# PATTERN AND PREDICTING MORTALITY IN A RURAL DISTRICT OF NORTHERN VIETNAM, 1999-2011: A POPULATION-BASED LONGITUDINAL STUDY

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*Evidence of mortality trend and pattern is useful for guiding public health action and for supporting the development of evidence-based health policy. The paper aimed to investigate the mortality pattern in the rural district of Ba Vi in Vietnam, over the thirteen-year period 1999 - 2011 as well as explore predicting factors of mortality of this target population. These data were based on quarterly household visits to collect data on vital events, covering 76,305 people and 3,653 deaths of observation over a thirteen-year period 1999 - 2011. To explore which factors predicted mortality, Cox proportional hazards survival models (Cox model) were computed for all residents who participated in the study. Overall mortality rate increased slightly from 4.2 per 1000 population in 1999 to 6.6 per 1000 population in 2011. However, were fluctutations in the first 7 years; there were 2 peaks in 2002 and 2005 (5.3 per population and 6.4 per 1000 population). After that, the mortality rate slowly increased from 2008 to 2011. Residents who were men, not married, identified as a member of a ethnic minority group, living in poor household on the river side, and low educational attainment experienced higher mortality risk compared to other people. The paper shows the lower mortality rate period 1999-2011 in a rural district in Vietnam compared to WHO estimates for whole country. Sex, marital status, ethnic group, educational level, household economic status, geographic areas were associated significantly with mortality in the population.*

**Keywords: crude mortality rate, mortality trend, predicting factors, rural Vietnam, population-based longitudinal study**

## I. INTRODUCTION

Vital statistic has become one of the main targets in the UN Millennium Development Goals as well as a component of the UN Human Development Index.[1] It was established as a thematic issue of the WHO bulletin. However, the validity of mortality information is still very weak in many countries, especially in low- and middle-income countries. In those nations, deaths normally occur at home without any certification, then the registration of deaths are still incomplete and the figures likely under- and misreported deaths.[2,3]

Vietnam has experienced a demographic transition characterized by decreasing fertility rates and mortality rates over the past two decades.[2,4] The adult mortality rate (15 - 60 years) has decreased from 200 in 1990 to 108 per 1,000 populations in 2011. Life expectancy at birth increased from 67 years in 1990 to 75 years in 2011 for both males and females in general; females tend to live longer than

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males as in many other countries.[5] In addition, an epidemiological transition is happening in Vietnam, a shift in the disease burden from infectious diseases to non-communicable diseases.[2] Reliable data on mortality patterns is thus useful and considered a crucial prerequisite for guiding public health action and for supporting the development of evidence-based health policy.[3,6]

Some studies have indicated that mortality rates are related to age group, sex, ethnicity, geographic and economic conditions.[7-11] In one study in India, child mortality rates were higher in rural than in urban areas. However, there was a larger reduction in rural mortality rates compared to urban ones over time. The mortality rate also related to ethnicity and economic status. Low-income groups have the highest mortality rates. However, it has been decreasing year by year while mortality rates are increasing among middle-income groups.[9] A Swiss National Cohort study showed that mortality rates have slightly decreased but it is various among males and females, diseases, and countries.[12] How it is, however, changing in low- and middle-income countries is still lacking of evidence due to incomplete vital statistic system, especially in Vietnam where the death records are mostly collected from public hospitals.[2,6,10] The Demographic Surveillance Site (DSS) established in Ba Vi District, Vietnam, is known as FilaBavi.[11,13] This study aimed to investigate the mortality pattern in a rural context in Vietnam, over a thirteen-year period (1999 - 2011) as well as to identify predictive factors of mortality of this target population. These findings could be utilized for population-based policy making and planning to reduce the mortality in developing countries.

## II. METHODS

### 1. Data sources

Data used in this research were obtained from a longitudinal health surveillance system in rural Viet Nam called FilaBavi.[13] FilaBavi is located in Bavi district of Vietnam. This is a rural district located in northern Vietnam, 60 km west of Hanoi, the capital. The district has a population of about 238,000 and covers an area of 410 $km^2$, consisting of lowland, highland, and mountainous areas. Agricultural production and livestock breeding are the main economic activities of the local people. FilaBavi's sample was selected randomly with probability proportional to population , whilst covering the range of geographical regions in the district. The sampling unit was hamlet or village sub-division (cluster). The sample included 67 clusters with a total population of about 51,000 inhabitants, and an estimated 11,300 households. The overall design was to create a study base representative of the population in the district, through a baseline household survey, and quarterly demographic surveillance of vital events among the study population subsequently, with a complete re-census every two years.

