people who are reluctant to confide in strangers or persons not affiliated with their immediate tribal group. To establish this system, the registrars and supervisors enumerate each household in the sample areas. They fill out in duplicate for each household the census information in blocks 1 and 2 of the questionnaire but do not seek information concerning events at this time. One copy of each questionnaire is kept by the registrar and the other is sent to the central office.

At the end of each month the registrar visits each household, taking along the initial questionnaire. He asks if any births, deaths, or in- or out-migrations took place since his last visit. He also inquires about pregnancies and serious illnesses. If any of these events occurred, he records them on two fresh questionnaires in blocks 3, 4, 5, or 6 and adjusts the census information in block 2. Again, one copy of the questionnaire is kept by the registrar and the other is sent to the central office via the supervisor. This process is continued throughout the year.

At the close of the first 6 months, a team of supervisors visits each sampling unit and completely re-enumerates the households, using a 6-month recall period and the same type of questionnaire. The supervisors do not have the registrars' records nor do the registrars take part in the re-enumeration. When the re-enu-

meration is completed the supervisors' reports are sent to the central office, where they are matched against the registrars' records for that period.

All household population imbalances and event mismatches are verified and coded as to which system picked up the event—the registrar, the supervisor, or both. At the close of the following 6-month period, the whole process is repeated except that the supervisors use a 12-month recall period. Again, mismatches are verified and appropriately coded. Machine runs are made of the results by a pickup method. The bookkeeping system is essentially the same as that used for financial transactions. The initial deposit is the original household population, each month subsequent deposits are births and in-migrations and the withdrawals are deaths and out-migrations. The current balance is adjusted continually to reflect the changes.

To enhance the basic system, several casefinding tools and enumeration and tabulation techniques have been used. The more successful ones are incentive payments to both the registrars and supervisors for every verified birth or death they record, diaries of pregnancies and serious illnesses, and letters of congratulations for births and condolences for deaths—both of which are in the form of official-looking documents. In addition, population imbalances between the two reporting methods are verified in the field regardless of whether or not an event was reported, and all events are tabulated by pickup methods as well as by selected characteristics of an event and the persons associated with it.

Although the casefinding tools and tabulation methods described were designed specifically to encourage the enumerators and respondents to record and report events regularly and accurately, and the enumeration model is considered as straightforward as any conceived thus far, there are inherent problems in applying some of these which positively and negatively affect the principles of the C-D formula. On the positive side, the C-D method requires that each collection system be completely independent. Unfortunately, no system can guarantee honesty regardless of how carefully controlled the system may be. Curbstoning (enumerations in the absence of respondents or collusion between enumerators) must be at least the second oldest profession. To discourage this practice, gang enumerations and the incentive system have been instituted.

### Incentive Payments

In Liberia's incentive system, the monthly enumerator is paid $1 for each birth or death that he records. The semiannual enumerator is paid $1 for each birth or death that he records which was not recorded by the monthly enumerator. All disagreements are verified by a third-party referee in the presence of the respondent to discourage curbstoning by registrars and supervisors.

If the registrars do not make their required monthly rounds, they may miss many births and deaths, particularly neonatal deaths, and thus they will lose money. Moreover, the fact that their supervisors may pick up the incentive money is particularly galling.

On the other hand, the supervisors, who are in an excellent position to curbstone, will be equally penalized for the practice. If a supervisor is so inclined, he needs only to record or note the births and deaths reported by the registrar, and when it is time for his semiannual round he can recopy the events, fake a few entries, and never bother to re-enumerate the unit. Under the Liberian system, however, this supervisor would not receive any money because he is paid for only those events not recorded by the registrar. The only way for a supervisor to get incentive events is to reinterview every household in the unit. Although there are obvious dangers in the incentive system, field verification of each mismatching event reduces them to a minimum. Thus far the incentive system has worked well in Liberia, and the number of reported and verified events is encouraging.

