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Development of a Verbal Autopsy Tool for Investigating Cause of Death: the Kanchanaburi Project

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Introduction

In any study of mortality, the data on death are crucial and fundamental. Valid measures of mortality depend upon the quality of data. Various indicators used in the analysis of burden of disease, such as age-sex-cause-specific death rates, person-years lived at each age and life expectancies need accurate data to yield meaningful estimates.

In Thailand, the availability of data on vital events is relatively complete as compared to many other developing countries. The civil registration system was initiated in 1916, almost one hundred years ago. Every birth and death is required by law to be registered at the district or municipality registrar offices located around the Kingdom. The number of population, births and deaths for the whole country and 76 provinces are reported annually by the Ministry of Interior. Cause of death codings are processed and reported by the Ministry of Health as annual health statistics and information.

However, the quality of registered mortality data in Thailand is still questioned. Death registration appears to be suffering from at least two shortcomings. First, it is quite certain that death registration coverage is incomplete. The most recent Survey of Population Change (SPC) 1995-96 suggests that at least five percent of all deaths are not registered. Secondly, the quality of cause of death coding is problematic; approximately 40% of registered deaths have an undefined or ill-defined cause coding.

Moreover, some specific cause codings are not reliable as many of them are not medically certified. As in many developing countries, when a death occurs at home or outside health facilities, the cause of death is usually identified and reported by lay people. These shortcomings tremendously devalue the quality of mortality data from this promising registration source.

The data on cause of death are increasingly significant in formulating and selecting among health policies and programs. To get valid information on cause of death, however, requires high cost, complicated medical postmortem autopsy. In Thailand, less than half of annual deaths occur in hospitals where their causes can be medically certified; moreover, it is unaffordable to have the causes of all deaths in the country certified by physicians.

Registration of cause of death in Thailand

In Thailand, the law requires that every death be registered. The organization responsible for compiling this vital data is the Bureau of Registration Administration (BORA) in the Department of Provincial Administration (formerly the Department of Local Administration), within the Ministry of Interior. The registrars are decentralized, with provincial, district and municipal offices in 76 provinces and 1000 districts around Thailand. When a death is registered at the local registrar office, two copies of that record are transferred by electronic means, one to the Bureau of Registration Administration (BORA) and the other to the Ministry of Public Health. BORA processes the death and birth records, before reporting total numbers for national and provincial levels to the public annually. The copies of the death records sent to the Ministry of Health are processed for age- and sex-specific cause of death, and subsequently reported as annual health statistics.

In the process of death registration, the law requires that anyone seeing a deceased individual must report the death to a government officer within 24 hours. To simplify the process of death registration in Thailand, the Ministry of Interior classifies deaths into three broad groups: (1) deaths occurring in hospital, (2) deaths of natural

causes occurring at home, and (3) deaths of unnatural or external causes. These three groups of deaths involve different registration steps.

(1) ***Deaths occurring in hospital.*** A physician diagnoses and certifies the cause in "**Tor Ror 4/1**" or the "**death certification form**". The deceased person's relative uses this form as evidence to register the death at the registrar's office in the district or municipality of the deceased's residence. The registrar then issues the "**death certificate**" for that decedent.

(2) ***Deaths from natural causes occurring at home.*** Natural causes refer to illness or disease. In the case of death occurring at home outside a municipal area, the deceased's relative reports a death to an "assistant local registrar", such as a village headman, who usually specifies the cause of death and issues "**Tor Ror 4**" or the "**death notification form**". The relative then uses this form as evidence to register the death at the district office of the deceased's residence. For the case of natural death occurring at home within a municipal area, the death is reported to the policeman responsible for checking causes of death. A copy of the police form "**record to file**" is used as evidence for registration at the municipal office, to obtain the "**death certificate**".

(3) ***Deaths from un-natural causes***. Unnatural causes of death include all external causes, namely suicide, homicide, accident, drowning, killing by animal, or natural disaster. In this category, anyone accompanying the deceased or seeing the dead body must report to a local administrative or police officer, who will be joined by a physician to perform a postmortem examination or autopsy to specify the cause of death. The "**record to file**" form and the result of the medical autopsy is used as evidence to register at the district or municipal office of the deceased 's residence to obtain the "**death certificate**".

