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**United Nations Expert Group Meeting on
Methodology and Lessons Learned to Evaluate the
Completeness and Quality of Vital Statistics Data from
Civil Registration**

New York, 3-4 November 2016

Report of the Meeting



United Nations

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Department of Economic and Social Affairs
Population Division

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This publication has been issued without formal editing.

Suggested citation: United Nations, Department of Economic and Social Affairs, Population Division (2017). *United Nations Expert Group Meeting on Methodology and Lessons Learned to Evaluate the Completeness and Quality of Vital Statistics Data from Civil Registration, New York, 3-4 November 2016: Report of the Meeting*, Working Paper No. ESA/P/WP.251. New York: United Nations.

1. BACKGROUND AND SCOPE OF MEETING

This meeting is of interest in the context of the Sustainable Development Goals (SDGs) adopted in 2015 by the UN General Assembly, which include specific targets and indicators reflecting the aspiration of the UN's Member States for further improvements in the registration of vital events throughout the world. It bears mentioning that the importance of a well-functioning civil registration and vital statistics (CRVS) system, which is the preferred source of data for vital statistics on fertility and mortality, is reflected explicitly at two locations within the seventeen SDGs. First, Goal 16 on peaceful and inclusive societies recognizes the importance of civil registration as a source of legal identity. Without legal identity, a person is not fully a person, lacking access to large sectors of the formal economy and to many public services as well. In particular, target 16.9 indicates that by 2030 legal identity should be provided to all persons. It gives specific mention to birth registration, which is widely recognized as a critical mechanism for providing legal identity.

Throughout the world, registering a child at birth is the first step in securing recognition before the law and safeguarding the person's human rights and access to justice. Despite recent progress, the births of more than one in four children under the age of 5 worldwide have not been recorded. In sub-Saharan Africa, more than half (54 per cent) of children under 5 years of age have not been registered. Globally, children living in urban areas are roughly 50 per cent more likely to be registered than their rural counterparts. In most regions, the prevalence of birth registration tends to be highest among the richest 20 per cent of the population.

Second, Goal 17 on the means of implementing the entire package of Goals includes target 17.19 on capacity-building in developing countries to support national development plans, in particular statistical capacity building in developing countries. In that context, indicator 17.19.2 includes, as one of its two elements, the proportion of countries that have achieved 100 per cent completeness in the registration of births and 80 per cent completeness in the registration of deaths. The World Health Organization (WHO) reported that 72 per cent of all births worldwide were registered in 2015, compared to roughly one third of all deaths.

The Population Division of the Department of Economic and Social Affairs of the United Nations, together with Statistics Korea (KOSTAT), Government of the Republic of Korea, as part of a joint technical cooperation agreement, organized an expert group meeting on "Methodology and lessons learned to evaluate the completeness and quality of vital statistics data from civil registration" held at the United Nations Headquarters in New York from 3 to 4 November 2016. The purpose of the meeting was to (a) examine the state of vital statistics based on civil registration, with emphasis on low- and middle-income countries (LMICs), (b) review the state-of-knowledge with analytical methods to evaluate the proportion of actual vital events that are registered by the civil registration of vital statistics (CRVS) system and quality of vital statistics collected through civil registration, and (c) review lessons learnt from local and international experiences in applying these methods to various settings.

The meeting brought together 25 international experts and academic researchers from 15 countries involved with the development and/or the application of direct and indirect analytical methods and validation studies using record linkage between multiple data sources to assess the completeness and quality of birth and death statistics from civil registration. The meeting was attended by about 50 people, and webcasted using Cisco WebEx, and about 20 persons connected through the two days meeting.

Participants to the meeting were asked to address the following core questions for each session:

- What are the most appropriate methods available to evaluate the completeness and quality of births and deaths records?
- What are the strengths and limitations of the various methods?

- What are the lessons learned from recent experiences with the application of these methods to different settings?
- What recommendations can be provided to LMICs to best evaluate the completeness and quality of their vital statistics, both at the national and at the local level?
- What further methodological research would be desirable to address any pending needs?

Each substantive session consisted of presentations by experts and a discussion. During the closing session, a short summary of each thematic session was presented by the moderator of each session.

This report summarizes the main points from each session and highlights crosscutting themes and recommendations and lessons learned. Materials from the expert group meeting (e.g., technical papers and presentations from experts, and video recording of the session) can be accessed at the website of the Population Division, www.unpopulation.org, at the following location:

<http://www.un.org/en/development/desa/population/events/expert-group/26/index.shtml>

2. SUMMARY OF SESSIONS

A. OPENING OF THE MEETING AND STATE OF CIVIL REGISTRATION AND VITAL STATISTICS SYSTEM IN THE WORLD

The Director of the Population Division, Mr. John Wilmoth, opened the meeting and welcomed all the participants. In his introductory remarks, Mr. Wilmoth highlighted the objectives of the meeting and the importance of having a complete and reliable set of vital statistics data from civil registration. He also explained how the meeting is of importance in achieving the SDGs specifically goal 16 (target 16.9) and goal 17 (targets 17.19 and 17.19.2). He underscored that the lessons learned and recommendations of this meeting would contribute to inform future reference materials by the United Nations for the evaluation of the geographic coverage of civil registration and the completeness and quality of vital statistics data derived from civil registration.

Mr. Wilmoth's address to the meeting was followed by three presentations from Ms. Adriana Skenderi from Statistics Division, Mr. Colin Mathers from the World Health Organization (WHO) and Ms. Karen Carter from the Secretariat of the Pacific Commission. The presenters gave an overview on the state of civil registration and vital statistics (CRVS) system in the world and reviewed key concepts coverage versus completeness.

A well-functioning civil registration system with information on births and deaths is the preferred source of data for vital statistics on fertility and mortality. Registration also helps to ensure that every person has a legal identity, facilitating access to the benefits and protections of the state. In the 2030 Agenda for Sustainable Development, the need for accurate and timely vital statistics has been reaffirmed. Goal 16 of the Sustainable Development Goals (SDGs) recognizes a direct link between civil registration and vital statistics (CRVS) systems, legal identity and sustainable development. Moreover, one of the indicators to monitor the progress in the achievement of Goal 17 is tracking the proportion of countries that have achieved 100 per cent birth registration and 80 per cent death registration by 2030. As of 2015, the World Health Organization estimated that 72 per cent of births were registered whereas only one third of all deaths globally were registered.

Ms. Skenderi (Statistics Division, DESA (UNSD)) gave a brief overview on how vital statistics from civil registration system are collected and reported annually (including metadata about coverage rate and method of assessment used) to the UNSD via the Demographic Yearbook Vital Statistics questionnaire. This questionnaire comprised of several tabulations, in order to collect data on a wide range of vital events and respective topics, according to the Principles and Recommendations for a Vital Statistics System. Her presentation focused on the status of official reporting of basic statistics on births and deaths compiled from the civil registration system and population censuses between 1995 and 2015. Ms. Skenderi highlighted that the availability of basic statistics on births and deaths compiled from civil registration systems remained at more or less the same levels during the period considered, with small improvements in registration and reporting of births in Africa. She underscored that more details of the basic and additional statistics (such as age of mother and sex for births, live birth order, marital status of mother, place of occurrence of vital event, and age and sex for deaths) would be required.

Ms. Skenderi noted that between 2010 and 2015, the latest period analysed, 72 per cent of countries/areas of the world have provided data on births and 71 per cent have provided data on deaths from civil registration systems. She also mentioned that the availability of data was less for the more disaggregated data: births by age of mother and sex of child; deaths by age and sex. Turning to metadata, she explained that 131 countries/areas in all regions have provided some metadata. 109 countries have reported their completeness on CRVS births statistics with 96 complete and 13 incomplete as of the latest

reference period reported. Demographic analysis followed by dual record check are the most commonly used methods of completeness evaluation for CRVS births and deaths statistics among the reporting countries, with 26 and 21 respectively.

Mr. Mathers (World Health Organization (WHO)) gave a brief overview on the availability of death registration data and institutional reporting mechanism used by WHO to obtain cause of death data from member states. Mortality data are collected and reported by Member States to WHO, and compiled into the WHO Mortality database where it undergoes standardization and analysis. Mr. Mathers highlighted some of the challenges which were inconsistency, poor quality data reporting by some countries, hard to reach areas within some countries, and residence inclusion criteria during the registration. He also cited some issues with data comparability. He underlined that data collection and reporting should be done on a yearly base but in most times the occurrence was not clear.

In the conclusion remarks, Mr. Mathers recognized the importance of death registration and real time cause of death data as was shown during the recent Ebola epidemic and the centrality of civil registration based vital statistics in providing data to inform health. He appreciated the increased and continuing involvement of the African Ministers of Health in improving registration of births and deaths, including the collection of information on cause-of-death. Mr. Mathers underscored the important role of the health sector in the delivery of civil registration services to ensure a coordinated and integrated approach in addressing the challenges of improving CRVS systems in Africa and called upon WHO, in collaboration with Pan African Organizations and other partners to intensify their efforts in developing real time death registration and causes of death information systems at country level.