The household baseline survey was carried out at the beginning of 1999, collecting information at household and individual levels. Re-censuses were conducted every two years. At the household level, information was collected on housing conditions, water resources, latrines, expenditures, income, agricultural land, access to the nearest commune health centre and hospital, and an assessment by the local authorities of the economic status of each household. For each household member, information on age, gender, ethnicity, religion, occupation, education, marital status, etc. was collected. Following the baseline survey, quarterly surveys have been carried out including data on marital status changes, migrations, pregnancy follow-ups, births, and

deaths. A more detailed descriptions of Bavi district as well as the FilaBavi can be found elsewhere.[14]

*Key variables:* In this study, we used the WHO definition for measuring crude death rate as the number of deaths occurring during the year, per 1,000 population, estimated at mid-year.

In this paper, a death case was defined if the household reported a new death case during quarterly household visits. Then crude mortality rates were calculated as the number of death cases divide for midyear of FLBV population each year that equivalent to the total of persons observed in selected households under the sample.

Other key covariates including sex were binary, marital status was dichotomous, and education level was an ordinal variable.

**3. Data analysis**

Data were analysed using Stata statistical software version 10. Both descriptive and analytical statistics are applied. To explore which factors predicted mortality, Cox proportional hazards survival models (Cox model) were computed for all residents participated in the study. A total of 8 covariates were entered simultaneously into the models, including two dichotomous variables (sex and ethnic), and categorical variables (marital status, educational level, occupation, ethnic, economic status, and geographical location and smoking), selected by preliminary identification of variables substantially predictive of mortality risk. The Cox models estimated hazard ratio for each covariate, which indicated the extent to which a covariate was associated with increased mortality as compared with a reference. For some time dependent covariates, creating interactions have been tested.

**4. Ethics**

The protocol of this study was approved by the Scientific and Ethical Committee in Biomedical Research, Hanoi Medical University. All human subjects in the study were asked for their consent before collecting data, and all had complete rights to withdraw from the study at any time without any threats or disadvantages. The Research Ethics Committee at Umeå University has given ethical approval for the FilaBavi household surveillance system, including data collection on vital statistics (reference number 02 – 420) in 1999.

## III. RESULTS

**1. Crude mortality rate and the trend over times**

From 1999 to 2011, 76,305 people received follow up, and 3,653 deaths were recorded. The overall mortality rate increased slighly from 0.42% in 1999 to 0.66% in 2011 (Table 1). However, figure 1 shows a fluctutating trend in first 7 years with 2 peaks in 2002 and 2005 (0.53% and 0.64%, respectively). After that, the mortality rate slowly increased from 2008 to 2011. Table 1 and Figure 1 also demonstrate that the mortality rate in males was higher than that of females in all periods; they had similar trend from 1999 to 2011.

**Table 1. Overall mortality rate in a rural district, Vietnam, 1999 - 2011**

| Year | Population size of Fila Bavi (30 June) | Number of death cases in the year | Crude death rate per 1000 population | | |
|---|---|---|---|---|---|
| | | | Overall | Male | Female |
| 1999 | 49,447 | 206 | 4.17 | 4.5 | 3.9 |
| 2000 | 49,558 | 244 | 4.92 | 5.4 | 4.4 |
| 2001 | 49,389 | 261 | 5.28 | 5.7 | 4.9 |
| 2002 | 49,542 | 264 | 5.33 | 6.4 | 4.4 |
| 2003 | 48,946 | 246 | 5.03 | 5.7 | 4.4 |
| 2004 | 48,940 | 270 | 5.52 | 6.4 | 4.6 |
| 2005 | 49,400 | 300 | 6.07 | 7.1 | 5.1 |
| 2006 | 49,487 | 288 | 5.82 | 6.5 | 5.2 |
| 2007 | 51,260 | 272 | 5.31 | 6.0 | 4.6 |
| 2008 | 51,152 | 316 | 6.18 | 6.9 | 5.5 |
| 2009 | 51,582 | 318 | 6.16 | 7.1 | 5.3 |
| 2010 | 51,815 | 323 | 6.23 | 7.1 | 5.5 |
| 2011 | 52,608 | 345 | 6.56 | 7.0 | 6.1 |

