Contribution of Smoking Behavior to Educational Differential in Active Life Expectancy in Nepal

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Abstract

Previous studies have consistently established the role of education in producing inequality in active life expectancy, both in developing and developed countries. However, there is little research on possible mechanisms responsible for generating such inequality. This study examines smoking as one possible mechanism by measuring the proportion of educational differences in active life expectancy explained by smoking status. By utilizing cross-sectional health and mortality data from Nepal, I employ a new method developed by Lynch and Brown (forthcoming) to construct education-and smoking-specific active life expectancy. The findings of this study demonstrate the substantial contribution of smoking to educational differentials in active life expectancy. The findings show that education is able to produce inequality in active life expectancy regardless of the existing social, economic, cultural, or developmental context. The findings of relative importance of both education and smoking in reducing health inequality should draw attention of policy makers in developing countries.

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Introduction

Active life expectancy, a population health measure calculated by combining disability prevalence and mortality probability, estimates average years of life lived free of disability. This study measures the proportion of educational differences in active life expectancy explained by smoking status. Previous studies on the contribution of socioeconomic status to disparities in active life expectancy have consistently shown that socioeconomic status is positively associated with active life expectancy. Findings from these studies indicate that people from higher socioeconomic status tend to live more years of active life and less years of disabled life compared to their counterparts (Guralnik, Land, Blazer, Fillenbaum, & Branch, 1993; Laditka & Wolf, 1998). Such studies draw from earlier work on the influence of socioeconomic status on health and mortality because active life expectancy incorporates both outcomes.

Extensive studies have demonstrated that socioeconomic status is significantly related to health and mortality (Mackenbach, Kunst, Cavelaars, Groenhof, & Geurts, 1997; House, Lantz, and Herd, 2005). Those studies alternatively employed education, income, or occupation as a measure of socioeconomic status with consistent findings regardless of the design, methods, and measure used. Among the measures used, education is the best predictor of health and mortality even after controlling for other socio-economic, health behavioral and demographic factors (Marmot et al., 1991; Ross & Wu, 1995; Lantz et al. 1998). People with a higher educational status have greater access to resources and also are able to use those available resources to their benefit such that they are able to avoid diseases which may be harmful to their health and could potentially lead to disability and death (Goesling, 2007). Findings on the influence of education have been consistent across different contexts and cultures indicating the importance of education as a major construct in determining health and mortality outcomes (Mirowsky & Ross, 2003).

Even after controlling for the influence of mechanisms such as health behaviors that mediate association between education, health and mortality, people with higher education enjoy better health and live longer compared to people with lower education (Lantz et al., 1998; Lantz et al., 2001; Dunn, 2010). Social support, psychosocial factors, health behaviors, and access to health care are some of the various mechanisms through which education is supposed to affect health and mortality outcomes (Adler et al., 1994). Some of the health related behaviors that have been linked to the effect of education on health and mortality are smoking, alcohol consumption, and physical activity. Previous research has shown that people with higher education smoke less, consume less alcohol, and are more physically active, whereas people with lower education tend to show higher involvement in these risky health-related behaviors (Gilman, Abrams, & Buka, 2003; Thrane, 2006). In addition, people with higher education are more likely to withdraw from risky health behaviors compared to people with lower education. Regardless of educational status, health behaviors also have an independent effect on health and mortality (Freund, Belanger, D'Agostino, & Kannel, 1993; Thun et al., 1997). Since both education and health related behaviors have an association between the two, and both independently affect health and mortality outcomes, it is implied that health related behaviors make up one of the pathways that explain the educational differential in health, disability, and mortality.

This study employs smoking as measure of health behavior because of its significant contribution to disease, disability, and death. Smoking is a major contributor to diseases such as cancer, cardiovascular diseases, arthritis, osteoporosis, and tuberculosis. All of the aforementioned diseases significantly contribute to disability and mortality (Ferrucci et al., 1999; Zaher, Halbert, Dubois, George, & Nonikov, 2004). Smoking, being related to both education and health and mortality outcomes, may be responsible for disparities in health, disability, and mortality among different educational groups. Previous studies on socioeconomic differential in disability and mortality either assesses their contribution to existing differentials in disability and mortality, or identify mechanisms that are attributable to those health outcomes (House et al., 1994; Rogers, Hummer, & Nam, 2000). In addition, extensive literature on the independent effect of those mechanisms such as smoking behavior on various disease outcomes, disability, and mortality is available (Stuck et al., 1999; Fagerström, 2002). Similarly, there exists a vast body of literature on educational differentials in life expectancy, healthy life expectancy, and active life expectancy (Crimmins & Saito, 2001; Meara, Richards, & Cutler, 2008; Lynch, Brown, & Taylor, 2009). Furthermore, there are studies which have examined the independent effect of smoking behavior on various life table measures such as life expectancy (Bronnum-Hansen & Juel, 2000). However, there is little research in either developed and developing countries that has looked at the role of health related behaviors in explaining such socioeconomic differential in active life expectancy. This type of research is virtually non-existent in developing countries except for research carried out by the World Health Organization (WHO) on construction of healthy life expectancy and disability free life expectancy based on age and gender (Mathers et al., 2000). One of the reasons for such disparity in the literature is due to the fact that construction of healthy life expectancy based on other covariates such as education has not been possible because of the lack of data and appropriate methodology. Earlier studies in the U.S. used multi-state methods for calculation of active life expectancy, which requires panel or longitudinal data that is not available in developing countries like Nepal.

This study used a new method developed by Lynch and Brown (forthcoming) to construct healthy/active life expectancy based on education from cross-sectional data. This study contributes to the broader literature available in this topic by assessing the previous research findings in the context of a developing country, thus offering the insight into the importance of socioeconomic status in creating differentials in active life expectancy under varying contexts. This research makes an assessment of the relative importance of both education and smoking to the health status of the population as measured by active life expectancy; thereby expect to assist developing countries like Nepal to prioritize the health status of their populations.

Background

Previous studies on socioeconomic inequality in health provide a basis for studies that examine socioeconomic differential in active life expectancy. Active life expectancy (ALE) is a measure of population health calculated by combining disability prevalence rates from cross-sectional health survey data with cross-sectional mortality information obtained from a census or vital statistics (Manton, Stallard, & Liu, 1993). Healthy life expectancy or active life expectancy allows us to partition total life expectancy into healthy and unhealthy years of life. It is used to draw inference about the well-being of a population, and also to monitor the change in the well-being of a population. This measure is widely used for policy purposes in both developed and developing countries by health agencies. It helps them to allocate necessary health resources to their population. Health agencies utilize this measure to assess the influence of their health programs by monitoring the change in this indicator over time (Murray, Salomon, & Mathers, 2000).

Studies that examine socioeconomic differentials in active life expectancy draw their support from earlier studies on socioeconomic differentials in health, disability, and mortality (Crimmins, Hayward, & Saito, 1996). These studies utilize various measures of socioeconomic status and various measures of health, disability, and mortality. However, findings from these studies have been consistent regardless of context, culture, design, and instrument used. Among different measures used to assess socioeconomic status, education is the best predictor of health, disability, and mortality (Kitagawa & Hauser, 1973; House, Lantz, & Herd, 2005; Lleras-Muney, 2005).

Education is widely used as a measure of socioeconomic status. Information on education, unlike income and occupation, is readily available which explains part of the reason behind its widespread use. More importantly, its role for influencing income generation, employment prospects, knowledge of health care, and health behaviors makes it an important construct for measuring socioeconomic status. In addition, it is relatively stable across the life course and also comparable across different national contexts. People attain education early in their life course, and it generally remains constant through their adulthood. Therefore, the influence of education persists for a longer period of time. Since people start attaining education early in their life, the issue of reverse causation is not as strong as in the case of income. There are some researchers who have found reverse causal direction while utilizing income as a measure of socioeconomic status. Their assertion was that people who are unhealthy earn less, which contradicted the notion that people with higher income have better health. Such findings support the idea of the social draft implying that poor health contributes to lower income rather than lower income contributing to poor health (Adler & Ostrove, 1999). Furthermore, some research has demonstrated that education more strongly contributes to disease outcomes and health risk than income and occupation (Winkleby et al., 1992; Zimmer, Liu, Hermalin, & Chuang, 1998).

Education as an indicator of socioeconomic status has been regarded as a "fundamental cause of disease" (Link & Phelan, 1995). As human capital, education serves as a foundational resource, which is linked to various mechanisms such as health behaviors and knowledge of health care that affect health outcomes. Those mechanisms are a byproduct of the educational status of individuals, which is subject to change at different times. The occurrence of such change in the mechanism results in the different patterning of disease outcomes as shown by the transition from higher prevalence of infectious diseases to chronic diseases in developed countries. Inequality in health, in terms of socioeconomic status, existed during the time of infectious disease when people in higher socioeconomic status were able to avoid those diseases by adopting behaviors such as eating a nutritious diet; drinking clean water; and making their environment clean through sanitation (Mirowsky & Ross, 2003). With the decline of various infectious diseases, non-communicable diseases such as cancer and heart disease have taken their place. However, inequality in health still persists, and one cause for such inequality is the socioeconomic status of people. Therefore, Link and Phelan (1995) argued that unless the fundamental cause is addressed, disparities in health will continue to exist even though mechanisms through which the fundamental cause is linked to health are addressed and resolved.

Previous research supports Link and Phelan's (1995) fundamental cause of disease hypothesis. Findings from studies looking at the influence of socioeconomic status and health have consistently shown that people with low socioeconomic status have a higher risk of morbidity, disability, and mortality even after controlling for other factors such as health behaviors (Antonovsky, 1967; House, Kessler, & Herzog, 1990; Ross & Wu, 1995; Hummer, Rogers, & Eberstein, 1998). Such findings have been consistent for different cultural and national contexts. For example, Olafsdottir (2007) compared the U.S. and Iceland to assess the impact of socioeconomic status on health and found that the influence of socioeconomic status on health remained strong despite the existence of different institutional arrangements (e.g., health care system) in both countries. In another comparative study utilizing mortality as a health outcome, Elo, Martikainen, and Smith (2006), demonstrated that the influence of education on mortality persists even across contexts which differed in health care and social welfare system. By utilizing samples aged 35-64 years from the U.S. and Finland, they showed that people with higher education survive longer than their counterparts. However, the influence of education became significantly lower after the introduction of income as a mechanism of explaining educational differences in mortality (Elo, Martikainen, & Smith, 2006). Negative association between socioeconomic status and mortality also holds for different measures of income such as family income and employment income, self-employment, and home ownership (Krueger, Rogers, Hummer, LeClere, & Huie, 2003).

Another study using U.S. data showed that education was inversely related to mortality and disability (Molla, Madans, & Wagener, 2004). Regardless of gender, people with a higher education level had a higher active life expectancy among both younger and older ages. Nonetheless, they found the educational disparity in active life expectancy to be higher among younger age groups than older age groups. Similar findings were observed by Freedman and Martin (1999) who associated decline in disability in the U.S. to the increasing educational attainment among older adults. These findings, observed in the U.S., also seem to hold true in the context of developing countries, despite vast differences in culture, institutional arrangement, or state of socioeconomic development. One study conducted in China by Liang, Liu, & Gu (2001) assessed the consistency of the earlier findings and observed longer functional independence among people with higher education. Those people not only remained functionally independent for a longer period of time, but also were able to avoid premature death. Higher educational status was associated with less probability of functional decline (Liang, Liu, & Gu, 2001).

Influence of Smoking on Health and Mortality

Extensive research on risk factors involved in functional decline has been conducted in developed countries, particularly in the U.S., and a majority of these studies utilize longitudinal data. Various socioeconomic, psychological, and behavioral factors are associated with functional decline. A comprehensive review of the literature on risk factors of functional decline by Stuck and his colleagues lists life style factors as a major determinant of functional decline. Smoking, listed as one of those life style factors, has significant contribution to functional decline, but the influence varies by smoking status. Current smokers have a higher probability of having functional decline as compared to former smokers and non-smokers (Stuck et al., 1999).

