# Experience with dual-registration validation studies in Thailand

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## Introduction

The civil registration (CR) system in Thailand is the main source of vital statistics of the country. It was first developed in 1909 under a legal act which mandated a formal listing of the population throughout the kingdom. This law also led to the first population census in 1910. The first birth, death, and a cross-sub-district migration registration law was enacted in 1917. Subsequently, during 1917 to 1947, the government issued five ministerial regulations and four acts related to civil registration and population census, respectively. However, the enforcement of these decrees was not uniform. Thus, a new, comprehensive law (the 'Civil Registration Act B.E. 2499') was enacted in 1956 and applied throughout the country, while the former laws were abrogated. In this act, a district or local registrar had to preserve house registration documents of all domiciles in their area of jurisdiction at a registry office and maintain up-to-date information on births, deaths, and in- out-migration. To improve the CR system, many measures for facilitating vital events registration were offered. Among these, the change from a hand-written or paper-based to a computer-based system, known as 'the Population Identification Number Project', was the most important. This transition took six years from 1982 to 1988 to complete the transfer of information from all house registration documents (approximately 12 million households covering 48 million population) to a mainframe computer. A unique 11-digit number was assigned to each domicile, and a unique 13-digit number was assigned to be a personal identification number for each Thai citizen. To accommodate these and other CR system changes, the Civil Registration Act B.E. of 2499 (1956) was replaced by the 'Civil Registration Act B.E. 2534' (1991). This law is still in use today, even though there were some minor revisions in 2008. The agency responsible for the CR system of Thailand is the Bureau of Registration and Administration (BORA), Department of Local Administration, Ministry of Interior (MOI).

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Some academics and stakeholders have questioned the validity of the vital registration (VR) data (i.e., births, deaths and population enumeration). Thus, this paper aims to express Thailand experience in the assessment of the completeness of VR data, especially from the most recent estimations using the technique of cross-matching between two sources. This paper has the following scope: 1) The methods used to evaluate the completeness and quality of births and/or deaths records in Thailand; 2) The strengths and limitations of the various methods; 3) The lessons learned from recent experience with the application of these methods to different settings; and 4) Recommendations and suggestions for further methodological research.

## Methods used to evaluate the completeness and quality of birth and/or death records in Thailand

### *a) Dual records procedure*

In addition to the VR system, which provides population and vital events data, Thailand also has the other important sources of population data. The population census is conducted every ten years by the National Statistical Office (NSO). The discrepancy of population data from these two sources was discussed during the first National Population Seminar, held in Bangkok in March, 1963. The recognition of these discrepancies led to the creation of the Survey of Population Change (SPC) which was first conducted during 1964-1966 as a joint project of the NSO, MOI, and Ministry of Public Health (MOPH) in order to create more reliable counts of vital rates and to measure under-registration of VR. Later on, the SPC became an intercensal population survey conducted by the NSO every 10 years at the mid-period between the two censuses. Up to the present, seven rounds of the SPC have been conducted: 1964-1966, 1974-1976, 1984-1986, 1989, 1991, 1995-1996, and 2005-2006. The latest round (2015-16) was in the process of data analysis at the time of this study.

The SPC is a consecutive, multi-round household survey. Data collection is undertaken every three months, except for the 2015-2016 SPC which collects data every six months. The data of the sample of households and their members are collected as a baseline in the first round of the survey. In subsequent rounds, only births, deaths, move-ins, and move-outs which occurred during the previous 3 or 6 months are collected. It should be noted that the duration of follow-up among those SPC rounds is different.

The first three SPCs employed a dual records procedure or matching of two independent sources, and the Chandrasekaran-Deming method was used to estimate the total number of births and deaths. Births and deaths from the sampled household and official registration records were compared manually, case by case, to determine whether they were recorded in both sources of data, or in only one source. Seven items from the survey and registration records were used as matching keys. For births, the items were name and family name of the new-born child, name of parents, sex, date of birth, age of mother, place of usual residence of mother, and birth certificate number (in municipal areas only). For deaths, the name and family name of the deceased, name of parents if the deceased was less than one year old, sex, age, date of death, place of usual residence of the deceased, and death certificate number (in municipal areas only) were used as matching keys. By this matching procedure, the percent completeness of birth and death registration could be derived.

***b) Direct estimates from a survey question***

The experience from the first three SPCs indicated that they were time consuming and costly. That might be part of reason why the methodology of estimation of under-registration used in the later SPCs was changed. Instead of using the dual records procedure, the 4$^{th}$ to the 7$^{th}$ SPCs applied direct estimation from positive answers to a single question on whether a birth/death event was reported to the local registrar.

In Thailand, the birth and death registration process involves two steps. In the first step, people have to notify an authorized person of a birth/death in order to get a birth/death notification form (if the event occurred outside a hospital) or hospital birth/death certification form. This form is used to validate that event in the next step of registration. When people register the birth/death at the district or municipal registry office, they receive a certificate. However, a single question on whether a birth/death event was reported to the registrar might be misunderstood by the respondent.

