UNIVERSITY OF CAPE COAST

EFFECTS OF GOLD MINING ACTIVITIES ON HEALTH OF HOUSEHOLDS IN THE OBUASI MUNICIPALITY IN GHANA

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BY

AMETEFEE KORBLA NORMANYO

Thesis submitted to the Department of Economics of the Faculty of Social Sciences, College of Humanities and Legal Studies, University of Cape Coast, in partial fulfilment of the requirements for the award of Doctor of Philosophy degree in Economics

JUNE, 2016

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature:.. Date: 18/09/2017

Name: Ametefee Korbla Normanyo

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature:.................................... Date: 18/09/2017

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Co-Supervisor's Signature:.. Date: 20/09/2017

Name: Prof. Samuel Kobina Annim

ABSTRACT

Despite the significant contribution of gold mining to Ghana's socio-economic development, it generates negative externalities which pose health hazards to residents near the source of extraction. The study estimates the effects of exposure to gold mining pollution on health expenditure, potable water and intergenerational health. A cluster sampling survey conducted in the Obuasi Municipality provided data for the study. An instrumental variables hedonic regression was employed to estimate the relationship between health expenditure and exposure to mining pollution while Marshallian demand and intergenerational transmission models were used to estimate the effect of pollution exposure on residential water usage and intergenerational health respectively. Results suggest, after controlling for factors such as current and long term health status, that gold-mining pollution has a positive effect on private healthcare expenditure, decrease water consumption and availability, and could be linked to intergenerational transmission of cardiovascular diseases, asthma and respiratory tract infections across generations. By directly estimating mining pollution impact on healthcare spending, compensation for exposure to such pollution could be calculated and victims better compensated. Thus, the distance to the tailings could be the yardstick for determining such compensation, all else being equal. Quality water availability should be improved by expanding the piped water networks. Specialized and well-resourced centres should be established to study, monitor and combat current health effects of mining pollution from affecting future generations while at the same time, generating longitudinal data for research.

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Lastly, I wish to thank my friends and family: my wife, children and my brothers and sisters for their moral and spiritual support.

DEDICATION

In memory of my brother, Duwonu (Shabaash) for his invaluable contribution to my formal education journey.

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LIST OF ABBREVIATIONS

AGA	AngloGold Ashanti
AMD	Acid Mine Drainage
AS	Arsenic
BoG	Bank of Ghana
DALYs	Disability Adjusted Life Years
FDI	Foreign Direct Investment
GhS/Gh¢	Ghana Cedis
GPA	Global Programme of Action
GSS	Ghana Statistical Service
IBS	Irritable Bowel Syndrome
IQ	Intelligence Quotient
INECAR	Institute of Environmental Conservation and Research
IUGR	Intrauterine Growth Restriction
LBW	Low Birth Weight
LRTI	Lower Respiratory Tract Infections
MeHg	methylmercury
MTM	Medication Therapy Management
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
OOP	Out of Pocket
QWB	Quality of wellbeing
UCC	University of Cape Coast
UNEP	United Nations Environment Programme
WAZ	Weight-for-age Z-Score
WTA	Willingness to Accept
WTP	Willingness to Pay

CHAPTER ONE

INTRODUCTION

Background to the Study

Although mineral resources account for a small share of world production and trade (Gugler, 2009), their supply is essential for the sustainable development of a modern economy (Highley, Chapman, & Bonel, 2004). Mineral extraction and trade, is capital intensive and for most developing countries, it is export-oriented. It is therefore, a source of export and fiscal revenues, employment, and growth to most of these resource-rich countries (Papyrakis & Gerlagh, 2004). In addition to these benefits, natural resource extraction also generates negative effects including considerable threats to the local environment and adverse social and health implications (Chuhan-Pole, Dabalen, & Land, 2017). As a result, resource-rich developing countries, particularly with weak institutions, appear to benefit very little from mining activities (Boschini, Pettersson, & Roine, 2007). This places resource supplying economies at a disadvantage in the long term since these are non-renewable natural resources. Mining activities generate many negative spill-over effects.

