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Paper for East and South Asian
Workshop on Strategies for
Accelerating the Improvement
of Civil Registration and
Vital Statistics Systems

VITAL REGISTRATION AND SAMPLE SURVEYS
ON POPULATION CHANGES IN CHINA

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Beijing, China

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Summary

After the third population census conducted in 1982, the State Statistical Bureau began to establish the system of sample surveys on the national population changes and conduct the sample survey annually, so as to timely and accurately keep abreast of the population changes of the whole country as well as the provinces, autonomous regions and municipalities. The data of the sample surveys are published in the statistical communiques and statistical yearbooks. The practice shows that this sample survey is one of the important channels to collect vital statistics. This paper gives detailed description concerning the sample size, the content of surveys, organization of the survey and the data-processing work. It gives an appraisal of the quality of the data of the sample surveys, and proposes some tentative plans for further improvement of the sample surveys.

I. Vital Registration in China

1. The Main Content of the Vital Registration

Vital registration is the administrative recording of the births, deaths, marriages, divorces, family members living apart, fertility, adopting children and other individual vital events. In China, the vital registration mainly refers to the registration of the births, deaths, marriages, divorces as well as the changes of the items in the residence registration. The vital registration in China is mainly conducted by the Ministry of Public Security and the State Statistical Bureau. Other departments concerned also provide certain supplementary information. The Ministry of Public Security is responsible for the regular population statistics based on the residence registration, including the registration of total population, number of births, deaths, migration (moving in and moving out) as well as the changes or corrections of the items in residence registration. The State Statistical Bureau is responsible for the vital registration and population statistics based on the sample surveys. During the past decade, the State Statistical Bureau has conducted a series of sample surveys to collect the data on the total population, births and deaths, mainly including the annual sample surveys on population changes which started in 1982, the sample surveys on women's fertility in several provinces and municipalities which were conducted in 1985 and 1987, and the

micro-census based on 1% of the whole population in 1987. It also organizes the decentral population censuses.

The other departments also conduct vital registration or vital statistics. The State Family Planning Commission focuses its attention to the fertility statistics; the department of civil affairs made registrations on marriages and divorces. The Ministry of Public Health is responsible for the statistics of the causes of deaths. The statistical data based on the vital registrations timely provide the information on the size, composition and distribution of China's population as well as the newest information on marriages, fertility, deaths and migration etc.

2. The Features and Difficulties of the Vital Registration

China is the most populous country in the world. By the estimation based on the sample survey on population changes in 1992, the population in the mainland of China at the end of 1992 totalled 1.17171 billion persons, which accounted for 21.5% of the world's total population of 5.42 billion persons, or 36.3% of the Asia's total population of 3.207 billion persons. In a country with so large a population, the timely, accurate and complete vital registration reflects the most important aspect of the national condition and strength and provides the important basis for formulating China's population policies, population programmes and the short-term and long-term plans for the national economic and social development.

In the practice of the improvement of the vital registration and population statistics, a comparatively complete and regular system of population registration as well as the system of sample surveys on population changes have been established in China. They have the following features: (1) They are formulated and conducted in accordance with the laws and decrees or the statistical system of the country, and they form one of the important components of the country's administrative work; (2) The State Council and the governments at lower levels have attached great importance to the population statistics and regarded the population statistical data as one of the important informations on the basic national conditions and the important basis for formulating government policies; (3) The data of vital statistics are collected by various departments and all of them are characterized with their high level of timelines, accuracy and completeness.

The difficulties of the work of the vital statistics in China are as follows: (1) China is a developing country with a very large population and has a poor economic foundation to start with. It lags far behind the developed countries in the computing technology used in vital registration. Its task of vital registration is therefore quite arduous. (2) Since the policy of reform and opening to the outside world was implemented, profound changes

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I. Vital Registration in China

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have taken place in China's society. Along with the establishment and development of the socialist market economy, some new features have appeared in the vital statistics. Firstly, the number of people who have moved from villages to cities or towns to work in factories or construction sites or engage themselves in trades has increased. Therefore, there is an increasing floating population (mobile population). Secondly, since Chinese government has stopped the rationing of food grains, vegetable oil, cloth and other daily necessities, the residents are not so enthusiastic to report their residence as before. Thirdly, The farmers in some regions are unwilling to report the children who have been born in excess of the birth quotas. Therefore, the number of persons unreported in the population statistics is on an increasing tendency. All of these have caused the difficulty to collect the accurate data of vital statistics.