**Table 1. Estimation methods to evaluate the completeness of birth and death registration used in Thai SPCs**

| *Survey years* | *Estimation method* |
|---|---|
| SPC 1964-1966 | Dual records procedure & Chandrasekaran-Deming method |
| SPC 1974-1976 | Dual records procedure & Chandrasekaran-Deming method |
| SPC 1984-1986 | Dual records procedure & Chandrasekaran-Deming method |
| SPC 1989 | Directly from positive answers to a single question on whether a birth/death was reported to the registrar |
| SPC 1991 | Directly from positive answers to a single question on whether a birth/death was reported to the registrar |
| SPC 1995-1996 | Directly from positive answers to a single question on whether a birth/death was reported to the registrar |
| SPC 2005-2006 | Directly from positive answers to a single question on whether a birth/death was reported to the registrar |

In addition to the SPCs, Thailand has assessed completeness of birth registration through direct questions in the Multiple Indicator Cluster Survey (MICS) Rounds 3 to 5 which were conducted by the NSO in the years 2005-2006, 2011-2012, and 2015-2016, respectively.

***c) Indirect demographic method***

A third method to estimate the completeness of civil registration data in Thailand is an indirect demographic technique, focusing on death registration only.

In 1980, Preston and Hill had proposed two indirect methods (stable population with known growth rate, and intercensal cohort survival) as alternatives to the original Brass Growth Balance method for estimating the completeness of death registration (Preston & Hill, 1980). Their alternative methods were applied to the 1960 and 1970 Thailand census data and death registration data during 1960 to 1970 where the results were consistent with the dual records procedure applied to the 1964-1966 SPC.

In 2007, Hill and his colleagues applied three indirect methods named Generalized Growth Balance (GGB), Synthetic Extinct Generation (SEG), and two-stage GGB-SEG to data from three consecutive Thailand censuses (1980, 1990 and 2000) in order to reassess the mortality trends

before and after the HIV/AIDS epidemic. The conflicting results between their study and official data pointed to the need to improve the coverage of mortality registration as well as to evaluate the quality of cause of death data (Hill et. al., 2007).

**Strengths and limitations of various methods**

The methods used to evaluate the completeness of VR data are different in terms of strengths and limitations as shown in Table 2.

**Table 2. Strengths and limitations of various methods used to evaluate the completeness of VR in Thailand**

| *Methods* | *Strengths* | *Limitations* |
|---|---|---|
| Dual records method | · Makes use of two independent sources of vital data<br>· Able to estimate the completeness of death registration by age and sex | · Requires two independent groups of data collectors<br>· Estimation is easily affected by births/deaths if they are low<br>· Time consuming (during data collection, data comparisons and processing)<br>· Costly |
| Direct estimate from survey question | · Makes use of a straightforward question<br>· Able to estimate the completeness of death registration by age and sex<br>· Requires only one group of data collectors | · May be an underestimate if respondents do not understand the correct process of VR |
| Indirect demographic method | · Can be the complement of the direct estimation method | · Assumes a stable population and no variance of age of the under-registration of deaths<br>· Provides average completeness among adult deaths only<br>· Not easy to apply to sub-groups or small populations |

**Experience of applying the dual records method in different settings**

This section examines the author's experience in applying the dual records method to the different settings from the work of the NSO. First was the application to the Kanchanaburi Demographic Surveillance System (KDSS) (Prasartkul & Vapattanawong, 2006). Second was the reassessment of under-registration of deaths from the 2005-2006 SPC data (Vapattanawong & Prasartkul, 2011). Third was the application to the Universal Health-care Coverage Scheme (UCS) data (from a paper presented at the Thai Population Association Conference 2013, not published yet).

***a) Applying the dual records method to the Kanchanburi Demographic Surveillance System (KDSS)***

The KDSS or the Kanchanaburi Project was a surveillance system operated by Institute for Population and Social Research (IPSR), Mahidol University under the support of the Wellcome Trust, during the year 2000-2004. The study focused on Kanchanaburi, a province located about 200 km to the west of Bangkok. Using a stratified systematic sample design, 86 rural villages and 14 census blocks from all 13 districts of Kanchanaburi were selected to be the field study areas. The population under surveillance was approximately 53,800 persons in 12,400 households. Annually, data on demo-socioeconomic, fertility, mortality, migration, health, and environment were collected by interview. In terms of mortality, respondents were asked whether any members of the household had died during the year prior to the survey. If yes, information about the death (e.g., death date, cause of death, and whether the death had been registered) was obtained.

Prasartkul and Vapattanawong (2006) conducted the study entitled 'The completeness of death registration in Thailand: Evidence from Demographic Surveillance System of the Kanchanaburi Project'. In this study, the author compared death records found in only 11 districts of the KDSS during July 1$^{st}$ 1999 to 30$^{th}$ 2003 with those from the civil registration records using first and last name of the deceased as matching keys. Two districts (Thong Pha Phoum and Sangkhlaburi) were excluded given their large population of ethnic minorities (Karen, Mon, Burmese) because the pronunciation and spelling of their names was subject to bias. In total, 1,024 death records were used in this study.

The author sent all 1,024 deceased's names to the Bureau of Registration and Administration (BORA), MOI for computer matching with death registration in Kanchanaburi Province during January 1st 1999 to December 31st 2003, ***using first and last name as the matching key***. Fully 719 names from the total 1,024 deaths, or about 70%, were perfectly matched.

It should be noted that the Thai script has 44 consonants, 21 vowel sounds, and 4 tonal marks. The same sound can be spelled several ways. The same name, if spelled with only one different consonant or vowel would be a different name according to the computer. In addition, Thai people always use a real or official name as well as a nickname. These features can make matching difficult.