In principle, certifications of all types of death are transferred into the death records at the district or municipal registrar offices. Cause of death should be coded according to the rules of the WHO International Classification of Diseases (ICD). In 2005, in agreement with the Ministry of Interior, the death database was transferred to the Bureau of Planning and Strategy at the Ministry of Public Health. Death cause is

now coded and processed at the MOPH, from which statistics on age- and sex-specific causes are annually reported.

The quality of data on cause of death in Thailand has been under scrutiny for some time. Not less than 40% of deaths are consistently reported with an undefined or ill-defined cause (Ministry of Public Health, 2003 and 2004). Senility is always a major cause, especially among rural elderly who die at home. A previous study reports that only 25% of registered causes of death are in agreement with those certified by physicians (Chanpen et al., 2001; Chanpen et al., 2004)

Verbal autopsy as an alternative tool

The demand for more complete and higher quality data on cause of death is rising in every developing country including Thailand. This need has inspired many researchers to seek out methods that could improve the quality of mortality data. Recently, the "verbal autopsy" (VA) methodology has been experimented with in many countries, including India, Ghana, Tanzania and Ethiopia (Chandramohan et al., 1998; Gajalakshmi et al., 2002; Kahn et al., 2000; Ministry of Health, 2001; Quigley, Amstrong and Snow, 1996; Yang et al., 2005).

VA is a technique of postmortem investigation to identify the cause of death by retrospective interviews of a relative or caretaker of the decedent. The interviews cover the history of the deceased and the train of events or circumstances preceding the death. Reports include complaints, signs and symptoms, duration of illness and treatment details of the illness prior to death, in order to identify the probable underlying cause of death.

A structured questionnaire is usually used as an interview tool. This method appears promising, especially for deaths occurring at home in remote areas. There are at least two approaches to assessing the information from a completed VA questionnaires to assign the cause of death (Quigley, Amstrong and Snow, 1996; Reeves and Quigley, 1997). In the first approach, one or more physicians review the completed questionnaire

and identify a probable cause of death according to their expert judgment. In this approach, the questionnaire includes open-ended inquiries to provide room for detailed descriptions. This approach, however, relies upon the availability of medical personnel.

The second approach is less dependent upon physicians' judgments. In this approach, the VA questionnaires contain close-ended questions which are assessed based on a standard algorithm, leading to a probable specific cause of death. The instrument requires physicians' expert judgment in the development stage and for validity testing, to ensure that questions are arranged based on medical and pathological logic.

The VA method is a promising method to improve cause of death data, at least in the interim, though it requires more experimentation. The method has been used successfully to assess causes of child and maternal deaths, but there has been less experience with adult death. Various studies recently report applying a data-derived-algorithm-VA questionnaire to ascertain underlying cause of death and compute cause specific death rates, with mixed outcomes (Madden, 2002; Quigley, Amstrong and Snow, 1996).

Objectives of the Study

A special study on verbal autopsy for all ages of death was conducted in both urban and rural areas of Kanchanaburi province as an integral part of the Demographic Surveillance System (DSS) from 2002-2003. The aims of the study were:

1. To develop a VA instrument using data-derived algorithms, and to test its utility in determining the specific cause of death in Thai settings.
2. To transform the VA tool into computer program to substitute a voluminous paper questionnaire.

In the longer term, this study hopes to result in the use of a valid VA tool, programmed into a computer, for use in demographic and health surveys, and ultimately, in the routine death registration system.

Methodology

To achieve the stated objectives, it was necessary to develop a standard set of VA tools to ascertain the underlying cause of death at all ages in Thai settings. There were four major steps to this process: the development of VA questionnaires, validation testing and revision of the questionnaire, transformation of the questionnaires into a computer program, and testing the application.

Development of VA questionnaires

In developing the questionnaires, two criteria were set forth. All questions to be included must be close-ended, as numeric conditions are needed to construct an algorithm to identify each cause of death. The answer choices pre-listed for each question decide the flow of the following questions. The questionnaires should thus cover all possible signs and symptoms respective to all causes of death prevailing in the study settings.

