***Southeast-Asian J. of Sciences,*** Vol. 9, No. 1 (2022) pp. 8-19

# A POPULATION-BASED INTERVENTION TO IMPROVE THE MORTALITY REPORTING SYSTEMS FOCUSED ON CARDIOVASCULAR DESEASES OCCURED DURING 2015-2016 IN HA NAM PROVINCE, VIETNAM

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**ACKNOWLEDGEMENTS** We deeply appreciate the officers of the Ha Nam provincial health departments; the Department of Preventive Medicine and Health Workers of 30 communes Health Stations for their valuable field data collection. The study was supported in part by the WHO office in Hanoi city. I wish to thank Mr. Barnabas Martin for reviewing and addressing any errors in the original English of this paper

**Conflict of interest:** There are no conflicts to disclose.

**Abstract**

**Background** Very few population-based interventions to improve the mortality reporting systems have been performed in Viet Nam where mortality information is still limited.

**Key words:** Population-intervention, CVD, mortality registration, Verbal Autopsy

**Methods** We performed a training workshop for 80 health officers in applying Verbal Autopsies (VA) to determine the cause of deaths occurring during 2015-2016 in 30 of 116 communes randomly selected in Ha Nam province. After a training workshop, an active mortality registration by household visit using a designed form to collect information of immediate-, underlying-, and contribute-causes of death was conducted. Next, a verbal autopsy (VA) was completed for all deceased participants. Diagnose tests were performed using STATA-10 to calculate the improvements data of mortality due to cardiovascular diseases (CVD) and its subgroups.

**Results**

Verbal Autopsy was completed for 2436 of a total of 2441 deaths. The estimated completion rate was 97%. After the intervention, the sensitivity, specificity, positive predictive value, and negative predictive values at 0.93, 0.98, 0.95, and 0.97 respectively were determined. Data quality was increased by sensitivity by 11%, specificity by 6%; positive predictive value by 12%, and negative predictive value by 5%; all P_value $< 0.05$. The estimated Kappa was increased by 17% (from 74% to 92%) for CVD; P_value $< 0.05$.

**Conclusions**

A population-based intervention to improve the mortality reporting systems operated by the Ministry of Health is practical, feasible, and reliable and should be applied in all 63 provinces/cities in Viet Nam.

# 1. BACKGROUND

Cardiovascular diseases (CVD) were the leading causes of morbidity and mortality from the last century to date in Viet Nam. During the 1990 decade, the prevalence of stroke (ICD-10: I60-I69) was estimated at 6 per 1000 in the South country (1). Stroke (ICD-10: I60-I69) and coronary heart diseases (ICD-10: I20-I25) were among the 12 leading causes of death in Quang Ninh province in 2014, North mountain areas, and nationwide in 2008 as confirmed by the recent VA studies (2, 3). Cardiovascular diseases (CVD, ICD-10: I00-I99) were also the leading causes of death with an estimated standardized mortality rate of 114.3 per 100,000 (29.9

Vital Registration (operated by the Justice Ministry of Viet Nam) has existed for a half-century, however, mortality registration was poorly performed and health information of population-based causes of deaths is not available to date (5). To overcome this limitation, a national mortality registration system (named A6) was established by the Ministry of Health in 1992. The A6 mortality reporting system is a national mandatory mortality registration conducted by commune health stations (CHS) throughout the country. For the deaths which occurred during 2005-2006, a list and the causes of 93,719 deaths was collected from 10,184 CHS (95%) from 638 districts of 64 provinces/cities and

examined for cancer mortality patterns in Viet Nam (6). The mortality reporting systems have been well established, however, data quality of accuracy and completeness need evaluation and enhancements.