The names that could not be matched by computer (305 deaths) were ***manually checked***. In this step, the author requested BORA to provide the print-out of all registered deaths in Kanchanaburi during January 1st 1999 to December 31st 2003. The names of deceased persons from the death registration who had resided in the survey villages were compared to the 305 unmatched names. This process uncovered some cases where last names matched, but first name did not, or names that were spelled differently. This step increased the number of matched cases to 799, or 78% of the total.

In the last step, the 225 names of the deceased persons from the survey that were still not found in registered deaths in Kanchanaburi were resent to BORA. Staff of BORA then checked the central registration database, covering the whole country. The ***first and last name as recorded in the survey were still used as matching keys*** for this step. The results of this step were as follows; a) 97 cases were matched b) 17 cases had the same name, and some were still alive, so it could not be concluded that the death was accurately registered; c) 83 names were not matched; and d) 28 people who were reported dead were found to still be alive. There were many possible reasons for names not being found in the registration, such as different spellings, deviation in name reported from that registered, or a deceased person being a non-Thai citizen.

The 128 unmatched deaths remaining in the last step could no longer be manually matched because it would not be worthwhile to hand check 1.6 million registered deaths.

Finally, all 128 unmatched deaths were assumed to be unregistered deaths found in the KDSS. Thus, the level of under-registration of deaths in the KDSS during 1999-2003 was 12.5%.

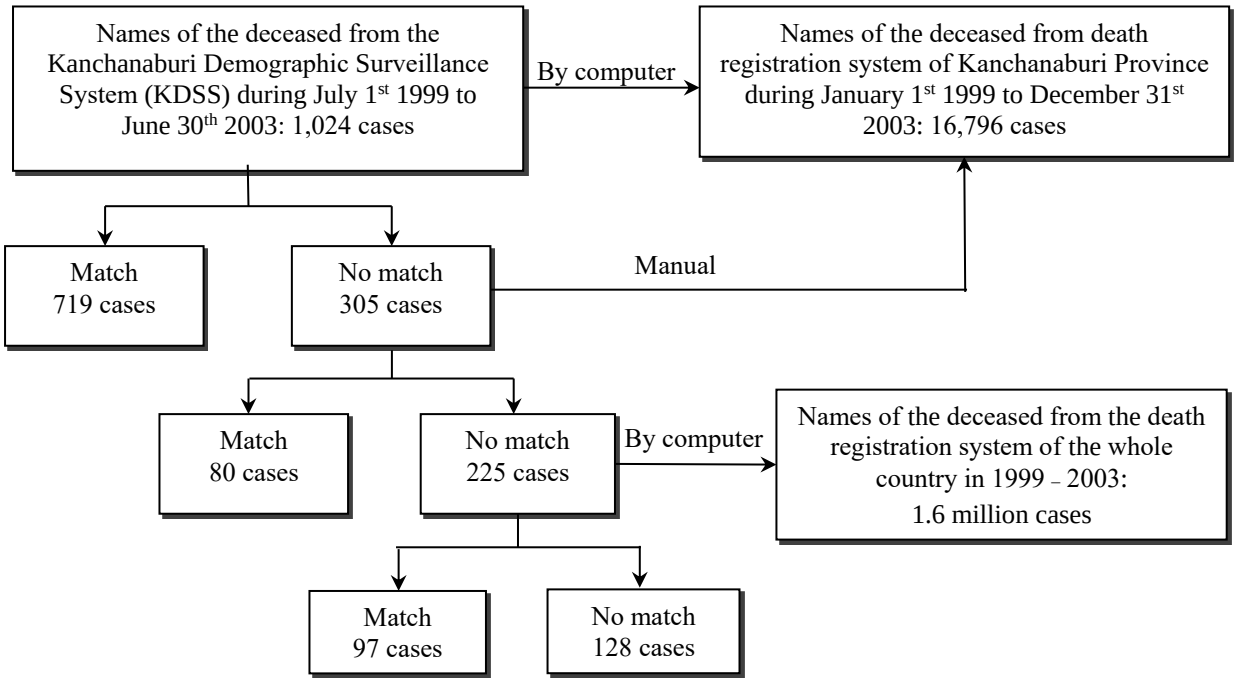


**Figure 1. Results of matching between death records from the Kanchanaburi Demographic Surveillance System (KDSS) and death registration**

In this study, the number of matched and unmatched deaths could be disaggregated by age and sex as shown in Table 3. The percent completeness of male death registration was slightly higher than that of females (88.0% compared to 86.7%). For both sexes, the percent death under-registration was about the same among persons aged 15 years and over, while it was highest (20.8%) for those under age 5 years.