Healthy life style factors play a significant role in reducing disability and death suggesting that people not only can live longer, but are also able to delay disability until later years (Fries, 1980; Terris, 1992; Verbrugge & Jette, 1994). Avoidance of risky health behaviors such as smoking is essential to prolong life and to live a higher proportion of that prolonged life in an active state. Smoking contributes to a significant amount of disability and death through its linkage to diseases such as myocardial infarction, stroke, osteoporosis, and cancer. Since pathologic conditions of these diseases are major causes of disability, smoking results in fewer years in an active state and more years in a disabled state (Ferrucci et al., 1999).

Smoking and other risky behaviors in middle and late adulthood are responsible for disability in later years. Therefore, disability in old age is a consequence of a cumulative health risk that people face over their life course due to risky health behaviors. These risky health behaviors can be a consequence of people's lower socioeconomic position. Therefore, adopting healthy behavior not only reduces the risk of disability and death, but also helps to postpone disability to later years (Vita, Terry, Hubert, & Fries, 1998). The evidence of the influence of behavioral experience during the life course is further supported by a study conducted in Britain which established that smoking in middle life results in locomotor disability (i.e., climbing, walking) in later life controlling for presence of disease (Ebrahim, Wannamethee, Whincup, Walker, & Shaper, 2000). Diseases associated with smoking behavior such as arthritis and cardiovascular diseases were found to relate to disability outcome.

Smoking also causes respiratory diseases such as asthma and COPD. A study among people over 18 years of age revealed that asthma and COPD contribute to work disability (Eisner, Yelin, Trupin, & Blanc, 2002). Work disability was assessed by their perceived difficulty with job related work as a consequence of these respiratory diseases. Influence of smoking on disability is observed in other contexts as well. Zimmer et al. (1998), utilizing a sample of people aged 60 and older in Taiwan, established the significant role of smoking in causing disability among those people who entered their study in an active state. Their study further demonstrated a substantial contribution of smoking to mortality among people who started in a disabled state (Zimmer, Liu, Hermalin, & Chuang, 1998).

Large numbers of deaths from fatal diseases such as cancer, cardiovascular disease, stroke, and respiratory diseases have been linked to smoking. A majority of smoking related deaths in the U.S. occur in older ages (Husten et al., 1997). More importantly, smoking has been associated with 15 types of cancer, which demonstrates the adverse effect of this behavior. Global mortality from cancer is increasing as indicated by the growth in cancer related deaths from 6 million in 1990 to 7 million in 2000 (Ezzati, Henley, Lopez, & Thun, 2005). Substantial impact of smoking on mortality, as indicated by decline in life expectancy, was also reported by one study in Denmark. Bronnum-Hansen and Juel (2000) showed that life expectancy would increase by 3 years for men and 2.1 years for women if deaths from smoking-related diseases could be avoided (Bronnum-Hansen & Juel, 2000). These findings were further corroborated by a cross-country study by Shaw, Horrace, and Vogel (2005) who utilized health data from OECD countries to study the determinants of life expectancy. They found tobacco consumption as one determinant of life expectancy with evidence of decline in life expectancy with the increase in tobacco consumption (Shaw, Horrace, & Vogel, 2005).

Influence of Education on Smoking Behavior

Health behaviors are also related to people's educational attainment. Except in their early stages of development, smoking related diseases such as cardiovascular diseases in now-developed countries are associated with people from a lower socioeconomic status. Clustering of smoking related diseases among people with lower education implies that prevalence of smoking is higher among people with lower education. Not only do people with higher education smoke less, but they also are more likely to quit smoking. A study by Husten et al. (1997) showed that the prevalence of smoking cessation among older adults increased with the advancement of their education. In contrast, people with lower levels of education are more likely to smoke and not be able to quit, making them more vulnerable to disease. Since people with higher education status are more aware of their health, knowledge about the hazardous consequences of smoking is likely to deter them from adopting that behavior. People with lower educational status are less likely to be aware of or care about the impact of their health behaviors. Such a pessimistic feeling about health could stem from the disadvantages related to a lack of resources, social support, and access to health care (Grzywacz, Almeida, Neupert, & Ettner, 2004; Mirowsky & Ross, 2003).

However, the smoking pattern among different socioeconomic groups in developing countries is not clear. There is little information on the smoking behavior of different socioeconomic groups. Indirect inference from a few studies suggests that a reverse pattern could exist in developing countries as observed in the earlier stages of development for now-developed countries. Before the publication of the First Surgeon General's report on smoking in 1964, cardiovascular diseases were known as diseases of affluent people because of their high concentration among people in a high socioeconomic standing. Even though disease impact started changing before the publication of the aforementioned report on the hazardous role of smoking, significant declines were seen only after the publication of this report. The conclusion is that the report led to the change in the smoking behavior among higher socioeconomic groups

(Adler & Ostrove, 1999). Liang et al. (2001) observed a similar pattern in China where they found coronary heart disease (CHD) to be more prevalent among people with higher socioeconomic status. This is further evidenced by a study from Ahmed et al. (2009) which showed concentration of non-communicable diseases such as heart disease among higher educated groups. Except for a few settings, their findings were consistent among most of the Asian countries they studied (Ahmed et al., 2009). Change in disease pattern in the later stage of the development of a country could be due to the increasing awareness of the harmful effects of their health behaviors among people with higher education. In addition, it could be possible that tobacco products became accessible to people with limited purchasing power.

Explanation for Socioeconomic Differential in Health, and Mortality

Since education is related to health outcomes, and health behaviors are related to both education and health outcomes, it can be deduced that health behavior acts as a pathway for explaining the educational differential in health, disability, and mortality (Terris, 1992; Pampel & Rogers, 2004). In one study of socioeconomic differences in health across the life course, House et al. (1994) found that various risk factors such as smoking, alcohol consumption, stress, and social support mediated that relationship across the life course. This study measured health with chronic disease and functional limitations. Larger differences were observed in middle age and early old age, with differences being narrow in early adulthood and late old age. Using a sample of people over 25 years of age, they found that the influence of socioeconomic status on health was generated through various risk factors as shown by the insignificant influence of education and income after considering their influence on health (House et al., 1994).

Health related behaviors such as smoking and alcohol consumption are among the different pathways that are utilized to explain educational differentials on mortality (Lantz et al., 1998). Smoking is associated with the development of various diseases such as cancer, heart diseases, and lung diseases which in turn are associated with major causes of death and disability. Therefore, smoking is supposed to significantly contribute to the educational differential in disability and mortality. According to Preston and Taubman (1994), smoking accounted for 15 percent of the male mortality differential in the U.S. between people who had obtained a high school degree versus people without a high school education. In addition, current smoking status was found to be significantly related to the possibility of having functional limitation even after controlling for other risk factors such as alcohol consumption, stress, social support, socio-demographic factors, and socioeconomic factors (House et al., 1994).

Furthermore, a study by Liu, Liang, Muramatsu, and Sugisawa (1995) in Japan utilizing a sample of older adults to study transition to disability and death from a state of independence found that both education and smoking status are significantly associated with functional decline and death. For example, a one year increase in education implied a decrease in disability and death by 0.36 and 0.28 percent respectively. Similarly, people who were current and former smokers had 4.2 and 3.9 percent greater risk of being disabled. It is highly likely that smoking, especially among people from lower socioeconomic status could put added burden of disease in addition to what they already acquire due to their disadvantaged state in other aspect of life. Since additional number of morbid conditions is likely to increase the probability of disability, people from lower socioeconomic status are likely to have higher burden of disability (Verbrugge, Lepkowski, & Imanaka, 1989). Influence of smoking on disability was also demonstrated by the significant influence of arthritis on disability, a disease which is also associated with smoking behavior (Liu, Liang, Muramatsu, & Sugisawa, 1995; Jagger et al., 2007). Arthritis, COPD (Chronic obstructive pulmonary disease), heart disease, and asthma are some of the diseases that contribute to educational differential in disability free life expectancy (Nusselder et al., 2005). Linkages of these diseases to smoking behavior signify the role of smoking in explaining educational differentials in active life expectancy.

Socioeconomic Inequality in Active Life Expectancy

Studies on socioeconomic inequality in active life expectancy generate support from previous studies on socioeconomic inequality in health outcomes. Instead of two separate health outcomes, these studies employ a combined measure as a population health outcome. Previous studies on socioeconomic inequalities in population health utilizing active and healthy life expectancy as an outcome have consistently found that socioeconomic status is positively related to healthy/active life expectancy. People with higher economic status live a higher proportion of their remaining years of life in healthy or active status compared to their counterparts. Research conducted in the US and other developed countries have consistently shown that people with higher education tend to live fewer years disabled and enjoy a higher active life expectancy. These findings have been consistent in various contexts and cultures regardless of the method, measure, and design of the study (Guralnik et al., 1993; Valkonen, Sihvonen, & Lahelma, 1997; Laditka & Wolf, 1998; Crimmins & Saito, 2001; Lynch & Brown, 2005; Minicuci & Noale, 2005).

A majority of these studies employ education as a measure of socioeconomic status and are often based on a sample of older adults. There are very few studies which utilize both younger and older people in their studies to understand the influence of socioeconomic status across various age groups. However, one such study conducted in the U.S. using a sample of adults aged 25 and older found that the influence of education on active life expectancy persists across all age groups. The influence of education on active life expectancy was established to be stronger at younger ages compared to older ages. Findings from this study by Molla et al. (2004) indicated that the influence of socioeconomic status persists even at the oldest ages. Crimmins and her colleagues (1996) have also found an education differential in active life expectancy even among people above 70 years of age. As the influence of socioeconomic status is greater on functional status than mortality, there exist larger socioeconomic differentials in active life expectancy compared to total life expectancy (Crimmins et al., 1996).

Similar results were observed by Land, Guralnik, and Blazer (1994). Using a sample of older adults, they found that education helps to push disability to later years of life. People with higher education were found to enjoy higher active life expectancy regardless of their gender (Land, Guralnik, & Blazer, 1994). Both these studies showed that the influence of education on active life expectancy is greater for females than males. Such findings were also observed by Manton and his colleagues who found that the impact of education on total life expectancy and disability is greater for females (Manton, Stallard, & Corder, 1997). Their study showed that the impact is almost four times greater for females than males. Greater impact of education on life expectancy for females as compared to males was due to greater mortality risk for males, mainly because of the higher concentration of fatal diseases among males (Kitagawa & Hauser, 1973).

Although a majority of these studies were conducted in the US, there are some studies which have been replicated in other developed countries with consistent findings. One study in Italy showed that people with higher education not only tend to live longer, but also live a higher proportion of those years in good health and without disability (Minicuci & Noale, 2005). Findings from this study indicate that the impact of socioeconomic status is higher for healthy life expectancy than for total life expectancy. This may be because people with higher education enjoy substantial advantage over their counterparts in terms of non-fatal diseases and disability. However, that advantage is not as strong when it comes to fatal diseases as the risk of an outcome is equally distributed among different socioeconomic groups.

As a further indication of consistent findings across various contexts, one study in China found that men and women with higher socioeconomic status tend to enjoy more years of active life expectancy as compared to their lower status counterparts (Kaneda, Zimmer, & Tang, 2005). Using various measures of socioeconomic status such as education, income, occupation, and household possessions, they were able to demonstrate the influence of socioeconomic status on life expectancy and active life expectancy. The influence of socioeconomic status on active life expectancy was higher for males compared to females. Even though findings of an influence of socioeconomic status on active life expectancy were consistent with earlier studies, this study did not find significant difference in inactive years of life between different socioeconomic groups.

The findings of previous studies on socioeconomic inequality in health are consistent regardless of the measures used to assess socioeconomic status and disability. One study in United Kingdom employing occupation as a measure of social status found that both men and women of higher social class expected to live a higher proportion of their life years in an active state. People in a higher social class lived less years in disability regardless of their gender (Melzer, McWilliams, Brayne, Johnson, & Bond, 2000). A similar study in France also demonstrated a socioeconomic gradient in active life expectancy. Managers were found to enjoy longer life expectancy as well as disability free life expectancy compared to manual workers (Cambois, Robine, & Hayward, 2001).