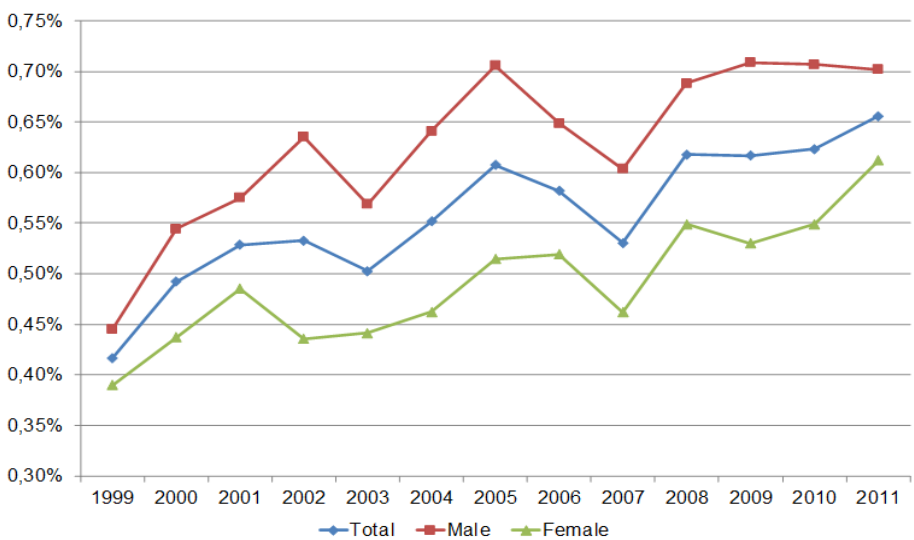


**Figure 1. Overal mortality rate over time, period 1999-2011, in a rural district Vietnam**

Figure 2 shows that the number of deaths fluctuated throughout the year ; after decreasing in February (the time of the Vietnamese New Year festivities), the number of deaths rose in March to 356 before decreasing during the following month. The last three months of the year saw the number of deaths rise from 266 to 325.

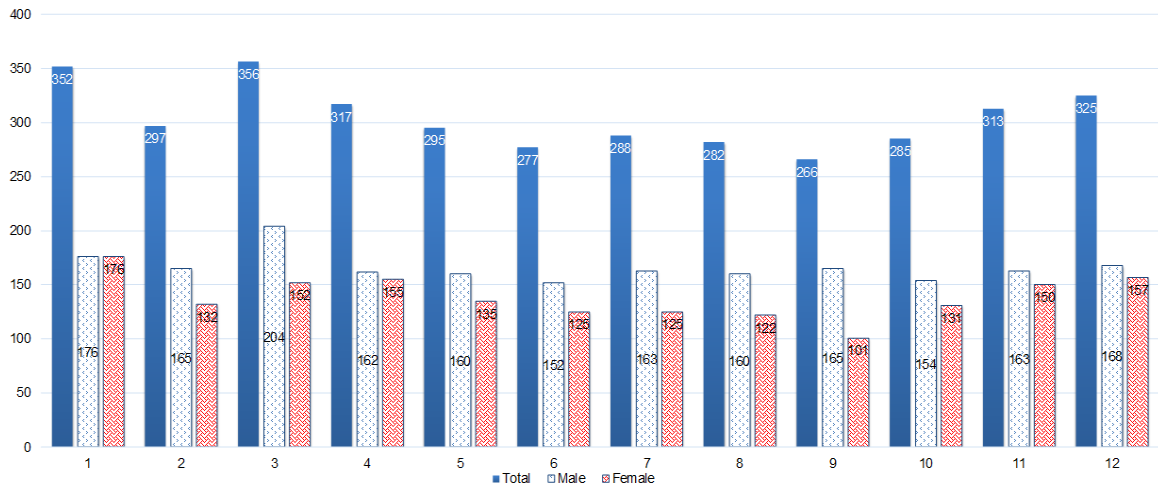


**Figure 2. Number of deaths by month during the year (lunar calendar), 1999 - 2011**

## 2. Mortality Patterns Over Time

Table 2 shows the demographic characteristics of the deceased. Proportion of male deaths was 54.53%, which was higher than that of females (45.47%).