Ms. Carter (Secretariat of the Pacific Community) reviewed key concepts in coverage (measure of the population served by the registry system) and completeness (measure of how well events were captured in that population) of CRVS data. Ms. Carter mentioned that coverage could be measured using Geographic Information System (GIS) through mapping of the registry locations to better understand both system coverage and performance. She pointed out that the measure of coverage is the best description of the population which was targeted and should likely be understood in terms such as “national” or “sub-national”; “facility” or “community-based”; “inclusive” or “targeted”.

Turning to completeness, Ms. Carter mentioned that the best methods used to measure completeness would be: the direct comparison with a “gold standard” (a source that is considered to be “true”), direct survey of registration completeness, comparison with an expected distribution of events (deaths) by age, and comparison with other sources which may also not be complete. Ms. Carter underscored that the importance of evaluating CRVS systems in underpinning development progress has increased over the last few years. She stated that there had been increasing attention to understanding the quality of the data that was collected through these systems. She underscored that for CRVS data on population and health outcomes to be useful to governments for both planning and monitoring interventions, there was a need to both understand the population which the data represents, and to be assured that the data is “fit for purpose”. This means that at the national level, the data should be relatively complete and reliably represent the population of interest.

B. ANALYTICAL METHODS TO EVALUATE THE COMPLETENESS AND QUALITY OF BIRTH REGISTRATION

The United Nations principles and recommendations states that a complete civil registration and vital statistics systems are achieved when every vital event has been registered in the system within a specified time period. Therefore, this completeness of the CRVS can be measured in terms of registration and coverage. In this session, the presenters gave an overview on data availability on birth registration,

illustrated the level of completeness and methods used to evaluate completeness of birth registration with examples from various countries. Claudia Cappa (UNICEF), Professor Robert Dorrington (University of Cape Town), Nadine Nannan et al (South Africa Medical Research Council), Professor Wei Chen (Renmin University), and Mr. Everton Campos de Lima (Universidade Estadual de Campinas) and Mr. Lanza Queiroz (Universidade Federal de Minas Gerais) were the presenters, and Professor Kenneth Hill was the moderator.

Ms. Cappa's presentation, which was an overview on available data and data sources on birth registration, was delivered by Danzhen You (United Nations Children Fund (UNICEF)). She highlighted that 166 countries out of the 197 countries (more than 80 per cent) in the UNICEF's world classification database had data on birth registration. She mentioned that the data sources included CRVS systems, censuses and household surveys with most of the countries having data for more than one point in time (between 1998 and 2015). Ms. You noted that the UNICEF database was updated once a year through country reporting on indicators for the goal (CRING) including birth registration. She mentioned that a rigorous check on data quality was done at the headquarters (UNICEF HQ). Ms. You stated that some of UNICEF's current activities on birth registration included testing of new survey questions, global review of CRVS data and systems and regional review of CRVS policies, systems and procedures.

Prof. Dorrington (Centre for Actuarial Research University of Cape Town) made a presentation on lessons from an investigation of the age distribution of younger people in the 2011 South African census, and the evaluation of the trend in births registration over time. Prof. Dorrington stated that before the year 2011, there had been cases of incomplete vital registration (VR) data, unsuccessful Demographic and Health Surveys, limited information on General Household Surveys, unreliability of community surveys and unpublished Human Science Research Council (HSRC) surveys and therefore this research was carried out in search for the 'truth' about the trend in births over time. Prof. Dorrington approached the study by comparing 1) reverse survival estimates to records of the number of the births, 2) estimates to reverse survival estimates from previous censuses and surveys, 3) the count of children by age to estimates of the population derived using school enrolment data from the department of education, 4) reverse survival estimates to estimates derived from the births from vital registration corrected for incompleteness of registration and lastly (5) estimated fertility implied by the reverse survival estimates and compared to total fertility derived from recent births in censuses. The results showed a trend in fertility that was confirmed at the national level but not within some sub-populations (e.g. specific ethnic population groups or provinces). The results also showed that consistency of trend over time was as important as increasing completeness or reducing lag in release of data at the expense of seriously disrupting a well-established trend.

Ms. Nannan et al. (Burden of Disease Research Unit, South African Medical Research Council) described a national and subnational experience with estimating the extent and trend in completeness of birth registration in South Africa. Ms. Nannan stated that South Africa had an established CRVS system since 1926 though it was only functional for selected subgroups. She mentioned that the study aimed to assess the completeness of birth registration in South Africa and to identify the methods for annual assessment. She noted that the registered births were compared with independent estimates of births based on (1) age specific fertility rate ASFR applied to population estimates from census, 2) recent estimates of the number of births represented in the 2011 census (estimated by reverse survival method) and finally alternative source of data from the District Health Information System (DHIS). The results show an increase of birth registration from 33 per cent to 83 per cent by the second birthday between 1996 and 2011. Ms. Nannan mentioned that this improvement was associated with better legislation, government commitment and the provision of child grant. She stated that the results also showed that DHIS was a valuable source of birth data during the intercensal period. Ms. Nannan pointed out that it was important that global comparisons of individual countries used well defined assessment criteria and methods of evaluations. She underscored that the assessment of completeness by age was a useful

method of evaluation, and that migration presented some challenges at the provincial level. She noted that more research was needed to ascertain the obstacle preventing communities from birth registration and to review the performance of linkage between birth and death register to assess completeness and monitor child mortality. Ms. Nannan also suggested to further examine the obstacles preventing certain communities from registering births.

Prof. Chen (Center for Population and Development Studies, Renmin University of China) described an evaluation of the completeness of birth registration in China by using analytical method and multiple sources of data. Prof. Chen noted that the sources of data considered in this study included household registration, hospital delivery statistics, family planning statistics, population census and annual survey. He mentioned that prior to this study, there was an under-reporting of births and under-utilization of birth registration data. Prof. Chen stated that the study brought together multiple sources of data, and different methods to reach a consistent estimation of completeness of China's birth registration between 2000 and 2010. The methods used were the integrated estimation method developed by Preston, age distribution data over age 10 from two censuses and generalized stable population models to estimate the average number of births. But Prof. Chen noted that the Preston estimation method showed that the different data sources and methods had consistent results of birth average between 16.6-16.8 million which was slightly higher than the results produced by the National Bureau of Statistics (NBS). He also mentioned that birth registration in China had been affected by the one child policy. Prof. Chen noted that with the start of the implementation of the two-child policy, birth data started to improve.

Mr. Lima (University of Campinas – Unicamp) and Mr. Queiroz (Federal University of Minas Gerais – UFMG) analysed the main sources of data and methods used to access the quality and to estimate fertility schedules in Latin America. In their presentation, they highlighted the unreliability of vital statistics in the region due to its inconsistency. They mentioned that with population census as the main source of data in the region, there was a population under-reporting of more than 3% in many countries. They noted that Demographic and Health Surveys (DHS) along with national surveys were the most important sources of data used for estimating fertility, infant mortality and nuptiality. They stated that more effort was needed in birth data collection ranging from promoting accurate information about the parents of the child being registered including their socioeconomic characteristics, using other sources of data, and combining two or more methods in evaluating completeness of birth registration and fertility change, for example a combination of Synthetic Relational Gompertz (SRG) model and Brass P/F ratio as a good tool to evaluate the completeness of births and to estimate the distribution of the fertility by age in the case of Brazil, especially in a scenario of fertility change. They also suggested the promotion of alternative data sources such as the (future) project of Latin American Fertility Database in Human Fertility Collection (HFC) and the Latin American census data in Cohort Fertility and Education (CFE) database.

In the ensuing discussions, participants recognized the need to use multiple sources of data and methods to evaluate data from civil registration. They also emphasized the need to investigate the obstacles to civil registration.

Regarding China, participants pointed out that it was difficult to assess what was the “truth” in birth registration. It was recommended that school age population be used to evaluate data on civil registration. Prof. Hill suggested using the synthetic method that tried to adjust for fertility change. Participants also suggested using the population aged 15 to evaluate birth registration since identification cards were mandatory at age 15.

The problem of coverage of population was raised. It was mentioned that it was important to identify the type of population covered (entire population, resident population (de facto or de jure)). The issue of completeness or representativeness was also raised.

The issue of performance of a particular method was raised. Participants agreed that there was a need to assess the performance of each method used to evaluate civil registration as some methods were likely to be more suitable than others.

The issue of comparability of questions in surveys was addressed. It was suggested using a model set of questions to allow international comparability over time and across countries.

C. ANALYTICAL METHODS TO EVALUATE THE COMPLETENESS AND QUALITY OF DEATH REGISTRATION (PART 1 OF 2)

In this session, four panellists took the floor and presented the various experiences of their institutions and countries on indirect methods used for the evaluation of death registration for the Global Burden of Diseases, and review of national estimates of completeness. The presenters were Professor Alberto Palloni (University of Wisconsin) and Hiram Beltran-Sanchez (University of California Los Angeles), Haidong Wang (University of Washington), Nan Li and Patrick Gerland (Population Division, DESA), and Romesh Silva (Statistics Division, Economic and Social Commission for Western Asia, United Nations). The session was moderated by Professor Kenneth Hill.