The completeness of A6 mortality registration has varied between populations. That was addressed at the nationwide level for the deaths occurred during 2006-2007 (men 69% and women 54%) (7), and during 2008-2009 (81%, men and women combined) (3), in 2014 in Quang Ninh province (89%, men and women combined) (2) and in Nghe An province (97%, men and women combined) (8). The accuracy of A6 mortality registration was also varied between populations. The estimated sensitivity was relatively low for stroke (ICD-10: I60-I69) and coronary heart diseases (ICD-10: I20-I25), as much as 67% and 34% respectively (2). CVD sensitivity of 63% was estimated (4, 9). In other recent studies conducted in Nghe An province (North Central Coast of Viet Nam), where health care systems were well operated, the data quality of mortality registration for CVD was much better with the estimated sensitivity for CVD of 87% (8). A progressing quality of mortality information regarding accuracy and completeness has been seen, however, we need a better and comparable database at the nationwide level to construct an action plan and make health policy based on evidence to improve people health in Viet Nam. An improvement of the accuracy of the A6 mortality statistics is needed in order to implement timely policies to respond to the growing burden of CVD in Viet Nam.

The present study aimed to examine the benefits of a population-based intervention to improve the data quality of accuracy and completeness for all cardiovascular diseases and subgroups of cerebrovascular diseases (I60-I69), heart failure (I30-I52), pulmonary heart disease (I26-I28), and coronary heart diseases (I20-I25) that occurred during 2015-2016 in Ha Nam province located in the Red Delta River, North Viet Nam.

## 2. METHODS

A population-based intervention was performed in the Ha Nam Province (see Figure 1). The local health network included 30 CHS that were randomly selected from the 116 CHS in the province.

A one-day training workshop was organized at a Ha Nam convention center in cooperation with the Ministry of Health and the provincial Department of Preventive Medicine for 80 health officers invited from randomly selected 30 commune health stations, five District Health Centers, and the provincial Department of Preventive Medicine. Definition of causes of death (underlying cause of death, immediate cause of death, and contributing cause of death); ICD-10 coding for all specific causes and 54 main group causes of deaths and the practice of VA to determine the cause of death during undertaking a household


Figure 1. Location of Ha Nam province in the North Viet Nam (Source: http://ontheworldmap.com/vietnam/)

visit were included in the content of training workshops (10, 11). The cause of death and ICD-10 coding was introduced to all participated health officers for specific causes and group of diseases of bacterial diseases (ICD-10: A00-A99); Virus and parasitic (B00-B99); Cancer (C00-D48); Blood diseases (D50-D89); Endocrine (E00-E90); Mental (F00-F99); Nervous (G00-G99); Cardiovascular diseases (I00-I99); Respiratory (J00-J99); Digestive (K00-K93); Skin (L00-L99); Musculoskeletal (M00-M99); Urology (N00-N99); Maternal (O00-O99); Newborn (P00-P96); Abnormality (Q00-Q99); Symptom (R00-R99); Injury and accident (S00-Y89). All causes of deaths were determined, then, the present study used data of cardiovascular diseases (I00-I99) and its subgroups in examination and presentation.

The cause and list of all deaths that occurred during 2015-2016 in all 30 selected CHS were routinely obtained from the Ha Nam provincial Department of Preventive Medicine, before the population-based intervention. Indicators such as name, age, and sex of the deceased, the date of death, and the cause of death were obtained and included (The first database). One ID# for further database merger was created for each case of death in the first database.

After the training workshop, an active mortality registration following the guideline of the underlying cause of death, the immediate cause of death, and contributing cause of death was conducted and established in the second database for indicators of the name, age, and sex of the deceased, the date of death and the cause of all deaths during 2015-2016. What was the underlying cause of death?; What was the immediate cause of death? and What was

the contributing cause of death? were included in the designed form. During household visits, the form was completed by the trained interviewers by a face-to-face interview. One ID# for further database merger was created for each case of death in the second database. Finally, VA was completed for all registered deaths during 2015-2016 across the same communes and district (see Figure 2). The deceased's household was visited by the trained interviewers of commune health workers who participated in the training to administer the verbal autopsy and complete one of three verbal autopsy questionnaires (0?28 day old child, 29 days to < 5 years old children, and 5 years old onwards). Cause of death assignment and ICD-10 coding for the VA's was undertaken independently by the head of CHS, then by an experienced physician who had more than 15 years of clinical experience. An underlying cause of death (the disease or injury which initiated the events directly leading to death) for all cases was assigned wherever possible. Immediate (the disease, condition, or complication that occurred closest to the time of death) and contributory (a condition originated in the underlying cause and terminated in the immediate cause) causes of death were also assigned. Assigning the cause of death was enhanced by utilizing a previously developed series of algorithms (4, 9, 10). Finally, the cause of deaths and ICD-10 codding were checked to avoid all errors (third database). One ID# for further database merger was created for each case of death in the third database.