The second criterion required that the language used should be as simple as possible, using non-technical terms, since neither interviewers nor respondents would be medical experts. Attempts were made to design the questionnaire for use in local dialects, which is especially important in rural areas.

In previous studies, questionnaires have been arranged in the form of flowcharts (Anker et al., 1999; Chanpen et al. 2001; Chanpen et al. 2004; Kanda, Yawarat and Angsana, 1999; Ministry of Public Health, 1990; Ministry of Public Health, 2001) Choices of responses are provided for each question, with the answer to each leading to subsequent questions. Questions about symptoms before death are arranged in order, to narrow broader categories into more specific symptoms, and ultimately to a probable underlying cause of death.

For the Kanchanaburi VA tool, the first screening questions classify a death into any of the following four major categories:

(1) External causes (F1)

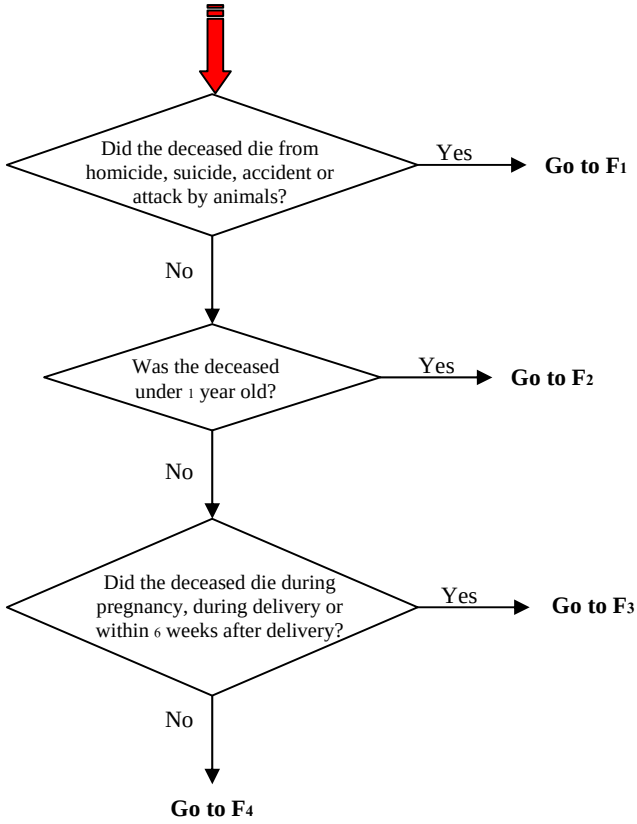
(2) Infant death or death under one year (F2)

(3) Maternal death or death of a woman occurring during pregnancy, delivery, or the 45-day period after delivery (F3)

(4) Natural causes, either sick or not sick before death for all other age groups (F4)

Figure 1

Initial screening flow chart of VA questionnaires



Once the death is categorized, more details about the symptoms, diseases or conditions occurring before death can be asked to identify its cause. The cause of death resulting from the VA is coded according to a shortened ICD tabulation list, which can

be mapped to ICD core codes. The tabulation list has been styled according to the principles of the ICD selected mortality list 2 (general mortality selected list): 80 causes of death each with a 3-digit code. This tabulation list contains most causes likely to be relevant for guiding policy and program development (WHO, 1993a; WHO, 1993b).

Testing the validity of the VA questionnaires

To test the validity of the questionnaires, the VA results were compared against a gold standard: deaths with medically certified causes from hospital records. In the first phase of testing, only deaths of natural causes such as illnesses and diseases were studied. External cases were excluded, as these are likely less problematic in identification by VA, as a previous Thai study indicated (Kanda, Yawarat and Angsana, 1999). The validation examined 921 cases of hospital deaths in Kanchanaburi, occurring throughout the year 2002. The validity testing was carried out from October to December of 2003, requiring one year of memory recall from interviewees.

There were some limitations to the design of this pilot study. First, the study was undertaken in only one of 76 provinces in the country, which may have covered an insufficient disease pattern. Secondly, the sample size of less than 1000 cases was too small to test the validity of the tool with confidence.