Prevalence of Smoking in Nepal and its Possible Consequences

Prevalence of smoking is higher in developing countries and Nepal is no exception. According to WHO, prevalence of current tobacco use among males and females age 15 years and above is 34.8 % and 26.4 % respectively (www.who.int/countries/npl/en/). High prevalence of smoking is characteristic of developing countries, a characteristic that resembles an early stage of development of now-developed countries. Developed countries like U.S. had high prevalence of smoking in the 1950s which declined mainly after the publication of the First Surgeon General's report on smoking in 1964. For example, prevalence of smoking in the

U.S. has dropped from approximately 40% in 1965 to 20.9% in 2005 (Rahilly & Farwell, 2007). Decline in the prevalence of smoking was followed by increases in life expectancy in the U.S. and also narrowing of the gap between male and female life expectancy, which may be largely due to the decline in smoking among males. Declines in smoking led to a lower number of deaths from heart disease, malignant neoplasm, and chronic lower respiratory disease among men (Hummer et al., 2009). In recent years, there has been a substantial decline in smoking among males as compared to females, which might be the reason why the gap in life expectancy is narrowing in favor of males (Preston & Wang, 2006).

It is not clear whether smoking prevalence will follow the similar pattern of decline in developing countries. Increasing educational status, public health education, increased taxation, and strict regulation banning smoking in public places were some of the measures taken to reduce smoking prevalence in developed countries (Terris, 1992). Strong political commitment is needed to impose those strict regulations, which political leaders in developing countries may be reluctant to do unless the public is able to exert pressure on them. Influence of multinational tobacco companies on political leaders does not allow such regulations to be put into action even if they are formulated (Mackay, 1998). In the absence of those regulations, increasing educational status and public health education are the only two interventions which have a strong potential to reduce smoking prevalence. Public health efforts alone may not be beneficial among people with lower educational status as indicated by the lower rate of cessation (Escobedo & Peddicord, 1996). As it is difficult to have immediate increase in the educational status of the population, it seems likely that decline in the smoking prevalence in developing countries will be slower than that of developed countries.

Assessment of the impact of smoking on health, disability, and mortality has not been done in Nepal. Looking at the high prevalence of smoking and its substantial impact on health, we could argue that it will have a huge impact on the health status of the population. Smoking is associated with many communicable diseases that contribute to disability and death. High prevalence of smoking in developing countries implies that these countries will share a high burden of disability and death in the future. For example, mortality from tobacco-related disease in developing countries is estimated to increase from 3.0 million in 1990 to 8.4 million in 2020 (Murray & Lopez, 1997). The likelihood of increased burden from non-communicable diseases in place of communicable diseases will pose different challenges to a developing nation's health care system.

State of Research on Health Inequality in Nepal

In developing as well as developed countries, WHO utilizes Sullivan's method to calculate healthy life expectancy, disability free life expectancy or disability adjusted life expectancy as an indicator to assess the health status of the population of WHO member countries. Health expectancies are calculated by the WHO for 191 countries in which healthy life expectancy at birth ranges from 29.5 years to 73.8 years. Healthy life expectancy at birth for the U.S. is 67.2 years, but with notable gender differences. For example, healthy life expectancy for males is 65.7 years, whereas for females it is 68.8 years. This research also shows that females tend to be in an unhealthy state more than males since their total life expectancy is greater than males. This finding is consistent with other research conducted in the U.S., which shows that females tend to have a greater healthy or active life expectancy, but spend higher proportion their life in unhealthy state compared to males. In contrast, Nepal is among the few countries that have a lower total life expectancy and healthy life expectancy for females as compared to males. For example, healthy life expectancy at birth for males and females is 47.5 and 44.2 years, respectively (Mathers et al., 2000).

Even though WHO calculates healthy life expectancy for policy purposes for developing countries, there is little published academic research related to this topic. Additionally, there is virtually no research on the relationship between socioeconomic status and healthy life expectancy. However, there is extensive academic research available on this topic in developed countries, particularly in the U.S. Earlier studies on healthy life expectancy only used age, sex and race since mortality information only contained those three variables. Given that Sullivan's method only allows the construction of life expectancy based on covariates present in mortality data, research efforts were only limited to covariates available in mortality data. Later with the development of multi-state methodology, researchers were able to incorporate other covariates such as education and income to study their impact on active/healthy life expectancy. Previous research on the relationship between covariates such as education and active life expectancy was carried out by utilizing multi-state life table methods which required panel or longitudinal data. A lack of panel or longitudinal data in developing countries made this method inappropriate to use for those countries, in turn limiting research efforts in this area to developed countries (Lynch & Brown, 2005).

Available research in developing countries is mainly restricted to the study of gender differences in active or healthy life expectancy as age and gender are the only variables available in mortality data. Application of multi-state method in developing countries is not feasible as multi-state methods require longitudinal or panel data to calculate transition rates between different health or disability states, which are then used to calculate healthy life expectancy. This method allows transitions between non-absorbing states (i.e., from not disabled state to disabled state). As inclusion of covariates required longitudinal data, these types of studies were not possible in developing countries which severely lack longitudinal data. With the extension of Sullivan's method by Lynch and Brown (forthcoming), active life expectancy based on the covariates available only in the cross-sectional health survey data can be constructed, thus, allowing us to study the impact of those variables in active life expectancy.

In terms of Nepal, there is little research available on the influence of socioeconomic status on disability and mortality, and in fact, no published research in peer reviewed journals. Similarly, there is little published literature on the role of smoking in determining mortality in Nepal. In addition, there is virtually no research on active life expectancy in Nepal, except a few studies carried out by the WHO. The majority of research on mortality looks only at the determinants and causes of infant, child, and maternal mortality. There is some research in Nepal which shows that smoking during pregnancy is a major predictor of mortality (Christian et al., 2004). According to Singh (2003), the major causes of death among both males and females above 65 years of age are cancer, heart disease and tuberculosis, which are considered to be associated with smoking (Singh, 2003).

Census data reports that considerable numbers of reported disabilities were caused by smoking and alcohol consumption. A few studies have looked at disability among older adults in Nepal, but its linkage with socioeconomic status and smoking behavior have not been studied (Shrestha & Weber, 2002; Dhungana, 2006; Chalise, Saitoa, & Kaia, 2008). Existing research on disability in Nepal centers on identifying different types of disabilities rather than their determinants. Physical disabilities affecting limbs, hearing, and vision are the major types of disabilities found in Nepal (Karkee, Yadav, Chakravartty, & Shrestha, 2008). The majority of disability research in Nepal does not distinguish between disability and functional impairment with both of them used interchangeably. However, recent studies have started distinguishing between those two different stages of the disablement process. Chalise et al. (2008) utilized various measures of ADL items to assess disability among older adults in Nepal and found that disability is higher among females than males. Similarly, another study also utilized measures of functional disability to examine the relationship between mental illness and disability. Mental illness was found to be associated with a risk of disability (Subedi, Tausig, Subedi, Broughton & Williams-Blangero, 2004).

Even though there is a substantial body of research on the influence of health related behaviors in explaining socioeconomic inequality in health, disability, and mortality, there is little research on the contribution of those health behaviors to educational differential in active life expectancy. I found only one study conducted in Denmark which examines the role of smoking behavior in creating differences in healthy life expectancy among different educational groups. By using Sullivan's method to calculate healthy life expectancy, Brønnum-Hansen and Juel (2004) examined the influence of smoking in educational differential in healthy life expectancy. They demonstrated the role of smoking in reducing the proportion of years lived in a healthy state within each educational group but were not able to explain the significant differential in healthy life expectancy that still exists between different educational groups (Brønnum-Hansen & Juel, 2004). However, that study employed a self-rated health measure instead of a disability measure as used in this study, and it did not measure the proportion of educational differential in healthy life expectancy explained by smoking behavior.

Research Question

This study addresses the following research question by assessing the proportion of educational differences in active life expectancy explained by smoking status:

Does smoking behavior explain some portion of educational differences in active life expectancy in Nepal? Examining previous literature on the influence of smoking on educational differential in disability and mortality, I expect to find a substantial proportion of educational differences in active life expectancy to be explained by smoking status due to its significant contribution to disability and mortality.

Methods

Data for this study come from a cross-sectional survey that was conducted in 2003 to collect information on the health status of the population and on the prevailing health system in Nepal. This survey was conducted by the World Health Organization (WHO) as a part of its effort to obtain comparable data on the health status of populations across its member countries. The population selected for sampling was residents above 18 years of age. This survey utilized a multistage household probability sampling method with each sample having non-zero probability of being selected. In the first stage, a sample of administrative wards (local authorities) was randomly selected. In the second stage, households were randomly selected from the wards chosen in the first stage. Finally, Kish selection tables (a table used to select samples from the household) were employed to select the sample from among eligible respondents from households selected in the second stage (World Health Organization, n.d.). The eligible sample selected from this process included 8,840 people. From these eligible persons, only 8,688 were successfully interviewed for a response rate of 98.28%.

Mortality information for this study was obtained from the Census Bureau of Statistics (CBS) in Nepal for 2001. CBS publishes a sample data set from the complete census data which contains information on causes of death disaggregated by age and sex. Mortality probabilities were calculated by dividing number of deaths in each group by mid-year population in that age group. This sample data set has mortality information for only 11.35% of the total number of deaths. It would have been desirable to match mortality information to the year when the health survey was taken, but mortality data for each age was not available from other sources. The United Nations (U.N.) office provides information on mortality for that year, but it is only available for certain age intervals. This method requires mortality probability for each age for the stability of the estimates; therefore, mortality information produced by the U.N. could not be used for this study. Thus, census data are the only reliable source of mortality data in Nepal as vital statistics information from other sources is incomplete and unreliable.

Variables and Measurement

Disability

Several measures of functional limitation available in this survey data were combined to construct a disability variable. In this survey, respondents were asked to report on their overall health, mobility, and self-care in order to measure their state of health. Respondents were asked to make subjective assessment of their overall health by answering the question “Overall in the last 30 days, how much difficulty did you have with work or household activities?”. Similarly, respondents were asked to assess their mobility status by answering the questions: “Overall in the last 30 days, how much difficulty did you have with moving around?”; and, “In the last 30 days, how much difficulty did you have in vigorous activities, such as running 3 km (or equivalent) or cycling?”. Except in urban areas, grocery stores are far and scattered in other parts of Nepal. Therefore, it is essential for people in Nepal, especially in areas which are not touched by transportation, to be able to ride a bicycle or be able to walk to the grocery. In mountain areas, people may have to walk for days to come to a market place. Failure to ride a bicycle or be able to walk to the grocery store could characterize a person as disabled under that context. Ability of self-care was measured by asking respondents to answer the questions: “Overall in the last 30 days, how much difficulty did you have with self-care, such as washing or dressing yourself?”; and, “In the last 30 days, how much difficulty did you have in taking care of and maintaining your general appearance (e.g., grooming, looking neat and tidy etc.)?”.

Responses in all these questions were recorded in a 5-point scale which ranged from none to extreme/cannot do. These responses were further classified in two categories. Respondents reporting none and mild disability were recoded as 0 indicating no disability, whereas, respondents reporting moderate, severe, and extreme disability were recoded as 1 indicating disability. Respondents reporting disability in any one of these items were recognized as disabled. This classification is relevant in the context of Nepal where disability is equated with physical handicaps or sensory impairments which contribute to severe functional limitations. Therefore, disability is associated with the severity of the functional limitation rather than the presence of the functional limitation. People are likely to continue working on the farm or in the household, unless their functional limitation is severe (Richardson, 1983). As long as people are able to perform their daily activities, they are not likely to consider themselves disabled even if they have mild functional limitations.

