THE SIGNIFICANT EFFECT INFLUENCING THE CHANGE OF MORTALITY RATE BETWEEN 1997 AND 2006

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ABSTRACT: After validating cause-of-death data following the modeled structure from verbal autopsy study, Katagawa decomposition technique was employed. The results provide evident that age effect and rate effect have affected population health. Age or demography effect consequently results in increasing of overall mortality, as well as three board causes of death, and some diseases which often relate to an increase with age and with accumulative risk over lifetime or degenerative disease. Whereas rate or epidemiologic effect has contributed to substantial changes either upward or downward mortality rate through complex nature of that disease and social context. Considering comparison of the percentage changes in age-adjusted mortality rates between age effect and rate effect influencing the increasing in specific-cause mortality rate, it seems ironic that rate effect was stronger than age effect. These findings indicated that enhancing comprehensively the relation of demography transition and epidemiologic transition is crucial for achieving public health policies of disease control and prevention.

Keywords: Kitagawa decomposition technique, changing of mortality rates

INTRODUCTION

Thailand has passed through the demographic and epidemiologic transitions since the beginning of the 1960s [1] and in median of industrialization [2]. It's empirical that accurate information is essential for the development of the country including the accurate health information used as lifeblood of decision-making to provide valid health propositions in developing public health policies and administrating public health campaigns [3]. Therefore, the system of vital registration was created for recording of vital status (birth, marriage, divorce and death) at state level and local level. It is also widely used as the primary source of information to track the health conditions; plan, implement, and evaluate health and social services. In other words, the strength of the vital records and statistics system provides complete census of events allowing for population-based analysis. But in most of the developing countries, this system is still in the developing stage. Likewise, Thailand's cause of death data are of limited use because the quality of these data is often inadequate both in terms of underreporting and misclassification. During the past two decades, although the coverage of recording by age, sex, and place at death has steadily improved nearly 95% but the content validity of causes of death report through medical certificate raises solely to 35% [4].

Consequently, the two verbal autopsy studies in 1997-1999 [5] and in 2005 [6] including demographic technique are necessary to improve the data quality for an access to the valid health information.

Changes in disease patterns are usually recognized in both demographic and epidemiologic changes. Between 1997 and 2006, demographic data show increasing of population from 60,466,243 to 62,623,416 and the proportion of elderly (60 and over) from 6.8% to 13.4% including the increasing number of deaths around 91,000 cases [4]. Kitagawa decomposition technique (1955) is chosen to explain and understand the changes of mortality rates for determinant strategic public health activity by using relationship between crude mortality rate and standardized rate [7].

The aim of the study is to investigate the significant effect on the changes of mortality rates by Kitagawa's decomposed technique. This method enables the separation of differences in mortality rates into three additive effects; Age effect of demographic change measures difference in size of population on specific age structure between 1997 and 2006, rate effect or epidemiologic change measures difference in age-specific mortality rate, and interaction effect measures the interaction between the change of the age effect and rate effect as the same period.

METHODOLOGY

Data used were taken from national vital registration system. The first two data sets were the annual death registration data in the year 1997 and

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in the year 2006. The other two data sets were age-sex mid-year population in the same year. An underlying cause of death in the annual death registration data was translated into the Tenth Revision International Classification of Disease code (ICD-10) by Ministry of Public Health. All deaths and conditions were classified according to the 2005 Global Burden of Disease Study systematic [8]. The health problems were grouped in a tree-like structure with three basic causes of death as follows: Group 1 communicable disease, maternal, prenatal and nutrition disorder, Group 2 non-communicable disease and chronic disease, and Group 3 external causes of death. Each group is divided into major subcategories that are mutually exclusive. These subcategories are ordered into the third and the forth levels to identify specific cause of death. Then death data were extracted for specific cause of death by five-year age group and sex. Before mortality estimating, cause-of death data need to be adjusted with underreporting and misclassification. Firstly, different errors in the coverage of death data in defined year were adjusted with 100% completeness following the results of Survey of Population Change in round 4 (1995-1996), round 5 (2005-2006) for specific child group under 10 years and of Preston and Coale Method for age group after 10 years (Appendix 1). Lastly, cause of death data has to be validated according to the modeled structure of the two verbal autopsy studies (in 1997-1999 [5] and in 2005 [6]) for seven age groups based on the assumption that increased or decreased number of death for its age group or underlying cause of death of five-year age group has the same distribution pattern as mortality pattern in vital registration data. After adjusting the data, ill-defined or undetermined cause of death would reduce from 34.5% to 12.37% in 1997 and 38.1% to 5.43% in 2006.