Cause of death certified by physicians as the gold standard

The medical histories and cause of death of decedents appearing in hospital records were verified by experts (physicians and researchers with experience in cause of death coding). These verified causes of death are considered true and accurate, and used as a gold standard for comparison. These causes are coded according to the ICD-10.

However, out of 921 hospital death records collected in the study, 88 cases (9.6%) could not be verified because, in some cases hospital records were not adequate, and in other cases, medical histories were lost from the hospital files.

VA assigned causes of death and fieldwork

The list of deceased persons' names and addresses from hospital records were given to a team of field interviewers. This list contained only names and addresses of the deceased persons to insure the independence between the cause identified via VA and the cause identified by medical review.

In the initial validation stage, five males and five females aged 20 to 25 years were recruited as interviewers, each holding a bachelor's degree in the field of social science. Interviewers with these qualifications were selected in order to test the feasibility of applying the VA questionnaires with non-health personnel. The interviewers located the addresses of deceased persons and interviewed surviving relatives or key informants regarding the train of disease, circumstances, signs and symptoms prior to the death.

Comparison of VA assigned and expert medical certified causes of death

Six hundred and fifty-two of 921 total case records, or 70.8%, could be compared between the VA-assigned and medically certified cause of death. The cause of death identified from both sources, coded according to the ICD-10, was defined as the underlying cause. These causes may have been followed by other intervening symptoms, leading to major organ dysfunction and loss of life. The ICD-10 identifies cause of death by 5-digit codes, combining one consonant and 2 to 4 numbers. For examples:

A09	means 'diarrhea',
J00	means 'common cold',
K35.0	means 'ruptured appendicitis',
S72.91	means 'open fracture of femur'.

It should be noted that it is not necessary to identify the full 5-digit code from a VA. In most cases, three digits are sufficient as the numbers in the fourth and

fifth position are just the detailed description. The World Health Organization recommends member countries to apply this short-list version of the ICD-10.

Transforming VA questionnaires into a computer program

Following the development and testing of the VA questionnaires, questions were revised by a team of researchers and medical experts. Revisions were made in terms of language and detailed symptoms. The revised version was then written as a computer program to substitute for the voluminous paper questionnaire. The VA program was designed for use with 'Personal Digital Assistance' (PDA) computers for convenience and portability. The program was written in Thai language.

The flowcharts of questions about the symptoms become a disease-algorithm leading to various probable causes of death. The final questionnaire program is characterized by a skipping pattern, such as when a respondent answers 'no', some more detailed questions are skipped automatically. On the other hand, if the response is 'yes', subsequent questions are asked to identify the probable cause of death. The program assigns a 3-digit code from the short list of the ICD-10 as soon as the algorithm determines cause of death.