For the above reasons, it is reasonable to make an assumption about mild functional limitation not implying disability. Moderate functional limitation could also be considered as not disabled, but there is no substantial evidence to make any valid judgment. Hence, moderate functional limitation is considered as a disability threshold with the assumption that moving the disability threshold from moderate limitation to severe functional limitation does not make a substantial contribution to active life expectancy estimates. This assumption is supported by earlier evidence which suggest that changing the definition of disability and the disability threshold may not alter the estimate of active life expectancy (Lynch, Brown, & Harmsen, 2003). *Cronbach's* alpha was calculated to examine how closely the five disability items relate to each other. The estimated reliability coefficient is 0.80 suggesting a close interrelationship among those disability items because the value of 0.70 or higher is usually considered acceptable in social science research (UCLA: Academic Technology Services, Statistical Consulting Group, n.d). Finally, confirmatory factor analysis was conducted to assess the fit of these five items which revealed a very good fit: $\chi^2(4) = 102.763$, $p = 0.00$, Tucker-Lewis index (TLI) = 0.981, Comparative fit index (CFI) = 0.995, Root mean square error of approximation (RMSEA) = 0.053, FMIN = 0.012. This test indicated that all five measures of functional limitation constitute a single construct, even though they do not come from one standard scale.

Education

Education was used instead of other measures of socioeconomic status such as income, and occupation, because it is stable across the life course and is comparable across different contexts. In addition, information on education is easily accessible, whereas information on income and occupation is not only inaccessible, but also is not comparable with those used in previous studies in developed countries. Education in Nepal is structured as school education and higher education. School education includes the primary level of grades 1-5 and the lower secondary and secondary levels of grades 6-8 and 9-10, respectively. Grades 11 and 12 are considered as higher secondary level. Higher education consists of bachelor, masters, and PhD levels. This study employs years of formal schooling as a measure of educational attainment. In order to sample regression parameters for the education variable, a continuous measure of years of formal schooling was utilized in a Probit regression model. However, specific year of formal schooling was used in each covariate profile (i.e., male non-smokers with 10 years of education) to generate life table estimates. For the purpose of this study, people with 10 years of education are considered as those having higher education and people with no formal education are considered as those having lower education. This differentiation, though not consistent with the majority of previous studies on socioeconomic inequality in health that have treated 12 years of education as a cutoff point, is relevant in the context of Nepal. Under the Nepali education system, grade 10 signifies a crucial phase of school education in Nepal. National level exams are conducted by a government educational body, and passing of that exam implies an entrance to higher education.

Gradually, the education system is changing with grade 12 taking the place of grade 10 as a phase of considerable importance. However, it has not completely replaced an earlier system which was highly prevalent at the time of this survey. The importance of grade 10 is even more emphasized in the context of Nepal where almost half of the population does not have any form of schooling. In this study, the level of respondent's education was determined by asking them to report the number of years of formal schooling completed. The education variable had 474 missing cases and also one outlier which was recoded as missing. These missing cases constitute 5.5% of the total sample. The missing values are random implying that they are equally distributed among all educational groups. Therefore, they are unlikely to have considerable effect on the results. Therefore missing values were deleted from the dataset by employing a list-wise deletion which deletes all other information pertaining to that missing value.

Health-Related Behaviors

Health-related behavior is measured by asking respondent's smoking status at the time of the survey. Information on alcohol consumption was excluded in this study because it tends to be unreliable and biased in Nepal. Alcohol consumption is heavily concentrated among certain ethnic groups, like the Tharu, who associate alcohol consumption with their cultural practices, whereas it not socially desirable for some groups like the Brahmin. It could be difficult to gather information on alcohol consumption from those groups whose cultural tradition is to abstain from alcohol consumption. High clustering of alcohol consumption among certain groups could reduce the variability and might produce biased estimates. Similarly, physical activity was excluded because physical activities such as walking, weight lifting, and bicycling are common in Nepal. Since people do these activities out of necessity due to the unavailability of transportation especially in rural and suburban areas, these activities are likely to be equally distributed among different socioeconomic groups. Since a majority of people live in rural and suburban areas, such patterning of physical activities among different socioeconomic groups could be generalized to the whole population of Nepal. Therefore, physical activities may do little to explain the socioeconomic differences in disability and mortality.

In order to measure smoking status, respondents were asked whether they currently smoke any tobacco products such as cigarettes, cigars or pipes. Observed responses were categorized as smoking daily, smoking but not daily, and not smoking. For the purpose of this study, smoking status is recoded into two categories. Respondents who smoke daily and who don't smoke daily are categorized as 1, and non-smokers are categorized as 0. The smoking status variable has 5 missing cases whose information was deleted from the dataset using list-wise deletion.

Control Variables

Age and gender were used as control variables where age is a continuous variable and gender is a dummy variable. For the purpose of this study, respondents between 18 to 85 years of age were selected. Samples over 85 years of age have been excluded because there is considerable fluctuation in mortality probabilities among those samples due to the small sample size. There were only 15 respondents over 85 years of age. Such fluctuation can result in unreliable regression estimates due to the failure of the regression model to capture such patterning of the data. Failure to represent the distribution of the data results in invalid estimates of parameters. Gender is recoded as 1 for females and 0 for males to allow it to be used as dummy variable in the regression model.

Plan of Analysis

A new method developed by Lynch and Brown (forthcoming) will be utilized to perform an analysis. This method adopts a Bayesian approach, and like the multistate method, allows for different state spaces such as active, inactive, and dead. Unlike multistate methods, transition probabilities are not directly observed from the data, but are estimated based on the prevalence rate at that particular state and age by using an ecological inference method. Estimates of active life expectancy years produced by this method are biased because it is practically not feasible to make direct estimates of active life expectancy based on the covariates only available in health survey data. However, the proportion of life years in an active state and in a disabled state calculated from those estimated active life expectancy years are accurate. Since information on disability status for covariates in health survey data is directly observed, estimate of proportions of total life lived in disabled or nondisabled state is valid.

The analysis for this study will be conducted in three stages. In the first stage, a probit regression model was set up to predict disabled, non-disabled, and dead states from covariates such as years of education, smoking status, age, and gender. The likelihood function for the observed data is,

$$L(\beta, \rho | \text{data}) \, \alpha \prod_{i=1}^{n} \left(\prod_{r=0}^{1} \prod_{c=0}^{1} \Phi_2\left(\tau_{1,1-r}, \tau_{1,2-r}; \tau_{2,1-c}, \tau_{2,2-c}; \rho\right)^{I(y_{i1}=r, y_{i2}=c)} \right)$$

where, $\Phi_2(a, b; c, d; e)$ is a function for a standard bivariate normal distribution with error correlation e, whose dimension 1 ranges from limit a to b and dimension 2 ranges from c to d. $\tau_{x,y}$ is the yth threshold that divides the xth dimension of the bivariate normal distribution into two bins. $I(y_{i1} = r, y_{i2} = c)$ is an indicator for whether the respondent belongs to the cell (r, c).

Instead of using a classical statistical approach to estimate regression parameters, a Bayesian approach was employed to sample parameters from the posterior distribution. The posterior distribution was obtained by combining prior information for each covariate with the likelihood function. Unlike a classical estimation procedure which produces a point estimate for each parameter, a Bayesian approach produces a sample of parameters from the posterior distribution treating parameters as random. In order to draw the parameters from the posterior distribution, a statistical method called Gibbs sampling was used (Lynch & Brown, forthcoming). In the second stage, covariate profiles (e.g., male smoker with 10 years of education) for which life tables are to be constructed were specified. Parameters specific to each covariate profile were applied to obtain z-scores for active, inactive, and dead for each age. These z-scores were converted into age-specific expected prevalence probabilities using a bivariate normal integration procedure. Age-specific prevalence probabilities were later used to produce transition probabilities by utilizing an ecological inference procedure. Ecological inference is a statistical method employed to draw inference about individual samples from aggregated information when disaggregated information is not available

In the final stage, each set of age-specific transitional probability matrices were converted into age-specific time hazard matrices ($\mu(x)$) which then were converted into multi-state life tables with the help of standard demographic calculations. Finally, an assessment of the contribution of smoking status to the educational differential in active life expectancy was conducted by examining the proportion of that differential explained by smoking status calculated with the following formula:

$$\% \text{ explained by smoking status} = 1 - \frac{ALE(Educated/Non-smokers) - ALE(Not\ Educated/Non-smokers)}{ALE(Educated/Non-smokers) - ALE(Not\ Educated/Smokers)}$$

Results

Descriptive statistics for the chosen variables are presented in Table 1. Average age of respondents is 38 years with average age for males being higher than females. There is a higher percentage of females as compared to males. A majority of respondents do not have formal education with significant gender differences in educational attainment. There are 69.2% of female respondents who do not have formal education; however, the percentage of males reporting no formal education is 37.6%. Similarly, higher percentages of males report having higher education than females. Descriptive statistics presented in Table 1 also show that a higher proportion of males smoke compared to females. Specifically, almost 59% of males smoke whereas only 30% of females smoke. Females report a higher number of disabilities than their male counterparts. The percentage of females with at least one disability is almost 53%, but the percentage is considerably lower for males with just 40% of them reporting such disability.

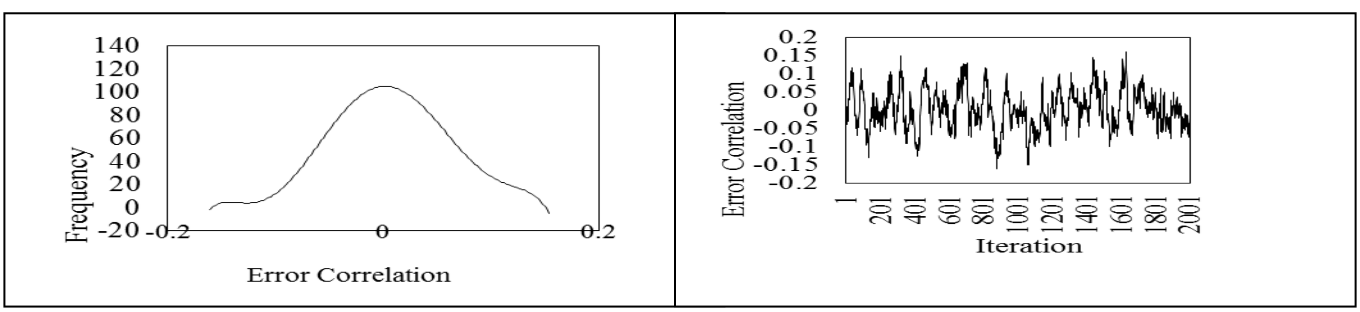
Table 1 Descriptive Statistics for Variables in the Analysis, World Health Survey, 2003

