

Capture–recapture methods for estimation of fertility and mortality in a rural district of Turkey

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طرق الالتقاط وعودة الالتقاط لتقدير الخصوبة والوفيات في المناطق الريفية في تركيا
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الخلاصة: استخدمت هذه الدراسة طرق الالتقاط وعودة الالتقاط لمعرفة فيما إذا كانت المعلومات حول الولادات والوفيات واستخدام وسائل تنظيم الأسرة والمستمدة من مصدرين للمعطيات تقدم المعلومات ذاتها أو معلومات أكثر اكتمالاً مما هو متوافر من مصدر واحد. وقد استمدت المعلومات من خمسة مصادر مختلفة هي: مختار القرية، المتطوعون لنممل الاجتماعي المحلي، مراكز الرعاية الصحية الأولية، وحدات رعاية الأمهات والأطفال، والوحدات الإدارية المحلية (رؤساء المجموعات الصحية) في عشر قرى منتقاة في منطقة ريفية في تركيا في الفترة بين أيار/مايو وتشرين الأول/أكتوبر 1999. ورغم أن أعداد الوفيات والولادات كانت تقديرية، فلم يكن هناك أي تقدير لعدد اللواتي يستخدمن وسائل منع الحمل. وتوضح الدراسة بعض المشكلات في جمع المعطيات في نظام الترصد في تركيا وتوصي بتقوية نظام الترصد الروتيني.

ABSTRACT The study used capture–recapture methods to determine if information on births, deaths and family planning use obtained from two data sources provides the same or more complete information than that available from a single source. Five different data sources used were: village heads (*mukhtars*), community health volunteers, primary health care centres, maternal and child care units and local administrative units (health group presidencies) in 10 selected villages in a rural area of Turkey from May to October 1999. Although the numbers of deaths and births were estimated, no estimation of the number of women using any family planning method could be made. The study highlights some data collection problems of the surveillance system in Turkey and recommends that the routine surveillance systems be strengthened.

Méthodes de capture-recapture pour l'estimation de la fécondité et de la mortalité dans un district rural en Turquie

RESUME L'étude a utilisé des méthodes de capture-recapture pour déterminer si les informations concernant les naissances, les décès et le recours à la planification familiale obtenues auprès de deux sources de données fournissent les mêmes informations ou des informations plus complètes que celles provenant d'une seule source. Cinq différentes sources de données ont été utilisées : les chefs de village (*mukhtars*), les volontaires de santé communautaires, les centres de soins de santé primaires, les services de soins de santé maternelle et infantile et les administrations sanitaires locales dans 10 villages sélectionnés dans une zone rurale de la Turquie de mai à octobre 1999. Bien que le nombre de décès et de naissances ait été estimé, aucune estimation n'avait pu être faite concernant le nombre de femmes utilisant des méthodes de planification familiale. L'étude met en évidence certains problèmes liés au recueil de données du système de surveillance en Turquie et recommande que le système de surveillance systématique soit renforcé.

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Introduction

Capture-recapture methods (dual enumeration) were first developed by ecologists for estimating total animal populations and are now used in many fields of science. Although use of the methodology in human populations was first documented in the literature in 1949 by Chandra-Sekar and Deming [1], it was used in population censuses in 18th century France. Since then, capture-recapture has been used in the estimation of the numbers of births and deaths in India and in the population census held in the United States in 1990 [2,3]. The methodology can be used for estimating unknown populations in epidemiological studies; some examples include estimating prevalences of spina bifida, congenital rubella syndrome, cancer and intravenous drug use [4-6].

In Turkey, factors such as migration from rural to urban areas and financial and technical inadequacies in health care provision may have a negative influence on the efficiency of the surveillance systems in the health service [7,8]. It is a common problem in developing countries that health care staff are unaware of how and why records are completed. These factors affect the reliability of the record systems, especially in rural areas. Therefore, another practical method such as capture-recapture can be used to estimate an unknown population.

The first objective of our study was to use capture-recapture methods to estimate births, deaths and the frequency of family planning use in a small rural area of Turkey from May to October 1999. A second objective was to determine to what extent collection of information on vital events and family planning acceptance from two sources of data provides the same or more complete information than is available from a single source.