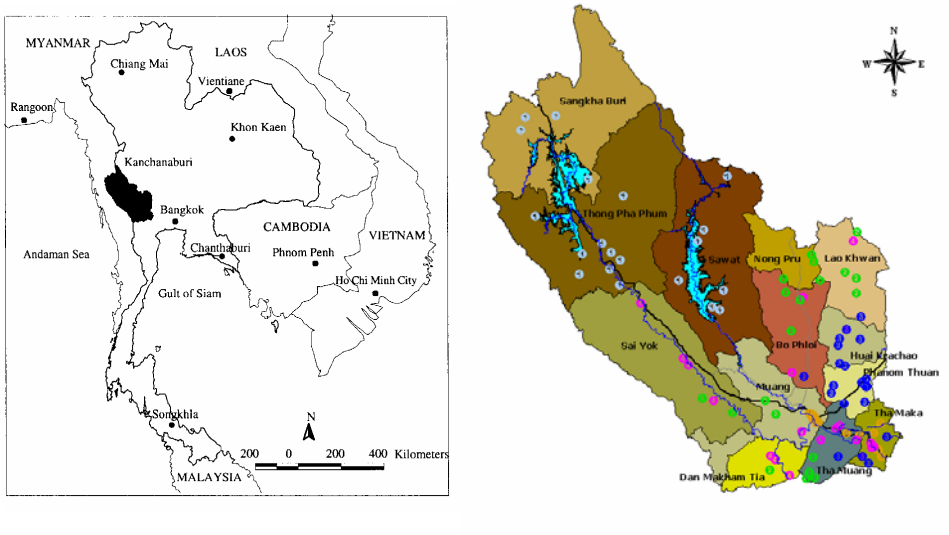
Results

Study protocol and data collection

Nine hundred and twenty-one death records were collected from all government hospitals in Kanchanaburi province, excluding those in the three furthermost border districts, Sangkhla Buri, Thong Pha Phum, and Si Sawat, where the proportion of ethnic minority residents is high. Figure 2 shows a map of the province under study.

Figure 2

Map of Thailand showing Kanchanaburi province



Each medical record was extracted or photocopied into a structured form, and reviewed by project researchers with backgrounds as registered nurses and medical record officers. The stages of the data collection process are shown in Figure 3.

Response rate of VA interview

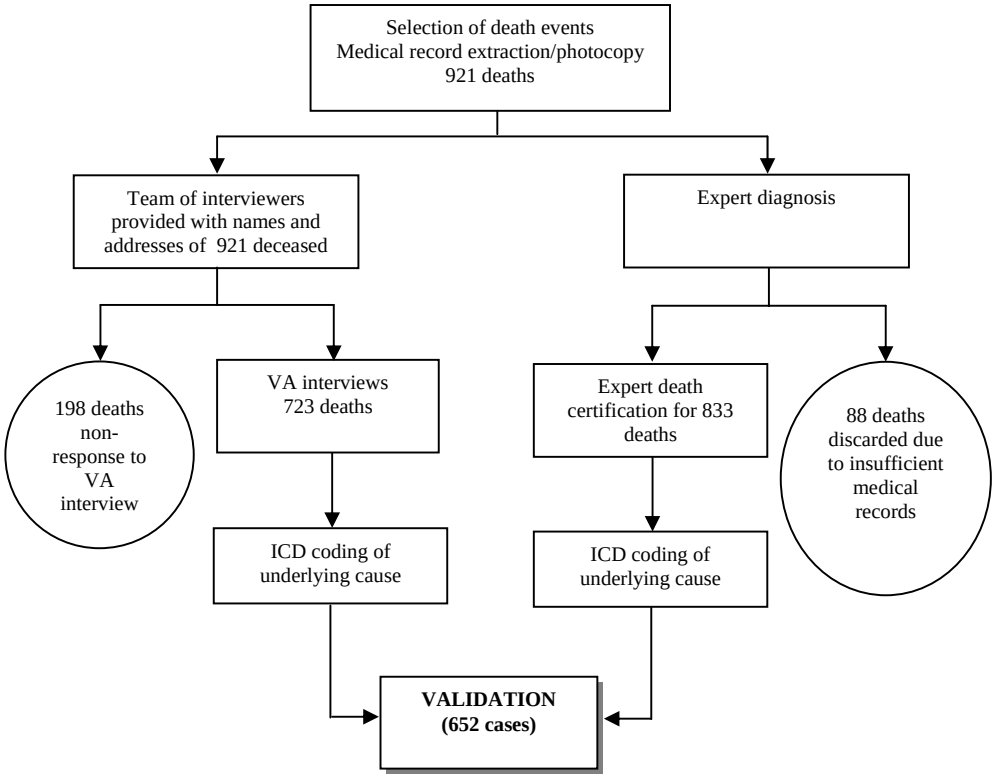
The response rate of this study was 78.5% among 921 deceased. The reasons noted by the field interviewers for not being able to interview are similar to previous studies (Chanpen et al., 2001; Kanda, Yawarat and Angsana, 1999):

- house no longer occupied;
- close relatives staying with the deceased before death moved to unknown address;
- no such names of deceased person in the household or village;
- no such address in the village;
- the deceased died outside the village, and key informant cannot be found;
- close person or caretaker has also died;
- no close relatives stayed with the deceased person;
- refusal to give an interview.