In the study, crude death rate, three disease group death rate, and specific-cause death rate were decomposed by Kitagawa's method based on the assumption of completing cause of death [9] that an underlying cause of death originated independently and does not have potential to develop a new cause or the stable cause of death. The results showed the three additive effects: age effect or changing population age structure, rate effect or changing age-specific mortality rate and interaction effect will affect with different amount. The higher value is the greater impact. When the result shows positive effect on mortality (+) that contributes to mortality increase, while negative effect (-) leads to decrease in mortality. This procedure was done as follows:

$CDR_{2006} - CDR_{1997}$ = Age effect + Rate effect – Interaction effect
Age effect = CDR 2006 – DS-CDR rate 2006, age 1997
Rate effect = CDR 2006 – DS-CDR rate 1997, age 2006

Appendix 1 The percentage of death registration coverage of Thailand in 1997 and in 2006

Age Groups	1997		2006	
	Male	Female	Male	Female
Less 1 Year[/1]	67.6	62.3	96.5	85.4
1-4 years [/1]	75.0	72.7	86.6	100.0
5-9 years [/1]	85.7	80.0	95.6	100.0
10-69 years [/2]	85.0	95.0	85.0	95.0
70 years and over	85.0	95.0	85.0	95.0

Source [/1] National Statistics Office, Survey of Population Change 1995-1996 and 2005-2006
[/2] Preston and Coale Method calculated from 2000 population census data

Hereby, CDR is crude death rate and DS-CDR is direct standardization technique.

RESULTS

Overall mortality in Thailand between 1997 and 2006

As the starting point, comparison causes of mortality in 1997 and in 2006 were examined. Table 1 reveals the results that HIV (11.67% of all deaths), road traffic injury (7.20%) cerebrovascular diseases (8.57%), and liver cancer (5.43%) were the first four causes of death in 1997. In 2006, three of them tended to decrease including HIV (6.66%), road traffic accident (5.59%) and liver cancer (3.81%), but only cerebrovascular disease increased to rank as the first cause of death from 8.57% of all deaths in 1997 to 9.86% of all deaths in 2006. Ischemic heart disease increased and ranked as the second cause of death in the 2006 or raised nearly double proportion of all death from 4.09% in 1997 to 7.43% of all deaths in 2006. Also slight increases for some diseases occurred including chronic obstructive pulmonary diseases (from 3.60% in 1997 to 4.36% in 2006), cirrhosis of the liver (from 2.53% in 1997 to 3.91% in 2006), lower respiration infection (from 1.74% in 1997 to 3.36% in 1997), and etc. Additionally, three diseases not showing figure on the top fifteen causes in 2006 were diabetes mellitus, pancreas cancer, violent/homicide while the prominence of hypertension disorder, fall, colon, and rectum cancer emerged in the first fifteen causes in 2006.

When comparing mortality by standardized rates in the study period the overall mortalities approximate the same level from a rate of 696.02 per 100,000 in 1997 to 700.67 per 100,000 in 2006. For particular diseases, the results raked by the frequency of death were generally consistent with the mortality rate. For example, decline of HIV and road traffic injury shows that age-adjusted rate in 1997 was higher than the corresponding crude rate in 2006, whereas increasing of cerebrovascular disease and ischemic heart diseases were having higher mortality rate in 2006 than age-adjusted mortality rate in 1997. The three new emergent diseases (hypertension, fall, and

Table 1 Comparison the leading cause of death by percentage of death and mortality rate, Thailand, between 1997 and 2006