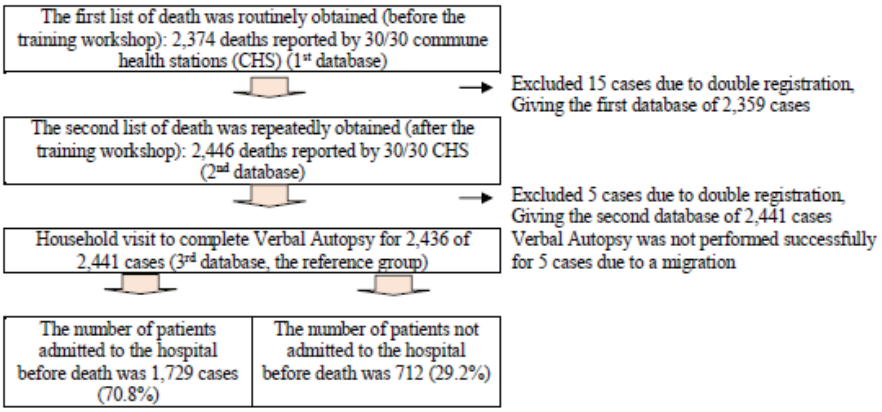


Figure 2. Flow chart of the three times repeated database developments

Statistical analysis: To estimate sensitivity, specificity, positive predictive value, and negative predictive value and Kappa (12) for the first and second obtained databases for all CVD, the sub-groups of cerebrovascular diseases (I60-I69), heart failure (I30-I52), pulmonary heart disease (I26-I28), and coro-

nary heart diseases (I20-I25), the VA was used as the reference group. These indicators of sensitivity, specificity, positive predictive value, and negative predictive values were compared between the second and first obtained databases using a two-sample test of proportions to observe changing values of those indicators indicating the benefits of intervention. Analytically programming was performed by STATA-10 (13).

The present study, part of the awarded project of "Evaluating and enhancing the national mortality reporting system in Viet Nam" supported by the Australian Government 2007 funding round, was approved by the Ethical Committee of Hanoi Medical University on Nov. 25, 2008.

## 3. Results

712 cases (29.2%) of unknown hospitalization information before the date of death were among a total of 2441 registered deaths. For the proportion of cases that received healthcare before the endpoint of diseases, men and women combined, about 4.1% cases visited district hospitals, 30.7% visited provincial hospitals, 20.4% of 2441 death cases visited central and specialized hospitals, and 14.7% cases of having had previously diagnosed suffering from chronic diseases were reported in Table 1.

**Table 1. Hospitalization information and healthcare received before the endpoints of diseases**

| Healthcare facilities | Men | | Women | | Total | |
|---|---|---|---|---|---|---|
| | Cases | % | Cases | % | Cases | % |
| Central and specified hospitals | 342 | 25.8 | 157 | 14.1 | 499 | 20.4 |
| Provincial hospitals | 437 | 33.0 | 313 | 28.0 | 750 | 30.7 |
| District hospitals | 50 | 3.8 | 50 | 4.5 | 100 | 4.1 |
| Commune health stations, private doctors | 13 | 1.0 | 9 | 0.8 | 22 | 0.9 |
| Previous diagnosed suffering from chronic diseases | 192 | 14.5 | 166 | 14.9 | 358 | 14.7 |
| Unknown hospitalization information | 290 | 21.9 | 422 | 37.8 | 712 | 29.2 |
| Total | 1,324 | 100.0 | 1,117 | 100.0 | 2,441 | 100.0 |