II. Sample Surveys on the National Population Changes

1. The Purpose of the Sample Surveys

The births and deaths of a population is one of the important content of the vital statistics. They are one of the basic data necessary for the formulation of the population policies and the implementation of family plans. The data on population changes collected in the regular population statistics by means of the statistical reports of complete enumeration are always not very accurate. The natural increase of the population computed with reported data on births and deaths differs quite greatly from the data on the increase of national total population obtained from the population census. The data cannot be used for any purpose. Therefore, after the third population census conducted in 1982, the State Statistical Bureau began to establish the system of sample surveys on the national population changes and conduct the sample survey annually, so as to timely and accurately keep abreast of the population changes of the whole country as well as the provinces, autonomous regions and municipalities (Hereinafter sometimes simplified as provinces), provide the central and provincial governments with reliable population data for formulating the plans for the economic and social development and for deciding the measures for controlling the population growth. The data of the sample surveys are published in the statistical communiques and the statistical yearbooks.

2. The Sample Size and the Content of the Survey

From 1982 to 1992, the State Statistical Bureau has conducted 10 sample surveys on population changes. The whole period can be roughly divided into two stages with the sample size and survey content taken into consideration:

(1). From 1982 to 1988

Sample Size: The sample size in this period was 0.5 million persons or so. The sampling fraction was 0.05%. The sample size of the province was decided by the proportion of the population of the province to the national population. For example, Sichuan Province had the largest population among all the provinces, and its sample size was therefore 46,000 persons while Qinghai Province, Ningxia Autonomous Region and some other provinces where the proportions of their population to the national population were small and had only to enumerate respectively 1800 persons in the annual sample surveys. Therefore, the survey data can be representative of the situation of the whole country, but can only give not very good pictures of the provinces.

Sampling scheme: In the sample design, the whole country was taken as the population, and the provinces, autonomous regions and municipalities were taken as the strata in the stratified sampling. In the three-stage sampling, the province selected the sample counties (or cities or districts); the sample counties (or cities or districts) selected the sample townships (or streets); and the sample townships (or streets) selected the sample villager groups (or resident groups). Systematic sampling method was used in the sampling of every stage. The sampling fraction $f=f_1 \times f_2 \times f_3 = 0.45\%$. ($f_1=15\%$, $f_2=10\%$, $f_3=3\%$). In other words, 15% of the counties (or cities or districts) were selected in the primary stage; 10% of the townships (or streets) were selected in the secondary stage, and 3% of the villager groups or resident groups were selected in the third stage. The data on the population were estimated on the basis of the sample data. The method of proportionate estimation was used here.

The Content of the Survey: Households were the units to be surveyed. Both the individual households and the institutional households were included in the survey. All the persons whose residence had been registered were to be enumerated. The following persons in the individual households and institutional households should be accordingly enumerated: (1) Persons who had been registered as permanent or usual residents. No matter how long they had been away from their places of registration, they should be enumerated at the places where their permanent or usual residence were registered. (2) Persons who were residing in the households, including those who had migration certificates, birth certificates or release certificates, but had not been registered as permanent or usual residents at any place, should be enumerated at the places where they resided. (3) Persons whose residence registration had not been made clear should be enumerated at the places where they resided. There were 8 items in the questionnaires concerning the whole households and 13 items concerning the individuals in the households. For example, the following items were those concerning the individuals: surname and given name, relationship to household head, how the residence was registered, sex,

the month and year of birth, marital status, educational level, is he or she residing in the household at zero hour of January 1 and 24 hours of December 31? situation on the natural changes, situation on migration, the number of children born by the woman aged 15-49 and the number of the surviving ones, is she giving birth to any child? Attention should be focused on the natural increase of the population and the total population increase.

(2) From 1989 to 1992

Sample Size: Since 1989, the sample design has been improved so as to accurately and timely keep abreast of the population changes in the country and in every province, autonomous region or municipality. The whole country was regarded as the population and the 30 provinces were regarded as the sub-populations. The main parameters taken into account in the design of the sample size were crude birth rate (CBR), permissible error (Δ), confidence probability (t), sampling fraction (f) and design efficiency ($deff$). The sample sizes of the provinces were decided according to the birth rates of the previous years and the sampling precision they required. The permissible error was controlled to be 0.1% or so. The confidence probability was designed to be 95% ($t=2$); The design efficiency was estimated to be 1.4.