### Letters to Respondents

The official-looking letters of congratulations for births and condolences for deaths are presented to the respondents by the registrars when a birth or death is reported. These documents have been particularly effective in encouraging respondents to report vital events, and they have been useful in helping supervisory personnel to evaluate the registrar's monthly reports.

In any country where literacy is low, the

Block 1 _____

1. Division _____ Unit Code

2. Village/City _____

3. Dwelling Unit No. _____

4. Name Of Head Of Household _____

5. Serial No. Of Household _____

**Block 2** Ask All Household Members – Total

| Serial No. | First Name (10) | Surname (11) | Relationship to head (12) | Sex M F (13) | Age year of birth (14) | Marrital Status (15) NW M W D/S |
|---|---|---|---|---|---|---|
| 01 | | | Head | 1 2 | | 1 2 3 4 |
| 02 | | | | 1 2 | | 1 2 3 4 |
| 03 | | | | 1 2 | | 1 2 3 4 |
| 04 | | | | 1 2 | | 1 2 3 4 |
| 05 | | | | 1 2 | | 1 2 3 4 |
| 06 | | | | 1 2 | | 1 2 3 4 |
| 07 | | | | 1 2 | | 1 2 3 4 |
| 08 | | | | 1 2 | | 1 2 3 4 |
| 09 | | | | 1 2 | | 1 2 3 4 |
| 10 | | | | 1 2 | | 1 2 3 4 |
| 11 | | | | 1 2 | | 1 2 3 4 |
| 12 | | | | 1 2 | | 1 2 3 4 |

**Block 3 – Births** Total (1 2 3)

Mothers Identifications – Child's Identification –

| Pick-up method | Mother's Serial No. from block 2 (22) | (from blk. 2) Mother's age (23) | Mother's Literacy Status (from blk. 2) (24) | Number of months since last birth (25) | Child's Sex M F (26) | Child's Date of Birth Month (01–12) (27) | Year (28) | Place of birth Home Hosp. Other (29) | Birth Order |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1 2 | | 1 2 | | | 1 2 3 | |
| | | | 1 2 | | 1 2 | | | 1 2 3 | |
| | | | 1 2 | | 1 2 | | | 1 2 3 | |
| | | | 1 2 | | 1 2 | | | 1 2 3 | |
| | | | 1 2 | | 1 2 | | | 1 2 3 | |
| | | | 1 2 | | 1 2 | | | 1 2 3 | |

**Block 5 – In Migration** Total (1 2 3)

| Pick-up method | Serial No. from block 2 (39) | Sex M F (40) | Age (41) | Date of migration Month Year (42) | Reason Seek wrk. found wrk. Mar. riage Ed. Other (43) | Place from This place Village City/Town Outside Liberia name (44) | Esti-mated length of stay Months (45) |
|---|---|---|---|---|---|---|---|
| | | 1 2 | | | 1 2 3 4 5 | 1 2 3 | |
| | | 1 2 | | | 1 2 3 4 5 | 1 2 3 | |
| | | 1 2 | | | 1 2 3 4 5 | 1 2 3 | |
| | | 1 2 | | | 1 2 3 4 5 | 1 2 3 | |
| | | 1 2 | | | 1 2 3 4 5 | 1 2 3 | |
| | | 1 2 | | | 1 2 3 4 5 | 1 2 3 | |

6. Name Of Registrar Or Supervisor _____

7. Date Of Interview | | | | | | | | | | | | |

8. ☐ Registrar Report — Date Monthly Visit — Official Date | | | | |

9. ☐ Supervisor's Report

(Check appropriate)