During gold mining operations, especially in developing countries, exposure to heavy metals (arsenic, cyanide, and mercury, etc.) is very high among residents around the mine. For example, tons of inorganic mercury goes into the atmosphere while the rest winds up in piles of mining waste, soils and waterways (Telmer & Veiga, 2009). In addition, high concentrations of arsenic are found close to areas of gold mining (Smedley, 1996). Both chemicals are hazardous to human health. Current studies suggest (see e.g., Downer et al., 2017) that present levels of exposure to methylmercury (MeHg have the potential of resulting in an elevated risk of cardiovascular diseases and neurological problems to a significant fraction of the population. However, MeHg, which passes more easily into the brain, is generally considered to be more toxic, particularly among children, who can experience IQ losses, delayed speech, and other neuro-developmental deficits from exposure (Mergler et al., 2007). Exposures later in life, on the other hand, produce more localized damage to the cerebellum, visual cortex, and motor strip.

Arsenic in drinking water can affect human health and is considered one of the most significant environmental causes of cancer in the world (Karagas, Gossai, Pierce & Ahsan, 2015; Singh, Kumar & Sahu, 2007). Others include non-carcinogenic effects such as diabetes (Maull et al., 2012; Thayer, Heindel, Bucher & Gallo, 2012), peripheral neuropathy, cardiovascular diseases (Chen et al., 2011; Moon et al., 2013; James et al., 2015); and low birth weight and adverse pregnancy outcomes (Quansah et al., 2015; Singh et al., 2007). Thus, it is important to pay particular attention to the health implications of mining pollution. While it is good to exploit the world's resources for the development of humanity, such exploitation need not put current and future livelihoods and health of the people or groups of people living in the environment, where the resources are being exploited, at risk or worse-off. Therefore, with the dearth of evidence linking pollution to poor health outcomes, efforts to reduce or prevent pollution prevent should be seen as investment in human capital—a key to sustaining increases in labour productivity and economic growth (see e.g., Graff Zivin and Neidell (2012).

In the case of Ghana, Mineral resources extraction has undoubtedly played a major role in the socio-economic and political life of the country for more than a century and remains a key industry for the growth and development of the Ghanaian economy. Ghana's mining sector contributes approximately 40% of gross foreign exchange earnings (of which gold alone contributes over 96%) and accounts for approximately 5.2% of Gross Domestic Product (GDP) (Ghana Minerals Commission, 2006). In 2012, non-oil minerals accounted for 43% of total export earnings, ahead of oil (22%) and cocoa (20.9%) and delivered 37% of corporate tax earnings (Bank of Ghana, 2013; Bermúdez-Lugo, 2014). Between 1983 and 1998, the mining industry in Ghana attracted approximately US$ 4 billion in Foreign Direct Investment (FDI) to Ghana, representing more than 60% of all such investment in the country (Aryee, 2001). In 2012 alone the minerals sector accounted for about $1 billion in investment inflows into Ghana and generated $5.4 billion in revenue of which gold contributed about 98% (Bermúdez-Lugo, 2014).

In terms of employment and technology, there are two major players in the minerals mining industry - small-scale/artisan miners and large-scale miners. Small-scale mining is largely illegal and therefore unregulated and employs over 300,000 people majority of whom are illiterates who, until recently, utilize rudimentary technology. This contrasts sharply with the large-scale mining sector which is highly regulated, uses advanced technology and thus employs very few (about 11,000 in all) but highly skilled individuals (Amponsah-Tawiah & Dartey-Baah, 2011).