It should be pointed out that the key component of the VA application is the availability of key informants who can give information about the deceased. If such a key informant is not available, the VA approach is useless. To increase the response rate, it may help if the interview is conducted soon after death or immediately at the time of registration.

Figure 3

Flow chart showing study protocol and data collection



Matched cases between VA assigned and expert medical certified causes of death

In this study, 3-digit codes from the ICD-10 were assigned to the cause of death from both sources. 652 cases could be validated. Table 1 shows expert medical certified causes of death by age of those 652 cases. The results of matching at this initial stage of the trial are shown in Table 2.

Table 1: Causes of death certified by medical experts, by age groups

Cause	Age group						
	0-14	**15-29**	**30-44**	**45-59**	**60-74**	**75+**	**Total Number (%)**
Tuberculosis	0	2	3	5	3	7	20 (3.0)
HIV/AIDS	6	31	68	12	4	0	121 (18.6)
Cancer ,all sites	0	4	9	8	21	16	58 (8.9)
Diabetes mellitus (DM)	0	0	2	13	20	6	41 (6.3)
Hypertensive disease	0	1	8	13	38	19	79 (12.1)
Ischaemic heart disease (IHD)	0	1	3	6	21	11	42 (6.4)
Cerebro-vascular disease (CVA)	0	1	2	8	141	18	43 (6.6)
Lower respiratory infection	6	0	4	4	11	6	33 (5.1)
Chronic obstructive pulmonary disease (COPD)	0	0	0	2	23	19	45 (6.9)
Cirrhosis of liver	0	0	13	13	8	2	33 (5.1)
Others	17	8	14	24	41	33	137 (21.0)
Total	**29**	**48**	**123**	**110**	**205**	**137**	**652 (100)**

From Table 1, the ten leading causes of death are ranked as follows: HIV/AIDS (B20-B24), hypertensive diseases (I10-I13), cancers (C00-C97), cerebro-vascular diseases (I60-I69), ischaemic heart disease (I20-I25), chronic obstructive pulmonary disease (J40-J44), diabetes mellitus (E10-E14), lower respiratory infections (J10-J18, J20-J22), cirrhosis of the liver (K70, K74), and tuberculosis (A15-A19, B90). These ten leading causes account for 78% of total deaths from hospital records.

Table 2: Matched cases between VA assigned causes of death and physicians' verification of hospital records

Matching result	Number of cases	Percent
Matched	295	45.2
Possible	*130*	*19.9*
Probable	*165*	*25.3*
Not matched	357	54.8
Total cases	**652**	**100.0**

Almost half of the total cases had matching causes of death from the two methods (Table 2). Only 20% exactly matched in all digits, while 25% were a probable match, since they could be classified into the same broad group of diseases but had some differences in detail. It should be noted that the cases selected for this study were only those who died of natural causes such as illness or disease. Previous studies in Thailand (Chanpen et al., 2001; Kanda, Yawarat and Angsana, 1999) report that almost 90% of external causes can be correctly assigned by VA methods; for this reason, we expect the percent of matched cases would be higher if those external causes were included. Vital registration suggests that registered deaths from injuries in 2001 accounted for 11% of total deaths, thus the percent of matching VA-assigned causes could be higher than 50% if external causes were included.

Validity testing of VA questionnaires

The sensitivity, specificity, and positive predictive value of thirteen selected causes (the most common in Thailand) were used as indicators of the validity of the VA questionnaires. Sensitivity is defined as the ability of the VA to correctly identify those who died from the cause of interest, while specificity is defined as the ability of the VA to identify correctly those who did not die from the cause of interest. The third measurement, positive predictive value (PPV), measures the true chance of death from this cause if diagnosed by VA.