Do not write in these spaces

Housing Types

| Ask all ever married | Ask All Women Over Age 14 Years | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ability to Read and Write English Literate Yes No (16) | School attendance Do (17) | Do not (17) | Age at first Marriage (18) | Number of Children still at home (19) | Number of Children away (20) | Number of Children who died (21) | Ever borne | Surviving | (additional questions) | | | |
| 1 2 | 1 | 2 | | | | | | | | | | |
| 1 2 | 1 | 2 | | | | | | | | | | |
| 1 2 | 1 | 2 | | | | | | | | | | |
| 1 2 | 1 | 2 | | | | | | | | | | |
| 1 2 | 1 | 2 | | | | | | | | | | |
| 1 2 | 1 | 2 | | | | | | | | | | |
| 1 2 | 1 | 2 | | | | | | | | | | |
| 1 2 | 1 | 2 | | | | | | | | | | |
| 1 2 | 1 | 2 | | | | | | | | | | |
| 1 2 | 1 | 2 | | | | | | | | | | |
| 1 2 | 1 | 2 | | | | | | | | | | |
| 1 2 | 1 | 2 | | | | | | | | | | |

Block 4 Deaths — All Deaths (1 2 3) — Infant deaths (1 2 3)

All Persons Dead –

| Pick-up method | Serial No. from blk. 2 of original questionnaire (30) | Sex M F (31) | Date of death Month (01–12) (32) | Year (33) | Age at death If over age 1 yr. No. of yrs. (34) | If under age 1 yr. No. of wks. (35) | Age of Mother Infant death only (36) | Mother's Literacy Infant death only (37) | Place of death Home Hosp. Other (38) |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 2 | | | | | | 1 2 | 1 2 3 |
| | | 1 2 | | | | | | 1 2 | 1 2 3 |
| | | 1 2 | | | | | | 1 2 | 1 2 3 |
| | | 1 2 | | | | | | 1 2 | 1 2 3 |
| | | 1 2 | | | | | | 1 2 | 1 2 3 |
| | | 1 2 | | | | | | 1 2 | 1 2 3 |

Block 6 Out Migration Total (1 2 3)

| Pick-up method | Serial No. from blk. 2 of old questionnaire (46) | Sex M F (47) | Age (48) | Date of migration Mth. Yr. (49) | Reason Seek wrk. Found wrk. Marriage Ed. other unknown (50) | Place to This place Village City/Town Outside Liberia name Unknown (51) | Estimated length of stay Months (52) | Unknown |
|---|---|---|---|---|---|---|---|---|
| | | 1 2 | | | 1 2 3 4 5 | 1 2 3 0 | | |
| | | 1 2 | | | 1 2 3 4 5 | 1 2 3 0 | | |
| | | 1 2 | | | 1 2 3 4 5 | 1 2 3 0 | | |
| | | 1 2 | | | 1 2 3 4 5 | 1 2 3 0 | | |
| | | 1 2 | | | 1 2 3 4 5 | 1 2 3 0 | | |
| | | 1 2 | | | 1 2 3 4 5 | 1 2 3 0 | | |

official-looking document, whether it can be read or not, becomes very precious. Moreover, when the respondent who is constantly harassed by a series of enumerators is actually given something for his cooperation, he becomes more inclined to help. This has been true in Liberia; since these documents are so highly prized, they are proudly produced by the respondent when requested to do so by the survey inspectors. When a spot check of a sample unit reveals that a birth or death occurred during the survey period and the respondent was not given a document, the inspector knows immediately that the event was missed by the registrar and corrective measures can be taken.

### Spurious and Mismatching Events

Other requirements of the C-D method that are positively affected by the enumeration and casefinding procedures used in Liberia are those concerning the elimination of spurious (erroneous) events and those requiring field verification of all mismatches of events. Spurious reports are easily eliminated and field verification has been minimized.

Since identical questionnaires are used in both the monthly and semiannual systems and all household members are listed at the start of the survey, the most common type of spurious event—that of including events which occurred before the survey reference period—can be largely eliminated. In the monthly system the registrar needs only to refer to the initial questionnaire when an event is reported to see if the person affected was listed. Similarly, with the semiannual system the "matching" editor in the office can make a cross reference to the registrar's initial questionnaire.