Prof. Palloni (University of Wisconsin-Madison) and Mr. Beltran-Sanchez (University of California Los Angeles) presented an overview of the methods they used to estimate life tables in the Latin American Mortality Database (LAMBDa). In this paper, Prof. Palloni and al. focused only on adjustments of life tables for the post-1950 period. To do so, they availed themselves of mortality data consisting of yearly deaths by age and gender and population censuses. Because methods to adjust for completeness of death registration were well-known, they focused on the description of relatively new methods to adjust for adult age misreporting. They then combined these different methods in an evaluation study designed to identify an optimal strategy to construct adjusted life tables for adult ages. This paper has six sections. In the first section, they briefly defined problems caused by defective vital statistics and census enumerations. In the second section, they proposed a model to represent the nature of adult age misreporting and in the third section they described a methodology to detect and adjust for adult age misreporting. The fourth section described an evaluation study designed to assess the performance of techniques to correct mortality indicators for both errors of coverage and age reporting. The fifth section discussed results from the evaluation study. The last section summarized results and argued that adjustment of imperfect mortality data was subject to uncertainty and that treatment of the adjusted data was best carried out with models that account for uncertainty.

Mr. Wang (Institute for Health Metrics and Evaluation at the University of Washington) made a presentation on the evaluation of death registration in the global burden of disease. Mr. Wang used a two-stage model, where he first predicted adult completeness based on child completeness, and then used a spatial-temporal regression model to incorporate information about adult completeness from the death distribution methods (DDM). The under-five mortality (U5) completeness was then calculated as the ratio between input 5q0 and the estimated 5q0 for the country using Spatial-temporal Gaussian process regression. In his conclusion, Mr. Wang highlighted the need for proper selection of methods that could be used to evaluate completeness of data. He noted that attention should be put in migration especially internal migration where there was little documentation and suggested to integrate uncertainty of completeness in the all-cause mortality estimation process.

Mr. Li and Mr. Gerland (Population Division, DESA) focused on evaluating the completeness of death registration for developing countries at old age considering conditions under which census populations could be used. They noted that the old age group was considered because migration was negligible compared to deaths. They used the Intercensal Cohort Survival Evaluation (ICSE) because it

could analyse the evaluation of errors when the two fundamental assumptions do not stand (that is first no migration; and second no census error or that the errors in the two censuses obey special relationships). The steps were as follows: subtracting the number of population in a certain old age group in the first census by the number of survivors in the second census gives the number of deaths computed by ICSE. On the other hand, the number of registered deaths that occurred along the surviving person-years could be counted using Lexis triangles, or estimated using assumptions such as evenly distributed over age and across time. The completeness of death registration (DR) was evaluated as the ratio of the corresponding number of DR deaths to the ICSE computed number of deaths. The ICSE is based on survival process, not on the balance of a growth process. The ICSE provides a simple comparison procedure to check the consistency based on two successive censuses and expected registered deaths. They highlighted that this analysis provided the conditions under which this approach could be used to evaluate death registration at old ages and noted that these conditions were more likely to hold in developing countries. They underscored that ICSE could not provide reasonable results for situations where mortality was low and completeness was high but ICSE could provide reasonable results for situations where mortality was not low and completeness was not high – but ICSE depends on the reliability of the census data. They noted that evaluation using different age groups, including data for open age group, provided further insights on the sensitivity and robustness of these results, and potential issues with the reliability of data at older ages in some countries or periods.

Mr. Silva (Statistics Division, United Nations Economic and Social Commission for Western Asia) made a presentation on disentangling sex differentials in death registration and mortality estimates. Mr. Silva applied different variants of death distribution methods (DDMs) to data on national populations using three methods: the generalized growth balance (GGB), the synthetic extinct generations (SEG), and the adjusted SEG methods. The study, which used Kuwait and Morocco data, assumed that there was information on migration, that completeness of death reporting was the same for all the ages, and that coverage of each individual census was the same for all ages. Mr. Silva highlighted that there were sex differentials in the completeness of death registration, and a limited insight from the application of DDMs in Morocco and Kuwait respectively. He concluded that there was a need to investigate the nature of census enumeration and to examine sex-specific cause of death data in Kuwait while more research was needed on the nature of sex differentials in death registration in both urban and rural areas in Morocco. At the regional level, Mr. Silva mentioned that there was a need to expand the completeness assessment beyond Kuwait and Morocco, and to coordinate with 2020 Population census round and household survey programs.

In the following discussions, participants addressed the issue of incorporation of migration into the estimation. It was agreed that the age distribution of migrants as well as their proportion in the destination countries should be taken into account, especially in countries with a large proportion of non-nationals such as Kuwait. Participants recognized that in countries with large proportion of migrants, the mortality of non-nationals was far higher than that of nationals because non-nationals were more involved in high risk activities.

D. ANALYTICAL METHODS TO EVALUATE THE COMPLETENESS AND QUALITY OF DEATH REGISTRATION (PART 2 OF 2)

In this session, Ms. Danzhen You (UNICEF), Mr. Michel Guillot (University of Pennsylvania), Professor Robert Dorrington (University of Cape Town), and Mr. Bernardo Lanza Queiroz (Universidade Federal de Minas Gerais) and Mr. Everton Campos de Lima (Universidade Estadual de Campinas) presented country-specific data sources and experiences on methods used to evaluate completeness of infant and neonatal mortality in LMICs. The session was moderated by Professor Kenneth Hill.

Ms. You (UNICEF) made a presentation on international experience with the use of analytical approaches and multiple data sources to evaluate the completeness of infant and neonatal mortality. Ms. You noted that the factors affecting birth and death registration might include misreporting of age, underreporting and/or omission of births, birth and death displacement, and misclassification of the records. Ms. You underlined that in order to evaluate the completeness and quality of child mortality from vital registration, the data had to be checked and compared with other data sources and other countries. She mentioned that the advantage of this method was that it was also applicable to subgroup estimates, and was useful to identify age heaping, potential omission and other errors associated with it. Ms. You highlighted that it was difficult to define the exact levels of omission, incompleteness, misreporting and misclassification and that this method required detailed information by age (and potentially other socio-demographic characteristics). She noted that more efforts were still needed in reporting neonatal deaths, availing detailed birth and death data. Ms. You mentioned that systems should be evaluated using multiple data sources and methods and standard definitions should be adopted, and the training of personnel should be promoted.

Mr. Guillot (University of Pennsylvania) presented an evaluation of infant death registration in Kyrgyzstan. Mr. Guillot focused on the impact of the breakup of Soviet Union on infant mortality. The sources of data were census, official vital registration data and sample surveys which could not detect short term changes in infant mortality rate (IMR) and estimate trends for subgroups due to small sample sizes. He found that infant mortality rate stalled in Kyrgyzstan following the Soviet Union breakup and remained high in rural areas and among Central Asian ethnic groups. Mr. Guillot noted that the quality of VR data deteriorated in 1990s but improved since 2004 and reported infant mortality rate was still underestimated by about 11 per cent.

Turning to lessons learned, Mr. Guillot noted that poor quality infant death registration was not systematic, but concentrated in some age groups allowing for the adjustment of IMR using model age patterns in the high-quality age ranges. He highlighted that the advantages of vital registration data adjustment compared to survey estimates were the detection of time patterns not apparent in survey information, and more up-to-date information. He underlined that his analytical approach did not address uncertainty around the adjusted estimates. Mr. Guillot mentioned that there was a need to publish more detailed age-specific information for children and deaths under-five years. He pointed out that in order to address uncertainty in adjusted estimates, wider range of high quality data should be used to expand model age patterns and that the exploration of other entry points less affected by reporting biases (e.g., between 3 months and 21 months in Kyrgyzstan) might be more relevant.

Prof. Dorrington (Centre for Actuarial Research University of Cape Town) described a national and subnational experience with estimating the extent and trend completeness of registration of deaths in South Africa using the rapid mortality surveillance (RMS). Prof. Dorrington highlighted some important points considered during the evaluation process for example: how an incomplete population register could be useful, how consistency of trend over time was more important than attempting to increase completeness or release data more rapidly at the expense of seriously disrupting a well-established trend, and when completeness was high direct estimates of IMR were not too inaccurate. He noted that the assumption of constant completeness by age was only true above age 30 in South Africa which was likely to be a problem in significantly heterogeneous populations (e.g. urban vs rural) and household deaths likely to be problematic unless stable multigenerational families.

Turning to the challenges in estimating mortality in sub-national populations, Prof. Dorrington highlighted the following issues: age problems (year of birth heaping) can be entrenched in the official data, the limiting usefulness of near-extinct generations (NEG) methods, and how a new statistical extension using generalized linear models (NEG-GAM) can potentially address age heaping issues but may not eliminate the age exaggeration in the death data (particularly when incentives exist to exaggerate

age), lack of correspondence between place of death and place of usual residence (which was usually not be captured in the vital registration data), the need of reliable estimates of sub-national migration and also that household deaths often violated the assumption of constant completeness by age and are typically available only for a short period creating uncertainty about the estimates. Dorrington and Timaeus (2015), propose a work around combining the two sources of data (vital registration deaths and deaths reported by households in the census) that makes use of the respective strengths of each to produce reliable estimates of sub-national mortality.