The formula for the sample size is as follows:

$$n = \frac{t^2 \times CBR \times (1-CBR) \times deff}{\Delta^2}$$

According to the above formula, the sample size was enlarged from the former 500 thousand persons to 1.8 million persons or so, with 1.6% as the sampling fraction. On an average, the sample size of a province was 60,000 persons. Sichuan Province, Henan Province and Shandong Province had bigger sample sizes than other provinces, because they had larger populations. 70000-80000 person were to be enumerated respectively in the sample surveys in the above provinces. The sample size for the majority of the provinces was averagely 50,000 persons. The sample size designed could ensure the requisite precision for the whole country and the provinces. The number of sample counties (or units equivalent to the county level) increased from the original 300 to 770 or more. The number of sample townships increased to 3000, and the number of villager groups (or resident groups) increased to 7,000. For example, in the sample survey on the population change in 1992, 771 counties(or cities, or districts), which were about one quarter of the total number of counties (or units equivalent to county level) in the 30 provinces, were included in the sample. From the sample counties, 2,889 townships (or towns or streets) were selected and from the sample townships, 6,873 villager groups (or resident groups) were selected. Finally 1.66 million persons were

enumerated. Among the 1.66 million persons, the population in the cities and towns had a share of 28.8% (See Table 1: on the distribution of the sample units in the sample survey on the population change in 1992).

Table 1: The Distribution of the Sample units in the Sample Survey on Population Change in 1992

Province	1991 CBR (0/00)	1991 Population (10000 persons)	Sample Size (10000 persons)	Permis- sible error (0/00)	Sampling fraction (0/00)	No.of counties* selected
Total	19.68	115823	166	0.25	1.44	771
Beijing	8.03	1094	5	0.94	4.57	18
Tianjin	11.94	909	5	1.15	5.50	18
Hebei	16.59	6220	6	1.23	0.96	36
Shanxi	21.56	2942	5	1.54	1.70	30
Inner- mongolia	16.77	2184	6	1.24	2.75	25
Liaoning	12.10	3990	6	1.06	1.50	28
Jinlin	17.09	2509	5	1.37	1.99	21
Helong- jiang	15.89	3575	5	1.32	1.40	22
Shanghai	7.68	1340	5	0.92	3.73	21
Jiansu	17.05	6844	6	1.25	0.88	27
Zhejiang	14.48	4202	5	1.26	1.19	22
Anhui	21.19	5761	6	1.39	1.04	20
Fujian	20.03	3079	6	1.35	1.95	23
Jianxi	21.20	3865	6	1.39	1.55	25
Shangdong	15.40	8570	7	1.10	0.82	34
Henan	19.78	8763	7	1.25	0.80	40
Hubei	20.70	5512	6	1.38	1.09	30
Hunan	20.50	6209	6	1.37	0.97	31
Guangdong	20.54	6439	6	1.37	0.93	33
Guangxi	21.89	4324	5	1.55	1.16	26
Hainan	22.97	674	5	1.59	7.42	20
Sichuan	15.82	10897	8	1.04	0.73	43
Guizhou	22.42	3315	6	1.43	1.81	22
Yunnan	21.80	3782	5	1.55	1.32	32
Tibet	23.53	226	0.25	7.17	1.11	3
Shaanxi	19.82	3363	6	1.35	1.78	27
Gangsu	19.38	2285	6	1.33	2.63	30
Qinghai	23.37	454	5	1.60	11.01	17
Ningxia	21.96	480	6	1.42	12.50	24
Xinjiang	24.45	1555	5	1.63	3.22	23

* or unit equivalent to county level.

Source: Statistical Yearbook of China 1991, Edited by State Statistical Bureau People's Republic of China. Sample Survey Designs on Population Change in China 1992.