Other spurious events are also readily identified, although most have to be verified in the field. For example, events that occurred outside the original geographic sample area will have no companion registrar or supervisor questionnaires to match, and events that occurred to household members when they were not living in the sample area are easily spotted because careful records are made as to when in- and out-migrating household members enter and leave the household.

With regard to minimizing verification of mismatching events, field verification is expensive, time consuming, and dangerous. Dangerous because questionnaires in which events are recorded are carried around in the field and easily lost. Therefore anything that can be done to minimize the need for field verification is all to the good.

In Liberia it has been found that the following kinds of mismatches can be safely reconciled without sending them to the field.

1. Selected mismatching events recorded by the registrars but not by the supervisors.

*Births and in-migrations.* If a registrar's record sheet (monthly system) has the same population as the supervisor's (semiannual system) and the newborn or in-migrant can be accounted for on the supervisor's record, differing slightly by age, it may be considered a reconciled event and coded as picked up by the registrar but missed by the supervisor. If the household populations are not balanced or the person is not present, field verification is needed. For example, if both records have five people in the household with the same name, including the baby's, but the registrar recorded a newborn with the same name and mother during one of the survey months, it can be assumed that the supervisor missed the event.

*Deaths and out-migrations.* If a registrar's household population is the same as the supervisor's, that is, say both have recorded six people with the same name but the registrar reported a death during one of the survey months, it can be assumed that the respondent "forgot" to tell the supervisor about the death. The event may be reconciled and credited to the registrar.

2. Selected mismatching events recorded by the supervisors but not by the registrars.

*Births and in-migrations.* If a supervisor recorded a birth or in-migration but an inspection of the registrar's initial record shows that the baby or in-migrant was already in the household when the survey started, the birth or in-migration can be assumed to have occurred before the survey and crossed off the record.

Although it is possible that by using these procedures to reconcile mismatches an occasional event may be erroneously included or lost, field tests have indicated that this rarely happens. For mismatching births, deaths, and migrations other than those mentioned, however, field verification is necessary.

### Household Population Imbalances

One enumeration and control procedure which negatively affects the field verification load is the necessity to verify household population imbalances in the field. These occurrences are so common and so potentially dangerous to the very concept of the Chandrasekar-Deming formula that serious attention must be given to them.

As mentioned before, the C-D method is based on the premise that vital events will be recorded in one of three ways—by both the registrar and the supervisor, by the registrar only, or by the supervisor only. However, this is often not the case. Sometimes births, deaths, and migrations are picked up by a careful screening of the questionnaires by the survey editors.

Classic examples of this situation are being experienced in Liberia, usually in the following manner. In a given household the monthly registrar reported five household members during his initial rounds, but reported no events during his subsequent six monthly rounds. During the supervisor's semiannual round, he recorded six persons in the same household, but no events. All such mismatches, of course, must be verified in the field. Usually, the extra person is revealed as an in-migrant. Occasionally, a birth is revealed. The same situation holds true for out-migrations or deaths.

These "induced" events do not fall into the conventional $C$,$N_1$, and $N_2$ categories, nor can they be arbitrarily assigned to one of the systems without biasing the results when applying the probability model $(N_1 \times N_2 \div C)$. What may be done is to withdraw the induced births and deaths before computing the probability formula and then add them to the overall results. For migrations, however, other more serious considerations make the application of the probability model extremely difficult to justify.

Migrations, unlike births and deaths, usually involve many people. Moreover, they occur frequently—perhaps every 2 or 3 months in some cultures. Therefore, the magnitude of migration rates is much higher than that for births and deaths. In Turkey, for example, in- and out-migration rates of more than 100 per 1,000 population were common (*18*), and the Liberian experience is proving to be similar. Because migrations are frequent, the number of induced events becomes quite large.

Other serious problems occur with migrations which are directly associated with another assumption of the C-D method, that is, although both recording systems are independent of each other, each must have an equal opportunity to obtain the same event.