When age was considered, the percentage of deaths of children younger than 5 years old was 4.9%. The percentage of total deaths among children 6-14 years old was 1.62%, 12% among the 15 - 44, 60 - 69, and 70 - 79 year age groups. The percentage of deaths peaked at 23.98% among the 80-89 year age group, before levelling off at 10.95% among the 90 and over age group.

Of the deceased, 92.55% of people who died were married, 93.98% were ethnically Kinh, and 96.17% did not practice any religion (Table 2).

**Table 2. Demographic characteristics of the deceased in a rural district of Bavi, Vietnam, 1999 - 2011**

| Variable | n | % |
|---|---|---|
| **Sex** | | |
| Male | 1,992 | 54.53 |
| Female | 1,661 | 45.47 |
| **Age groups** | | |
| <= 5 | 179 | 4.9 |
| 6 - 14 | 59 | 1.62 |
| 15 - 44 | 455 | 12.46 |
| 45 - 59 | 452 | 12.37 |
| 60 - 69 | 404 | 11.06 |
| 70 - 79 | 828 | 22.67 |
| 80 - 89 | 876 | 23.98 |
| >= 90 | 400 | 10.95 |

| Variable | n | % |
|---|---|---|
| **Marital status** | | |
| Married | 102 | 2.79 |
| Divorced | 3 | 0.08 |
| Widowed | 67 | 1.83 |
| Single | 100 | 2.74 |
| No answer/do not know | 3,381 | 92.55 |
| **Ethnicity** | | |
| Kinh | 3,433 | 93.98 |
| Others | 220 | 6.02 |
| **Religion** | | |
| None | 3,513 | 96.17 |
| Catholic | 75 | 2.05 |
| Buddism | 3 | 0.08 |
| Missing | 62 | 1.7 |
| **Main occupation** | | |
| Hard work | 53 | 1.45 |
| Middle work | 18 | 0.49 |
| Minor work | 197 | 5.39 |
| Others | 3,385 | 92.66 |
| **Economic status according commune people's committee assessment** | | |
| Very poor | 20 | 0.55 |
| Poor | 272 | 7.53 |
| Average | 1,143 | 31.64 |
| Upper average | 236 | 6.53 |
| Rich | 35 | 0.97 |
| None classified | 1,906 | 52.77 |

**3. Predicting factors of mortality of the population**

The hazard ratios for mortality adjusted for 8 covariates are given in the Table 3. It shows that sex, marital status, ethnicity, educational level, economic status and geographical area are highly significant in the model. In the simplified model without control for occupation and smoking, people who were not identified as having Kinh ethnicity were associated with increased mortality as compared with women or Kinh ethnicity (HR = 1.14, 95%CI: 1.12 - 1.16) and HR = 1.12, 95%CI: 1.08-1.17). The crude mortality rate among women and men was 13.16 and 19.15 per 10 000 person-years, respectively. The rates among Kinh and other ethnicities were 15.58 and 21.45, respectively.

Similarly, people who were single/divorced/widowed had an increased hazard ratios than people who was married (HR = 2.51, 95%CI: 2.46 - 2.57).