Leading causes of death in 1997	%	Mortality Rate (per 100,000)	Leading causes of death in 2006	%	Mortality Rate (per 100,000)
1. HIV	11.67	65.93	1. Cerebrovascular disease	9.86	69.10
2. Cerebrovascular disease	8.57	48.42	2. Ischemic heart disease	7.43	51.49
3. Road traffic injury	7.20	40.69	3. HIV	6.66	46.66
4. Liver cancer	5.43	30.67	4. Road traffic injury	5.59	39.15
5. Diabetes mellitus	4.62	26.08	5. Chronic obstructive pulmonary disease	4.36	30.57
6. Ischemic heart disease	4.09	23.11	6. Cirrhosis of the liver	3.91	27.39
7. Chronic obstructive pulmonary disease	3.60	20.32	7. Liver cancer	3.81	26.70
8. Cirrhosis of the liver	2.53	14.30	8. Lower respiration infection	3.36	24.46
9. Nephritis and nephrosis	2.38	13.42	9. Nephritis and nephrosis	2.94	20.72
10. Self-inflicted injuries	2.38	13.42	10. Trachea, bronchus and lung cancer	2.52	17.64
11. Pancreas cancer	2.23	12.62	11. Hypertensive disorder	2.11	14.77
12. Tuberculosis	2.07	11.71	12. Self-inflicted injuries	2.02	14.13
13. Trachea, bronchus and lung cancer	2.07	11.69	13. Tuberculosis	1.60	11.21
14. Violent / Homicide	1.81	10.24	14. Falls	1.49	10.47
15. Lower respiration infection	1.74	9.83	15. Colon and rectum Cancer	1.48	10.37
Total deaths = 341,532			Total deaths = 438,783		

Table 2 Comparison of the age-adjusted mortality rate in 1997 and mortality rate in 2006 by the first fifteen leading causes of death, Thailand

Leading causes of death	Age-adjusted of Mortality rate (per 100,000) in 1997*	Mortality rate (per 100,000) in 2006	Percentage difference
All causes	696.02	700.67	+0.67
1. Cerebrovascular diseases	65.51	69.10	+5.48
2. Ischemic heart disease	30.22	51.49	+70.38
3. HIV	69.90	46.66	-33.25
4. Road traffic injury	41.47	39.15	-5.59
5. Chronic obstructive pulmonary disease	28.38	30.57	+7.72
6. Cirrhosis of the liver	17.61	27.39	+55.54
7. Liver cancer	39.97	26.70	-33.20
8. Lower respiration infection	9.83	24.46	+148.83
9. Nephritis and nephrosis	17.21	20.72	+20.40
10. Trachea, bronchus and lung cancer	14.82	17.64	+19.03
11. Hypertensive disorder disease	0.03	14.77	+492.33
12. Self-inflicted injuries	14.10	14.13	+0.21
13. Tuberculosis	15.02	11.21	-25.37
14. Fall	2.17	10.47	+382.49
15. Colon and rectum cancer	1.82	10.37	+469.78
16. Violent / Homicide	10.84	9.20	-15.13
17. Diabetes Mellitus	33.57	6.59	-80.37
18. Pancreas cancer	17.08	2.74	-83.96

* Direct standardized mortality rates by using the population in 2006 as reference population

colon and rectum cancer) had increased with significant percentage accounting for 492.33 %, 382.49%, and 469.78 % respectively (Table 2).

Kitagawa' s components on crude death rate

The significant effect on the difference between two mortality rates in 1997 and 2006 is measured by the change of mortality rate and the change of age structure by using the relationship between crude death rate and standardized rate or Kitagawa decomposition technique (1955). The interpretation of the finding should be cautious with the sign of the effect (+/-). If it is a positive effect on mortality, it would contribute to mortality increase. On the other hand, the negative effect would be in an opposite direction or mortality decrease.

Table 3 presents the differences of crude death rates grouped by sex and Kitagawa's components. The results conclude that the overall increase of crude mortality rate from 1997 to 2006 was mainly

Table 3 Summary of Kitagawa's components on crude death rate by gender between 1997 and 2006

Summary Crude Death Rate	CDR 1997 (per 100,000)	CDR 2006 (per 100,000)	Age effect	Rate effect
All mortality	564.83	700.67	+142.40	+4.65
Male	713.24	845.52	+152.13	-4.25
Female	417.38	559.46	+131.46	+18.31

*CDR = Crude Death Rate

Table 4 Summary of Kitagawa's components on three broad categories of deaths by gender, Thailand, between 1997 and 2006