In spite of the positive contribution of gold mining to the economy of Ghana, it generates negative externalities. For example, Obiri, Dodoo, Okai-Sam and Essumang (2006) reported eleven major cyanide spillages in Ghana between 1989 and 2004 into rivers and streams. Households in adjacent communities who utilize such polluted waters suffer health consequences, including cyanide intoxication (Amegbey & Adimado, 2003). Obiri et al, (2006) found that approximately 230 and 43 resident adults along River Bogo Upstream were at risk of suffering from cyanide intoxication related chronic non-cancerous diseases through oral and dermal contact respectively. Studies by Essumang, Dodoo, Obiri and Yaney (2007) and Obiri, Dodoo, Okai-Sam, Essumang and Adjorlolo-Gasokpoh (2006) paint similar pictures. High concentration levels of arsenic, mercury and cadmium above the WHO recommended levels were found in cocoyam and water cocoyam in the Tarkwa area (Essumang et al., 2007). Obiri et al. (2006) also found that 10 out of 100 resident adults in the Tarkwa, Bogoso and Prestea are likely to suffer cancer related diseases due to consumption of the high toxic-laden cassava cultivated in these gold mining areas. In a later study Adei, Addei and Kwadjosse (2011) found increased incidence of some diseases, including malaria, resulting from the commencement of large-scale mining operations in Ntotroso in the Asuotifi District of the Brong Ahafo Region in Ghana. In addition to the health risks posed by mining pollution, the acquisition of large tracts of farmlands by mining companies for large scale surface mining operations deprives residents living around these concessions of their source of livelihood and drives them to the fringes of poverty (Akabzaa & Darimani, 2001). Again, the use of heavy machinery in exploiting the minerals (surface mining) also has a destructive effect on the environment such as the destruction of the vegetation and the generation of a lot of dust (ILO, 2005) and noise pollutants. The fact is that sufficient information is not generally available regarding the negative impacts of mining activities (Stephens & Ahern, 2002) to enable the estimation of their net effects (Oxfam America, 2008; Women's Voice for the Earth, 2004).

Artisanal gold mining is quite volatile and its intensity is a function of socio-economic conditions of the typical poor regions where it occurs. While the use of mercury in small-scale mining in Ghana is assuming alarming proportions, small-scale gold miners in Ghana are now increasingly resorting to the use of heavy machinery such as excavators, bulldozers and water pumping machines to dig for gold everywhere and anyhow thereby rapidly destroying and inundating the environment (News Ghana, 2015; The Ghanaian Chronicle, Sept. 2014). This situation is usually exacerbated by the increasing world price of the metal coupled with increasing impoverishment of the people and the fact that very little benefit accrues to residents from regulated large-scale gold mining. The principal elements of the environment (i.e., land, water and air) have been severely affected by mining activities in Ghana. The addition to the health risks posed by mining pollution, the acquisition of large tracts of farmlands by mining companies for large scale surface mining operations deprives residents living around these concessions of their source of livelihood and drives them to the fringes of poverty (Akabzaa & Darimani, 2001). Again, the use of heavy machinery in exploiting the minerals (surface mining) also has a destructive effect on the environment such as the destruction of the vegetation and the generation of a lot of dust (ILO, 2005) and noise pollutants. The fact is that sufficient information is not generally available regarding the negative impacts of mining activities (Stephens & Ahern, 2002) to enable the estimation of their net effects (Oxfam America, 2008; Women's Voice for the Earth, 2004).

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In Ghana, due to the laxity in enforcing environmental regulations, cyanide and arsenic spillages and seepages into drinking water sources are rampant and mercury concentration within the mining communities is very high (Smedley, 1996). Again in Ghana, the elevated concentrations of the metals in various media such as soils, streams (including sediments), crops, fish (e.g., mudfish), plants (e.g., fern) and humans have been reported (e.g., Amegbey & Eshun, 2003; Ansa–Asare et al., 2014; Aryee, Ntibery and Atorki, 2003; Cortes-Maramba et al., 2006; Donkor, Bonzongo, Nartey & Adotey, 2006; Essumang et al, 2007; Hilson, 2006; Tschakert and Singh, 2007).