In practice, it is extremely difficult to fully equalize any two systems concerning migrations regardless of which enumeration model is used. The most frequent system, for example, will always have a distinct advantage over the least frequent. In Liberia the monthly registrars not only use a much shorter recall period—30 days versus 6 months—but they also have in their possession the questionnaire containing the history of the household composition and thus they have the advantage of being able to record in- and out-migrations as they occur. By checking his list of people in the household and noting additions or omissions, the registrar will know if a migration occurred.

On the other hand, the semiannual enumerators are at the mercy of the respondent, since they do not have the questionnaire to provide tipoffs—a necessity to preserve independence. Moreover, when several whole or partial family in- and out-migrations take place, the semiannual enumerators may not even have anyone to interview. This situation is demonstrated by the following figures on gross verified migrations in the Voinjama Division from May 1 through October 30, 1969, according to the type of recording method used.

| *Migrations recorded by—* | *Number* |
|---|---|
| Monthly and semiannual enumerators | 196 |
| Monthly enumerator only | 486 |
| Semiannual enumerator only | 147 |
| Editors only | 149 |

Of the 829 migrations recorded by both methods, excluding those recorded by the editors, 682 migrations (82 percent) were recorded by the monthly system while only 343 (41 percent) were recorded by the semiannual system. If the conventional C-D probability formula for estimating events missed by both systems was carried through in this not atypical example, the results would yield 365 migrants $(486 \times 147 \div 196)$ missed by both systems. Although this result may be true, it could hardly

be published. The only way to take this advantage from the registrars would be to conduct dual monthly enumerations. However, this would be prohibitively expensive and would quickly wear out the respondents.

Because of the problems discussed and because it is usually not possible to determine the kind of migration that could not be picked up by the semiannual system, it probably is not wise to apply the C-D probability model to migrations.

### Pregnancy and Serious Illness Diaries

In the same vein, a similar criticism can be made of the use of diaries of pregnancies and serious illnesses which are kept by the monthly enumerators. When a pregnancy is reported, the month of the report is checked off and a continuous followup is maintained. The serious illness diary is checked each time someone in the household is reported as too ill to leave the house and having been that way for at least a week. Again, a continuous followup is maintained. Both diaries give a definite edge to the monthly registrars, although here the magnitude of events is smaller than for migrations.

The pregnancy and serious illness diaries, particularly the former, have proved to be the most effective casefinding tools thus far. Most pregnant women become physically obvious to the monthly local registrar—particularly in a tropical country where wearing apparel and indoor confinement are minimal. Moreover, since the pregnant state is neither successful or unsuccessful so far as the child is concerned, pregnancy reports are given quite freely—many times it is not even necessary to ask. Once the registrar identifies the pregnant woman, he needs only to followup each month and, of course, either a live birth or a stillbirth will occur or the woman will leave the area. Many births followed immediately by neonatal deaths—the most difficult kind of event for an enumerator to obtain—are recorded by use of the pregnancy diary. Although some women who give birth had not reported being pregnant, such instances are relatively rare and usually result from inadequate monthly coverage by the registrars.

The serious illness diary, although not as effective as the pregnancy diary, has proved relatively successful in identifying the bedridden, long-term chronically ill persons who have a high probability of dying. It has not been successful, however, in identifying persons who died after a short illness—the most common type of death in Liberia.

Fortunately, the diaries, even though favoring the monthly system, do not seriously affect the C-D probability model except in the rare case of births or deaths in households which eventually out-migrated. Of course, such events have a greater chance of being missed by the semiannual enumeration system. Even here, it is possible to withdraw these events before applying the probability model.

### Tabulation Technique

Another valuable technique used in the Liberian survey, which has long been recommended by Chandrasekar and Deming and others (*12*, *13*) and yet rarely used in fertility surveys, is the tabulation of selected characteristics of persons associated with a given event with the system by which the event is recorded. The twofold purpose of this tabulation is to reduce any bias which may be due to the lack of independence of the two collection systems and also, from an operational point of view, to provide information on what types of events and respondents are more likely to be picked up by both systems, by one system, or missed by both systems.