**Table 3. Registered and unregistered deaths from the Kanchanaburi Demographic Surviellance System (KDSS) during July 1st 1999 to June 30th 2003 by age and sex and percent under-registration of deaths (both sexes) by age**

| *Age* | *Male deaths* | | *Female deaths* | | *Both sexes* | |
|---|---|---|---|---|---|---|
| | *Number of registered* | *Number of not registered* | *Number of registered* | *Number of not registered* | *Number of total deaths* | *%Under-registration* |
| < 5 | 14 | 1 | 5 | 4 | 19 | 20.8 |
| 5 – 14 | 12 | 0 | 4 | 1 | 16 | 5.9 |
| 15 – 24 | 27 | 6 | 15 | 0 | 42 | 12.5 |
| 25 – 34 | 70 | 14 | 35 | 6 | 105 | 16.0 |
| 35 – 44 | 67 | 10 | 26 | 3 | 93 | 12.3 |
| 45 – 54 | 57 | 11 | 34 | 3 | 91 | 13.3 |
| 55 – 64 | 87 | 12 | 41 | 10 | 128 | 14.7 |
| 65 – 74 | 101 | 9 | 67 | 8 | 168 | 9.2 |
| 75 – 84 | 76 | 6 | 73 | 8 | 149 | 8.6 |
| 85+ | 32 | 5 | 53 | 11 | 85 | 15.8 |
| All age | 543 | 74 | 353 | 54 | 896 | 12.5 |

***b) Applying the dual records method to the reassessment of under-registration of deaths from the 2005-2006 SPC data***

The experience from the 2006 study by Prasartkul & Vapattanawong motivated the author to scrutinize the very large increase in death registration observed in the 1995–1996 SPC relative to previous SPCs. Coincident with the most updated evaluation of completeness of death registration from the SPC 2005-2006, Vapattanawong & Prasartkul had developed a new study in order to reassess the completeness of death registration observed in the 2005-2006 SPC (Vapattanawong & Prasartkul, 2011). The required data in this study (2005-2006 SPC and death registration) belonged to two different government agencies and, thus, the author had to forge strong collaborative relationships with both agencies for the study to be successful.

The 2005-2006 SPC, which covered 2,050 sample rural villages/urban blocks and 82,000 households, was the first SPC that collected the personal 13-digit number of the sample

population. Because first and last name as well as address of the sample population is not included in any NSO survey ***it was necessary to use only the 13-digit number as a matching key in this study***.

In 1996, the MOPH signed an agreement with the MOI regarding utilization of VR data from the central registration database. Thus, the author requested the MOPH to facilitate the matching task. The 13-digit number data from the 2005-2006 SPC were sent to the responsible officer at the MOPH in order to match with deaths registered in the same period as the survey (i.e., July 1st 2005 to June 30th 2006). According to the 13-digit number recorded in the 2005-2006 SPC dataset, it was found that, of a total of 327,735 records in the SPC, 638 records had personal ID numbers with less than 13 digits, 33,683 records had no 13-digit number, and 2,789 records had a duplicate 13-digit number. Thus, only 290,625 records (88.7%) could be sent to the MOPH for matching with the death registration. Then, those data were sent back to the author for further analysis.

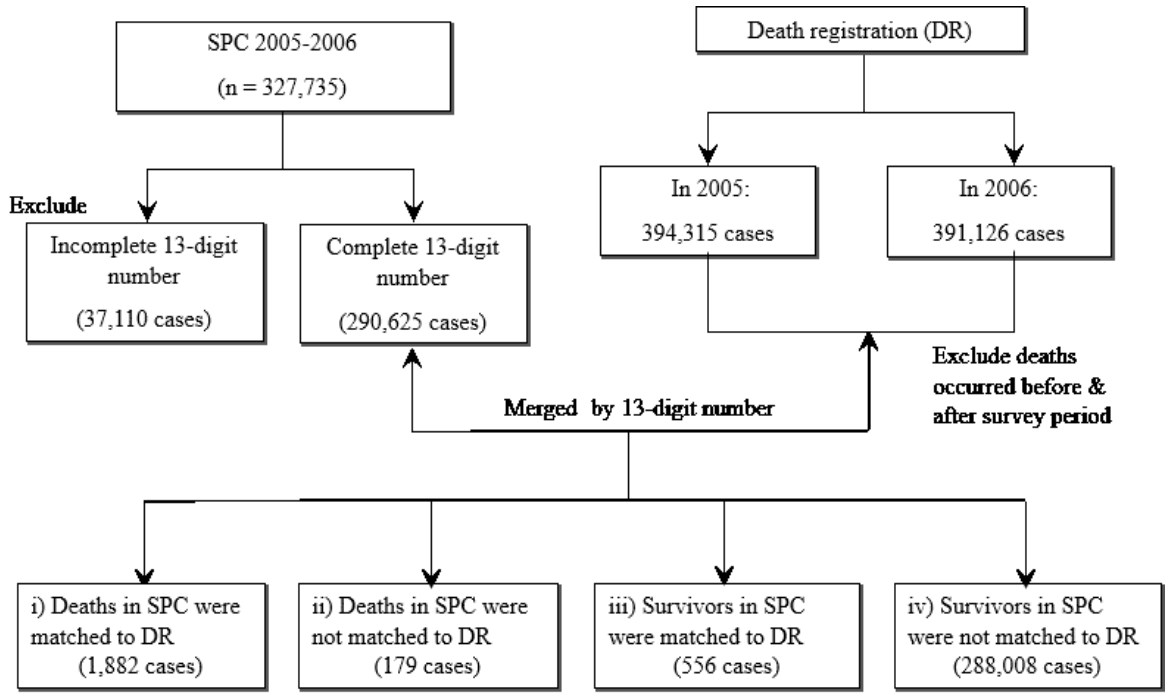


**Figure 2. Process of matching recorded deaths from the Thailand 2005-2006 Survey of Population Change (SPC) and the death registration system**

There were four matching outcomes: i) 1,882 deaths recorded in the SPC matched deaths in the vital event registry; ii) 179 deaths recorded in the SPC could not be matched to

deaths in the registry; iii) 556 people reported as survivors in the SPC matched with deaths in the registry; and iv) 288,008 people reported as survivors in the SPC did not match with deaths in the registry. Although the matching key in this study was only the 13-digit number, the author double-checked the age and sex of each pair of cross-matching cases. By doing this, it was possible to ensure that a recorded death in each pair were the same person. The outcomes in category ii) could reflect the under-registration of deaths, while those in category iii) might reflect the quality of the survey in terms of counting errors. Only the first three outcomes were used to analyse the under-registration of deaths by age and sex.