In a study of concentration of heavy metals in the blood of residents, Armah, Luginaah and Obiri (2012) found the risk of acute respiratory infections among residents of Tarkwa Nsuaem Municipality and Prestea-Huni Valley District (PHVD) (the exposed communities) to be 40-times and 12-times respectively higher than that of Cape Coast Metropolis (the unexposed group). The same study also estimates the risk of diabetics Mellitus in the two gold mining communities to be 20 and four times respectively higher than the unexposed group.

Statement of the Problem

Most of these studies have identified the presence and concentration of pollutants in the various media of the environment and have, in some cases, estimated the associated number of residents at risk after comparing their findings with established dose-response indicators (see e. g., Graff Zivin and Neidall, 2013). The economic values of these risks and their impact on future generations have largely not been explored.

The impact of mining on health is direct and indirect. The direct impact results from the pollution of the air, land and water bodies by dust, noise and the discharge of dangerous chemicals like mercury, cyanide and arsenic into water bodies exposing people to upper respiratory tract infections, cardiovascular diseases (Mergler et al., 2007), skin infections like keratosis and other cancerous infections and malaria (Adei et al., 2011). The consumption of food cultivated in the polluted environment, due to these discharges and consumption of the polluted water, results in diarrhoeal and other related diseases. Exposure to these dangerous discharges could also lead to fetal neurotoxicity (Mergler et al., 2007). The indirect impacts come from loss of productivity of the degraded and polluted land, joblessness due to the loss of farmlands leading to poverty (Aragón and Rud, 2016) and inability to respond promptly and satisfactorily to individual and household health needs such as higher health care costs. The miners themselves are at risk of increased frequency of cancer of the trachea, bronchus, lung, stomach, and liver; increased frequency of pulmonary tuberculosis (PTB), silicosis, among others, and decreased life expectancy.

The health impact could be instantaneous, which is fast and easier to measure and/or long-term, which is slow and multi-channeled and not easily discernible but equally devastating. These impacts—direct and indict, long term or short term—can all result in short and long-term health consequences such as increased health care expenditure, poverty, and decreased availability of quality water. Although evidence exists that both impacts are present in mining communities within the country (see e.g., Amegbey & Adimado, 2003; Essumang et al., 2007; Obiri et al., 2006), to the best of my knowledge, these studies fall short of estimating the economic value (cost) of the health-related consequences of gold mining externalities in Ghana. Relatively, little is known about the measurement of intergenerational transmission of health status (Thompson, 2014). In addition, the measurement of extent to which gold mining pollution-related health problems are transmitted across generations in Ghana remains largely unexplored. The estimation of the gold mining pollution-related health effects could compliment efforts at establishing the full cost (including externalities) of mining projects.

As a result, the study seeks to employ revealed and stated preference methods to value some gold mining related negative externalities in Ghana. Specifically, the study will estimate the health effects of such negative externalities in Ghana.

Objectives of the Study

This research seeks to assess the health effects of exposure to pollution from gold mining activities among households residing in gold mining areas in Ghana using Obuasi Municipality as a case. The specific objectives are to:

i. determine the relationship between health expenditure and exposure to mining pollution in the Obuasi Municipality;

ii. estimate the effect of mining pollution exposure on residential water usage in the Obuasi Municipality;

iii. determine the pollution related intergenerational transmission of health in the Obuasi Municipality.

Hypotheses of the Study

The main hypothesis is that gold mining activities has a negative effects on the health of the people of adjoining communities.

The specific hypotheses are:

1. $\mathbf{H_0}$: Gold mining pollution concentration has no effect on health expenditure among residents in the Obuasi Municipality.

   $\mathbf{H_1}$: Gold mining pollution concentration affects health expenditure of residents in the Obuasi Municipality.