Methods

Background

Health services in Turkey

The organization of health care services in Turkey is relatively complex. Health services are provided by both the public and private sectors. In the public sector, the Ministry of Health (MOH) is the leading health care provider at primary, secondary and tertiary levels. Health care at primary level is mainly provided by the MOH through primary health care centres, which provide outpatient health care and primary prevention activities, and collect routine data on maternal and child care, infectious diseases and vital events [9]. A number of primary health care centres report to another office under the MOH, the health group presidency (HGP), which facilitates administrative activities at the district level and collects data from the health centres. Public hospitals provide secondary and tertiary health care activities. Other public institutions and private institutions also have important roles in providing health care services in Turkey.

Recording births and deaths in Turkey

In Turkey, the General Directorate of Population and Citizenship Affairs (GDPCA) of the Ministry of Interior is a centralized structure, responsible for keeping population registers such as births, deaths and other vital events. It branches into the country through the office of the district directorate of population (DDP). The DDPs keep population registers and record vital events at the district level then transfer them to the provincial offices of GDPCA. All the data are gathered in the capital office based in Ankara.

There are some differences between the birth and death registration systems in urban and rural areas in Turkey. In urban areas, as soon as a birth occurs, the birth

certificate of the newborn should be registered by the DDP at the district level. In rural areas, if the delivery occurs in hospital, the hospital should issue the birth certificate. But for a home delivery the certificate might be issued either by the nurse from the primary health care centre or by the *mukhtar* who is the village head. The *mukhtar* is also responsible for issuing death certificates when a death occurs in the village. He should then officially inform the DDP at the district level. In urban areas, municipalities issue the burial permits and report deaths to the State Institute of Statistics (SIS) [10].

Maternal and child health care services in Turkey

Maternal and child health care services are usually provided by primary health care centres and by maternal and child health care and family planning units (MCHU), also within the MOH. Nurses, midwives and physicians are service providers in all of these units. Midwives and nurses are the staff responsible for determining and following up women of reproductive age living in their working area, improving the use of family planning methods, identifying and following up pregnant and postpartum women and infants as well as following up newborns for the first 6 years and carrying out immunizations.

Study area and population

Polatlı is a district of Ankara province located about 76 km west of the capital Ankara. The rural part of Polatlı includes 90 villages. In recent years, migration from rural to urban areas of Polatlı has increased. Therefore, some vital statistics (crude birth rate, crude death rate, the number of women using family planning, etc.) have been underestimated in the recorded health service data [11].

Hacettepe Public Health Foundation has set up a project entitled "Community based reproductive health services for adolescents and adults in Polatlı district, Ankara" in 26 villages of Polatlı. The aim of the project is to increase the health status of the target population by using community participation methods. Within the project, community health volunteers who have the potential to be leaders in their own community are determined and selected from women and men in the study villages. Female health volunteers are responsible for registration of births, identification of women aged 15–49 years, registration of women's gynaecological complaints, follow-up of pregnant/postpartum women, identification of newborns, distribution of condoms, oral contraceptives and folic acid iron deficiency pills for anaemia, and education of women about reproductive health. Male community health volunteers are responsible for informing men about reproductive health, especially about sexually transmitted diseases, distributing condoms, recording deaths and supporting the women health volunteers. Community health volunteers use data forms to record their activities in the field, including follow-up of women aged 15–49 years; follow-up of pregnancy, postpartum and newborn care; and birth and death records [11].

Data estimations

The current study was conducted in the region of the community participation project. Ten out of 26 villages were selected proportionally according to the population sizes of the villages. As it was planned as a method trial, the most important issue was not the representation power of the total 26 villages but obtaining the greatest coverage of the population.

Number of births

Two independent data sources were used to estimate births: the records of the HGPs and the birth records (infant determination forms) from the community health volunteers. The formula used for estimation of births for the capture-recapture method was:

$$N = \frac{(M+1)(n+1)}{(m+1)} - 1$$

where

- N = the unknown total number of births
- M = number of births in community health volunteer records
- n = number of births in HGP records
- m = number of births identified in both captures (matches).