Among four sub-groups of CVD, cerebrovascular diseases (ICD-10: I60-I69) were the leading cause of CVD deaths (responsible for 80% (620/779 cases), followed by heart failure diseases (9%, 73/779 cases) and coronary heart diseases (5%, 36/779 cases) was also reported. Before the training workshop, a routine mortality registration (the first database) for 2359 total cases of deaths, giving the completeness of 96.6% (2359 per 2441 cases) was conducted. The results of routine mortality registration have successfully registered 619 of 754

cases of CVD (ICD-10: I00-I99); 17 of 36 cases of coronary heart diseases (I20-I25), 5 of 13 cases of pulmonary heart disease (I26-I28), 35 of 73 cases of heart failure diseases (ICD-10: I30-I52), and 463 of 596 cases of cerebrovascular diseases (ICD-10: I60-I69). After the training workshop, 728 of 779 cases of CVD (ICD-10: I00-I99) was successfully registered in an advanced mortality registration; including 35 of 36 cases of coronary heart diseases (I20-I25), 6 of 13 cases of pulmonary heart disease (I26-I28), 66 of 73 cases of heart failure diseases (ICD-10: I30-I52), and 546 of 620 cases of cerebrovascular diseases (ICD-10: I60-I69), Table 2.

**Table 2. Distribution of disease and non-disease (Verbal autopsy) by testing groups**

| Cardiovascular Diseases (CVD) | Verbal Autopsy | Before the intervention (Group 1) | | | After the intervention (Group 2) | | |
|---|---|---|---|---|---|---|---|
| Sub-group | | Disease (Test1) | Non-disease (Test1) | Total | Disease (Test2) | Non-disease (Test2) | Total |
| CVD (I00-I99) | Disease | 619 | 135 | 754 | 728 | 51 | 779 |
| | Non-disease | 126 | 1,479 | 1,605 | 35 | 1,622 | 1,657 |
| Cerebrovascular Diseases (I60-I69) | Disease | 463 | 133 | 596 | 546 | 74 | 620 |
| | Non-disease | 101 | 1,662 | 1,763 | 18 | 1,798 | 1,816 |
| Heart failure (I30-I52) | Disease | 35 | 38 | 73 | 66 | 7 | 73 |
| | Non-disease | 8 | 2,278 | 2,286 | 13 | 2,350 | 2,363 |
| Pulmonary Heart disease (I26-I28) | Disease | 5 | 8 | 13 | 6 | 7 | 13 |
| | Non-disease | 38 | 2,308 | 2,346 | 9 | 2,414 | 2,423 |
| Coronary Heart Diseases (I20-I25) | Disease | 17 | 19 | 36 | 35 | 1 | 36 |
| | Non-disease | 11 | 2,312 | 2,323 | 7 | 2,393 | 2,400 |
| Cases matched to Groups 1 and group 2 | | | | 2,359 | | | 2,436 |

The estimated sensitivity, specificity, positive predictive value, and negative predictive value was 0.82, 0.92, 0.83, and 0.92, respectively for the total CVD (ICD-10: I00-I99); 0.47, 1.00, 0.61, and 0.99, respectively for coronary heart diseases (I20-I25); 0.38, 0.98, 0.12, and 1.00, respectively for pulmonary heart disease (I26-I28); 0.48, 1.00, 0.81, and 0.98, respectively for heart failure diseases (ICD-10: I30-I52); and 0.78, 0.94, 0.82, and 0.93, respectively for cerebrovascular diseases (ICD-10: I60-I69) was reported in Table 3.