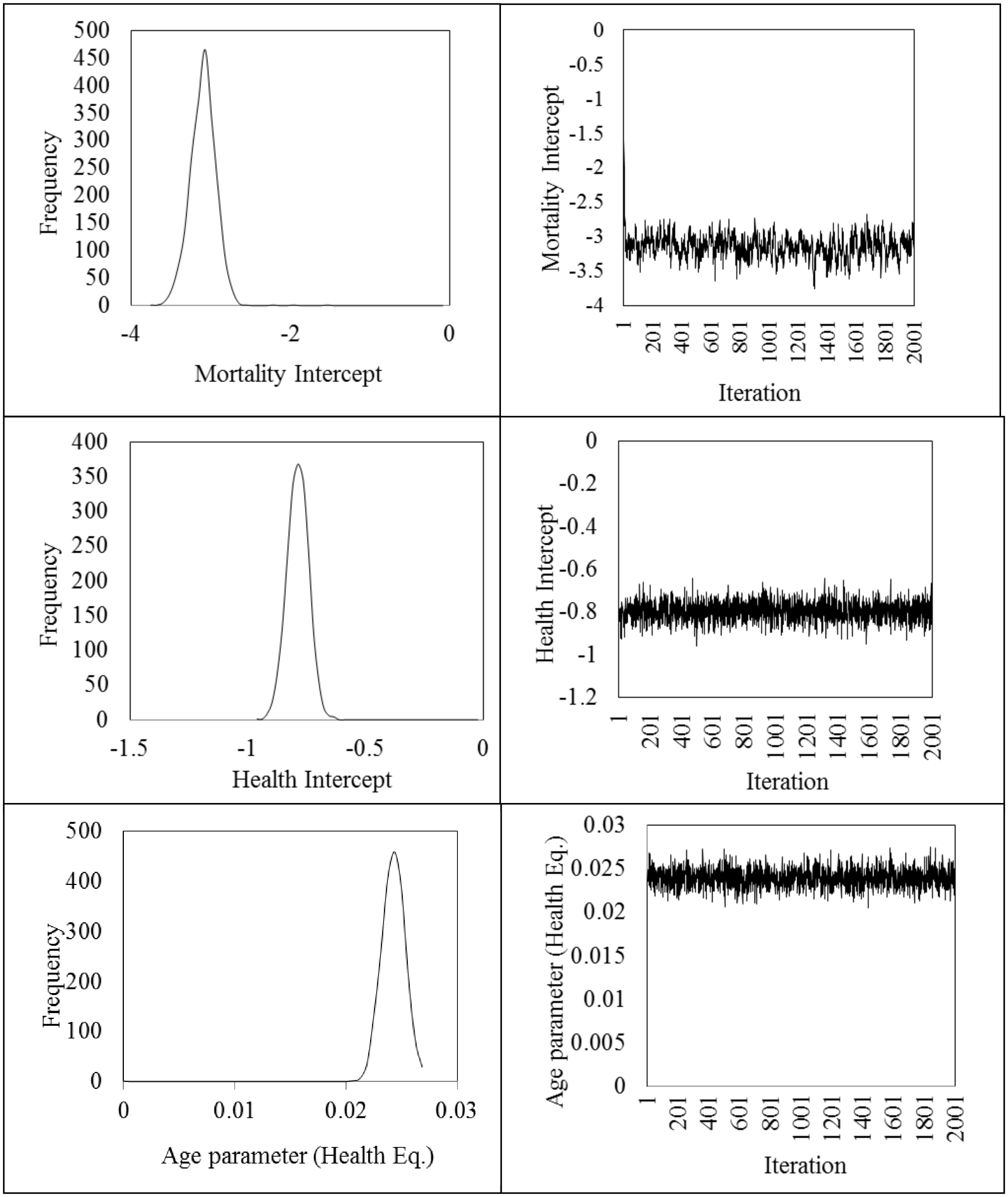
Variables	Males	Females	Total
Age			
Mean (Standard Deviation)	40 (15.84)	37 (14.89)	38 (15.38)
Gender (%)	43.1	56.9	100
Education (%)			
No education	37.6	69.2	55.6
Primary (1-5 years)	21.4	12.1	16.1
Lower secondary (6-8 years)	11.6	6.8	8.9
Secondary (9-10 years)	17.7	8.3	12.3
Higher secondary (11-12 years)	7.0	2.8	4.6
Undergraduate (13-15 years)	3.5	0.6	1.9
Graduate (16+ years)	1.1	0.2	0.6
Disability (%)			
Disabled	39.2	52.9	43.7
Not disabled	60.8	47.1	56.3
Smoking Status (%)			
Smokers	58.7	29.3	42
Non-smokers	41.3	70.7	58

Gibbs sampling was used to generate samples of parameters from the posterior distribution for the observed data. In addition, a Metropolis–Hastings (MH) algorithm was applied within the Gibbs sampling procedure to sample parameters for error correlation. Gibbs sampling requires conditional distributions for parameters which are to be sampled for estimation. However, it can sometimes be difficult to develop conditional distributions when the mathematics of a distribution is complex. Metropolis–Hastings (MH) is another sampling procedure which is utilized to deal with such complexities as it does not require conditional distributions. Both these sampling procedures were set to run for 10000 iterations and every fifth iteration was accepted which resulted in the acceptance of 2000 iterations. These sampling algorithms produce sample values of the parameters which are not independent. That is, each sampled value is influenced by the value sampled immediately prior to that iteration. The acceptance of every k^{th} iteration is recommended to avoid such autocorrelation which could result in invalid variance estimates.

The final acceptance rate for the Gibbs sampler was around 70% which is conventionally on the higher side, but is within an acceptable limit. An acceptance rate of around 50% or slightly lower is considered ideal; however rates between 25% and 75% are still acceptable. The assessment of an acceptance rate is essential in evaluating the performance of Gibbs sampling. A low acceptance rate indicates that algorithm is neither converging nor mixing well. Similarly, a high acceptance rate implies that the algorithm is converging very slowly or mixing very slowly. In addition, too high or too low acceptance rate as indicative of slow mixing could worsen the problem of autocorrelation (Lynch, 2007).

Figure 1 Histograms and Trace Plots of Gibbs Samples for Selected Parameters Estimated from Bivariate Probit Regression Model




Frequency
500
450
400
350
300
250
200
150
100
50
0
-4
-2
0
Mortality Intercept
Mortality Intercept
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
1
201
401
601
801
1001
1201
1401
1601
1801
2001
Iteration
Frequency
400
350
300
250
200
150
100
50
0
-1.5
-1
-0.5
0
Health Intercept
Health Intercept
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
1
201
401
601
801
1001
1201
1401
1601
1801
2001
Iteration
Frequency
500
400
300
200
100
0
0
0.01
0.02
0.03
Age parameter (Health Eq.)
Age parameter (Health Eq.)
0.03
0.025
0.02
0.015
0.01
0.005
0
1
201
401
601
801
1001
1201
1401
1601
1801
2001
Iteration

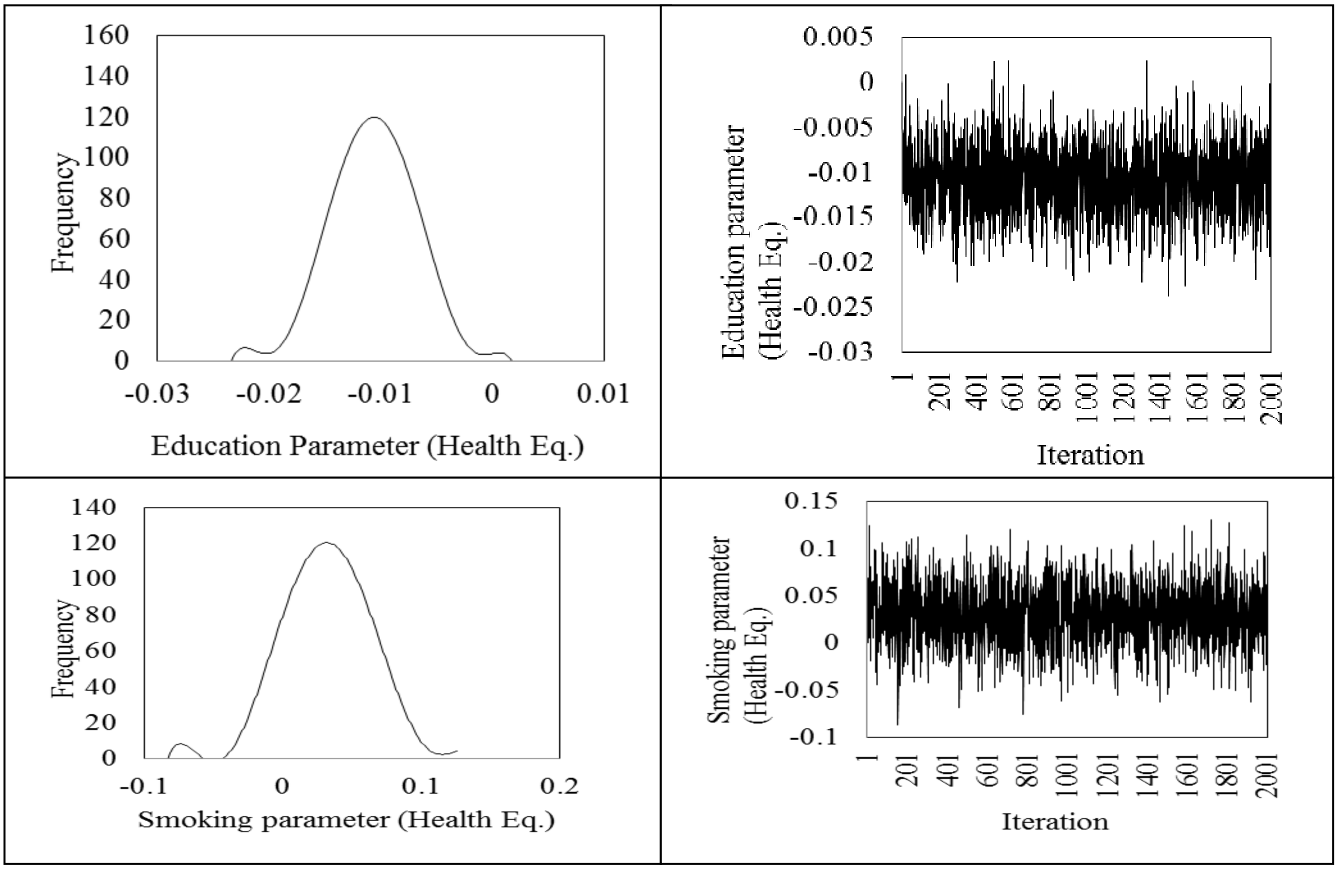
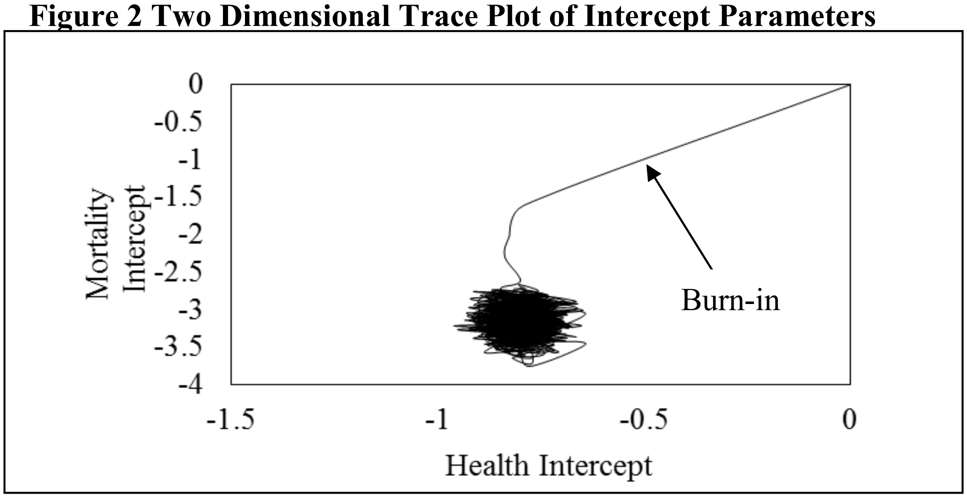


Figure 2 Two Dimensional Trace Plot of Intercept Parameters



Examination of the trace plots is also necessary to evaluate performance of the Gibbs sampler. The trace plots are used to monitor the convergence and mixing of an algorithm used for Gibbs sampling. In a trace plot, the x-axis represents the number of iterations of the algorithm, and the y-axis represents the value of a given parameter at each iteration of the algorithm. Figure 1 displays the trace plots (right hand side) and the histograms (left hand side) for the error correlation, health intercept, mortality intercept, age parameter, education parameter, and smoking parameter, which were each estimated using a probit regression model. The trace plots in the figure indicate that algorithm converged very quickly from the starting values of 0 and lies in that converged region throughout the remaining iterations. For instance, the trace plot for the age parameter (health equation) starts from 0 and then quickly converges at 0.025 stabilizing around that point throughout the remaining iterations.

The left hand side of Figure 1 presents the histograms for the selected parameters and intercepts after removing the first 1000 iterations. Figure 2 shows the two dimensional plot of the health and mortality intercept depicting the convergence of the algorithm to a narrow region from the starting value of 0 for both intercepts. Rapidity of the convergence helps to decide on the burn-in number (i.e., initial sample values discarded from the total Gibbs sample values obtained from whole sampling process). These values are discarded to reduce the influence of initial sample values on the final estimates (e.g., average active life expectancy). Initial values produced by an algorithm tend to be affected by the problem of autocorrelation. That problem gradually declines with the increase in the number of iterations approaching zero as the number of iterations reaches infinity (Lynch, 2007).