The formulas shown below were used to calculate the variance (Var) and 95% confidence interval (CI) for the estimate of N :

$$\text{Var}(N) = M \times n (M - m) (n - m) / m^3$$

$$N = \pm 1.96 \sqrt{\text{Var}(N)}$$

For estimation of births, 5 matching criteria specific enough to define the case were recorded in each data source. The degree of matching was defined based on 5 different standards (A-E). For standard A, all the criteria should be exactly the same in both data sources. For standards B-E, the criteria were progressively reduced so that each subsequent standard required one less criterion for matching.

Number of deaths

In this study, the deaths occurring in the previous 6 months were evaluated using 2 independent data sources: death certificates registered by the *mukhtar* and death records (death determination forms) from the community health volunteers. If all the criteria in both records matched exactly,

then the matching standard was accepted as standard A. For standards B-E, the criteria were progressively reduced, so that each subsequent standard required one less criterion for matching, as was done for estimating births.

Number of women using family planning

Data on the forms of community health volunteers, primary health care centres and MCHUs were used to calculate the number of women using family planning methods. The name and surname of the women were used as matching criteria.

$$N = \frac{n}{k} \prod_{i=1}^k (1 - E_i)$$

where

- N = total number of women using family planning methods.
- k = number of data sources used.
- E_i = the probability that the event occurs in the 'i'th source.
- $(1 - E_i)$ = the probability that the event does not occur in the 'i'th source.
- $n = (n1 \cup n2 \cup n3) = n1 + n2 + n3 - (n1 \cap n2) - (n1 \cap n3) - (n2 \cap n3) + (n1 \cap n2 \cap n3)$
- $n1$ = number of women using family planning methods in community health volunteer forms.
- $n2$ = number of women using family planning methods in primary health care unit forms.
- $n3$ = number of women using family planning methods in MCHU forms.

Results

In this study, 5 different data sources were used for estimating the unknown numbers of births, deaths and women using any family planning method (Table 1): *mukhtar*,

Table 1 Data sources and sample sizes in the first capture for each data source (Polatly, May–October, 1999)

Variable	Data source				
	CHVs	PHCs	HGPs	Mukhtar	MCHUs
No. of births	10	–	17	–	–
No. of deaths	24	–	–	21	–
No. of women using family planning	382	23	–	–	5

CHV = community health volunteer.

PHC = primary health care centre.

HGP = health group presidency.

Mukhtar = village head.

MCHU = maternal and child health care and family planning unit.

– indicates not recorded.

community health volunteers, primary health care centres, maternal and child care units and health group presidencies.

Births

According to the records of the community health volunteers, 10 births occurred between May and October in the study villages. During the same time period, there were 17 births according to the records of the HGP.

The estimated number of births was 65 ± 31 if all the matching criteria were the same in both data sources. This number was found to be 32 ± 18 when 4 of 5 matching criteria were the same in both data sources. If only 1 criterion of 5 was the same, the estimated number was 21 ± 5 . It was assumed that at least 3 of the criteria would define a birth in each data source. From this perspective, standard 'C' was the least accepted category (Table 2).

Deaths

There were 21 deaths recorded in the community health volunteers' forms. This number was 24 according to the registries of the Public Registration Office based on

information from the village mukhtar between May and October 1999.

The estimated number of deaths was 109 ± 101.4 if all the matching criteria were the same in both data sources (Table 3). This number was 49 ± 16 if 5 of 6 matching criteria were matched and 27 ± 1 if 1 of 6 matching criteria was matched. The least accepted category for death numbers was the standard 'C'. However, in each category 'C', 'D' and 'E' the estimated number

Table 2 Estimated number of births by the capture–recapture method (Polatly, May–October 1999)

Standard	No. of matches (out of 5)	No. of people	Estimated no. of births \pm 95% CI
A	5	2	65 ± 31
B	4	5	32 ± 18
C	3	5	32 ± 18
D	2	5	32 ± 18
E	1	8	21 ± 5

Matching criteria: name, surname, name of husband, date of birth, sex of baby.

CI = confidence interval.