For all CVD (ICD-10: I00-I99), data quality was increased in sensitivity by 11% (elevated from 82% to 93%), specificity by 6% (elevated from 92% to 98%); positive predictive value by 12% (elevated from 83% to 95%), and negative predictive value by 5% (elevated from 92% to 97%); all P_value $<0.05$. For cerebrovascular diseases (ICD-10: I60-I69), data quality was increased in sensitivity by 10% (elevated from 78% to 88%), specificity by 5% (elevated from 94% to 99%); positive predictive value by 15% (elevated from 82% to 97%), and negative predictive value by 3% (elevated from 93% to 96%); all P_value

**Table 3. Changes in quality indicators of mortality registration after the intervention**

| Cause determined by Verbal Autopsy | *Training* | Cardiovascular Diseases (I00-I99) | | Cerebrovascular Diseases (I60-I69) | | Heart failure (I30-I52) | | Pulmonary Heart disease (I26-I28) | | Coronary Heart Diseases (I20-I25) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean (95% CI) | *P* | Mean (95% CI) | *P* | Mean (95% CI) | *P* | Mean (95% CI) | *P* | Mean (95% CI) | *P* |
| Sensitivity | After | 0.93 (0.92, 0.94) | | 0.88 (0.87, 0.89) | | 0.90 (0.89, 0.92) | | 0.46 (0.44, 0.48) | | 0.97 (0.97, 0.98) | |
| | Before | 0.82 (0.81, 0.84) | | 0.78 (0.76, 0.79) | | 0.48 (0.46, 0.50) | | 0.38 (0.36, 0.40) | | 0.47 (0.45, 0.49) | |
| | ***Changes*** | ***0.11 (0.10, 0.13)*** | ***0.00*** | ***0.10 (0.08, 0.12)*** | ***0.00*** | ***0.42 (0.40, 0.45)*** | ***0.00*** | ***0.08 (0.05, 0.10)*** | ***0.00*** | ***0.50 (0.48, 0.52)*** | ***0.00*** |
| Specificity | After | 0.98 (0.97, 0.98) | | 0.99 (0.99, 0.99) | | 0.99 (0.99, 1.00) | | 1.00 (0.99, 1.00) | | 1.00 (0.99, 1.00) | |
| | Before | 0.92 (0.91, 0.93) | | 0.94 (0.93, 0.95) | | 1.00 (0.99, 1.00) | | 0.98 (0.98, 0.99) | | 1.00 (0.99, 1.00) | |
| | ***Changes*** | ***0.06 (0.05, 0.07)*** | ***0.00*** | ***0.05 (0.04, 0.06)*** | ***0.00*** | ***0.00 (-0.01, 0.00)*** | ***0.30*** | ***0.01 (0.01, 0.02)*** | ***0.00*** | ***0.00 (0.00, 0.01)*** | ***0.31*** |
| Positive predictive value | After | 0.95 (0.95, 0.96) | | 0.97 (0.96, 0.98) | | 0.84 (0.82, 0.85) | | 0.40 (0.38, 0.42) | | 0.83 (0.82, 0.85) | |
| | Before | 0.83 (0.82, 0.85) | | 0.82 (0.81, 0.84) | | 0.81 (0.80, 0.83) | | 0.12 (0.10, 0.13) | | 0.61 (0.59, 0.63) | |
| | ***Changes*** | ***0.12 (0.11, 0.14)*** | ***0.00*** | ***0.15 (0.13, 0.16)*** | ***0.00*** | ***0.02 (0.00, 0.04)*** | ***0.05*** | ***0.28 (0.26, 0.31)*** | ***0.00*** | ***0.23 (0.20, 0.25)*** | ***0.00*** |
| Negative predictive value | After | 0.97 (0.96, 0.98) | | 0.96 (0.95, 0.97) | | 1.00 (0.99, 1.00) | | 1.00 (0.99, 1.00) | | 1.00 (1.00, 1.00) | |
| | Before | 0.92 (0.91, 0.93) | | 0.93 (0.92, 0.94) | | 0.98 (0.98, 0.99) | | 1.00 (0.99, 1.00) | | 0.99 (0.99, 1.00) | |
| | ***Changes*** | ***0.05 (0.04, 0.07)*** | ***0.00*** | ***0.03 (0.02, 0.05)*** | ***0.00*** | ***0.01 (0.01, 0.02)*** | ***0.00*** | ***0 (0, 0)*** | ***0.71*** | ***0.01 (0.00, 0.01)*** | ***0.00*** |

CI: Confident Interval

$< 0.05$. The estimated sensitivity was increased by 42% (elevated from 48% to 90%) for heart failure diseases (ICD-10: I30-I52); by 8% (elevated from 38% to 46%) for pulmonary heart disease (I26-I28); and by 50% (elevated from 47% to 97%) for coronary heart diseases (I20-I25), Table 3.