The list of characteristics to be selected for a given type of event could be quite large. Unfortunately, however, no data have been generated which demonstrate the optimum set of characteristics to use. In Liberia, the following seem logical.

*Birth.* Each pickup method (recorded by both registrar and supervisor, by registrar only, or by supervisor only) is tabulated with birth order, sex, and age of mother.

*Death.* Each pickup method is tabulated separately with age and sex of the deceased.

*Infant death.* Each pickup method is tabulated separately with age of the infant in weeks, sex, and age of mother.

*In- and out-migrations.* Each pickup method is tabulated with origin or destination of the migrants by age and sex.

The outcome of this tabulation is not yet

known. However, it should help to clarify the problem of missing events and provide valuable information on the relationship between pickup method and a given type of respondent or event.

## Conclusion

The field experience and implementation techniques described suggest some of the problems associated with carrying out the Chandrasekar-Deming technique in the Liberian Population Growth Survey and how some of these procedures have actually affected the C-D technique.

Many technicians in the demographic field believe that the basic theory underlying the C-D method is the best one known at this time. Probably its greatest strength is that it involves systematic cross-checking. Because of the two independent methods, collecting the same information and covering the same population and time period, the technician is continually confronted with discrepancies which must be verified. At the same time, he knows where the field problems are, what kinds of errors are occurring, and who is responsible for their occurrence. Although fertility studies not based on this technique are simpler to do and less expensive to operate, the technician must accept the data at face value.

A survey does not become Holy, however, because the Chandrasekar-Deming technique is used. The method of carrying out the dual system is equally as important as the technique itself. The object of the technique, to obtain a record of all the events that occurred in the area surveyed, is directly related to such factors as the frequency of enumeration, casefinding methods used, quality of the enumerators employed, and thoroughness of matching and verifying. The following procedures have thus far proved successful in Liberia.

- Monthly enumerators have a better opportunity to record events, particularly migrations, than do the enumerators who use a longer recall period.
- Local, resident enumerators receive more cooperation from respondents than do enumerators who are not from the immediate sample area.
- Independence and coverage of the two systems can be improved by offering selective, incentive payments to both the monthly and semiannual enumerators.
- Information on migrations should be obtained and recorded as diligently as that on births and deaths.
- Population imbalances between the two systems must be verified in the field.
- The pregnancy diary is among the more effective methods of obtaining births and infant deaths.
- The official-looking documents presented to respondents when they report births or deaths improve rapport between enumerators and respondents and provide a convenient method for checking field coverage.
- Spurious events and full field verification of mismatching reports can be minimized safely by carefully maintaining a household population balance between both reporting systems and by carefully editing and cross-referring each mismatching questionnaire pair.

## REFERENCES


(1) United Nations: Guanabara demographic pilot survey. ST/SOA/Series A/35. New York, 1964.

(2) United Nations: The Mysore population study. ST/SOA/Series A/34. New York, 1961.

(3) Majumdar, M.: Estimation of vital rates in the Indian National Sample Survey. World Population Conference, Doc. No. B.6/I/E/312. Belgrade, 1965.

(4) Sabagh, G., and Scott, C.: An evaluation of the use of retrospective questionnaires for obtaining vital data: the experience of the Moroccan multi-purpose sample survey of 1961–1963. World Population Conference, Doc. No. B.6/V/E/56. Belgrade, 1965.

(5) Ahmed, N., and Krotki, K.: Simultaneous estimations of the population growth. The Pakistan experiment. Pakistan Development Rev 3: 37–65 (1963).

(6) Cantrelle, P.: Repeated demographic observation in a rural area in Senegal: method and first results. World Population Conference, Doc. No. B.6/V/F/207. Belgrade, 1965.