Table 3 Estimated number of deaths by the capture-recapture method (Polatlı, May–October 1999)

Standard	No. of matches (out of 6)	No. of people	Estimated no. of deaths \pm 95% CI
A	6	4	109 \pm 101
B	5	10	49 \pm 16
C	4	19	27 \pm 1
D	3	19	27 \pm 1
E	2	19	27 \pm 1

Matching criteria: name, surname, sex, place of death, date of death, age of death.

CI = confidence interval.

was 19. In other words, there was no difference between the standards in which either 4 or 2 criteria matched. The criteria that did not differ from each other were: name, surname, sex and name of the village. The *mukhtar* reported more deaths than community health volunteers did.

Women using family planning

According to the community volunteers' records, 382 women were using any method of family planning between May and October 1999 in the study villages. This number was only 23 in primary health care unit records and 5 in the records of the MCHU. The number of women using any family planning method could not be estimated.

Discussion

Only 10 villages were included in this study, thus the study population was too small to generalize the results. The study was designed as a trial for assessing the applicability of the capture-recapture methodology in the field, which has not

been commonly used before now in Turkey. The capture-recapture method is very sensitive to the matching procedure. The matching criteria developed for estimation should be specific enough to define the cases. The cut-off point for the matching criteria might change the results of the study. If the matching criteria are less strict, the estimated total number of cases is lower. For this reason, matching criteria were selected very carefully in this study. The criteria for births—women's name, surname, husband's name, date of birth and sex of baby—were descriptive enough to define a birth in Turkey.

In Turkey, there are some legal obligations in recording births and deaths. In this study, there were some problems about determining and recording these 2 vital events. Both traditionally and culturally, people give more importance to deaths than to births. As soon as a person dies, traditional ceremonies are performed in the community. This means that community health volunteers are sensitive to the occurrence of a death and therefore their death records might be more accurate than their birth records. Furthermore, the *mukhtar* is legally required to report deaths within a specified time. This is one of the most important reasons why estimation of deaths are more accurate than the estimates of births and family planning.

Although there are legal regulations about registration of births by primary health care centres, no births were registered by these centres. This is why we used the HGP records for estimation of birth numbers.

One of the basic assumptions of the capture-recapture method is that the study population should be closed [5]. In our study, the study region is very close to the capital and the migration rate is very high in the area. In addition, a number of people live in the district centre in winter and re-

turn to their villages for the agricultural activities in summer. These factors might have weakened the property of being a closed population and affected our estimations.

Another key assumption for applying capture-recapture is that the data sources should be independent of one another [12]. In this project, we should take into consideration that community health volunteers might refer people who are pregnant or have health problems to the health centres. In this situation, a positive dependence might have caused a lower estimate of 'N' than the expected values. Nevertheless, the prevalence of referring people to health centres was 4.3% among community health volunteers [11]. Therefore, the estimation of birth numbers might be lower than the expected number.

The number of women using any family planning method could not be estimated. The capture-recapture method has usually been used for estimating rare and diagnosable diseases such as birth defects and spina bifida [2,13]. In the case of family planning, however, there is the problem that couples may change their family planning method over time. For example, a woman using an intrauterine device at the beginning of the study might have changed this method and begun to use oral contraceptives at the end of the study period. There was also the problem that data sources for family planning method use are widely dispersed and not coordinated within the area. The private sector plays an important role in providing family planning services and it was impossible to match the records of the public and the private institutions. For this reason, estimating the

number of women using any family planning method was not possible.

The capture-recapture method has been used extensively for estimating the size of animal populations where marking of animals after capture lessens the possibility of errors. For epidemiological studies with humans, the estimation is more complicated.

In conclusion, it can be said that the method of verification of the number of vital events as used in this project has been pre-tested. We hope that this study highlights some data collection problems of the surveillance system in Turkey. By using capture-recapture, some health measures, especially births and deaths, could be estimated in a rural area in Turkey, but the matching criteria, distribution of the health institutions and other limitations might affect the estimates of the real numbers of deaths and births.

It should be remembered that the capture-recapture method is an alternative method for the estimation of unknown events. The major approach should be to strengthen the routine surveillance systems in developing countries.

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