**Table 3. Predictive factors of mortality in a rural district, Vietnam, 1999-2011**

| Variable | Death/10000 years | Crude Hazard ratio (95%CI) | Adjusted Hazard ratio (95%CI) |
|---|---|---|---|
| **Sex** | | | |
| Women | 13.16 | 1 | 1 |
| Men | 19.15 | 1.10 (1.09 - 1.12) | 1.14 (1.12 – 1.16) |
| **Marital status** | | | |
| Married | 1.67 | 1 | 1 |
| Single/Divorced/Widowed | 4.95 | 2.23 (2.19 - 2.27) | 2.51 (2.46 – 2.57) |
| **Ethnic** | | | |
| Kinh | 15.58 | 1 | 1 |
| Others | 21.45 | 1.09 (1.05 – 1.13) | 1.12 (1.08 – 1.17) |
| **Educational level** | | | |
| Illetarate/Primary school | 34.17 | 1 | 1 |
| Secondary school | 8.32 | 0.70 (0.69 – 0.72) | 0.78 (0.77 – 0.81) |
| High school | 4.25 | 0.47 (0.46 – 0.48) | 0.51(0.49 – 0.52) |
| College/University | 6.11 | 0.59 (0.57–0.60) | 0.63 (0.61 – 0.64) |
| **Economic status** | | | |
| Poor/very poor | 28.51 | 1 | 1 |
| Average | 17.12 | 0.84 (0.81 – 0.87) | 0.93 (0.89 – 0.97) |
| Upper average/rich | 14.92 | 0.88 (0.84 – 0.92) | 0.97 (0.90 – 1.03) |
| **Geographical area** | | | |
| Hill | 15.28 | 1 | 1 |
| Moutainous area | 15.22 | 0.99 (0.98 – 1.02) | 0.97 (0.95 – 1.01) |
| River sides | 17.48 | 1.12 (1.09 – 1.15) | 1.10 (1.07 – 1.12) |
| Middle of the river | 13.75 | 0.99 (0.94 – 1.05) | 0.90 (0.85 – 0.96) |

However, results from the table also show that, people who had a higher level of education had a decreased hazard ratio compared to people with only a primary school education or were illiterate (for high school: HR = 0.51, 95%CI: 0.49 - 0.52). The death rate in people who were illiterate or had a primary school education was 34.17 per 10 000 person-years, compared with people at other levels of education.

Similarly, poor/very poor people were associated with increased mortality as compared with middle class or rich people (for average living standard: HR = 0.93, 95%CI: 0.89 - 0.97 and for rich

living standard: HR = 0.97, 95%CI: 0.90 - 1.03).

Finally, people living by riverss had a higher hazard ratio compared to people living in mountainous areas (HR = 1.10, 95%CI: 1.07 - 1.12).

## IV. DISCUSSION

In this study, we have demonstrated the overall mortality rate, the trend of mortality over 12-year period 1999 - 2011, and predicting factors of mortality from the population-based longitudinal study in a rural district of Vietnam. The findings would be useful for guiding public health action and for supporting the development of evidence-based health policy.[3,6]

The study found that the overall mortality rate during the period 1999 - 2011 had increased from 4.17 per 1000 population to 6.56 deaths per 1000 population. This figure was initially lower than the national average for the period of 1999 - 2007. Then mortality reached the national average in 2008 - 2009. However, the mortality rate in the studied area was higher in 2010 and 2011 than the national average (2010: 6.23 vs 5.97 and 2011: 6.56 vs 5.96).[15] This finding highlights the challenge for local health systems when the crude mortality rate of whole country declined but the popularity of the district has increased. The gap might be explained by the fact that the crude mortality rate of the whole country is based on a reporting system that might be incomplete. In Vietnam, health system factors that contribute to under-reported mortality rate due include the absence of both benefits for reporting and legal sanctions for not reporting a death case.[3] Generally, predictive factors found in this study were similar to previous studies from Vietnam[2,6,10,11,16] and other developing countries.[7-11] Sex, marital status, ethnic group, educational level, household economic status, geographic areas were significantly associated with increased mortality in this population. These findings suggest that male, non-married, minority ethnic group, low educational level, poor households and household in river side area should be prioritized in reducing mortality rate in the similar setting.

Males had an increased mortality risk compared to females, which was similar to previous studies.[6,10,11,12,17] Much of the difference can be explained by the combined effects of unhealthy behaviors such as smoking tobacco, alcohol consumption and other exposures that lead to injuries.[18] Apart from injuries, Vietnamese males have been observed to be at a significantly increased risk of cancer when compared to females.[17,19,20,21] Narrowing of this gap will be a major challenge for Vietnam.