For the purpose of this study, the initial 1000 Gibbs sample values were discarded, and the remaining 1000 sample values were applied to produce life table quantities for each selected covariate profile (e.g., male smokers with 10 years of education). Table 2 provides active life expectancy estimates and estimates of the proportion of life remaining to be in active state for males and females. Although this method produces biased estimates of active life expectancy years once covariates from the health survey data are included in the model, ALE estimates based only on the covariates from the mortality data are valid. ALE estimates in this table show that males have higher active life expectancy than females. For example, a male at 25 years of age can expect on average to live 22 years of their remaining life in an active state, whereas females can expect to live 19 years in an active state. In addition, the table shows that females live longer than males, but the proportion of their remaining life to be lived in an active state is much lower than males.

Table 2 Active Life Expectancy and Proportion of Life Remaining to be Spent Active for Males and Females at 25 years of Age

Gender	Active life expectancy (ALE) in years	Inactive life expectancy in years	Proportion of life remaining to be spent active	95% empirical interval estimate for ALE years	95% empirical interval estimate for proportion of life remaining to be spent active
Male	22	18	0.56	[20.8,24]	[0.53,0.58]
Female	19	24	0.44	[17.9,20.7]	[0.42, 0.47]

Figure 3 Histograms of Proportion of Life Remaining to be Spent Active for Male and Female Non-Smokers with No Formal Education at 25 years of Age

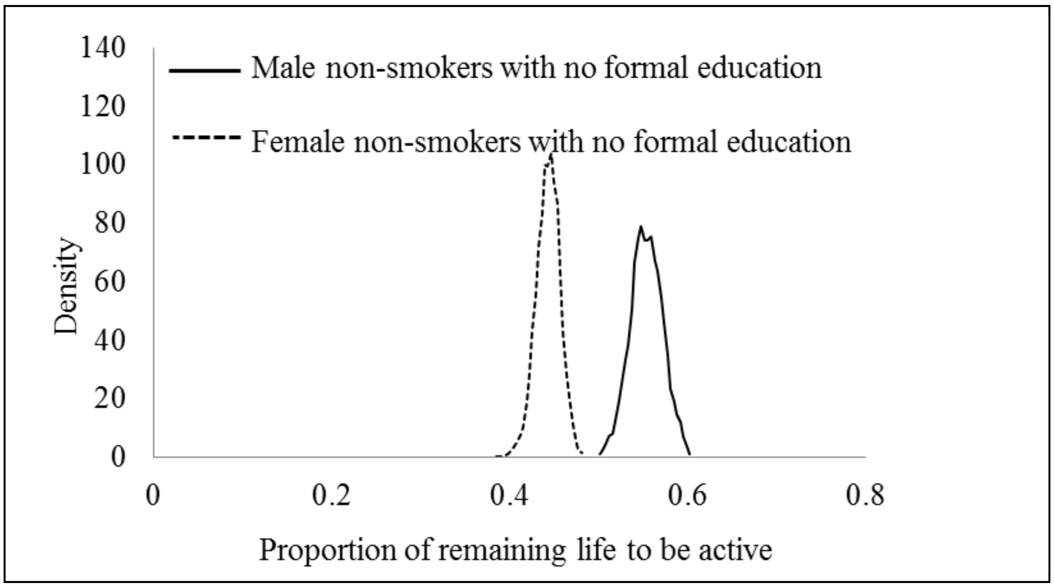


Table 2 also presents the 95% empirical interval estimates for active life expectancy in years and for the proportion of remaining life to be lived in an active state. These estimates were obtained by sorting the values of the life table estimates in an ascending order and taking 2.5th and 97.5th percentile values among the total 1000 values as lower and upper limits for the interval. Empirical interval estimate for active life expectancy and the proportion of remaining life to be spent active for both males and females do not overlap indicating the presence of significant gender difference. For example, the empirical interval for active life expectancy for females [17.9, 20.7] does not lie in a region corresponding to the empirical interval for males [20.8, 24]. This non-overlapping of interval estimates also applies to empirical interval estimates for the proportion of remaining life remaining to be spent active for both males and females. A significant gender difference in active life expectancy is further demonstrated with the histograms in Figure 3. Histograms for the proportion of remaining life to be spent active for male and female non-smokers with no formal education at 25 years of age do not overlap, which suggests a significant difference between these two subgroups.

Table 3 shows that the gender difference in the proportion of life remaining spent active exists even among people with higher education. Empirical intervals for male and female non-smokers with 10 years of education do not overlap up to 45 years of age, but after that those intervals have some overlap. Although a gender difference persists even after 45 years of age, it is not significantly different. For example, empirical interval estimates for age 65 and age 85 for males and females show considerable overlap. It is to be noted that these are empirical intervals (unlike confidence intervals) which are directly drawn from the posterior distribution. Therefore, even though differences are small (not significant), they are considered real as though estimates were generated from the population data. Inference drawn from empirical intervals is also supported in figure 4. Histograms for males and females at 25 years of age overlap, but do so only in a small area near the tails.

In figure 5, histograms for males and females at age 65 overlap to a considerable degree indicating a substantially smaller difference, which supports the conclusion drawn from empirical interval estimates. The proportion of life remaining to be spent active for male non-smokers with 10 years of education gradually declines as they age, and such finding is consistent for females. For example, the estimate of the proportion of life remaining to be spent active for

Table 3 Proportion of Life Remaining to be Spent Active for Non-Smokers with 10 years of Education

Age	Proportion of life remaining to be spent active for males	Proportion of life remaining to be spent active for females	95% empirical interval estimate for males	95% empirical interval for females

25	0.591	0.481	[0.545,0.63]	[0.426,0.528]
35	0.544	0.433	[0.497,0.584]	[0.377,0.482]
45	0.495	0.386	[0.445,0.538]	[0.329,0.437]
55	0.447	0.343	[0.394,0.493]	[0.286,0.395]
65	0.406	0.309	[0.345,0.455]	[0.248,0.368]
85	0.374	0.295	[0.298,0.458]	[0.213,0.394]

Figure 4 Histograms of Proportion of Life Remaining to be Spent Active for Male and Female Non-Smokers with 10 years of Education at 25 years of Age

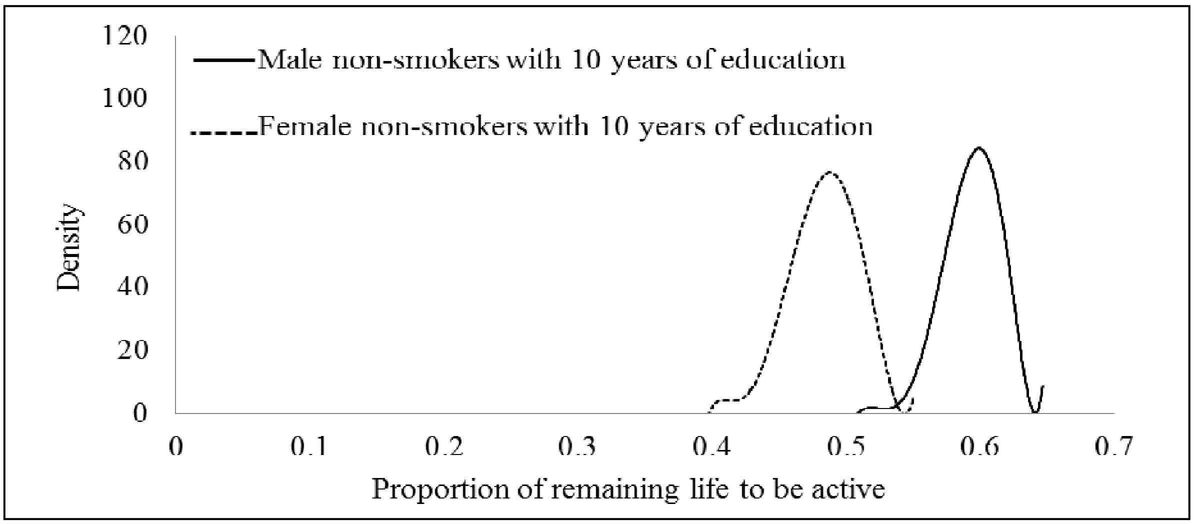
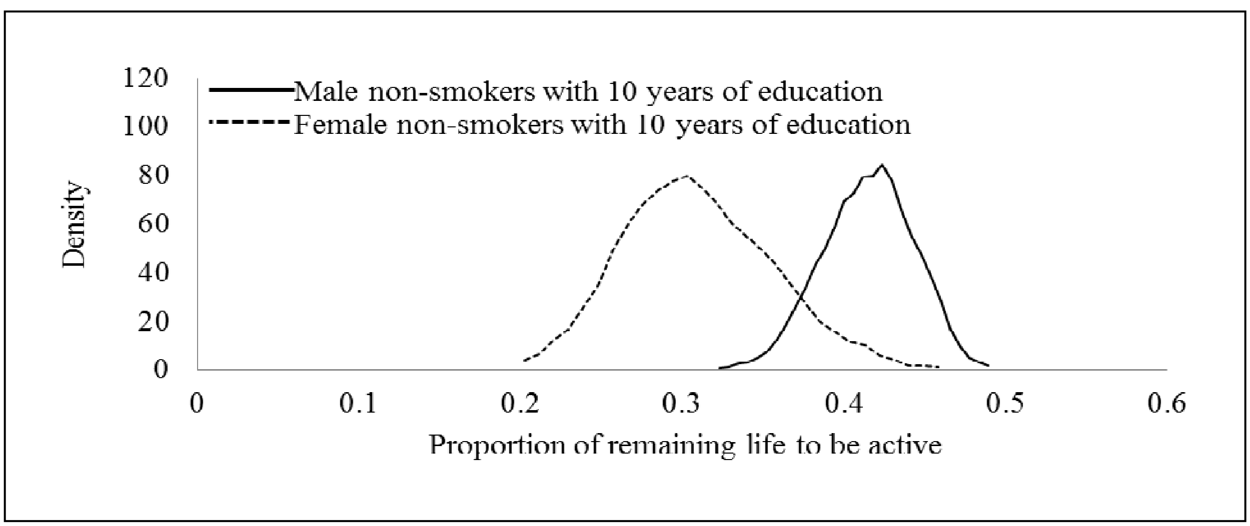


Figure 5 Histograms of Proportion of Life Remaining to be Spent Active for Male and Female Non-Smokers with 10 years of Education at 65 years of Age



males at 25 years of age is 0.591, which declines to 0.374 at 85 years of age. Similarly, that proportion for females at 25 years of age is 0.481, which declines to 0.295 at 85 years of age.

Table 4 shows a significant gender difference in the proportion of life remaining to be spent active for male and female non-smokers with no education. Such differences exist at all ages except at 85 years of age when empirical interval estimates of proportions for both males and females overlap substantially. Table 3 and Table 4 show that proportions of life remaining to be spent active for non-smokers with 10 years of education is greater than non-smokers with no formal education. Such difference holds regardless of age or gender. However, this difference may not be significant for all groups as evidenced by histograms in Figure 6 and Figure 7. Histograms for male non-smokers with 10 years of education and male non-smokers with no formal education at 35 years of age do not overlap, demonstrating the existence of strong difference between the two male subgroups. Such significant difference does not exist for the matching female subgroups because histograms presented in Figure 7 overlap.

The influence of education on the proportion of remaining life years in an active state is slightly higher for males compared to females except at 25 years of age. For example, the influence of education is 0.043 at 25 years of age for both males and females, but such influence is lower for females at other age groups as shown in Table 5.

