IMPROVING THE PLUS 1 METHOD OF RANDOM DIGIT DIALING

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Random digit dialing is the preferred method for conducting household telephone surveys. The large number of unlisted telephones, especially in metropolitan areas, makes telephone-directory-based sampling biased. There are several sampling procedures used in random digit dialing. Unrestricted random digit dialing is absolutely unbiased. Unfortunately, however, it is very expensive, since a large number of nonworking numbers and commercial numbers are reached. Waksberg's method of random digit dialing operates on the principle of Lahiri's method of selection in PPS sampling. It is more economical, since telephone companies usually do not activate numbers randomly within an exchange. They make several banks (denoted by either the first digit or first two digits of the last four digits of a telephone number) active and Waksberg's method of sampling concentrates on dialing numbers in banks proved to be active. However, this method requires a large amount of bookkeeping.

The Plus 1 method is a rather simple method of random digit dialing. Household telephone numbers are selected at random from telephone directories and one is added to every selected number to randomize the set. The resulting numbers are dialed. A larger proportion (40 to 60 percent) of the dialed numbers reach households. However, this is a biased method of sampling which is not often recognized. It stems from the fact that every number so generated has an equal probability of selection. If K numbers are listed in the directory, then every number obtained by adding one to each of the original K numbers listed has an equal probability of selection. This is definitely true. But let us examine the K numbers that are obtained. A bank that is relatively full will have more numbers than a bank that is relatively empty.

Let us examine two banks: One is completely full, i.e., all the numbers are active; the other is half full--only half the numbers are active, and these numbers are randomly distributed within the bank. Every number in the first bank has an equal probability of selection, while in the second bank, only half the active numbers have a nonzero probability of selection. If the numbers in a bank were activated in a continuous manner, this biasing effect would be almost nonexistent.

Mathematically, the probability of selection of a number in a bank is as follows:

$$\frac{Li}{L} \cdot \frac{1}{100}$$

where Li = number of listed numbers in the ith bank.
L = total number of listed numbers

It is easy to see that the probability of selection of numbers varies from one bank to another, since Li varies from one bank to another. However, a simple procedure will reduce the bias due to the reason above. This procedure is as follows:

The plus 1 number is dialed. If a household is reached, there is no problem. If a household is not reached, the next number is dialed. This continues until a household is reached. The probability of selection of a household in the ith bank is

$$\frac{Li}{L} \cdot \frac{1}{Ti}$$

where Ti = total numbers of households with telephone in the ith bank

If we make an assumption that

$$\frac{Li}{L} = \frac{Ti}{T}$$ the Plus 1 method becomes completely unbiased

where T = total number of households with telephone.

Unfortunately, such an assumption is not true, since we know the proportion of listed numbers varies depending on such factors as urbanization.

Nevertheless, this procedure would reduce the original bias considerably since:

$$\frac{Li}{Ti} \text{ is in general more stable than } \frac{Li}{100}.$$

However, in addition, if strata are formed on the basis of degree of urbanization,

$$\frac{Li}{Ti}$$

becomes almost constant within a strata. This will have the effect of further reducing the bias.

The statistical principle used in the procedure above is similar to the procedure used in Sudman (1973).

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