Similar to past studies, this study found that people living in rural areas had an increased risk of mortality compared to other areas.[6,9,10,11,22] It might be partially explained by the fact that rural districts were at higher risk of exposure to newborn, maternal, infant, HIV/AIDs and all types of infections; road traffic injury mortality and well as cancer and all injury causes. Generally, rural districts were at a significantly increased risk of newborn and infant mortality. In addition, findings related to economic status and education level were consistent with previous studies . Poor people, low education attainment, and non-Kinh people were associated with increased morbidity and lower access to quality of health services that may lead to higher mortality rates.[22] This finding may help to target health resource allocation more effectively and guidance towards future programming as the MDG deadlines approaches.

This study was the first attempt to determine whether marital status was significantly

associated with mortality risk; married people experienced lower mortality than others. Further study on mortality and marital status should be further explored.

***Limitations of the study***

The study has some strengths and weaknesses. This study is a population based with a large sample size that was randomly selected in order to reflect the true studied population.[13] Thus, the findings of this study can be generalized to the studied population and to any other country's population similar to Vietnam. In addition, this is a longitudinal study that allows the researcher to draw the trend of the mortality over time.

However it is also important to stress the weaknesses in this type of study. First, the specific-cause of death was not gathered, which could have given more clarity in determining predictive factors.[6,11,23,24,25,26,27] In addition, other factors are known to be associated with mortality which were not available for analyzing under the current study, such as alcohol consumption[28 - 33] and weather factors.[34,35]

## V. CONCLUSION

The paper shows the low mortality rate period 1999 - 2011 in a rural district in Vietnam compared to WHO estimates for the whole country. Sex, marital status, ethnic group, educational level, household economic status, geographic areas were associated significantly with the mortality in the population.

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## REFERENCES

1. Hill K. Making deaths count. *Bull World Health Organ*, 2006, 84: 162.

2. Hoi le V, Phuc HD, Dung TV, Chuc NT, Lindholm L. Remaining life expectancy among older people in a rural area of Vietnam: trends and socioeconomic inequalities during a period of multiple transitions. *BMC Public Health*, 2009, 9: 471.

3. Huy TQ, Johansson A, Long NH. Reasons for not reporting deaths: a qualitative study in rural Vietnam. *World Health Popul*, 2007, 9: 14-23.

4. GSO. The population change and family planning survey 2006, 2007, Hanoi.

5. WHO Global Health Observatory (GHO): Life expectancy. *WHO*.

6. Ngo AD, Rao C, Hoa NP, Hoy DG, Trang KT, et al. Road traffic related mortality in Vietnam: evidence for policy from a national sample mortality surveillance system. *BMC Public Health*, 2012, 12: 561.

7. Gillum RF, Mehari A, Curry B, Obisesan TO. Racial and geographic variation in coronary heart disease mortality trends. *BMC Public Health*, 2012, 12: 410.

8. Hufanga S, Carter KL, Rao C, Lopez AD, Taylor R. Mortality trends in Tonga: an assessment based on a synthesis of local data. *Popul Health Metr*, 2012, 10: 14.

9. Minnery M, Jimenez-Soto E, Firth S, Nguyen KH, Hodge A. Disparities in child mortality trends in two new states of India. *BMC Public Health*, 2013, 13: 779.

10. Byass P. Patterns of mortality in Bavi, Vietnam, 1999-2001. *Scand J Public Health Suppl*, 2003, 62: 8-11.

11. Huong DL, Minh HV, Vos T, Janlert U,

Van do D, et al. Burden of premature mortality in rural Vietnam from 1999-2003: analyses from a Demographic Surveillance Site. *Popul Health Metr*, 2006, 4: 9.

12. Schmidlin K, Clough-Gorr KM, Spoerri A, Egger M, Zwahlen M. Impact of unlinked deaths and coding changes on mortality trends in the Swiss National Cohort. *BMC Med Inform Decis Mak*, 2013, 13: 1.

13. Chuc NT, Diwan V. FilaBavi, a demographic surveillance site, an epidemiological field laboratory in Vietnam. *Scand J Public Health Suppl,* 2003, 62: 3-7.

14. Chuc NTK, Diwan VK. FilaBavi, a demographic surveillance site, an epidemiological field laboratory in Vietnam. *Scand J Public Health*, 2003, 31: 3-7.