Table 4 Proportion of Life Remaining to be Spent Active for Non-Smokers with No Formal Education

Age	Proportion of life remaining to be spent active for males	Proportion of life remaining to be spent active for females	95% empirical interval estimate for males	95% empirical interval estimate for females
25	0.548	0.438	[0.511,0.584]	[0.411,0.463]
35	0.501	0.391	[0.463,0.536]	[0.361,0.418]
45	0.452	0.346	[0.414,0.488]	[0.314,0.374]
55	0.405	0.305	[0.366,0.443]	[0.272,0.336]
65	0.366	0.275	[0.324,0.407]	[0.239,0.31]
85	0.34	0.266	[0.282,0.40]	[0.215,0.326]

Figure 6 Histograms of Proportion of Life Remaining to be Spent Active for Male Non-Smokers with 10 years of Education and Male Non-Smokers with No Formal Education at 35 years of Age

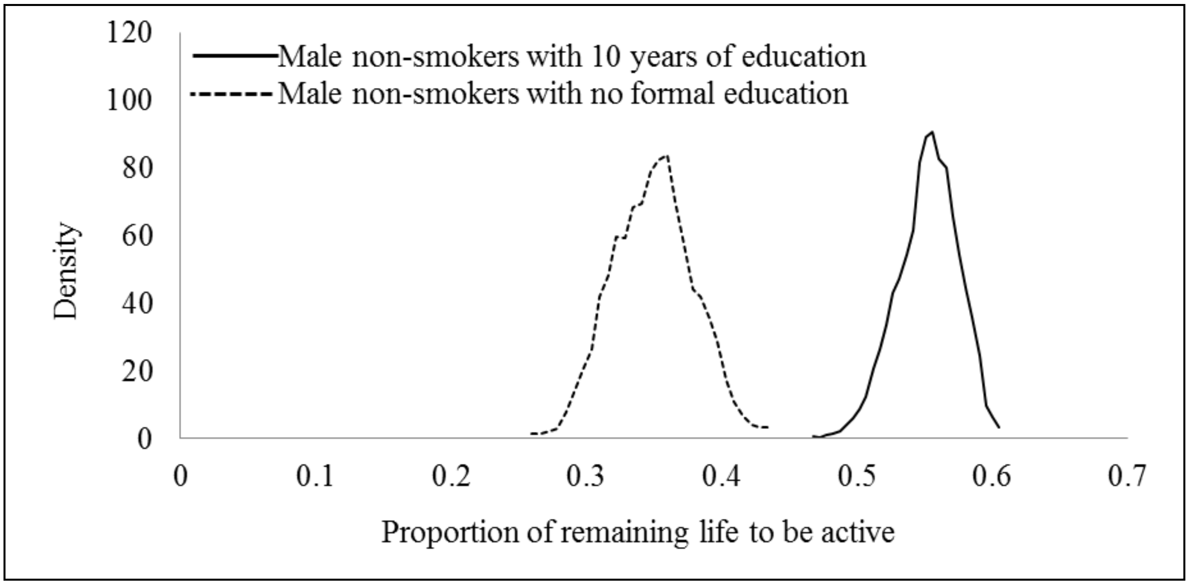


Figure 7 Histograms of Proportion of Life Remaining to be Spent Active for Female Non-Smokers with 10 years of Education and Female Non-Smokers with No Formal Education at 35 years of Age

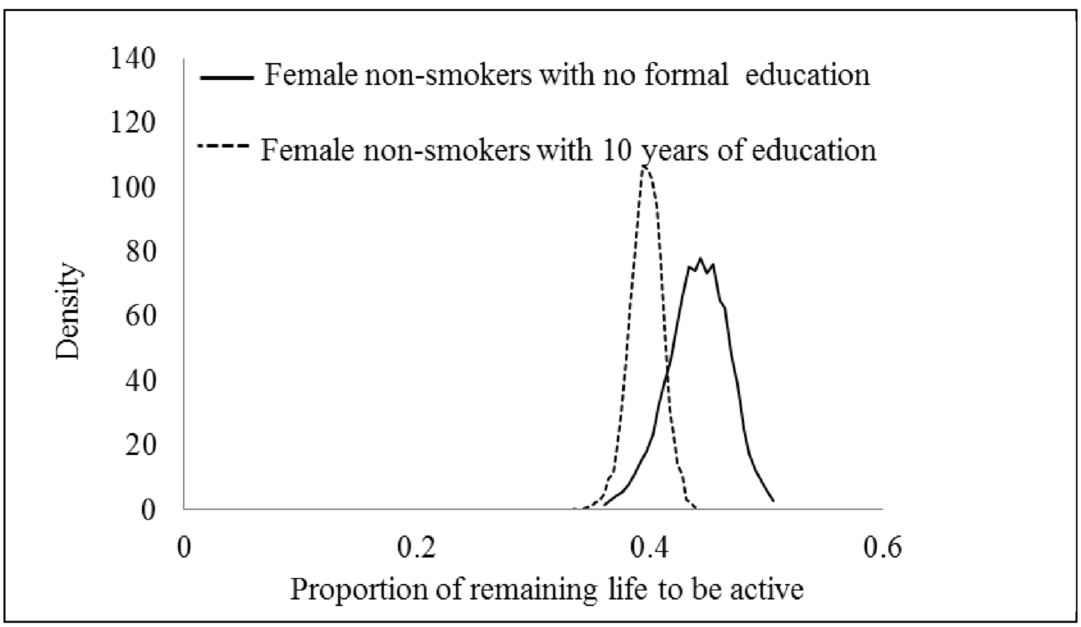


Table 5 Proportion of Life Remaining to be Spent Active for Smokers with No Formal Education

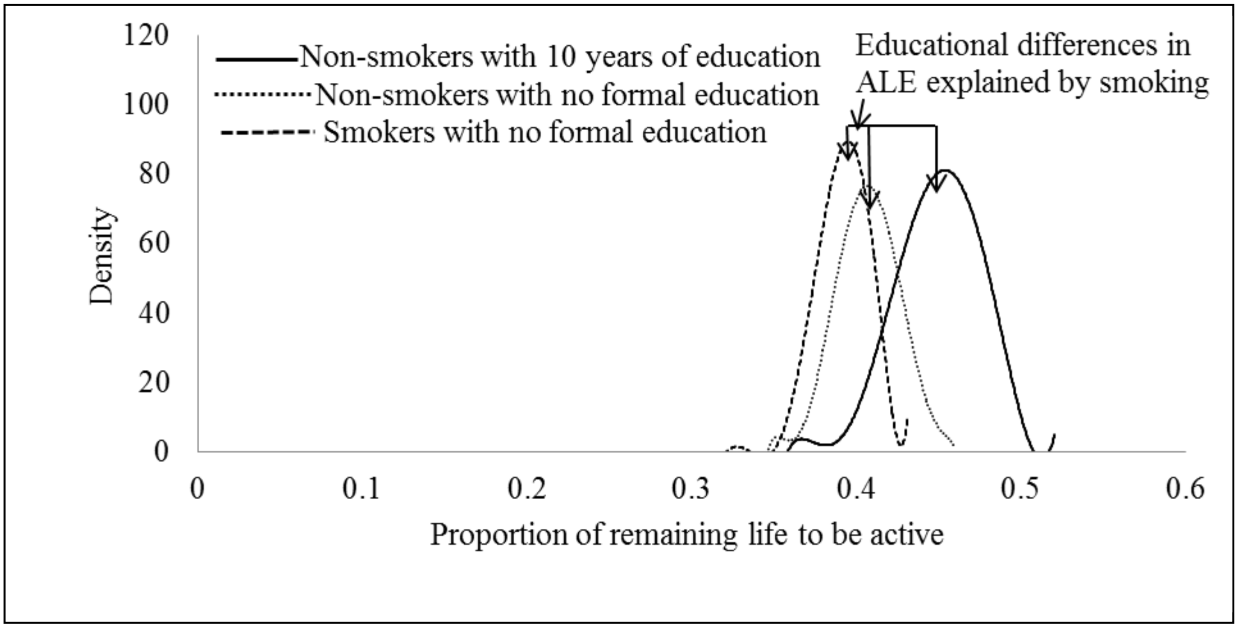
Age	Proportion of life remaining to be spent active for males	Proportion of life remaining to be spent active for females	95% empirical interval estimate for males	95% empirical interval estimate for females
25	0.533	0.423	[0.505,0.562]	[0.395,0.451]
35	0.485	0.376	[0.457,0.514]	[0.348,0.404]
45	0.437	0.332	[0.408,0.466]	[0.302,0.36]
55	0.391	0.292	[0.36,0.42]	[0.262,0.323]
65	0.352	0.263	[0.318,0.385]	[0.23,0.297]
85	0.326	0.254	[0.276,0.38]	[0.204,0.312]

Table 5 shows that gender differences, a pattern similar to non-smokers with no formal education, exists for smokers with no formal education. Male and female smokers with no formal education significantly differ on their proportions of remaining life years lived in an active state. That difference exists across all age groups selected for this study except 85 years of age when difference becomes insignificant.

Comparisons between smokers and non-smokers with equal education status based on Table 4 and Table 5 suggest that the proportion of remaining life years in an active state is lower for smokers compared to non-smokers. The difference in the proportions between smokers and non-smokers with no formal education is 0.015 for both males and females at 25 years of age. This difference is constant across all age groups with only slight decline at older ages. For instance, the difference declines to 0.014 for males at 85 years of age, whereas it declines to 0.012 for females at same age.

As displayed in Figure 8, three subgroups were considered to estimate the proportion of educational differential in active life expectancy attributable to smoking. In order to estimate that proportion, histograms of proportion of life remaining to be spent active for male non-smokers with 10 years of education, male non-smokers with no formal education, and male smokers with no formal education were compared. Since the first two groups' smoking statuses are similar, the difference between their proportions is due to their educational status.

Figure 8 Histograms of Proportion of Life Remaining to be Spent Active for Males with 10 years of Education and Males with No Formal Education at 55 years of Age



Similarly, the last two groups' educational statuses are similar, which implies that difference between their proportions is due to smoking. However, comparison between the first and the last subgroups shows that the difference is attributable to both education and smoking. As the difference between the first two subgroups is purely due to education; the differences between last two subgroups stand out as purely due to smoking. These two quantities add together to equal the difference between the first and the last subgroups. Therefore, difference between the last two subgroups divided by the difference between the first and the last subgroup provides the contribution of smoking to the educational differential in active life expectancy for males in Nepal.

Table 6 presents the proportion of the educational differential in active life expectancy explained by smoking status for males and females. Results show that smoking has similar contribution to the educational differential in active life expectancy across all age groups for both males and females. Such contribution is slightly higher at 85 years of age regardless of gender. For example, for males at 85 years of age, 29.3% of the education differential in active life expectancy is due to smoking, which is comparatively higher than its contribution at earlier ages.

Table 6 Proportion of Educational Differential in Active Life Expectancy Explained by Smoking

Age	Males	Females
25	0.26	0.256
35	0.256	0.253
45	0.255	0.251
55	0.255	0.252
65	0.262	0.257
85	0.293	0.288

A similar pattern exists for females at 85 years of age for whom 28.8% of the educational differential in active life expectancy is attributable to smoking. Table 6 also shows that the contribution of smoking to the educational differential in active life expectancy is slightly higher for males than females across all age groups. For instance, for males at 25 years of age 26% of the educational difference in active life expectancy is due to smoking, whereas for females it is 25.6%. Such gender difference in the amount of contribution persists even at older ages. At 65 years of age, for males 26.2% of the educational differences in active life expectancy are due to smoking, but such contribution for females is 25.7%.

Discussion

Much of the research on educational differential in active life expectancy has been carried out in developed countries, particularly in the U.S. Though there is some research conducted on this topic in developing countries, there exists no such research in Nepal. Previous studies on the educational differential in active life expectancy have consistently established the influence of education in producing differences in active life expectancy. Various mechanisms such as smoking are expected to generate those differences as inferred from previous studies on educational inequalities in health, disability, and mortality. However, little research has examined the contribution of smoking to educational differentials in population health measures such as healthy life expectancy and active life expectancy. One study examined the influence of smoking demonstrating its substantial contribution to educational differential in health life expectancy (Brønnum-Hansen & Juel, 2004). Apart from this study, there is a lack of research on mechanisms such as smoking responsible for educational inequality in population health measures. In fact, no study is available which measured the contribution of smoking to educational differential in active life expectancy.