Sampling scheme: After the sample size was enlarged from 500,000 persons to 1.8 million persons, most provinces applied the technique of stratified, three stage cluster sampling, with probability proportionate to size. The municipalities under the direct leadership of the central government and a few provinces applied similar sampling scheme, but two-stage sampling was used instead of the three stage one. In the three-stage sampling, the units in the sampling frame of the primary stage were counties(or cities); those in the secondary stage were townships (or towns or streets) and those in the third stage were the enumeration districts, namely the villager groups (resident groups). The enumeration district should have a compact area, and the number of persons should be controlled to be 250 or so. The provinces, autonomous regions or the municipalities under the leadership of the central government stratified the units of the county (city, district) level. Because the population changes in the different areas were closely related with the proportions of the population engaged in agricultural and non-agricultural production, the level of economic and cultural development as well as geographical conditions, the units of county level were classified into strata in accordance with the known data on population changes, economic level (economically developed or underdeveloped counties), and geographical features (mountain area, plain, or hilly land), so that the sample units could be better distributed in the different areas and could be better representative of the actual situation of the province. The sampling fraction in the primary stage (f_1) in the province was decided to be 25% or so. On an average, 25-35 counties (cities or districts) were selected in a province; 4-8 townships were selected in the sample county, and 2 enumeration districts were selected in the sample township. In each stage, the sample units were selected with the random systematic sampling method.

Content of the Survey: After the sample size was enlarged, only those who had been registered as the permanent or usual residents were to be enumerated. It changed the past practice that those whose residence had been registered should be enumerated. The households were still the units to be surveyed. Both the individual households and the institutional households were included in the survey. The following persons in the individual and institutional households should be enumerated: (1) Persons who resided in the enumeration district and whose residence were registered in the county or city where the enumeration district was situated ; (2) Persons whose residence were registered in the enumeration district and whose residence registration were not yet decided; (3) Persons who had resided in the enumeration district for more than one year and whose residence were registered in other county or city; (4) Persons who had resided in the enumeration district for less than one year, but had left the place where their residence were registered for more than one year. The former survey

items were mainly retained so as to achieve the continuity of the time series. For example, the main items were included in the sample survey on the population change in 1992: surname and given name, relationship to household head, how the residence was registered, sex, month and year of birth, the population at the zero hour of January 1 and 24 hour of December 31 of the year, month and year of the first marriage, the number of children born by women and the number of the surviving ones, birth, death, migration. Among the total items, 13 items were enumerated for individuals in the household, and 8 items were enumerated for the whole household.

3. The Reference Time for the Survey and the Organization of the Survey

Since 1982, zero hour of January first has been taken as the reference time for the sample surveys on the population changes. The population change in the previous year was surveyed and the complete annual population data were collected. Under the unified leadership of the State Statistical Bureau, The statistical bureaus of the provinces, autonomous regions and the municipalities under the leadership of the central government were responsible for organizing the surveys. Under the assistance of the local authorities, those persons who knew the local situations well and had strong sense of responsibility for their jobs were selected and recruited as the enumerators. The enumerators were trained. The enumerators visited the households and made the enumeration in the interview with the household members. They should keep the information of the households confidential. In order to ensure the quality of the survey data, a series of measures were laid down by the national and local statistical agencies. Since 1992, the sampling post-enumeration check on the data quality has been conducted so as to accurately keep abreast of non-sampling error.

4. Data-processing and Sampling Errors

The Computing Centre of the State Statistical Bureau is responsible for the whole data processing work of the sample surveys on population changes. As designed in the sampling plan, the national data can be obtained by weighting and tabulating the provincial data. The annual natural increase rate and the total size of the national population can be estimated on the basis of the sample data on birth rate, mortality and natural increase rate of the population. Since 1989, the data of the sample surveys on the annual population changes have been better representative of the situation of the provinces, autonomous regions and municipalities under the leadership of the central government than before and able to accurately and objectively show the actual conditions. They were therefore published in the statistical yearbooks. According to the appraisal of the sampling error after the enumeration, the relative error of data on the birth rate in provinces was

controlled to be less than 10%, The permissible error of them was controlled to be 0.1%-0.15%. The relative error of the data on the mortality and the natural increase rate of the population was controlled to be less than 20% and the permissible error of them was controlled to be 2% or so. The relative error of the data on the birth rate of the national population was controlled to be less than 5%, and the permissible error of them was controlled to be less than 0.03%; the permissible error of the data on mortality and natural increase rate of the population had both met the requirements of the design.