Mr. Queiroz (CEDEPLAR, Universidade Federal de Minas Gerais, Brazil) and Mr. Lima (University of Campinas, Brazil) presented a research on national and subnational experience estimating completeness of registration of deaths in Brazil. Mr. Lima and Mr. Queiroz used different methods to estimate the completeness of death registration. The choice of Brazil was made based on the availability of vital registration data and a large population that was distributed in a large territory. They used vital registration system, Ministry of Health database and population census as the main sources of data and discussed how demographic methods could be combined using statistical methods to produce small area estimates.

Turning to the results, they found a consistent level of improvement at national level though not homogeneous over space, which they said, was associated with investments in the public health care system and administrative procedures to collect vital statistics. They found that remarkable regional differences existed in the completeness of deaths counts and adult mortality across three last decades. They noted that the quality of death registration in Brazil had improved over time and across the country. They stated that methods and combination of methods worked well for sub-national level and that the results from 1980 to 2010 for meso-regions were very promising even using traditional demographic methods. They observed that for small areas, there were limitations with migration flow data (violated assumption), random fluctuations and zero cases.

E. RECORD LINKAGES AND VALIDATION STUDIES TO EVALUATE THE COMPLETENESS AND QUALITY OF VITAL REGISTRATION (PART 1 OF 2)

During this session, three panellists shared their experiences and recommendations from using record linkage studies to evaluate completeness: Prof. Chalapati Rao (Australian National University), Mr. Salah al Muzahmi (Oman's Ministry of Health), and Mr. Khameshwar Ohja (India's Ministry of Home Affairs). This session was moderated by Mr. Romesh Silva (United Nations Economic and Social Commission for Western Asia).

Prof. Rao (Australian National University) provided a general overview of the application of record linkage to evaluate completeness of mortality data, limitations of record linkage, and conclusions from its application to different contexts. Prof. Rao also provided suggestions for future use of record linkage and addressed gaps in the literature. Mr. Rao expressed the utility of reconciling fragmented data sources to develop a more robust source of data. Expressing the limitations of record linkage surveys, he explained the implications of various biases such as response correlation bias associated with record linkage and stressed the importance of local staff involvement during the process of matching. He presented a research guide presenting a hierarchy of study designs based on the following criteria: statistical independence, cost, sub-group analysis, and sample size. Prof. Rao stressed the significance of achieving good quality data for all variables in every data source available. Discussing suggestions for future applications of record linkage studies, Prof. Rao also emphasized the importance of achieving a deep understanding of procedures such as matching and data collection procedures. He noted that dedicating time to clearly defining all procedures would facilitate consistent data quality assurance and problem investigation.

Mr. al Muzahmi (Oman's Ministry of Health) presented a study conducted in Oman that used the capture-recapture method to assess death registration completeness across the Omani population using the records about recent household deaths from the 2010 census and individual death notifications from the Ministry of Health. He began by providing a brief description of the Omani population and history of Oman's death registration. Discussing the rationale for utilizing the capture-recapture method, Mr. Muzahmi mentioned that the capture-recapture method allowed for variable correction, unification of related variables, and estimation of registration completeness in children. He explained that the capture-recapture method can improve completeness in under-represented subgroups. Mr. Muzahmi elaborated on the study's methodology and mentioned some of its limitations. These included the absence of non-Omani data, discrepancies in values for the same variable, and missing or erroneous key matching variables. He suggested that the discrepancies matched data could be a result of recall bias. Mr. Muzahmi identified that direct methods were useful in Oman's context, allowed for a more complete view of data and have been useful to improve the existing reporting mechanisms.

Mr. Ohja (India's Ministry of Home Affairs) informed the audience about India's experience using a Sample Registration System (SRS). Mr. Ohja provided an overview of the SRS system, the record matching process, data sources used for matching, and studies available that evaluate completeness of births and deaths registration in India. Mr. Ohja started by discussing the main components of the SRS: a baseline survey, continuous enumeration, a half-yearly survey (HYS), matching events, event reverification, and the aberrant unit. He provided a review of each data source's coverage as well as the actors responsible for data collection, including Part Time Enumerators (PTE) who collect data through a complex social network. Mr. Ohja noted that in order to prevent PTEs from overlooking events, they conduct monthly visits to urban households and visits once every three months to rural households. Mr. Ohja explained the utility of an aberrant unit as a means of determining if a resurvey should be conducted. He mentioned that resurveys were conducted if the number of netted events was 25% greater or less than the HYS of the previous year. Mr. Ohja also briefly discussed completeness studies of births and deaths registration in India. He referred to an investigation conducted in 1980-1981 and an investigation conducted 5 years later that suggested a decrease in the omission rate from 3.1% for birth registration and 3.3% for death registration to 1.8% and 2.5%, respectively. He summarized that completeness studies indicated an overall omission rate of vital events in India between 5-10%.

In the general discussion, the discussant, Mr. Silva, appreciated the previous presentations and gave a brief presentation on how to use record linkage to assess the completeness of data. The discussant also appreciated the use of direct method (capture-recapture) in Oman, and urged participants for the need for sharing and publishing the findings of the study.

Participants highlighted issues concerning geographical coding and the potentials for technology such as what3words.com, and pointed out the challenge of using geographical codes because not all countries follow or use the same codes during a census for example. It was acknowledged that this lack of common standards can result in problems with linking data collected from civil registration with other existing administrative or statistical records.

It was agreed that there was a need for common geographical framework. It was recommended that the presentations and discussions of this expert group meeting be availed and shared with the international community, and published online.

F. RECORD LINKAGES AND VALIDATION STUDIES TO EVALUATE THE COMPLETENESS AND QUALITY OF VITAL REGISTRATION (PART 2 OF 2)

In this session, a focus was placed on a series of country-specific applications. Four panellists continued to share their experiences from conducting record linkage studies in order to evaluate completeness: Professor Maigeng Zhou (National Center for Chronic and Non communicable Disease Control and Prevention of China), Ms. Patama Vapattanawong (Mahidol University, Thailand), Ms. Eliane de Freitas Drumond (Health Department of Brazil), and Ms. Ji-Youn Lee (Statistics Korea (KOSTAT)). This session was moderated by Professor Chalapati Rao (Australian National University).

Prof. Zhou (National Center for Chronic and Non Communicable Disease Control and Prevention of China) described the Disease Surveillance Point system (DSPs), methods used to estimate death registration completeness and uncertainty, and China's progress in death registration completeness over time. Mr. Zhou familiarized the audience with the history of the Disease Surveillance Point system (DSPs). He noted China's achievement of a state of national representativeness in 2004 and in 2014, both national and sub-national representativeness. Prof. Zhou summarized the workflow of registration of deaths in and outside the hospitals, stressing the unique involvement of the Center For Disease Control and Prevention (CDC) in the process. Prof. Zhou then described China's underreporting survey and emphasized the interviewer training. He also discussed the matching process which uses national ID as a unique identifier, and a combination of name, gender and age in the absence of national ID. China uses a computer-based matching process followed by the manual verification of unmatched records. Prof. Zhou continued by describing the propensity score (PS) weighting method used to develop model estimates, the weighted estimates of the number of deaths, the underreporting rate, and the uncertainty calculation. Prof. Zhou underscored that the propensity score was valuable for a variety of reasons including its consideration of underreporting's multiple covariates. Prof. Zhou highlighted that the underreporting survey was an independent mode of data collection and could be used to rapidly estimate the underreporting rate. However, he noted the challenge of acquiring representative data through surveys. In addition, acquiring consistently high quality data through large-scale field surveys was not easy as surveys were resource-intensive. He informed the audience about China's future steps to improve death registration included reducing their underreporting rate for subnational populations and utilizing sources outside of the underreporting survey for matching.

Ms. Vapattanawong (Mahidol University, Thailand) provided a brief overview of Thailand's CRVS system, methods used to evaluate CRVS completeness, and experiences and lessons learned from applying the dual records method in different contexts. Ms. Vapattanawong mentioned that during a 1963 population meeting, discrepancies were found between the growth rate found from the CRVS data and population census. This prompted a study to determine the true rate of population growth and resulted in the development of the Survey of Population Change (SPC). Ms. Vapattanawong specified that both indirect and direct methods were used to estimate CRVS data completeness: the dual records procedure, direct estimation from a survey question on births and deaths communication to registrars, and indirect demographic analysis. Ms. Vapattanawong also described experiences employing the dual records method in different contexts: the Kanchanaburi Demographic Surveillance System (KDSS), reassessment of the 2005-2006 SPC, and Universal Coverage Scheme (UCS). Ms. Vapattanawong noted multiple lessons that would be helpful for future applications of record linkage from these studies. Ms. Vapattanawong emphasized that inter-organizational collaboration was essential, as well as close cooperation between researchers and organization. She emphasized the importance of ensuring that officers possessed necessary knowledge and skills and, in their absence, providing training and ensuring clear communication of goals. She underscored that different means of record matching should be employed within different settings and highlighted that parallel studies should be conducted where multiple sources of data are available. Ms. Vapattanawong suggested that future research should be

conducted using the Ministry of Public Health (MOPH)'s family folder system containing health data at the household level to evaluate completeness at a subnational level.