**Table 4. Results of cross-matching between individual records from the 2005-2006 SPC and death registration system**

| *Status in SPC* | *Matching with the death registration* | | *Total* |
|---|---|---|---|
| | *No* | *Yes* | |
| Alive | 288,008 | 556 | 288,564 |
| Dead | 179 | 1,882 | 2,061 |
| Total | 288,187 | 2,438 | 290,625 |

The 2 x 2 contingency table was filled in by cross-matching cases (Table 5), and the Chandrasekaran-Deming formula was applied to compute the total deaths estimation (Chandrasekaran & Deming, 1949). The estimation required four key assumptions; i) The population of interest was closed; ii) Events recorded in both systems could be cross-matched; iii) The probability of an event occurring in one system was independent of the probability of its occurring in the other; and iv) Each case had an equal probability of ascertainment in either source.

**Table 5. Number of deaths in 2005–2006, obtained by cross-matching data from the Survey of Population Change (SPC) and the death registration system in Thailand**

| *Death in SPC* | *Death registration* | |
|---|---|---|
| | *Yes* | *No* |
| Yes | 1,882 | 179 |
| No | 556 | Missed by both systems |

The following formula was used to estimate total events (*N*) according to the Chandrasekaran-Deming (Sekar & Deming, 1949):

$$N = \frac{(M + NS) \times (M + NR)}{M} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where M (matched) stands for the events found in both systems; NS (not surveyed) stands for the events missed by the survey but found in VR records; and NR (not registered) stands for the events missed by registration but found in the survey. An estimate of the variance of N was calculated using the following formula:

$$Var(N) = \frac{Nq_1q_2}{p_1p_2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where $p_1 = \frac{M + NS}{N}; p_2 = \frac{M + NR}{N}; and\ p_1 + q_1 = p_2 + p_2 = 1$

The 95% confidence intervals (CIs) of *N* were calculated using the formula:

$$95\%\,\mathrm{CI} = N \pm 1.96\sqrt{\mathrm{Var}(N)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The formula of $p_1$ gave the estimated completeness of death registration. Thus, the under-registration ($D_u$) could be estimated from $1 - p_1\,(or\ q_1)$ and the variance of $q_1$ was calculated as (Bernillon et. al., 2000):

$$Var(q_1) = \frac{(1 - p_1)p_1}{N(1 - p_1)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The estimated total number of deaths occurring during the 2005–2006 survey and its 95% CI were:

$$N = \frac{(1882 + 556) \times (1882 + 179)}{1882} = 2670$$

$$95\%\ CI\ of\ N = 2670 \pm 1.96 \times \sqrt{\frac{2670 \times \left(1 - \frac{1882 + 556}{2670}\right) \times \left(1 - \frac{1882 + 179}{2670}\right)}{\left(\frac{1882 + 556}{2670}\right) \times \left(\frac{1882 + 179}{2670}\right)}}$$

$$= 2{,}653 - 2{,}687$$

where the result was rounded to the nearest integer. In addition, the estimated under-registration of deaths, and its 95% CI could be calculated as:

$$D_u = \left[1 - \left(\frac{1882 + 556}{2670}\right)\right] \times 100 = 8.69\%$$

$$95\%\ CI\ of\ D_u = 8.69 \pm 1.96 \times \sqrt{\frac{\left(1 - \frac{1882}{1882 + 179}\right) \times \left(\frac{1882}{1882 + 179}\right)}{2760 \times \left(1 - \frac{1882}{1882 + 179}\right)}}$$

= 8.65% – 8.72%.

The author repeated the calculation according to equation (1) to (4) to estimate the under-registration of deaths by sex. Table 6 presents the age-sex specific number of deaths in 2005–2006 as recorded by the SPC and VR records, and Table 7 shows the estimated percentage of under-registration of deaths.

**Table 6. Number of deaths in 2005-2006, by age and sex, obtained by cross-matching data from the Survey of Population Change (SPC) and the VR system**

| *Sex/death data details* | *No. of deaths* | | | | | | |
|---|---|---|---|---|---|---|---|
| | *< 1 year* | *1-4 years* | *5-14 years* | *15-59 years* | *60-74 years* | *75+ years* | *All* |
| ***Male deaths*** | | | | | | | |
| In both systems (*M*) | 15 | 5 | 11 | 289 | 222 | 408 | 950 |
| In SPC only (*NR*) | 8 | 6 | 9 | 29 | 18 | 24 | 94 |
| In vital registry only (*NS*) | 3 | 4 | 4 | 112 | 74 | 89 | 286 |
| Estimated total no. (*N*) | 28 | 20 | 27 | 441 | 320 | 526 | 1,358[a] |
| 95% CI of *N* | 24-31 | 11-28 | 22-33 | 433-449 | 314-326 | 521-531 | 1,346-1,371 |
| ***Female deaths*** | | | | | | | |
| In both systems (*M*) | 11 | 2 | 4 | 138 | 205 | 572 | 932 |
| In SPC only (*NR*) | 1 | 5 | 1 | 24 | 17 | 37 | 85 |
| In vital registry only (*NS*) | 4 | 1 | 0 | 75 | 73 | 117 | 270 |
| Estimated total no. (*N*) | 16 | 11 | 5 | 250 | 301 | 734 | 1,312[a] |
| 95% CI of N | 15–18 | 3–18 | 5–5 | 241–260 | 295–307 | 727–740 | 1,300–1,323 |

[a] These figures are not the sum of the values in each age group.