III. The Appraisal of the Quality of the Data of the Sample Surveys

1. A Comparison of the Data of the Sample Survey with the Data of the Regular Population Registration

The data of the third population census had provided a good basis for the improvement of the methodology of China's demographic statistics. At the end of 1982, The State Statistical Bureau conducted the first sample survey on the population changes after it had achieved a successful population census. According to the result of the sample survey, the net increase of the population in 1982 was 14.54 million persons, and the natural increase rate was 14.49%. It had only a difference of 510,000 persons as compared with the net population increase of 14.95 million persons which was estimated on the basis of the 1982 census. According to the regular population registration, the natural increase rate of the population in 1982 was 12.42%, and the net increase of the population was 12.47 million persons. There was a difference as big as 2.04 million persons when it was compared with the data obtained from the sample survey on the population change. From 1982 to 1988, both the regular population registration and the sample surveys on population changes took the registered population to be counted; but there was quite big a difference between the data collected with the above two methods. On an annual average, the number of births obtained from the former source was 3 million persons less than that obtained from the latter source.

Non-sampling errors are greatly reduced in the sample surveys on population changes as compared with those existing in the annual statistical reports based on the regular population registration. The regular population statistics are collected from the reports level by level based on the nationwide registration of the residence. In China, more than 70% of the population are rural population; the statistical capacity in the rural area are weak, and the statistical task there is arduous. Along with the development of the activated economy, the floating population increased much, and many members are away from the households. Since the contracted responsibility system with remuneration according to output was

carried out, the binding force of the system of residence management over the births of the farmers has become weaker and weaker and the number of births unreported has increased. The range of the residence management differs greatly from the actual situation. It has caused the increase of the errors arisen in the residence registration. The sample survey on population change is quite different from the regular residence registration. Using the sampling technique, it selects a part of the population as the sample to be enumerated. The national and provincial population changes can be estimated and analysed on the basis of the data of the sample. The registration error in the statistics of complete registration can be reduced in the sample survey and the quality of the population statistics can be improved.

2. A Comparison Between the Survey Data and the Census Data

Though the quality of the data of the sample survey is higher than that of the regular residence registration, there is still a certain amount of non-sampling errors as well as the sampling error in them. The fourth population census in 1990 has provided a great amount of data for comprehensively and thoroughly analysing the situation of China's population. We have got the comparatively accurate data on the total population and its age structure and are able to use them to check the quality of the data of the sample surveys on population changes. The population census in 1990 shows that the total population in China on July 1, 1990 was 1.13368 billion persons and that by the end of 1989 was 1.12704 billion persons. There was a difference of 15.13 million persons between the data obtained from the census and the data obtained from the sample survey on population change in 1989. Therefore, based on the age structure of the population shown in the 1990 census and using the method of retrospective estimation, we estimated the birth rates, mortality, natural population increase rates and total population in the 1982-1989 period, and compare them with the data of the sample surveys on population changes.

Year	total-1 (10000 persons)	total-2 (10000 persons)	Difference (10000 persons)	CBR-1 (%)	CBR-2 (%)	Difference (%)
1982	101654	101590	64	22.28	21.09	1.19
1983	103008	102764	244	20.19	18.62	1.57
1984	104357	103876	481	19.90	17.50	2.40
1985	105851	105044	807	21.04	17.80	3.24
1986	107507	106529	978	22.43	20.77	1.66
1987	109300	108073	1227	23.33	21.04	2.29
1988	111026	109614	1412	22.37	20.78	1.59
1989	112704	111191	1513	21.58	20.83	0.75

Total-1 refers to the total population adjusted with the census data.

Total-2 refers to the total population estimated on the basis of the sampling data.

CBR-1 refers to the birth rate adjusted with the census data.

CBR-2 refers to the birth rate computed with the sampling data.

Source: Statistical Yearbook of China 1990, 1991. Edited by State Statistical Bureau People's Republic of China.