Ms. Drumond (Health Department of Brazil) presented an overview of Brazil's experience with sub-national and national level record linkage studies, a brief history of civil registration in Brazil, and the creation of the National Information System on Live Births (SINASC) in the 1990's used to collect births data in Brazil. Ms. Drumond shared that completeness was an issue particularly for poorer regions because of underreporting. Ms. Drumond highlighted the issue of underreporting of vulnerable populations such as the elderly, women, economically-deprived, and afro-descendants. She explained that the correction factors used to compensate for the lack of data among these individuals were limited in nature because they don't allow for corrections in causes of deaths (CoD) data. Methods proposed to address these issues include active searches for CoD data, the development of the Committee of Child, Perinatal, and Maternal Mortality responsible for compiling the actual number of maternal and child deaths via CoD investigation, and the Ministry of Health's freely available system to tabulate data on mortality and related issues. Ms. Drumond noted measures that are being taken to alleviate the issue of ill-defined CoDs. These measures involved highlighting the accurate completion of death declaration information by doctors and verbal autopsies. She relayed that, in order to improve the quality of record linkage studies and CRVS data, it was crucial to develop and disseminate low-cost and simple methodologies. This would reduce biases that resulted from possessing limited knowledge of methodological issues. Ms. Drumond also mentioned additional suggestions for future application of record linkage methods including the utility of statisticians and epidemiologists as trained health staff, establishing mechanisms to maintain ethical and privacy considerations, and utilizing unique identification numbers. Ms. Drumond acknowledged the value of widespread recognition of record linkage methodologies in order to enhance the quality and timeliness of health data and stressed the crucial nature of timeliness in policy development.

In this presentation, Ms. Lee (Statistics Korea (KOSTAT)) described the enhancement of Korean infant mortality statistics through linking administrative data with survey data, provided a review of Korea's CRVS systems, summarized birth and death registration completeness, and described methods used for their evaluation. Ms. Lee explained that there are two main civil registration systems in Korea: the family register and population register. The first creates a record of legally effective births, deaths, divorce, and marriage information. The second is the backbone of the Korean registration system, holding information such as Resident Registration Number, name, place of residence, and relationship of household members. Ms. Lee explained that despite the belief that 99% of all deaths are registered, infant and foetal deaths are not accurately reported. As a result, efforts had been made towards improving infant mortality statistics. She mentioned that one improvement made towards enhancing these data was developing complementary data sources to CRVS data, specifically the Crematory Registration and Infant and Maternal Mortality Supplementary Survey. Ms. Lee noted that linking administrative data with survey data helped to enhance vital statistics including infant mortality and birth statistics and produced richer data. Ms. Lee mentioned that collecting and combining information from several data sources could improve the coverage of vital statistics and identification of underreported cases. She summarized that due to record linkage of complementary data and registered infant deaths, IMR increased from 2.3 deaths per 1000 births in 1998 to 4.5 deaths in 1999. Improving infant mortality statistics in Korea resulted in an increase in birth registration completeness, and recently a level of nearly 100% birth registration completeness.

During the session discussion, participants acknowledged the importance of collecting and combining information from several data sources in improving the coverage of vital statistics and in identifying the under-reporting cases. Participants asked for clarification on how economic level was used in stratifying samples in Prof. Zhou's presentation.

Participants also highlighted the importance of registration numbers in improving infant mortality statistics by linking administrative and survey data in Ms. Lee's presentation.

Regarding the generation of registration numbers for live births that die within a few hours after delivery, participants raised question on the mechanism that was put in place to reach this goal. Participants also noted the usefulness of the dual record method in countries where several sources of vital data exist which allows for cross-matching.

G. CRITERIA USED TO EVALUATE THE QUALITY OF MORTALITY DATA FROM CIVIL REGISTRATION AND VITAL STATISTICS

In the final session, four panellists presented lessons learned from employing various methods to evaluate births and deaths registration data, and focused on various criteria to evaluate deaths registration data. The panellists were Dmitry Jdanov (Max Planck Institute for Demographic Research, Germany), Professor Tim Adair (Bloomberg Data for Health Initiative, University of Melbourne), Jane Joubert (South African Medical Research Council), and Gretchen Stevens (World Health Organization (WHO)).

Mr. Jdanov (Max Planck Institute for Demographic Research, Germany) focused on data quality problems in countries with full coverage of CRVS data. He provided an overview of the Human Mortality Database (HMD) and recommended methods for different contexts and ways to improve data use in the event of problematic data quality. These scenarios include cases where intercensal population estimates for old ages are unreliable or unavailable. Mr. Jdanov explained that another way to evaluate quality of data was by comparison of data to other countries with reliable statistics. Although standard demographic methods may work well with data from developing countries, Mr. Jdanov pointed out that they often may not apply to problematic data from countries with functioning statistical systems. He advised using country-specific approaches, coupled with the use of alternative sources of data. Mr. Jdanov noted that these approaches should be combined with standard principles for all countries, in order to allow comparison of HMD statistics across space and time.

Prof. Adair (Bloomberg Data for Health Initiative, University of Melbourne) delivered an overview of the various methods employed by the Data for Health Initiative (D4H) project to evaluate completeness and quality of birth and death registration data. Prof. Adair explained that the D4H Initiative aimed to strengthen the CRVS systems of 18 low and middle income countries and cities. These countries and cities included Mumbai (India), Shanghai (China), Rabat (Morocco), Ghana, Brazil, and Sri Lanka. Prof. Adair addressed indirect methods, direct methods, and methods for regions that were unable to apply either indirect or direct methods of evaluation. He presented lessons learned from applying these methods to CRVS data in D4H countries and cities, including how to address problems of quality and incompleteness of CRVS data. Prof. Adair explained that teaching more complex methods of completeness evaluation might improve the ability of countries and cities to apply more appropriate methods of evaluation to their data. Prof. Adair elaborated by discussing D4H's training curriculum. He emphasized improving data quality such as that of age data and utilizing other data sources to close gaps in births and deaths registration data. Prof. Adair provided a number of recommendations to close these gaps, including emphasis on the use of record linkage to reconcile data, training, and routine estimation of completeness.

Ms. Joubert (South African Medical Research Council) reviewed lessons learned using nine criteria for the evaluation of quality and completeness of CRVS mortality data in South Africa. Ms. Joubert presented the criteria, rating system for the criteria, and data sources used. Some of the criteria used for evaluation were completeness, coverage, timeliness, and availability of sub-national data. She

explained that four criteria were used to evaluate an annually updated CRVS dataset produced by Statistics South Africa (Stats SA) containing 11 years of national mortality data. Five criteria were used to evaluate other sources, including web-based data repositories and statistical releases. Ms. Joubert described the results of applying each criterion to the data sources as well as constraints discovered that prevented satisfactory performance. Some of constraints included differences in death certification practices between regions, misclassification or non-specific classification of causes of death, and different policies regarding death registration. She noted that although significant research existed regarding the identification of data quality criteria and performance for health information systems (HIS), there was less regarding criteria and frameworks for the evaluation of CRVS data.

Ms. Stevens (World Health Organization (WHO)) presented on WHO's assessment of CRVS data, specifically for data used to create the Global Health Estimates. Ms. Stevens discussed WHO global health estimates, which included comprehensive estimates of deaths by cause, life tables, all-cause mortality, and Disability-Adjusted Life Years (DALY). She explained that various data sources that were available were combined to develop more consistent and comprehensive estimates. Ms. Stevens explained that WHO used the UN's Population Division population and life table estimates produced for 5 year periods to calculate total number of deaths and mentioned the importance of developing annual estimates. She explained that WHO estimates were used to create global health estimates for specific causes of death such as HIV and malaria. However, for countries without usable death registration data, Ms. Stevens explained that the Global Burden of Disease (GBD) 2015 analyses were used to produce estimates for non-specific causes of death such as cardiovascular disease. Ms. Stevens also discussed WHO definition of the two most important dimensions of quality: completeness and deaths assigned to ill-defined causes. She emphasized the importance of having no ill-defined causes which were for example, causes of death such as heart failure. Discussing low-resource areas, Ms. Stevens mentioned the Start-Up Mortality List (SMoL). SMoL was developed to assist low-resources areas in collecting better quality causes of death data. Ms. Stevens pointed out other approaches to improve vital registration data, which included providing training and electronically integrating all data sources into one central repository through an interface that enables access to researchers.

In the general discussion, the following issues were raised: how do we prioritize decisions within the system knowing that a census comes with large investments and is time bound? How do we bridge the gap between training country specialists to understand and apply methods to measure registration completeness and to justifying decisions to bring appropriate results?

2. CONCLUSIONS AND RECOMMENDATIONS

In the concluding session, each moderator delivered a brief recap of their sessions' key points.