**Table 7. Estimated percentage under-registration of deaths, by age and sex, Thailand, 2005-2006**

| *Age group (years)* | *Under-registration of deaths* | | | | | |
|---|---|---|---|---|---|---|
| | *Males* | | *Females* | | *Both sexes* | |
| | *%* | *95% CI* | *%* | *95% CI* | *%* | *95% CI* |
| < 1 | 34.78 | 34.48-35.08 | 8.33 | 7.87-8.80 | 25.71 | 25.46-25.97 |
| 1–4 | 54.55 | 54.25-54.84 | 71.43 | 71.11-71.75 | 61.11 | 60.89-61.33 |
| 5–14 | 45.00 | 44.72-45.28 | 20.00 | 19.22-20.78 | 40.00 | 39.74-40.27 |
| 15–59 | 9.12 | 9.03-9.21 | 14.81 | 14.70-14.93 | 11.04 | 10.97-11.11 |
| 60–74 | 7.50 | 7.39-7.61 | 7.66 | 7.55-7.77 | 7.58 | 7.50-7.65 |
| 75+ | 5.56 | 5.47-5.64 | 6.08 | 6.016.15 | 5.86 | 5.81-5.91 |
| Overall | 9.00 | 8.95-9.05 | 8.36 | 8.31-8.41 | 8.69 | 8.65-8.72 |

In 2005-2006 under-registration was 8.69% (95% CI: 8.65-8.72%) for both sexes combined and, for all ages, it was 9.00% (95% CI: 8.95-9.05%) for males and 8.36% (95% CI: 8.31-8.41%) for females. These figures are approximately 1.8, 1.7 and 1.9 times higher than the percentages estimated directly by the NSO from the questions in the SPC (NSO, 2007). This is because this study captured more deaths, especially 556 deaths that were in the VR system but had not been counted in the survey.

In terms of a pattern, the highest under-registration was found among children age 1-4 years: 54.55% in males and 71.43% in females. However, at age less than 1 year, under-registration of male and female deaths decreased as age increased. Furthermore, deaths among older males and females showed less than 10% under-registration.

As discussed in the published article (Vapattanawong & Prasartkul, 2011), our re-estimation may be lower than the true rate of under-reporting (which is unknown). However, the findings from this study are still valuable because it can confirm that the evidence of significant improvement in the completeness of death registration since the mid-1990s is the result of discrepancy of the methodology used.

### *c) Applying the dual records method to the Universal Coverage Scheme data*

Thailand launched its universal health care coverage program in 2001, in which each Thai citizen is insured by one of three main public health care insurance schemes: The Civil Servant Medical Benefit Scheme (CSMBS), the Social Security Scheme (SSS), and the Universal Coverage Scheme (UCS). Among these three schemes, UCS covers the largest number. Currently, three-fourths of Thai population are under the UCS (HISRO, 2012). The National Health Security Office (NHSO) is responsible for administering the UCS.

The UCS and the other two insurance schemes use the Diagnosis-Related Groups (DRGs) as its payment mechanism for in-patient health service. The data for care of in-patients covered under the UCS are sent from the attending hospital to the NHSO for reimbursement. The standard dataset consists of essential information for DRG calculation, and includes discharge status of those in-patients. In addition, the 13-digit number of each in-patient is recorded. Moreover, based on the agreement with the MOI, the NHSO can also access the VR system. Thus, it is possible to assess the completeness of death registration by cross-matching death records in the NHSO's UCS database during the year 2008-2012 with the VR system.

An official letter of request for cooperation was sent to the NHSO for approval. Once approved, the author contacted the responsible officer assigned by the NHSO to assist with the study. This officer was a person who had authority to access the UCS database and was able to manipulate large datasets as well. The cross-matching between the two datasets was done by this officer using the ***encrypted 13-digit number as a matching key***. Then, the dataset of death records in the UCS database and results of cross-matching were sent to the researcher for analysis.

Table 8 shows the total number of deaths recorded in the UCS database during the year 2008 to 2012 and in the VR system of the same years. It should be noted that the numbers in latter source are selected for just those in the UCS. It can be seen that the numbers from both sources increase over time. However, the numbers from the UCS database in 2008 are much lower than in the later years, and this was a result of the early stage of system development. Tables 9 to 11 and Figures 3 and 4 present all the results of completeness of death registration from cross-matching in this study.