2. $\mathbf{H_0}$: Pollution from gold mining has no relationship with residential water use in the Obuasi Municipality

   $\mathbf{H_1}$: Pollution from gold mining has a relationship with residential water usage in the Obuasi Municipality

3. $\mathbf{H_0}$: There is no pollution related intergenerational health mobility in the Obuasi Municipality

H_1: There is pollution related intergenerational health mobility in the Obuasi Municipality

Significance of the Study

Besides income and household size it is expected that more pollution impacted households spend more on their health and water collection than less impacted ones, all things being equal, and will continue at an increasing rate among future generations. This has a tendency to increase poverty levels in these communities and presents a new dimension for efforts to reduce poverty since residents affected by mining pollution have to spend higher proportions of their already shrinking incomes on health care.

Health issues rank high among the socio-economic indicators of living conditions of a people. Knowing how mining activities affect the health of residents of mining communities will be an important step towards efforts aimed at internalizing these negative externalities. The study is, therefore, a contribution to the efforts aimed at determining the full social cost of large-scale mining operations.

Scope of the Study

The study is about how large-scale gold mining activities affect the health of residents of the communities near where they are located. One of these mining communities is the Obuasi Municipality where the Obuasi mine is located. The study was limited to this area because this mine has been in existence for centuries and has passed through various regimes of mining and is expected to have been a good reservoir of pollutants.

The study uses both revealed and stated preference methods to measure the relationship between mining pollution and health outcomes, water usage and the nature of intergenerational health mobility of residents. A hedonic model is developed to measure the behaviour of a utility-maximizing household's effort to maintain a healthy household or prevent the household from 'bad' health in the face of mining pollution. This is followed by a demand for water model showing how mining pollution can influence water use for the second objective. Finally, and for the third objective a logit model is used to estimate how paternal socio-demographic characteristics and environmental risks affect intergenerational health transmission.

The main measure of pollution is the distance between dwelling and the nearest major mine or tailing site (determined by household members). Other issues are the health conditions, illness or injuries sustained, and expenditures incurred by residents including health expenditures covering the 12 months prior to June 2014. The data was collected in June and July 2014.

Outline of the Thesis

The rest of this study is structured as follows. Chapter Two presents a critical review of the literature. This covers concepts, determinants and measurement of health. Other concepts considered include environmental pollution and economic methods its measurement, and intergenerational transmission of socio-economic status. The third chapter looks at the theoretical framework of the study where models and analytical approaches for evaluating the set objectives of the study were considered. Chapter Four provides the methodology of the study. The fifth, sixth and seventh chapters are based on the objectives of the study and constitute the empirical chapters while the eighth chapter concludes the study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

This chapter reviews the relevant literature on the study. A comprehensive review of the literature is important for providing an up-to-date understanding and identification of methods used in previous research on the subject-matter or topic It also helps in knowing how to approach research questions and provide comparisons for one's research fmdings. As a result, the chapter adduces theoretical and empirical works from reports on scholarly works of health and environmental Economists, health practitioners, researchers and other relevant works related particularly to mining related pollutants. The major areas looked at are concepts of health, health theories, determinants and measurement of health. Others include the environment, environmental pollution and its related health issues; mining and water pollution and its effects on water quality and household water supply. The chapter concludes with mining and its related foreign direct investment inflows and effects of the latter on gold production and finally, the state of some health conditions globally and locally.