We classify sensitivity into three groups to indicate the degree of validity of our tool: 'good' (≥ 75%), 'tolerable' (50 – 75%), and 'poor' (<50%) (Gonghuan et al., 2005). As seen in Table 4, only breast cancer falls in the group of good validity, while AIDS, ischaemic heart disease, pulmonary TB, liver cancer and cancer of cervix are in the second group of tolerable validity. Hypertensive disease, cerebro-vascular disease, diabetes mellitus, chronic obstructive pulmonary disease, pneumonia, cirrhosis of the liver and lung cancer are in the poor validity classification. Despite 'tolerable' or 'poor' validity specified by sensitivity, degrees of specificity of our VA questionnaires for all 13 selected causes of death are very high, all higher than 90%. This finding indicates that the tested VA tool has high potential to correctly identify those who did not die from specific causes of death. (Table 3, 4)

Table 3: Validation characteristics of verbal autopsy procedure for thirteen selected causes of death in Kanchanaburi

Cause	Age group	ICD code	MC* death	VA death	Sensitivity (95% CI)	PPV (95% CI)	Specificity
AIDS likelihood	15-49	B20-B24	108	64	58.3 (51.7-65.0)	98.4 (96.8-100)	99.0
Hypertensive disease	40+	I10-I13	75	50	38.7 (34.3-43.0)	58.0 (53.6-62.4)	94.9
CVD	40+	I60-I69	41	10	24.4 (20.6-28.2)	100.0 (100-100)	100.0
IHD	35+	120-I25	40	48	52.5 (48.2-56.8)	43.8 (39.5-48.0)	94.5
DM	40+	E10-E14	40	36	47.5 (43.1-51.9)	52.8 (48.3-57.2)	96.2
Pulmonary TB	15+	A15-A16	18	13	66.7 (63.0-70.4)	92.3 (90.2-94.4)	99.8
COPD	50+	J40-J44	40	20	37.5 (31.1-43.9)	75.0 (69.2-80.8)	97.2
Pneumonia	15+	J12-J18	27	23	40.7 (36.9-44.6)	47.8 (43.9-51.7)	98.0
Liver cirrhosis	40+	K74	25	18	32.0 (27.9-36.1)	44.4 (40.0-48.9)	97.8
CA liver	35+	C22	8	14	62.5 (58.4-66.6)	35.7 (31.6-39.8)	98.3
CA breast	35+	C50	5	4	80.0 (74.9-85.1)	100.0 (100-100)	100.0
CA cervix	35+	C53	3	2	66.7 (60.7-72.7)	100.0 (100-100)	100.0
CA lung	35+	C33-C34	11	5	36.4 (32.3-40.5)	80.0 (76.6-83.4)	99.8

Note: * MC = Medical certified

Table 4: VA-assigned causes of death classified into groups of sensitivity percentages

% Sensitivy	Defined degree of validity	Cause of death
> 70%	Good	CA breast
50-70%	Tolerable	AIDS, IHD, Pulmonary TB, CA liver, CA cervix
< 50%	Poor	HT, CVA, DM, COPD, Pneumonia, Liver cirrhosis and CA lung

Since for most causes of death, the VA performs with a lower than "good" level of validity, further analysis of the patterns of misclassification of these causes is instructive. Table 5 shows the matrix of misclassification error between verbal autopsy assigned causes and expert medical certification. Among those causes with tolerable validity, most were similarly misclassified as ill-defined. Among those in the poor validity group, misclassification errors were more often coded to other causes of death rather than as ill-defined, especially to diabetes mellitus, hypertensive disease, ischaemic heart disease or chronic obstructive pulmonary disease.

Table 5: Distribution of misclassifications of VA –assigned cause of deaths as compared to expert medical certified

VA death	MC death															Total VA death
	TB	AIDS	CA liver	CA lung	CA breast	CA cervix	DM	HT disease	IHD	CVD	pneumo nia	COPD	Liver cirrhosis	ill-defined	Others	
TB	**12**	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13
AIDS	0	**69**	0	0	0	0	0	0	0	0	0	0	0	0	1	70
CA liver	0	1	**6**	2	0	0	0	0	0	0	0	0	2	0	6	17
CA lung	0	1	1	**3**	0	0	0	0	0	0	0	0	0	0	1	6
CA breast	0	0	0	0	**4**	0	0	0	0	0	0	0	0	0	0	4
CA cervix	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	0	2
DM	0	4	0	0	0	0	**22**	3	1	1	0	2	0	0	8	41
HT disease	0	0	1	0	0	0	3	**33**	0	0	0	2	0	1	12	52
IHD	1	5	0	0	0	0	1	0	**26**	0	2	5	2	0	10	52
CVD	0	1	0	0	0	0	0	0	0	**10**	0	0	0	0	0	11
pneumonia	0	0	0	0	0	0	1	2	3	0	**15**	0	2	0	6	29
COPD	1	1	0	0	0	0	0	0	2	0	0	**17**	0	0	2	23
Liver cirrhosis	0	4	0	0	0	0	0	2	0	1	3	2	**10**	0	2	24
Ill-defined	1	10	0	0	1	0	2	14	2	12	5	2	2	**0**	11	62
Others	3	25	1	7	0	1	12	25	8	19	8	12	12	0	**113**	246
Total of MC death	18	121	9	12	5	3	41	79	42	43	33	42	30	1	173	652