**Table 8. Total deaths recorded in the Universal Coverage Scheme (UCS) database and in the VR system of Thailand, year 2008-2012**

| *Thailand / Region* | *Deaths recorded in the UCS database* | | | | | *Deaths recorded in the VR system** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *2008* | *2009* | *2010* | *2011* | *2012* | *2008* | *2009* | *2010* | *2011* | *2012* |
| Thailand | 27,379 | 96,301 | 104,002 | 106,795 | 111,037 | 192,349 | 189,078 | 204,569 | 205,893 | 212,569 |
| Region | | | | | | | | | | |
| Bangkok | 2,739 | 8,038 | 8,480 | 8,348 | 8,724 | 10,502 | 10,857 | 11,557 | 11,790 | 12,301 |
| Central | 9,200 | 3,2673 | 35,675 | 36,951 | 38,553 | 47,026 | 46,236 | 49,952 | 50,231 | 52,167 |
| North | 6,010 | 21,403 | 23,627 | 23,618 | 24,215 | 46,260 | 45,225 | 49,537 | 48,705 | 50,010 |
| Northeast | 6,336 | 23,253 | 24,741 | 25,901 | 26,646 | 67,486 | 65,541 | 70,913 | 72,343 | 74,136 |
| South | 3,093 | 10,929 | 11,475 | 11,948 | 12,810 | 21,075 | 21,219 | 22,610 | 22,824 | 23,955 |

* Only those who were under UCS

**Table 9. Number and percent of cross-matching results between deaths recorded in the UCS database and the VR system by year**

| *Cross-matching result* | *2008* | | *2009* | | *2010* | | *2011* | | *2012* | | *2008-2012* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Number* | *%* | *Number* | *%* | *Number* | *%* | *Number* | *%* | *Number* | *%* | *Number* | *%* |
| Match | 24,567 | 89.7 | 89,891 | 93.3 | 99,706 | 95.9 | 100,755 | 94.3 | 106,234 | 95.7 | 421,153 | 94.5 |
| No match | 2,812 | 10.3 | 6,410 | 6.7 | 4,296 | 4.1 | 6.040 | 5.7 | 4,803 | 4.3 | 24,361 | 5.5 |
| Total | 27,379 | 100.0 | 96,301 | 100.0 | 104,002 | 100.0 | 106,795 | 100.0 | 111,037 | 100.0 | 445,514 | 100.0 |

**Table 10. Percent completeness of registration of death from the UCS database by sex and year**

| *Sex* | *% completeness of registration of death from the UCS database* | | | | | |
|---|---|---|---|---|---|---|
| | *2008* | *2009* | *2010* | *2011* | *2012* | *2008-2012* |
| Males | 89.8 | 93.2 | 95.6 | 94.3 | 95.7 | 94.4 |
| Females | 89.6 | 93.6 | 96.2 | 94.4 | 95.7 | 94.7 |
| Both sexes | 89.7 | 93.3 | 95.9 | 94.3 | 95.7 | 94.5 |

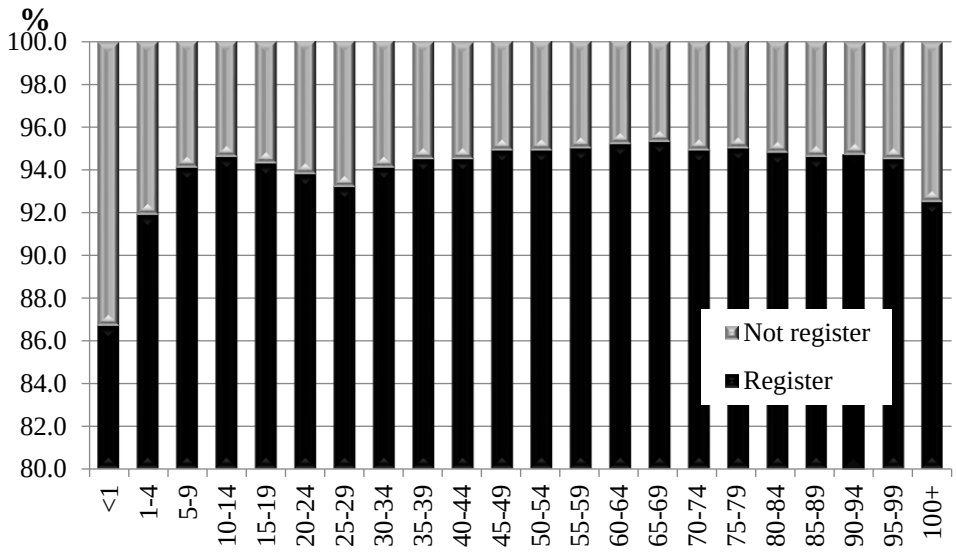


**Figure 3. Percent completeness of registration of death from the UCS database by age, (2008-2012)**

**Table 11. Percent completeness of registration of death from the UCS database by region and year**

| *Region* | *% completeness of registration of death from the UCS database* | | | | | |
|---|---|---|---|---|---|---|
| | *2008* | *2009* | *2010* | *2011* | *2012* | *2008-2012* |
| Bangkok | 85.8 | 93.4 | 95.2 | 93.7 | 94.8 | 93.7 |
| Central | 88.8 | 93.3 | 95.5 | 93.9 | 95.6 | 94.3 |
| North | 90.7 | 93.5 | 96.5 | 95.0 | 96.2 | 95.1 |
| Northeast | 92.2 | 93.6 | 96.3 | 94.8 | 96.0 | 95.0 |
| South | 88.8 | 92.8 | 95.2 | 93.8 | 94.9 | 93.9 |
| Total | 89.7 | 93.3 | 95.9 | 94.3 | 95.7 | 94.5 |