15. Ministry of Health. *National Health Survey*, 2012, Hanoi.

16. Hoa NP, Thorson AE. Excess mortality and tuberculosis among individuals with prolonged cough: a population-based study from Vietnam. *Int J Tuberc Lung Dis*, 2006, 10: 851-856.

17. Ngoan le T, Anh NT, Huong NT, Thu NT, Lua NT, et al. Gastric and colo-rectal cancer mortality in Viet Nam in the years 2005-2006. *Asian Pac J Cancer Prev*, 2008, 9: 299-302.

18. Murray CJ, Lopez AD. Global mortality, disability, and the contribution of risk factors: Global Burden of Disease Study. *Lancet*, 1997, 349: 1436-1442.

19. Ngoan le T, Lua NT, Hang LT. Cancer mortality pattern in Viet Nam. *Asian Pac J Cancer Prev*, 2007, 8: 535-538.

20. Ngoan le T. Cancer mortality in a Hanoi population, Viet Nam, 1996-2005. *Asian Pac J Cancer Prev*, 2006, 7: 127-130.

21. Ngoan le T. Development of population-based cancer mortality registration in the North of Viet Nam. *Asian Pac J Cancer Prev*, 2006, 7: 381-384.

22. Huong DL, Minh HV, Byass P. Applying verbal autopsy to determine cause of death in rural Vietnam. *Scand J Public Health Suppl*, 2003, 62: 19-25.

23. Hoang VM, Dao LH, Wall S, Nguyen TK, Byass P. Cardiovascular disease mortality and its association with socioeconomic status: findings from a population-based cohort study in rural Vietnam, 1999-2003. *Prev Chronic Dis*, 2006, 3: A89.

24. Minh HV, Byass P, Wall S. Mortality from cardiovascular diseases in Bavi District, Vietnam. *Scand J Public Health Suppl*, 2003, 62: 26-31.

25. Moharamzad Y, Taghipour H, Hodjati Firoozabadi N, Hodjati Firoozabadi A, Hashemzadeh M, et al. Mortality pattern according to autopsy findings among traffic accident victims in Yazd, Iran. *Chin J Traumatol,* 2008, 11: 329-334.

26. Rish BL, Dillon JD, Weiss GH. Mortality following penetrating craniocerebral injuries. An analysis of the deaths in the Vietnam Head Injury Registry population. *J Neurosurg*, 1983, 59: 775-780.

27. Murray CJ, Lopez AD. Mortality by cause for eight regions of the world: Global Burden of Disease Study. *Lancet*, 1997, 349: 1269-1276.

28. Boyle SH, Mortensen L, Gronbaek M, Barefoot JC. Hostility, drinking pattern and mortality. *Addiction*, 2008, 103: 54-59.

29. Laatikainen T, Manninen L, Poikolainen K, Vartiainen E. Increased mortality related to heavy alcohol intake pattern. *J Epidemiol Community Health*, 2003, 57: 379-384.

30. Morch LS, Johansen D, Lokkegaard E, Hundrup YA, Gronbaek M. Drinking pattern and mortality in Danish nurses. *Eur J Clin Nutr*, 2008, 62: 817-822.

31. Murray RP, Connett JE, Tyas SL, Bond R, Ekuma O, et al. Alcohol volume, drinking pattern, and cardiovascular disease morbidity

and mortality: is there a U-shaped function? *Am J Epidemiol*, 2002, 155: 242-248.

32. Tolstrup JS, Jensen MK, Tjonneland A, Overvad K, Gronbaek M. Drinking pattern and mortality in middle-aged men and women. *Addiction*, 2004, 99: 323-330.

33. Trevisan M, Schisterman E, Mennotti A, Farchi G, Conti S. Drinking pattern and mortality: the Italian Risk Factor and Life Expectancy pooling project. *Ann Epidemiol*, 2001, 11: 312-319.

34. Zanobetti A, Schwartz J, Samoli E, Gryparis A, Touloumi G, et al. The temporal pattern of mortality responses to air pollution: a multicity assessment of mortality displacement. *Epidemiology*, 2002, 13: 87-93.

35. Zanobetti A, Schwartz J, Samoli E, Gryparis A, Touloumi G, et al. The temporal pattern of respiratory and heart disease mortality in response to air pollution. *Environ Health Perspect*, 2003, 111: 1188-1193.