The result of the estimation shows that the total population and the birth rates estimated on the basis of the census data are both higher than those obtained from the sample surveys. The annual difference in the total population is averagely 2 million persons. The birth rates estimated on the basis of the census data is annually 1.8 percentage point higher. The main reasons for the difference are as follows: (1). The quality of the data was affected by the surveys conducted on the basis of the residence registration in 1982--1988. Since the 1980's, the number of births not reported has increased; more and more members have left the households; the discrepancy between the population of the registered residence and the population of the usual residence has enlarged; and this discrepancy has certainly affected the accuracy of the data of the year. Year after year, the lowly estimated population base plus the lowly reported birth rates has thus accumulatedly caused the problem of millions of children failing to report their births. (2). In some regions, the population of registered residence was used as the sampling frame. Such a sampling frame is obviously incomplete. The problem of the births not reported has not been taken into account in the sample design. (3). We have not made a thorough analysis of the non-sampling errors of the survey data and have thus caused the enlargement of the accumulated errors year by year. Accordingly, based on the data of the fourth population census, we have revised the data of the sample surveys conducted between the 1982 and 1990 censuses, so that the data on population changes can more accurately reflect the actual situation.

IV. Some Tentative Plans for Further Improving the Sample Surveys

Since the 1990's, along with the establishment and development of the socialist market economy, new situations and new issues have arisen in the sample surveys on the population changes. How to ensure the quality of the survey data is an important problem to be solved by us.

1. Ensuring the Quality of the Survey Data

We should strengthen the researches on the design of sampling plan, survey methods, data appraisal, data revision, data use and other aspects, so as to improve the quality of data. The main purpose of the sample surveys on the population changes is to collect the reliable data on births deaths and the natural in-crease of the population. As a principle, the design of the

survey items should be helpful to get accurate figures of births and deaths, and easy to be operated in the actual enumeration. Particularly, we should pay more attention to the enumeration of the births and deaths of the floating population. Rotation sampling technique can be used in selecting the sample units. Under the precondition that the quality of data should be ensured, the Provincial Statistical Bureaus can decide the specific survey methods in the light of the concrete conditions in the provinces and put them into operation. The training of the enumerators should be strengthened in particular. The enumerators should have strong sense of the responsibility for their jobs. The intervention caused by outside influence should be prevented. The enumeration should be conducted in accordance with the principle that the truth must be sought from the facts. The rewards and punishments of the enumerators should be linked with the quality of the data they collected.

2. Changing the Reference Time for the Survey

Since 1982, zero hour of January 1 has been taken as the reference time for the sample surveys on the population changes, the population changes of the previous years have been surveyed; and the data of whole years have been collected. By our preliminary considerations, we intend to change the reference time for the surveys in the future. October 1 of the current year, Instead of January 1 of the next year, will be taken as the reference time; and the population changes from October 1 of the previous year to October 1 of the current year will be surveyed. The above mentioned period will be called a "population year". However, the data on the last quarter of the current year will be estimated on a scientific basis, and the population data of the complete calendar year will be published in the statistical communique as before. The main advantages of this change are as follows: First, the statistical departments are usually very busy in the ending months and beginning months of every year to do the preparatory, collecting and processing work for the annual statistical reports. When the reference time for the sample survey is changed to October 1, the statistical departments will no longer conduct the sample survey in this busy period and will have more statisticians to conduct the sample survey. Second, when the reference time for the survey is changed, there will be sufficient time to do enumeration work, to check and recheck the data and to conduct the post-enumeration sample check on the quality of data. Third, January is a very cold month in the northern region in China. It is very difficult to conduct the survey in such a month. In some areas, when the mountain are covered with snow, the enumerators are confronted with the transport difficulties. If the reference time for the sample survey is changed to October 1, all these difficulties will disappear.

3. Strengthening the Publicity Work

The importance of the sample surveys on the population changes should be made well-known to the public by means of various publicity media and publicity methods. Letters can be sent to the respondent households; primary school students can be mobilized to visit them and do the publicity work; and the enumerators can make interviews with the members of the households and give the necessary explanations so as to get the understanding and the support from the members of the respondent households. Only in this way, can the households truly report their real situations and the phenomena of hiding truths or failing to report be avoided to the utmost.

Since 1982, the sample surveys on population changes have been conducted in China for ten times. A lot of experiences have been obtained. Great achievements have been made. The superiority of the quality of the sample survey data over that of the regular population registration has become increasingly evident. The practice shows that the sample survey is one of the important channels to collect the vital statistics. Although there are certain errors in the data collected from the sample surveys on the population changes as compared with the data collected from the population census, the errors lie within the range of permissible errors. At the same time, the quality of the data of the sample survey is still to be enhanced, and the survey methods are to be improved and perfected so that the result of the sample can give a more accurate picture of the real situation.

Reference:

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