Note: A15-A16 = Pulmonary TB, B20-B24 = HIV/AIDS, C22 = Liver cancer, C33-C34 = Lung cancer, C50 = Breast cancer, C53 = Cervical cancer, E10-E14 = Diabetes mellitus, I10-I13 = Hypertensive disease, I20-I25 = Ischaemic heart disease, I60-I69 = Cerebrovascular disease, J12-J18 = Pneumonia, J40-J44 = Chronic obstructive pulmonary disease, K74 = Liver cirrhosis

The results of misclassification can help to inform revisions to the algorithm in the next step of development of the VA tool. In the case of AIDS, for example, there are 121 AIDS deaths certified by medical experts, of which 69 cases, or 57%, match with the VA diagnosis. Many AIDS cases are identified through VA as ischaemic heart disease, liver cirrhosis, diabetes mellitus, or ill-defined. This 43% misclassification rate may be due to the disease algorithmnot including sufficient high predictive validity items. For instance, a previous study in Thailand (Chanpen et al., 2001; Kanda, Yawarat and Angsana, 1999) included a question as to whether the decedent was HIV sero-positive. This may have improved our tool, as the current HIV-epidemic context in Thailand means that many individuals have been screened.

Discussion and Conclusion

The ultimate objective of this research study is to improve the quality of mortality data in Thailand, especially related to cause of death. It is our ambition to develop an effective tool to help identify causes of death, initially to be used in a mortality or health survey, and ideally to be integrated into the national vital registration system. We feel the tool would be most valuable if it could be used by non-medical personnel. The verbal autopsy, based on experiences in other countries, was selected as the core mechanism for data collection.

While there are two approaches to conducting a verbal autopsy, the present study was based on data-derived algorithms, because of the need to make the tool useable by individuals without an extensive medical background. The other, expert-judgment approach relies on detailed, open-ended questions and medical expert review to identify the cause of death. The VA serves as a medium between the deceased and medical experts. The data-derived algorithm used in this study does not require the same intensive medical expertise during its use. Instead, the series of questions are accessed from a practical PDA computer for convenient use in the field, allowing the interviewer to automatically determine a cause of death via a pre-programmed algorithm. The cause of death derived from this VA tool appears to be more standardized than in conventional survey questionnaires.

It is critical to remember that the causes of death identified by a VA tool are based on the information received from lay people. However, identifying cause of death can be very complicated, especially when dealing with a death from multiple causes as usually occurs among adults. Thus, we should not expect the VA tool to yield an exactly accurate cause of death at the same quality as that identified by a medical autopsy. However, the quality of the VA tool tested in this study can be improved upon. The validity of the tool, as measured by the degree of sensitivity and specificity, can certainly be increased by revising the algorithm. Improvements to this VA tool must be made with the recognition that we are identifying cause of death from lay people's perception of symptoms, and not from scientific experts or medical autopsy. Therefore, the ICD short list of mortality (80 causes) should be used instead of the ICD-10 detailed list.

It should be emphasized here that this study only selected deaths caused by diseases in hospital. External causes, such as accident, suicide and homicide are not included. Based on experiences from previous studies, these external causes tend to be less difficult for lay people to identify than diseases. Thus, if the external causes are included, it is likely that the degree of overall validity of this VA tool will increase.

Acknowledgement

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