Prof. Hill addressed key points from the initial session. He started by pointing out two key objectives of civil registration: social protection and demographic measurement, and monitoring. Highlighting that each objective requires different levels of quality, he noted that from a social protection point of view, a 100% level of births registration is necessary because individuals who aren't registered probably need it the most. In terms of demographic measurement, Mr. Hill noted that the quantity of data necessary for demographic estimation depends on the data source's ability to be accurately representative of the population. Mr. Hill discussed the importance of clearly defining coverage before completeness, in order to understand the covered population. He stressed the importance of multiple data sources for evaluation and incomplete data. He emphasized the need to use context-specific methods. Mr. Hill noted as well the knowledge gap in survey and census procedures. He noted that research in this area would allow for empirical evidence to guide phrasing and implementation of questions. Highlighting that most methods that are employed were developed three to four decades ago, Prof. Hill suggested an investigation into novel methods addressing existing issues.

Mr. Silva mentioned some key points from presentations on the use of record linkage to assess the completeness of data at sub-national levels. Mr. Silva addressed the challenge of employing indirect methods without having adequate migration data. He also noted the heavy reliance on certain data sources when conducting direct linkage studies that was present in the existing literature. He summarized the need to explore other data sources such as cremation grounds data that were not usually considered part of a statistical system. In order to close the knowledge gap of uncertainty and error, Mr. Silva stressed the importance of developing clear definitions for error and uncertainty quantification. He mentioned that it would be useful to determine all available data sources for future record linkage studies, even on a preliminary or small-scale level. Mr. Silva also noted the importance of completely using all available data, collaboration between individuals involved with population census rounds and CRVS data, and the lack of record linkage studies in some regions including sub-Saharan Africa.

Prof. Rao summarized key points and recommendations from presentations covering country-specific applications of record linkage. Prof. Rao highlighted the challenge of establishing independence between different systems. He mentioned India's reliance on sharing data between two sources and the use of a reconciled data set in order to estimate mortality. He noted that this would be helpful especially because of the existing desire to move towards multiple record systems. He also referred to Korea's experience of using all available sources of data without the use of assumptions to estimate missed events. Prof. Rao also noted China's consistency in completeness over past two decades at approximately 15% from surveys conducting in DSPs. With regards to the Thai experiences, he commended the persistence of the Thai researchers in applying the dual records methodology in three different environments to evaluate vital registration completeness in Thailand. He noted that a lesson learned from Thailand's experience was that the same methodology could be used to exploit any available data source or look at potential avenues for applying record linkage. He noted problems that could arise from their experiences, including the use of a 13-digit identifier numbers as the sole variable for the linkage. Prof. Rao explained that reporting a 13-digit number was prone to some degree of error and could create false positives and false negatives. The next point he brought up was the importance of field verification of events of, at minimum, a sample of the cases if not all, as practiced in the SRS and DSPs for a dual record system. Prof. Rao also noted that the use of the RecLink software, mentioned by Ms. Drummond, could be useful for countries that implement a probabilistic methodology to link records. Prof. Rao noted as well the importance of pursuing data quality in measuring mortality, as demonstrated by the Korean experience in making every infant death count.

Ms. Carter noted that all methods discussed throughout all of the sessions suffer from problems in the availability and quality of the data sources. She mentioned the importance of combining the following into one discussion: completeness, origin of data, available data, the ability of data to fit into the broader system, and the subjectivity of system work. She noted the importance of finding ways to bridge the capacity gap between the academic works of assessing completeness and explaining to countries how methods relate to their data. Ms. Carter stressed the need to keeping in mind intended uses of data for example. She concluded by addressing a quote by Mr. Jdanov's in the previous session: "standardized approaches applied uniquely." Ms. Carter addressed the need to build as much standardization as possible around methods and Demographic and Health Survey (DHS) questions while being able to effectively place them into national and subnational contexts.

In concluding the Expert Group Meeting (EGM), Mr. Wilmoth, Director of the Population Division, emphasized its relationship to the 2030 Agenda for Sustainable Development. He discussed the 2030 Agenda for Sustainable Development's reference to the importance of birth registration in providing legal identity to people. He stressed that it was vital for an individual's comprehensive inclusion in society and enabled access, in many cases, to health care and education. To elaborate on the importance of promoting utilization of CRVS data, he referred to a meeting in April of 2016 during which the Commission on Population and Development adopted a resolution on strengthening the demographic evidence base for the 2030 Agenda for Sustainable Development. The meeting considered all of the forms of demographic data and with regards to registration data, the commission urged governments to improve CRVS systems in order to attain timely, universal, and trustworthy data to promote the use collection of causes of death data, that was compliant with WHO's International Classification of Diseases (ICD). Mr. Wilmoth stressed that the material learned from the EGM on the methodologies and lessons learned from the experiences of studies contributed greatly to knowledge of analytical methods at the national and subnational level, particularly for low- and middle-income countries (LMICs). He mentioned that the results of the meeting would contribute to the development of new reference materials by the United Nations for the evaluation of the geographic coverage of civil registration and the completeness and quality of vital statistics data derived from civil registration at the national and subnational levels. Mr. Wilmoth expressed that this meeting was made possible by the support of Statistics Korea (KOSTAT), and expressed thanks to the Republic of Korea for financing the expert group meeting. He also expressed gratitude to his colleagues in the Population Division, led by Patrick Gerland, for their commitment to organizing this meeting. He thanked all participants for their attendance and contributions and for the panellists' time and commitment dedicated to participating in the international discussion of these issues at the United Nations.

In preparing this report, a number of cross-cutting lessons learned and recommendations emerged through the different thematic sessions:

First, in respect to the use of direct or indirect analytical methods to evaluate the completeness of vital statistics data from civil registration:

- The comparison of data with a standard data source is the simplest method to measure completeness that is most commonly used to evaluate registration completeness in countries that lack a national coverage of births and deaths information.
- Census data often play a critical role, especially for the analysis of sub-populations or at subnational level, and the forthcoming 2020 round of censuses will present renewed opportunities for evaluation of vital statistics from civil registration.
- Analytical methods in general are very cost-effective in term of time and resources because they require limited amount of tabular data, but the timeliness of estimates is often

problematic because these methods assess completeness only for the most recent year before the census, or for intercensal periods.

- In general, indirect methods relying on two censuses provide more robust estimates than those relying only on one census, but intercensal cohort analysis requires the two censuses to be spaced at most by 10 to 15 years and completeness is measured essentially in comparison to the completeness of population data.
- Due to underlying assumptions, results must often be interpreted with caution especially when applied at subnational level.
- Once completeness is high or very high, and especially when fertility or mortality are low, existing analytical methods to evaluate death registration are unable to measure completeness with sufficient accuracy (5-20% of more as typical net error rate when one or more underlying assumptions are violated) and other approaches such as record linkage studies should be considered (e.g., between registered infant death and birth registration in Brazil and Republic of Korea).

Secondly, in respect to the strengths and limitations of Dual/Multiple Record Systems and capture-recapture validation studies to evaluate the completeness of vital statistics data from civil registration:

- Record linkage studies have several strengths that make them more valuable than simpler analytical approaches:
 - They can help to identify systemic weaknesses in the registration system, including in specific population sub-groups and at subnational level.
 - They enable age-specific measurements of completeness and data reconciliation, especially among infants and young children and using additional fragmentary sources to help close gaps in information about causes of death.
 - They can be potentially timelier than indirect methods and for health surveillance based on routine data.
 - The results can be more readily interpretable by policy makers than indirect methods.
 - Linking two or more sources of data facilitate the correction of incorrect variables (i.e., can help to improve data quality) and the potential to merge additional variables of interest into an analysis.
 - They are useful in the context of unreliable in- and out-migration data, age misreporting, and incomplete death reporting not necessarily constant by age.
 - 95% confidence intervals can be easily computed.
 - Probabilistic matching (e.g., RecLink in Brazil) can help to facilitate linkage of records, and propensity score can help to deal with under-reporting and missing data (e.g., China DSP).

- However, record linkage studies have also several significant constraints and limitations:
 - Applicable only in some settings given data requirements, time and resource-intensive nature.
 - Many challenges in data quality contribute to reporting incompleteness: defects from various studies such as missing fields, frequent spelling mistakes, differences in the age or date of death, and differences in the sex of infants. The quality of age reporting (e.g., age heaping at ages ending in 0 and 5) is a significant problem for some countries and cities.
 - Use of lengthy unique identifiers as the sole variable for linkage can be problematic because a long string of digits is prone to some degree of error. This can result in false positives and false negative linkages.
 - Use of individuals' first and last name as a unique identifier can result in the inability to match many records (e.g., Thailand). This is mainly because of the different ways that are possible to spell a name and under-registration.
 - Other challenges with such studies may include the absence of out-of-scope events, the use of homogenous capture probability, the need for statistical independence of different data sources used, and the accuracy of record matching (e.g., missing data, errors in spelling of name and errors in reporting of dates, local judgment critical for decision-making, etc.).
- Based on the various record linkage studies reviewed as part of this meeting, several recommendations are possible:
 - Emphasize the use of unique identifiers, validation, enforcement, the accuracy of the date of death, age, name spellings, and address variables to improve data quality.
 - Improve assessment of compatibility between data sources in order to minimize the matching of out-of-scope events.
 - Employ different means of record matching within different settings. Although cross-matching is practical, it requires adjustments based on the context of the country.
 - Improve uncertainty and bias reporting in record linkage studies.
 - If follow-up study or record linkage is planned using vital events collected from a census, then collect also the individual names in the census to check or to facilitate matching.
 - Conduct a field verification of events after record linkage using a sample of matched records.
 - Utilize a defined hierarchy of study designs based on statistical independence, cost, sub-group analysis, and sample size to guide research.