Three broad categories of death	CDR 1997 (per 100,000)	CDR 2006 (per 100,000)	Age effect	Rate effect
1. Communicable diseases	108.99	113.95	+17.32	-4.98
Male	156.40	144.37	+20.13	-25.01
Female	61.89	84.28	+14.38	+15.85
2. Non-communicable diseases	300.82	458.27	+106.93	+72.44
Male	351.70	520.23	+114.60	+75.96
Female	250.27	397.87	+98.15	+71.66
3. External causes	85.10	90.38	+5.98	+2.14
Male	138.18	148.05	+119.48	+5.67
Female	32.35	34.15	+3.96	-0.33

*CDR = Crude Death Rate

affected by changing of age structure, greater than changing of mortality rate. It can be simplified that the increasing of the population age structure was strongly influenced on increasing of crude mortality rate. Carefully considering the changes of crude mortality rates by sex, the most important contribution to increase in crude mortality rate was age effect occurring for both males (+152.13) and females (+131.46). This finding gives a justification that age effect value is with greater effect than rate effect value (rate effect -4.25 for male and +18.31 for female). However, the results show that for the rate effect attributing increasing of mortality there was a positive sign seen on overall mortality and female mortality. Also, the apparent result of the negative rate effect on male mortality means that mortality rates among males were declining.

Additionally, result presentation could be reported with percentage difference of change or Kitagawa adjustment [10]. This method suggests to use proportion of rate effect (or proportional difference of crude death rate in 2006 and age-adjusted mortality 1997) in related to crude death rate in 2006 and multiplied by 100. Based on Kitagawa adjustment, the percentage difference of change for males (-4.25/845.52)X100 = -0.50. Change of life expectancy can be viewed from mortality situation. It' s clear that total life expectancy at birth among males had increased by half a year or 0.5 year as a result from decrease in male mortality from 1997 to 2006. For female, that is (+18.31/559.46)X100 = +3.24 it is indicating that the life expectancy at younger age gradually improved for males but substantially declined for females. The gender differences in life expectancy at birth appeared to be narrowing from 1997 to 2006 due to mortality declines in male from infection diseases.

Kitagawa's components on three broad categories death rates

There have been continuous improvements of mortality in Thailand. Although crude mortality rate remains on level from a year to a year, the cause-specific mortality rate and age specific mortality are in progress. With widely considering crude death rate of three board categories which were observed during 1997 to 2006, the results indicate that crude mortality rates from communicable diseases, non-communicable diseases, and external causes of death slightly increased. When these mortality rates were decomposed by Kitagawa technique, all age effects showed positive effect and those values are higher than rate effects. Therefore, the major contribution to the increases of mortality of three broad categories from 1997 to 2006 was demographic changes. Also rate effects or changes of mortality rates from non-communicable diseases and external causes contribute to mortality increase with an exception that rate effect from communicable diseases was negative contributor. It's obvious that rate effect played an important role on decreases of male morality for communicable diseases but it was insufficient to offset the effect of changes in age structure (Table 4). On the other hand, decreased mortality of communicable diseases among males had mainly affected on rate effect contracted to increased mortality among females. So this group had mainly effect on both rate effect (+15.85) and age effect (+14.38).

Kitagawa's components on primary cause-specific death rate

Table 5 summarizes the result of Kitagawa's components on leading causes of death from 1997 to 2006. Indeed, mortality rate is composed of population age structure and age-specific mortality

Table 5 Summary of Kitagawa's component on cause-specific death rates, Thailand, between 1997 and 2006

Leading causes of death	CSDR 1997 (per 100,000)	CSDR 2006 (per 100,000)	Age effect	Rate effect
1. Cerebrovascular diseases	48.42	69.10	+18.88	+4.00
2. Ischemic heart disease	23.11	51.46	+13.70	+21.27
3. HIV	65.93	46.66	+4.07	-23.25
4. Road traffic injury	40.69	39.15	+0.52	-2.32
5. Chronic obstructive pulmonary diseases	20.32	30.57	+8.71	-2.19
6. Cirrhosis of the liver	14.30	27.39	+5.48	+9.78
7. Liver cancer	30.67	26.70	+5.78	-13.26
8. Lower respiration infection	9.83	24.46	+7.12	+14.63
9. Nephritis and nephrosis	13.42	20.72	+4.88	+3.51
10. Trachea, bronchus and lung cancer	11.69	17.64	+3.96	+2.82
11. Hypertensive disorder disease	0.03	14.77	+4.11	+14.74
12. Self-inflicted injuries	13.42	14.13	+1.46	+0.03
13. Tuberculosis	11.71	11.21	+2.72	-3.81
14. Fall	1.43	10.47	+2.61	+8.30
15. Colon and rectum cancer	1.38	10.37	+2.40	+8.55
16. Violent / Homicide	10.23	9.20	+0.34	-1.64
17. Diabetes mellitus	26.08	6.59	+1.20	-26.98
18. Pancreas cancer	12.62	2.74	+0.68	-14.34