For Kappa estimation, after the training workshop, the estimated Kappa was increased from 74% to 92% for all CVD (ICD-10: I00-I99), from 63% to 90% for cerebrovascular diseases (ICD-10: I60-I69), from 59% to 86% for heart failure diseases (ICD-10: I30-I52), from 17% to 43% for pulmonary heart disease (I26-I28), and from 52% to 90% for coronary heart diseases (I20-I25). These elevations of Kappa estimation were significant; all P_value $<0.05$, Table 4.

## 4. Discussion

The estimated sensitivities of databases for total CVD for both before (routine mortality registration) and after the intervention were ranked between 82% and 93%. That is, the quality of mortality registration systems operated by the Ministry of Health for cardiovascular diseases were very good (routine mortality registration) and were considered excellent (after the completed intervention) with a relatively large sample size of a total of 2441 registered deaths. In addition, among four sub-groups of CVD, a pattern that the cerebrovascular diseases were the leading cause of CVD deaths, followed by heart failure diseases, and coronary heart diseases was shown in the findings.

For the quality of data, the present findings are constant with the previous

**Table 4. Changes in Kappa estimation after the training intervention**

| Cause of death was determined by Verbal Autopsy | Training | Kappa (95% CI) | *P* |
|---|---|---|---|
| Cardiovascular Diseases (I00-I99) | After | 0.92 (0.91, 0.93) | |
| | Before | 0.74 (0.73, 0.76) | |
| | ***Changes*** | ***0.17 (0.15, 0.19)*** | ***0.00*** |
| Cerebrovascular Diseases (I60-I69) | After | 0.90 (0.89, 0.91) | |
| | Before | 0.63 (0.61, 0.65) | |
| | ***Changes*** | ***0.27 (0.25, 0.29)*** | ***0.00*** |
| Heart failure (I30-I52) | After | 0.86 (0.85, 0.88) | |
| | Before | 0.59 (0.57, 0.61) | |
| | ***Changes*** | ***0.27 (0.25, 0.29)*** | ***0.00*** |
| Pulmonary Heart disease (I26-I28) | After | 0.43 (0.41, 0.44) | |
| | Before | 0.17 (0.16, 0.19) | |
| | ***Changes*** | ***0.25 (0.23, 0.28)*** | ***0.00*** |
| Coronary Heart Diseases (I20-I25) | After | 0.90 (0.88, 0.91) | |
| | Before | 0.52 (0.50, 0.55) | |
| | ***Changes*** | ***0.37 (0.35, 0.39)*** | ***0.00*** |

CI: Confident Interval

results of the completed intervention in Nghe An province for 1581 registered deaths that occurred in 2014. Consequently, for CVD, the significant improvement of specificity, positive predictive value, and negative predictive are reported (8). However, an improvement of sensitivity following the completed population-based intervention is not detected in the previous study, possibly due to the smaller sample size when compared to the present study (2441 versus 1581) and the omission of a standardized form for household visits when collecting data information from next of kin of deceased participants in developing the second database (8). Regarding completeness of data, an excellent estimation of 97% that is consistent with the study using VA conducted in Bavi mountain district of Hanoi city in 1999-2000 (81%) (14), a study in three provinces represented three regions of Viet Nam in 2008-2009 (94%) (4, 9), a national VA study in 2009 (81%) (3), and the study in Quang Ninh and Thais Nguyen provinces in 2014 (89%) (2) and Nghe An Province in 2014 (97%) (8) is observed in the present findings. A relatively low percentage of completeness (69% in men and 54% in women) in the first national VA study conducted for deaths occurred in 2006-2017 is seen, possibly because deaths were registered by the other systems of the 1999 population census (7), when compared to the present study.