- Invest time in developing an efficient study design when conducting record linkage analyses, and consider alternative methods of data collection and the scope of the desired outcome measures, such as disaggregation by age or geography.
- Achieve a clear understanding and definition of all data collection procedures, to facilitate consistent data quality assurance, problem investigation, and the evaluation of bias.
- Develop and disseminate free, simple, and easy record linkage methodologies.
- Increase the incorporation of statisticians and epidemiologists as trained health staff for future record linkage applications.

Finally, the meeting was an opportunity to gather a more general set of lessons learned with the application of various evaluation methods, and recommendations about the choice of the most appropriate ones:

- Many studies provide insufficient details about the method(s) and assumptions used (e.g., demographic analysis), and lack error margins and an evaluation of biases for their estimates. More efforts should be made to provide adequate methodological details whenever possible.
- No universal method is appropriate for all regions, and it is critical to apply standardized approaches, but to adapt them to the country or region.
- All methods of evaluation have strengths and limitations, but they vary based on their complexity and resource requirements.
- Strengths and limitations are also dependent on factors such as the need for additional sources, level of detail of the data sources, independence of sources, need for migration assumptions, and reporting patterns by various groupings, and in comparison to neighbouring regions.
- There are significant advantages to the use of multiple (independent) data sources (e.g., even an incomplete population register can be useful), and multiple methods, but participants underscored that the results obtained by different methods could be very different.
- It is important to understand the impact of the assumptions made by each method, and subsequently select the most appropriate approach depending of the setting, data and resources availability, timing and complexity of the method(s), disaggregation requirements, and purpose of the assessment.
- The value of country-specific approaches was demonstrated by the Republic of Korea's use of supplementary sources of data such as the Infant and Maternal Mortality Supplementary Survey. Compared to the regular death registration, the survey contained additional information on the infant, mother, and delivery, useful as well to support policies regarding healthy pregnancy and delivery.
- The methodology used by the Human Mortality Database (and Human Fertility Database) provide an appropriate standard to evaluate countries with a full coverage of vital statistics information and continuous population statistics. In particular, after each new census, it is

advisable to update intercensal population estimates and recompute vital rates for the latest intercensal period.

- Overall, it is critical to foster political will and drive, technical expertise, and collaboration among stakeholders, organizations, and researchers: more effort should be done by all parties to encourage stronger national ties, academic links, and funding for research to address the complexity of the evaluation methods, particularly for training in the application and understanding of the various approaches.
- It is essential to incorporate into more routine procedures and quality control processes the estimation of the completeness of vital registration within national statistical systems, including greater public disclosure of margins of error and non-sampling biases.
- While data protection issues often pre-empt data access for further evaluation of vital statistics, robust mechanisms should be setup to address ethical and privacy considerations, yet allow analytical research and record linkage under appropriate confidentiality protection safeguards.

**UNITED NATIONS EXPERT GROUP MEETING ON THE METHODOLOGY AND LESSONS
LEARNED TO EVALUATE THE COMPLETENESS AND QUALITY OF VITAL STATISTICS
DATA FROM CIVIL REGISTRATION**

Population Division
Department of Economic and Social Affairs
United Nations Secretariat
New York
3-4 November 2016

ORGANIZATION OF WORK

Thursday, 3 November 2016

08:45 – 09:00 Registration Conference Room DC2-1949

09:00 – 10:15 **1. Opening of the meeting**

- Introduction and objective of meeting: *John Wilmoth, Population Division, United Nations Department of Economic and Social Affairs (UN DESA)*
- State of civil registration and vital statistics (CRVS) systems in the world: brief overview of vital statistics data availability based on civil registration and international reporting to UN and WHO
 - *United Nations Statistics Division, Adriana Skenderi*
 - *World Health Organization, Colin Mathers*
- A review of key concepts: coverage vs. completeness, *Karen Carter (Secretariat of the Pacific Commission, Noumea, New Caledonia)*

10:15 – 10:30 Break

10:30 – 12:45 **2. Session on analytical methods to evaluate the completeness and quality of birth registration**

- Moderator and discussant: *Kenneth Hill (Independent Consultant)*
- Overview of available data and data sources on birth registration, *Claudia Cappa (United Nations Children Fund)*

- Methods for estimating the numbers of births: Lessons from an investigation of the age distribution of younger people in the 2011 South African census for the estimation of completeness of vital registration, *Robert Dorrington (University of Cape Town)*
- National and subnational experience with estimating the extent and trend in completeness of birth registration in South Africa, *Nadine Nannan (Medical Research Council of South Africa), Robert Dorrington (University of Cape Town) and Debbie Bradshaw (Medical Research Council of South Africa)*
- Evaluation of the completeness of birth registration in China using analytical methods and multiple sources of data, *Prof. Wei Chen (Renmin University, Beijing, China)*
- Lessons learned with the use of demographic methods and multiple sources of data to evaluate the completeness and data quality from birth registration in Latin America, *Everton Campos de Lima (University of Campinas, Brazil) and Bernardo Lanza Queiroz (CEDEPLAR, Universidade Federal de Minas Gerais, Brazil)*

12:45 – 13:45 Lunch

13:45 – 15:45 **3. Session on analytical methods to evaluate the completeness and quality of death registration (part 1)**

- Moderator and discussant: *Kenneth Hill (Independent Consultant)*
- Lessons learned with the application of indirect methods for the evaluation of death registration in Latin America, *Alberto Palloni (Univ. of Wisconsin) and Hiram Beltran-Sanchez (UCLA)*
- Indirect methods used for the evaluation of death registration for the Global Burden of Diseases, and review of national estimates of completeness, *Haidong Wang (Institute for Health Metrics and Evaluation, University of Washington)*
- Evaluating the Completeness of Death Registration for Developing Countries at Old Ages, *Nan Li and Patrick Gerland (UN Population Division)*
- Lessons learned with the application of indirect methods for the evaluation of death registration in the ESCWA region, *Romesh Silva (United Nations Economic and Social Commission for Western Asia, Beirut, Lebanon)*

15:45 – 16:00 Break

16:00 – 18:00 **4. Session on analytical methods to evaluate the completeness and quality of death registration (part 2)**

- Moderator and discussant: *Kenneth Hill (Independent Consultant)*
- International experience with the use of analytical approaches and multiple data sources to evaluate the completeness of infant and neonatal mortality in LMICs, *Danzhen You (UNICEF)*
- Lessons learned with the application of indirect methods for the evaluation of (infant) death registration in Central Asian republics by subnational characteristics, *Michel Guillot (Univ. of Pennsylvania)*

- National and subnational experience with estimating the extent and trend in completeness of registration of deaths in South Africa, *Rob Dorrington (Centre for Actuarial Research, Univ. of Cape Town)*
- National and subnational experience with estimating the extent and trend in completeness of registration of deaths in Brazil, *Bernardo Lanza Queiroz (CEDEPLAR, Universidade Federal de Minas Gerais, Brazil) and Everton Campos de Lima (University of Campinas, Brazil)*

Friday, 4 November 2016

09:00 – 10:45 **5. Session on record linkages and validation studies to evaluate the completeness and quality of vital registration (part 1)**

- Moderator and discussant: *Romesh Silva (United Nations Economic and Social Commission for Western Asia, Beirut, Lebanon)*
- Overview of the principles and international experiences in implementing record linkage mechanisms to assess completeness of death registration, *Chalapati Rao (Australian National University, Canberra, Australia)*
- Experience of Oman with nationwide record linkage between death registration data and census recall deaths for 2010, *Salah al Muzahmi (Ministry of Health, Oman)*
- Experience of India SRS with the use of record linkage studies to assess the completeness of the reporting of vital events, *Kameshwar Ohja (Office of the Registrar General & Census Commissioner, VS(SRS) Division, Min. of Home Affairs, New Delhi, India)*

10:45 – 11:00 Break

11:00 – 13:00 **6. Session on record linkages and validation studies to evaluate the completeness and quality of vital registration (part 2)**