*CSDR = Cause-Specific Death Rate

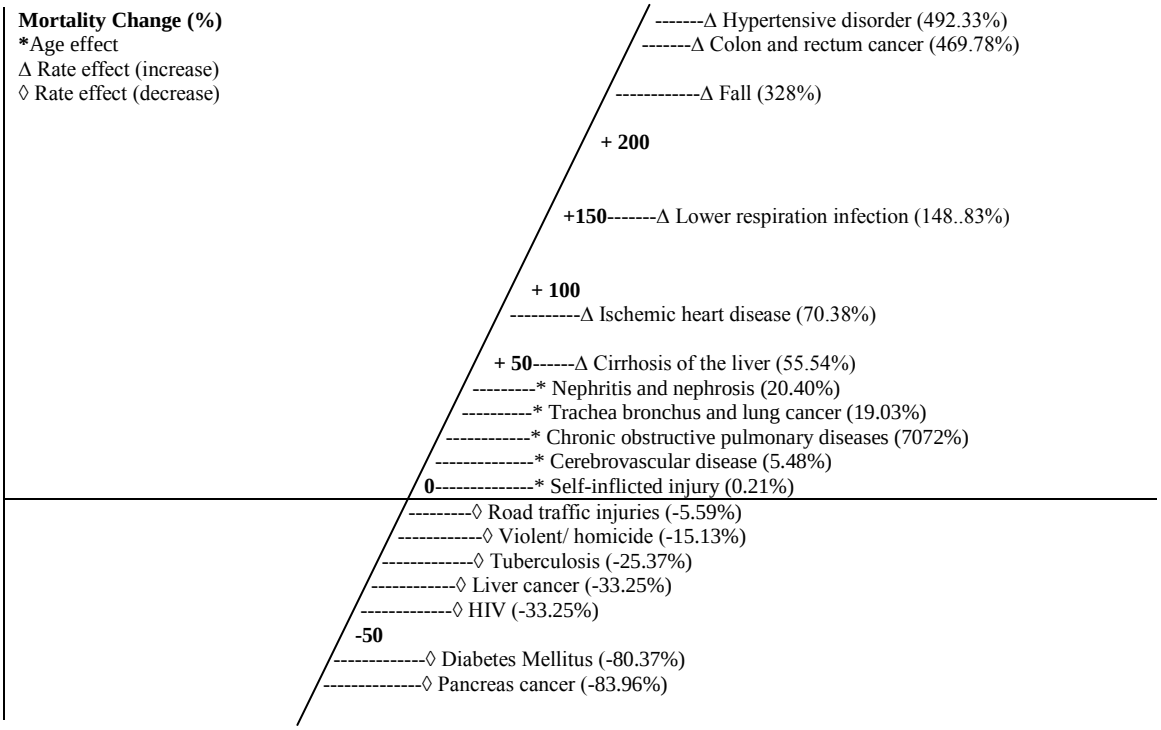

Figure 1 Percentage changes in age-adjusted mortality rate of leading causes of mortality labeled by the result of Kitagawa's decomposing, Thailand, 1997 – 2006

rate. The increased population from 1997 to 2006 can directly affect the increase of the mortality rates. But rate effect can be affected whenever there is an outbreak or pandemic of some diseases. Their rate effects might be strong influences on sharply increasing mortality. On the other hand, if the effective measures to treat or prevent diseases are available, the mortality rates may result in decreasing. The finding can be summarized as follows:

the first group: increase in mortality is strongly influenced by changing of age structure or increasing in population occurring due to five diseases, cerebrovascular disease (age effect vs. rate effect = +18.88 vs. +4.0), chronic obstructive pulmonary diseases (+8.71 vs. -2.19), nephritis and nephrosis (+4.88 vs. +3.51), trachea, bronchus and lung cancer (+3.96 vs. +2.82), self-inflicted injuries (+1.46 vs. +0.03).