The main purpose of this study was to expand the previous literature by extending this type of research to a least developed country. In this study, I examined the influence of education in producing inequality in active life expectancy and also assessed the contribution of smoking behavior to this educational differential. Based on the existing literature, I formulated a hypothesis that differences among educational subgroups in terms of their active life expectancy exist, and a substantial portion of that difference is attributable to differences in smoking behavior. The findings of this study support the hypothesis that education creates differentials in active life expectancy and that smoking behavior substantially contributes to these differentials. However, the significant amount of the educational differential in active life expectancy remains unexplained, indicating the contribution of various other factors such as access to health care to such differential. The significant educational differential in active life expectancy unexplained by smoking indicates that inequality in health persists even if mechanisms, through which health outcomes are produced, are altered and removed. Therefore, this finding confirms the "fundamental cause of disease" idea proposed by Link and Phelan (1995) which considers education as a distal cause of disease linked to disease outcomes through proximal causes such as smoking. Link and Phelan (1995) assert that distal causes are fundamental causes of diseases which, if unaddressed, continue to generate inequality in health through new proximal causes even though the existing proximal causes are removed. The finding of this study further demonstrates the consistency of education as the best predictor of health outcomes and shows that education is able to produce inequality in active life expectancy regardless of the existing social, economic, cultural, or developmental context (Link & Phelan, 1995).

This study reiterates the importance of education in reducing disparities in active life expectancy and emphasizes the role of smoking in explaining existing educational disparities in active life expectancy. The findings show that people with higher education spend a higher proportion of their remaining life in an active state compared to people with lower education. Such findings were consistently reported by previous studies on educational differentials in active life expectancy across various cultural and national contexts (Crimmins et al., 1996; Laditka & Wolf, 1998; Minicuci & Noale, 2005; Kaneda et al., 2005). This could be due to the advantage people with higher education enjoy regardless of the existing social system. Every social system provides a structure that protects people from vulnerability, but it also has constraints which leaves them vulnerable. For example, developed countries provide social insurance to protect people from possible vulnerabilities due to their socioeconomic background, whereas family provides this type of protection in developing countries. High cost of health care, lack of health infrastructures, and equal access to quality health care are some of the constraints people are likely to face in any social system. However, people with higher education are able to negotiate existing constraints in that social system through opportunities provided by reward structures available in a given society to gain health benefits over their less educated counterparts. In addition, people with higher education are more likely to adopt healthy behaviors, less likely to face stressful life events, and have better social networks to gain social support. These factors place them in a better position, not only to avoid, but also to treat diseases and disabilities that may occur (Zimmer et al., 1998; Freedman & Martin, 1999; Grzywacz et al., 2004).

Among the factors responsible for the better health status of people with higher education, health behaviors (particularly smoking and alcohol consumption) stand out as important contributors to their health advantage. The findings of this study support earlier evidence that demonstrated the influence of smoking in producing differential health status among various educational groups (Dunn, 2010). The assessment of the contribution of smoking to the educational differential in active life expectancy reveals substantial influence of smoking in producing differences among educational subgroups. These findings are consistent with previous studies on mechanisms responsible for producing socioeconomic inequality in health, which reported significant influence of health behaviors to alter such inequality (Lantz et al., 1998; Liu et al., 1995). Further, it supports the finding of the previous study which examined the influence of smoking to educational differences in healthy life expectancy (Brønnum-Hansen & Juel, 2004). Smoking status explains differences among educational groups because of its differential clustering among different educational groups. As indicated by earlier studies, people with higher education are less likely to smoke compared to lower education counterparts, and thus, are less vulnerable to smoking related disease and deaths (Pampel & Rogers, 2004; House, 2005; Meara et al., 2008**).**

Even though the contribution of smoking to the educational differential in active life expectancy is consistent across all age groups for both males and females, a slightly higher contribution is found at older ages. Such a pattern could be due to the higher concentration of smoking related disabilities and deaths among older cohorts. Since people with higher education are more likely to avoid these smoking related disabilities and deaths at older ages, their active life expectancy is likely to be much higher at older ages compared to lower educated counterparts. This study also demonstrates the significant influence of smoking on educational differential in active life expectancy even at younger ages. It is difficult to provide an explanation for this finding as it contradicts earlier findings which argued that an excess number of smoking related deaths occur at older ages (Burns, 2000). It could be possible that smoking related disabilities and deaths occur much earlier for people with lower socioeconomic status because of the disadvantages they face from an early childhood.

The majority of people in Nepal live in poverty, so it is likely that people with lower education are raised in an insanitary environment with shortages of even a basic supply of clean water. In addition, they are less likely to receive a nutritious diet and less likely to have access to appropriate health care during their childhood. The effect of these disadvantages may be confounded with risky health behaviors such as smoking to produce disease, disability, and death much earlier than usually observed among higher socioeconomic groups. It could also be possible that disability among people with lower education may not actually be due to smoking or it may have occurred before a person started smoking. Other factors such as accidents and complications from acute illness may also result in a disability, but a higher smoking prevalence among people with lower education may imply that those disabilities could be due to smoking.

This study suggests that smoking has a higher contribution to the educational differential in active life expectancy for males compared to females for all age groups. In Nepal, smoking prevalence among males is higher than females, which may result in the higher number of disabilities and deaths among males than females (www.who.int/countries/npl/en/). With the likelihood of higher concentration of smoking, and therefore smoking related diseases, among lower educated males, the disparity could be higher for males than females. Significant gender differentials in active life expectancy observed in this study reflect discrimination against females that is prevalent in Nepal. Females face disadvantages from their early childhood in terms of sanitation, food, and health care. Such discrimination against females still exists in Nepal, but it is more prevalent in rural areas particularly among lower educated parents. These gender differentials exist even among higher educated groups. The extent of the discrimination appears so significant that females, even if they are educated and adopt healthy behaviors, live a higher proportion of their remaining life in disability compared to males who are smokers and have no formal education. Nepal is among a few countries where females not only have lower life expectancy, but also have lower healthy life expectancy. In developed and in many developing countries, females have higher total and active life expectancy than males (Mathers et al., 2000). However, similar to the findings of previous studies in developed and developing countries, this study reports that females spend a higher proportion of their remaining life in disability. Such finding implies that even though females do not live longer, they face diseases which are more disabling compared to their male counterparts.

This study has several limitations. These are related to the measures, method, and the design used for this study. In a country like Nepal, whose economy is dominated by agriculture, education is less likely to represent people's actual socioeconomic status. The rewards of higher education may not be as significant as in developed countries since opportunities for formal employment are limited. Even though people with higher education are more likely to be aware of their health and have better social networks, a lack of formal employment limits the availability of avenues to increase economic resources. Lack of economic resources may limit people's access to health care. Therefore, education may not be able to produce significant differentiation in health. Land acquisition, home ownership, or wealth could also generate a similar differentiation in health as education because of the higher economic potential of those socioeconomic indicators in an economy driven by agriculture. Future studies should also include other measures of socioeconomic status to examine whether influences of education remain even after controlling for the influence of other socioeconomic indicators.

The disability measure used for this study is not a standardized scale, so it is not clear whether disability items employed for this study correctly reflect smoking related disability in Nepal. More importantly, no scientific information is available from studies that define what really constitutes disability in Nepal. Future studies should use a disability scale that is more likely to reflect the social and cultural context of Nepal. The measure of smoking status utilized for this study is also not consistent with previous studies. This measure does not provide information on previous smokers which could mute the difference between different smoking groups. Previous smokers have more health risk than non-smokers even though they perform better than current smokers. Lack of such classification reduces the variability that previous smokers could bring to the data. There is also no information about smoking history or consumption patterns of smokers which could help explain more variation. Future research should employ better measures of smoking status including various classifications.

Even though the life table method used here allows for the use of covariates available in the cross-sectional health survey data, active life expectancy estimates constructed for those covariates are biased since their mortality information is not available. Therefore, active life expectancy estimates calculated from this method are likely to be more influenced by disability information rather than mortality information. In addition, this method does not allow for reverse transitions. Therefore, it is likely that lower estimates of active life expectancy will be produced because disabled people who may have transitioned back to the not disabled state will be considered disabled. This may not pose a significant problem in the context of least developing countries like Nepal since recovery from disability is less likely. In Nepal, there is high probability that people may remain disabled once they incur disability for two possible reasons. First, they are less likely to be able to purchase health care; and second, they may not be aware of the advantages of seeking health care. However, there is always a likelihood that people may recover from disability. So, it will be desirable to conduct this type of study with a longitudinal data utilizing a multi-state method so that the influence of reverse transitions can be accounted. Longitudinal data is also necessary to address the problem of temporality. For example, it cannot be inferred from this data whether disability occurred before people started smoking.

Mortality data was not matched to a year in which a health survey was taken, and this may have resulted in slightly lower estimates of active life expectancy. Evidence suggests that the mortality rate in Nepal is declining, so mortality probabilities could be lower than those provided by census data. Such estimates may not correctly reflect the health status of the population at the time of the survey. In addition, mortality rates were calculated from a sample number of deaths which may not accurately reflect the mortality profile of the population. Such a possibility is indicated by higher life expectancy estimates reported in the current study for both males and females. These estimates are different from those estimated by various agencies such as the Central Bureau of Statistics in Nepal. Life expectancy estimates at the time of the survey were much lower, which could imply that mortality probabilities calculated from the sample data file were lower than the actual probability.

The influence of smoking could in fact be due to other confounding factors such as alcohol consumption. Smoking is associated with alcohol consumption (Anthony & Echeagaray-Wagner, 2000). Since alcohol consumption also contributes to disability, smoking related disability could be due to its interaction with alcohol consumption (Taylor & Rehm, 2006). Future research should include alcohol consumption so as to single out the independent contribution of smoking to disability. In addition, people in Nepal use firewood for cooking, and smoke generated from that fire contributes to "inner" pollution (i.e., poor air quality inside the home). Research has shown that inner pollution is harmful for health. The harmful impact of inner pollution is further increased by smoking behavior, and the interaction between both could result in a higher likelihood of acquiring tuberculosis (Lin, Ezzati, & Murray, 2007). Furthermore, active smoking is independently associated with the probability of having tuberculosis (Davies et al, 2006). Smoking also affects people who live in the same household or in close proximity. Such passive smoking could lead to diseases such as tuberculosis, and thus, both types of smoking pose a significant threat to the health status of the population (Leung et al., 2010). Future research should include these possible confounding factors so that the independent effect of smoking can be estimated.

Despite these limitations, this study has contributed to the vast body of literature available in this topic. This study is important for future policy formation to reduce health inequality in Nepal. The findings of this study emphasize the importance of education in reducing health inequality and also shed light on health inequality generated by smoking behavior. In order to reduce health inequality, both issues should be addressed. Initiatives should be taken to increase the education status of the population, while at the same time, public health measures should be taken to reduce smoking prevalence. These issues, if unaddressed, are likely to further increase inequality in health. As the rewards associated with higher education increase with the modernization of the economy, inequality between people who have higher education and people who have lower education is likely to increase in the future.

In order to reduce educational inequality in active life expectancy, formulation of policies to reduce smoking are essential as smoking helps to further expand health inequality by placing increased burden of disease and disability among people with lower education. Since people who smoke are more likely to be from a lower socioeconomic status, an increased burden of disease and disability implies a further lowering of socioeconomic status among those people (Wagstaff, 2002; Gilman et al., 2003; Nielsen, 2004). There is high probability that the impact of smoking in Nepal could be more adverse than found in developed countries. A majority of people live in poverty and lack even basic education. Therefore, people face many socioeconomic disadvantages from early childhood which include lack of nutrition, sanitation, vaccination, and appropriate health care. The cumulative disadvantage of these factors could become even more problematic when people adopt risky health behaviors such as smoking.

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