- Moderator and discussant: *Chalapati Rao (Australian National University, Canberra, Australia)*
- The experience of China with the Disease Surveillance Point system (DSPs) and validation studies to evaluate the completeness of death registration, *Maigeng Zhou (National Center for Chronic and Noncommunicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing, China)*
- Experience with dual-registration validation studies in Thailand, *Patama Vapattanawonga (Institute for Population and Social Research, Mahidol University, Thailand)*
- Experience with record linkage validation studies in Brazil at national and subnational level, *Eliane de Freitas Drumond (Health Department, Belo Horizonte, Brazil)*
- Enhancing Korean infant mortality statistics by linking administrative data and surveys, *Ji-Youn Lee and Ju-Hwa Song (Vital Statistics Division, Social Statistics Bureau, Statistics Korea, Republic of Korea) and Sun-Jae Hwang (Chungnam National University and Asia Pacific Population Institute)*

13:00 – 14:00 Lunch

14:00 – 15:45 **7. Session on criteria used to evaluate the quality of mortality data from CRVS**

- Moderator and discussant: *Karen Carter (Secretariat of the Pacific Commission, Noumea, New Caledonia)*
- Traditional and newly emerging data quality problems in countries with functioning vital statistics, *Vladimir Shkolnikov (MPIDR, Germany) and Dmitry Zhdanov (MPIDR, Germany)*
- Lessons learned from recent experiences with the evaluation of the quality of vital statistics from civil registration in different settings, *Tim Adair (School of Population and Global Health, University of Melbourne, Melbourne, VIC, Australia)*
- Lessons learned with different criteria used and comparative approaches to evaluate the quality of mortality data: national and subnational experience in South Africa, *Jane Joubert (Burden of Disease Research Unit, South Africa Medical Research Council)*
- WHO assessment of CRVS quality for use in Global Health Estimates, *Gretchen Stevens (World Health Organization)*

15:45 – 16:00 Break

16:00 – 17:30 **8. Summary and conclusions**

- Summary of key points from each session
- Discussion and recommendations
- Concluding remarks: *John Wilmoth, Population Division, United Nations Department of Economic and Social Affairs (UN DESA)*

Annex 2

LIST OF PARTICIPANTS

INVITED EXPERTS, MODERATORS AND RAPORTEURS

Professor Tim Adair

Principal Research Fellow
Melbourne School of Population and Global Health
The University of Melbourne
Level 5, Building 379, 207 Bouverie Street,
Carlton Victoria 3010
Australia

Mr. Salah Al Muzahmi

Director
Health Information and Statistics
Ministry of Health
Muscat, Oman

Mr. Hiram Beltran-Sanchez

Assistant Professor
Department of Community Health Sciences
University of California, Los Angeles
405 Hilgard Ave
Los Angeles, CA 90095
United States of America

Mr Everton Campos de Lima

Assistant Professor
University of Campinas
Cidade Universitária Zeferino Vaz-Barão Geraldo
Campinas - SP, 13083-970
Brazil

Ms. Karen Carter

Statistics for Development Division
Pacific Community, Secretariat of the
Pacific Commission
BP D5, 98848 Noumea
New Caledonia

Professor Wei Chen

Renmin University of China
59 Zhongguancun St. Haidian District
Beijing 100872
China

Ms. Eliane de Freitas Drumond

Physician
Health Department in Belo Horizonte
Minas Gerais, Brazil

Professor Robert Dorrington

Director
Centre for Actuarial Research
University of Cape Town
Private Bag, Rondebosch 7700
South Africa

Mr. Michel Guillot

Associate Professor of Sociology
University of Pennsylvania
3718 Locust Walk, McNeil Building, Ste. 113
Philadelphia, PA 19104-6299
United States of America

Professor Kenneth Hill

74 Moose Walk Road
P.O. Box 630, NH 03254
United States of America

Mr. Sun-Jae Hwang

Senior Researcher
Asia Pacific Population Institute
No.302 Magnolia building
148, Cheongsu-ro, Seo-gu, Daejeon, 35209
Republic of Korea

Ms. Janetta Joubert

Specialist Scientist
Burden of Disease Research Unit
Medical Research Council of South Africa
Cape Town, South Africa

Mr. Bernardo Lanza Queiroz

Associate Professor
CEDEPLAR, Universidade Federal de Minas Gerais
Av. Antônio Carlos , 6627
Belo Horizonte, MG / CEP:31270-901
Brazil

Ms. Ji-Youn Lee

Director of Vital Statistics Division
Social Statistics Bureau
Statistics Korea
Government Complex-Daejeon
189 Cheongsu-ro, Seo-gu, Daejeon 35208
Republic of Korea

Mr. Nan Li
Population Affairs Officer
Mortality Section
Demographic Studies Branch
Population Division
Department of Economic and Social Affairs
United Nations

Mr. Colin Mathers
Coordinator
Mortality and Burden of Diseases Unit
World Health Organization
Geneva, Switzerland

Ms. Nadine Nannan
Senior Scientist
Medical Research Council of South Africa
Cape Town, South Africa

Mr. Kameshwar Ojha
Additional Registrar General, India
Office of the Registrar General of India
Ministry of Home Affairs
Government of India
New Delhi – 110001, India

Professor Alberto Palloni
Center for Demography and Ecology
University of Wisconsin-Madison
4434 Social Science Bldg.
1180 Observatory Dr.
Madison, WI 53706
United States of America

Mr. Chalapati Rao
Associate Professor
Australian National University
Canberra, Australia

Mr. Vladimir Shkolnikov
Head of the Laboratory of Demographic Data
Max Planck Institute of Demographic Research
Rostock, Germany

Mr. Romesh Silva
Demographer and Statistician
United Nations Economic and Social
Commission for Western Asia
Beirut, Lebanon

Ms. Adriana Skenderi
Statistician
Demographic Statistics Section
Demographic and Social Statistics Branch
Statistics Division
Department of Economic and Social Affairs
United Nations

Ms. Gretchen Stevens
Mortality and Burden of Diseases Unit
World Health Organization
Geneva, Switzerland

Ms. Patama Vapattanawong
Assistant Professor
Institute for Population and Social Research
Mahidol University
Bangkok, Thailand

Mr. Haidong Wang
Associate Professor
Institute for Health Metrics and Evaluation
University of Washington
Seattle, WA
United States of America

Ms. Danzhen You
Coordinator, UN Inter-agency Group for Child
Mortality Estimation
United Nations Children Fund

Mr. Dmitry Zhdanov
Research Scientist
Max Planck Institute of Demographic Research
Rostock, Germany

Mr. Maigeng Zhou
Professor and Deputy Director
National Center for Chronic and Noncommunicable
Disease Control and Prevention
Chinese Center for Disease Control and Prevention
Beijing, China

UNITED NATIONS SECRETARIAT

Population Division, United Nations Department of Economic and Social Affairs

Ms. Lina Bassarsky
Population Affairs Officer
Estimates and Projections Section
Demographic Studies Branch

Mr. Victor Gaigbe-Togbe
Population Affairs Officer
Mortality Section
Demographic Studies Branch

Mr. Patrick Gerland
Chief
Mortality Section
Demographic Studies Branch

Mr. Danan Gu
Population Affairs Officer
Estimates and Projections Section
Demographic Studies Branch

Ms. Florence Gune Mindra
Intern
Mortality Section
Demographic Studies Branch

Ms. Sara Hertog
Population Affairs Officer
Population and Development Section
Demographic Studies Branch

Mr. Stephen Kisambira
Population Affairs Officer
Fertility and Family Planning Section
Demographic Analysis Branch

Ms. Francois Pelletier
Chief
Estimates and Projections Section
Demographic Studies Branch

Ms. Dakshayani Rajabhathor
Intern
Mortality Section
Demographic Studies Branch

Ms. Cheryl Sawyer
Population Affairs Officer
Estimates and Projections Section
Demographic Studies Branch

Mr. Thomas Spoorenberg
Population Affairs Officer
Estimates and Projections Section
Demographic Studies Branch

Mr. John R. Wilmoth
Director
Population Division

Statistics Division, United Nations Department of Economic and Social Affairs

Ms. Maria Isabel Cobos
Statistician
Demographic Statistics Section
Demographic and Social Statistics Branch

Mr. Raj Gautam Mitra
Inter-Regional Adviser
Statistical Services Branch

Mr. Srdjan Mrkic
Chief
Demographic Statistics Section
Demographic and Social Statistics Branch

UNITED NATIONS SPECIALIZED AGENCIES

United Nations Children Fund (UNICEF)

Ms. Lucia Hug

Statistics and Monitoring Specialist
Data and Analytics Section
Division of Data, Research and Policy

United Nations Population Fund (UNFPA)

Mr. Tapiwa Jhamba

Technical Adviser: Population, Data and Research
Population and Development Branch, Technical
Division
United Nations Population Fund,
605 Third Avenue
New York, NY 10158

Mr. Hyungseog Kim

Technical Advisor
Population and Development Branch
United Nations Population Fund
605 Third Avenue
New York, NY 10158

OTHER PARTICIPANTS

Ms. Li Lui

Assistant Professor
Johns Hopkins Bloomberg School of Public Health
615 N Wolfe Street, Room E4144
Baltimore, MD, 21205

Ms. Adrienne Pizatella

Bloomberg Philanthropies
25 East 78th Street
New York, NY 10075

Mr. Peng Yin

Associate Professor
Chinese Center for Disease Control and Prevention
Beijing, China