(7) Lauriat, P.: Field experiences in estimating population growth. Demography 4: 228–243 (1967).

(8) Rumford, J. C., Heperkan, Y., and Fincancioğlu, N.: The principles and preliminary results of the Turkish Demographic Survey. Public Health Rep 83: 573–582, July 1968.

(9) Vukovich, G.: The U.A.R. project for measuring vital rates in rural areas. World Population Conference, Doc. No. B.6/I/E/68. Belgrade, 1965.

(10) Republic of Liberia: Liberian population growth survey, handbook 1969. Department of Planning and Economic Affairs, Monrovia, 1969.
(11) Demographic Unit, University of Ghana: Demographic sample survey. Accra, 1968. Mimeographed.
(12) Chandrasekar, C., and Deming, W. E.: On a method of estimating birth and death rates and the extent of registration. J Amer Stat Assoc 44: 101–115, March 1949.
(13) Grove, R.: Studies in the completeness of birth registration. Part I: Completeness of birth registration in the United States, December 1, 1939 to March 31, 1940. U.S. Bureau of the Census. Vital Statistics—Special Reports, vol. 17, No. 18. Washington, D.C., 1943.
(14) Coale, A. J.: The design of an experimental procedure for obtaining accurate vital statistics. International Population Conference. New York, 1961, pp. 372–375.
(15) Jabine, T. and Bershad, M.: Some comments on the Chandrasekar-Deming technique for the measurement of population change. Paper presented at the CENTO Symposium on Demographic Statistics, Karachi, Pakistan, Nov. 5–12, 1968. Mimeographed.
(16) Seltzer, W.: Some results from Asian population growth studies. The Population Council, New York, 1969. Mimeographed.
(17) United Nations: Methods of estimating basic demographic measures from incomplete data. Population Studies No. 42, manual IV, ST/SOA/Series A/42. New York, 1967.
(18) Ministry of Health and Social Welfare, Turkey: Vital statistics from the Turkish Demographic Survey. School of Public Health, Ankara, 1967.

**Tearsheet Requests**

John C. Rumford, Demographic Survey Adviser, U.S. AID, PAD, APO 09155, New York, N.Y.

## Federal Clean Car Incentive Program

A Federal Clean Car Incentive Program to spur development of a low-pollution automobile has been established by the Department of Health, Education, and Welfare. Administered by the National Air Pollution Control Administration (NAPCA), the program is designed to stimulate private efforts to market a passenger car by the 1980's that will match the performance and convenience of the present-day automobile, but will have a fundamentally pollution-free powerplant.

The Federal Clean Car Incentive Program offers graduated financial incentives in three phases—prototype, demonstration, and fleet test. Stringent requirements must be met by any vehicle accepted for entry into the prototype phase. Each prototype must demonstrate essentially pollution-free characteristics, adequate road performance, and a potential for mass production.

Any vehicle which meets the prototype criteria may be considered for the demonstration phase of the program. In this phase, NAPCA will purchase 10 models of the vehicle to test under various operating conditions for several months. To enter this phase, a car must continue to meet the same rigorous standards for emission limits. Factors such as driveability, durability, safety, economy, and noise control will be examined carefully. Acceptance criteria governing these factors for vehicles entering this phase will be set by a Government board made up of representatives of NAPCA, the Department of Transportation, and the General Services Administration.

Vehicles successfully completing the demonstration phase may be considered candidates for entry into the fleet test phase, for which NAPCA will purchase some 300 models for lengthy, intensive testing in fleet use by selected Government agencies under typical driving conditions. During the last phase, each vehicle's low emission features must retain their effectiveness during prolonged use. Other major considerations will be driver reaction, frequency of repair, safety, fuel economy, and other features peculiar to the vehicle's hardware or design.

Any car completing all phases of the Federal Clean Car Incentive Program could be considered for certification for procurement by Government agencies for fleet use if pending legislation is adopted. About $20 million is expected to be required to conduct the program over the next several years.