The A6 mortality reporting systems were created in 1992 and have been conducted in all 10,769 Commune Health Stations within 761 district Health Centers of 64 provinces/cities nationwide in 2007 (6, 15). From 2005, annual mortality registration is collected by the Ministry of Health and data have been published annually for the deaths that occurred from 2005 to date, focusing on

injury mortality nationwide (16). The present population-based intervention was timely and significant achievements were obtained, because the systems have been well organized in Viet Nam.

That a national database of CVD and all other causes of death will be soon available for multipurpose usage by macro-policy makers based on evidence to social action against CVD, cancer, injury by effective primary prevention is predicted. To determine the cause of death and to develop a database of mortality for health planning, priority setting, monitoring, and evaluation in countries with incomplete or no vital registration system it is recommended to utilize verbal autopsy (17). Vital registration systems are expensive to set up and require close collaboration between the Ministry of Health and sectors responsible for the registration of persons, immigration, and the judiciary. The A6 mortality reporting system is the leading mortality reporting system for the Ministry of Health in Viet Nam and it is evaluated for being an excellent data source for three leading causes of cardiovascular diseases, cancer, and injury (2-4, 8, 9, 14). The present approach of using VA to address the significant benefits of population-based intervention is performed to strengthen the A6 mortality reporting system, which focused on CVD in the participated population in Northern Viet Nam and is being recommended for application for national use in Viet Nam as soon as possible.

Cardiovascular diseases have been reported as the leading causes of deaths in Viet Nam, of which cerebrovascular diseases were responsible for about 4 in 5 deaths (2, 4). The proportion of current premature deaths under the age of 70 years old was determined at about 54% in men and 30% in women, according to the WHO estimation for Viet Nam (18). The four preventable groups of risk factors of CVD have been recognized and include tobacco smoking, unhealthy diet, physical inactivity, and harmful use of alcohol. These risk factors should be controlled by active campaigns for primary prevention by both policymakers and the public (18). The observed pattern of CVD in Viet Nam was different when compared to a global level. Furthermore, the leading CVD morbidity and mortality causes in developed countries, for both men and women, were reported as coronary heart diseases (I20-I25), about 46% and 38% respectively (17). However, this group of coronary heart diseases was ranked as the third most common in the present study and other studies in Viet Nam (2, 3). Cerebrovascular diseases (I60-I69) were determined as the leading causes of CVD death that have been reviewed as being caused by hypertension, tobacco smoking, family history, and diabetes mellitus (17). By management and controlling for hypertension in communities from 2007 to 2010, the risk of deaths from cerebrovascular diseases was significantly decreased in the intervention communes with the estimated mortality rates ratio 0.64, 95% confident interval 0.43, 0.96, P_value 0.03 (19). These initial findings could be applied

nationally. Our present findings would be useful for further control of CVD and other non-communicable diseases (NCDs).

Validation of data accuracy and completeness has been conducted routinely in performing model observational research and study to control for NCDs by risk identifying and risk management (20, 21). An association between these malignancy diseases with exposure to meat mutagens intake has been shown in previous prospective cohort studies, with an estimated sensitivity of 96% of registered colorectal cancers (22). More population-based intervention to improve the sensitivity of mortality registration systems should be strongly recommended.

Limitations have been considered in the present study, as there exists no available morbidity database to link with the mortality database to analyze the survival of diseases, especially for cancer and other non-communicable diseases. Another limitation is found when considering that about 29% of all registered deaths have no information of intensive care before the date of death. Due to a lack of information from health care facilities, the cause of death might be misunderstood between the underlying-, immediate-, and contributing causes.

## 5. Conclusions

Data quality for total CVD and its sub-groups of coronary heart diseases (I20-I25), pulmonary heart disease (I26-I28), heart failure (I30-I52), and cerebrovascular diseases (I60-I69), was significantly improved after the intervention, which would be applicable in a national setting to enhance mortality data for identifying and planning preventive strategies to target the leading causes of deaths due to CVD in Viet Nam.

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