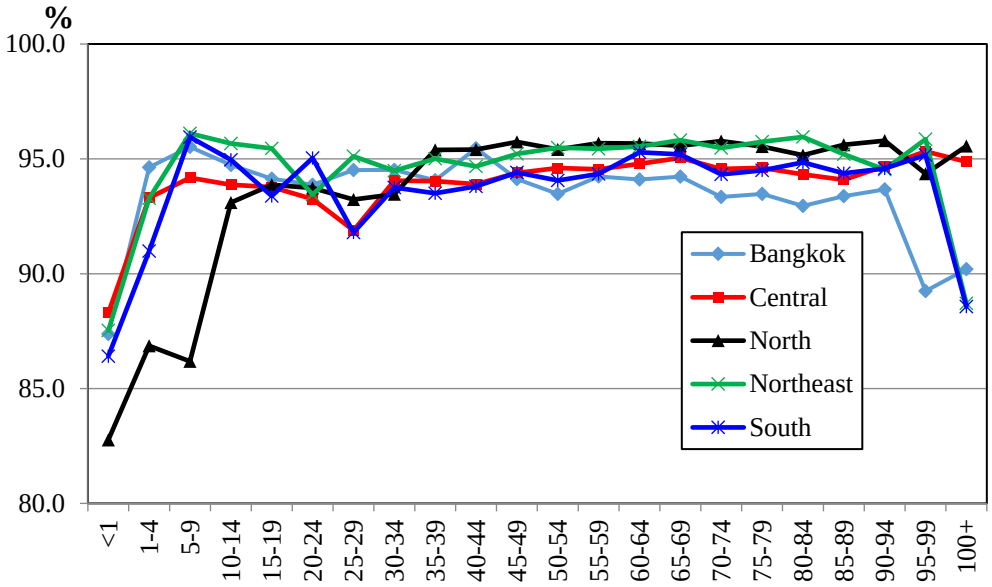


**Figure 4. Percent completeness of registration of death from the UCS database by age and region (2008-2012)**

The results found in this study do not have the same meaning as in the study by Vapattanawong & Prasartkul (2011). Instead, they reflect the completeness of UCS in-patient death registration only. The results can be summarized as follows; i) Except for the year 2008, percent completeness of UCS in-patient death registration during 2009 to 2012 is quite high and stable at around 95%; ii) In each year, the completeness of UCS in-patient death registration is negligibly different between males and females; iii) The lowest and second lowest completeness are found in deaths of persons less than 1 year and 1-4 years of age, respectively; iv) The UCS in-patient death registration of the North and Northeast regions is slightly more complete than the others, while for Bangkok it is lowest; and v) The pattern of completeness of UCS in-patient death registration of each region is not different from the national pattern.

Though the completeness of UCS in-patient death registration found in this study seems to be very high, it is not yet satisfactory. All UCS in-patient deaths should be registered because the deceased's relatives are informed about the process of death registration from health personnel before they bring the body back home for cremation. In addition, if these findings are correct, it implies that the completeness of outside hospital/home death registration may be much higher than 10%.

**Lessons learned from recent experience with the application of the dual records method to different settings**

The lessons learned from applying the dual records system to evaluate the completeness of death registration in three different settings in Thailand indicate that the success or failure of those studies depends on several factors. The lessons learned are as follows:

- ***Close collaborative among responsible organizations***: The methodology of the dual records system requires data from two sources. There will be no problems if these data belong to one organization. In the case of Thailand, however, these data belong to separate agencies. Thus, close collaboration among the organizations which are responsible for each data source is crucially important. The collaboration in the first SPC among NSO, MOI, and MOPH is the best example of this.
- ***High level of cooperation between the responsible organizations and research team***: If the study is performed by academic researchers, they have to request access to the data from the responsible organization, such as the MOI, MOPH, or NSO. In the absence of close connections/network/formal or informal relationship, access to the required data will be difficult to obtain. The 2006 study (Prasartkul & Vapattanawong) was successful because of the strong relationships between the research team and BORA and the MOPH. In this study, additional cooperation was obtained through formal/official contacts.
- ***Knowledge and skill of responsible officers (operators)***: The process of data matching requires operators who thoroughly understand the research objectives. Normally, the responsible officers have job descriptions which do not include academic work. In that case, the researcher will have to train the operators how to manage the data or even work together with them in order to get the required data.
- ***Different settings, different means to perform cross-matching***: The experience mentioned in this paper shows that, even when three different studies use the same methodology, the means of matching are different. The differences are based on what kinds of data available, and whether the data are stored electronically or paper-based or both.
- ***Still practical but requiring some proper adjustments***: This paper shows that, even if the dual records system is no longer used by the NSO, it still works very well. However, this methodology should be tailored to the context.

- ***Parallel study if data available***: This paper indicates that the vital events data in Thailand are available in the MOPH and NHSO databases, as well as the VR system. These data should be more openly accessible to academic researchers. Parallel studies using data from different sources should be done, for example, such as the official study (in the SPC) by the NSO together with an academic research team.

**Recommendations and need for further methodological research**

The dual records system is still useful, especially in countries where several sources of vital events data exist as in Thailand. Cross-matching between two or more than two sources if data is recommended.

For Thailand, research on the evaluation of completeness of VR data at the sub-national level (e.g., province) should be considered. The MOPH has developed the family folder system to collect and record data on individual health and health services at household level. This source of data is appropriate for cross-matching if the data are regularly updated.

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