the second group: increase in mortality is strongly influenced by increasing of mortality rate such as ischemic heart disease (+13.70 vs. +21.27), cirrhosis

of the liver (+5.48 vs. +9.78), lower respiration infection (+7.12 vs. +14.63), hypertension disorder diseases (+4.11 vs. +14.74), fall (+2.61 vs. +8.30), colon and rectum cancer (+2.40 vs. +8.55).

the third group: decrease in mortality is greatly affected by decreasing of mortality rate occurring for HIV (+4.07 vs. -23.25), road traffic injury (+0.52 vs. -2.32), liver cancer (+5.78 vs.-13.26), violent / homicide (+0.34 vs.-1.64), diabetes mellitus (+1.20 vs.-26.98), pancreas cancer (+0.68 vs. -14.34), tuberculosis (+2.72 vs. -3.81).

Figure 1 clearly depicts after comparing mortality in different periods with age-adjusted mortality rate. The percentage differences in age-adjusted specific-cause mortality rates (Table 2) were presented with the results of Kitagawa's components (Table 5). It can be noted that rate effect has stronger influence on the changes of specific-cause mortality rates than age effect. The age effect contributes to increase the percentage changes in age-adjusted mortality rates from 0.21 to 20.40%, while rate effect contributes to increase the percentage changes in age-adjusted mortality rates from 55.54% to 492.33% or effect to decrease in percentage change in age-adjusted mortality rates from 5.59% to 83.96%

DISCUSSION

The differences of mortality rates between two point times were explored by Kitagawa decomposition techniques. The results displayed that the significant effects are consistent with mortality trends. In the situation, age effect including increase in total population or in specific age group affects only on increasing in crude mortality rate, three broad categories death rates, and some diseases. These changes occur slightly or having fairly stable rate due to increases of both nominator and denominator in the same time. While rate effect is more sensitive on changing of mortality rates than age, it may affect on increase or decrease in mortality rate by assuming that there may be changes in incidence rate reflecting changes in risk factors exposures and prevention activities or changes in case-fatality rate reflecting improvement of treatment effectiveness. Moreover, social context could involve this change such as urbanization or modernization, globalization, education expansion, changing of women role, economic transition, politics technological innovation, trade liberation and etc [11]. Although the theory of demographic transition used to describe the differences in population structures by the interplay between mortality and fertility under dissimilar level of social and economic development has different point of view from epidemiologic transition referred to the series of interrelated and complex changes in health and disease pattern, they have complex interrelationship and cannot divorce each other. For example, when mortality transition took place, age structure of population was affected. Conversely, increasing of older age structure will turn effecting to determine mortality or disease pattern. These illustrate the association transformations in the age, causes, and sex structure of death. In fact, although nowadays rising in population ageing has established major public concern on morbidity, mortality and social welfare, the newly emerging infection disease of HIV/AIDS in the late 1980's or Swine Flu (AH1N1) in 2009 has alarmed the protracted epidemiologic transition in the century as well.

As you may have seen from the results when examining the large data sets or large indicators such as overall mortality rate or three board categories death rate, increasing accumulated death numbers mainly caused increase in mortality. But when considering specific cause of death, it clearly demonstrates nature of diseases or changing in mortality rate was the main cause of changes. The results stem from group effect or the different unit of measurement.

Last but not least, as for data adjustment, the quality of new reconstruction data depends on the different quality of data used resulting in the different verbal autopsy methodology or tools, or the different processes of adjusting may lead to uneven results. For instances, the underlying causes of death diagnosed by medical record give more accuracy and a large number of diseases than using verbal autopsy questionnaire. Therefore, some diseases cannot be captured in 2006 such as diabetes mellitus, pancreas cancer, violent/homicide while the emerging of hypertension disorder, fall, colon and rectum cancer in the first fifteen causes in 2006 cannot be captured in 1997.

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