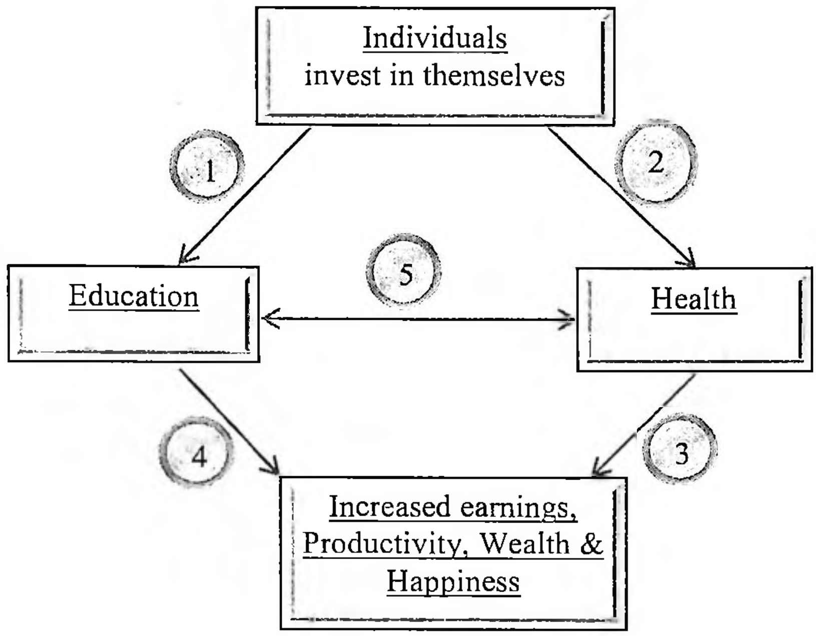
The Concept of Health

There are conceptual difficulties involved in the definition of health at both the individual and community levels (Hunt and McEwen, 1980; Kelman, 1975). The difficulties involved in defining health are due to the multidimensional nature of health and the different concepts of health held by different groups of people at different points in time (Kelman, 1975). Health concepts are also evolutive in nature due to society's effort at resolving health problems as they arise at any point in human history (McDowell, 2006). According to McDowell, the resolution of one health problem brings in its wake a new health issue, which dampens the worth of the prevailing health indicator, necessitating its review or replacement by others thereby making it redundant or unsuitable for the prevailing concept or definition of health. This dynamic nature of society's approach to health problems has led to a shift away from conceptualizing health in terms of survival; through a phase of defining it in terms of freedom from disease; then to an emphasis on one's ability to perform daily activities or social roles; and to the more recent definitions which place the emphasis on positive themes of happiness, social and emotional well-being and quality of life (Krabbe, 2017). For example, the World Health Organization [WHO] in 1946 described health as "*a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*" (Grad, 2002. p. 984; WHO, 1978. p. 1). Health is therefore more than a state of being free from illness or injury. The editorial of *The Lancet* (2009) however, disagrees with WHO's 1946 definition on the grounds that human health is influenced by the environment. Since the environment itself is subject to change, it follows that it is impossible to have a risk-free wellbeing. The Lancet, therefore, defines health as the ability to adapt to one's environment. This (health), according to The Lancet, should be judged by the individual according to his or her functional needs and not by a doctor. Again, during the Ottawa Charter for Health Promotion in 1986 the WHO describes health as a *"a resource for everyday life, not the objective of living. Health is a positive concept emphasizing social and personal resources, as well as physical capacities."* (Ottawa Charter for Health Promotion, 1987 p..iii). This description fits Grossman's (1972) reference to health as a form of human capital.

Investment in Health and Health Production

According to Grossman (1972), gross investments in health capital are made by household production functions whose direct inputs include the own-time of the consumer and market goods such as medical care, diet, exercise, recreation, and housing as well as certain environmental variables notably, pollution.

Again, Grossman considers demand for healthcare by consumers for both consumption and investment purposes as the demand for good health. Health care is the effort aimed at maintenance and restoration of health by the treatment and prevention of disease especially by trained and licensed professionals. Health, as a commodity (Fuchs & Zeckhauser, 1987), is demanded by individuals both because it generates utility directly and also impacts performance in the labour market (Wagstaff, 1986; Whitehead & Ali, 2010). The foregoing discussion is vividly captured by Figure 1.



1. *Direct spending on market goods and opportunity cost of time on educating oneself. This angle was used by Becker (1967) and Ben-Porath (1967) to develop models that determine the optimal quantity of investment in human capital at a given age.*
2. *Gross investments in health capital are produced by household production function with such direct inputs as the own time of consumer and market goods in the form of medical care, diet, exercise, recreation and housing. It also depends on some environmental variables such as pollution. This is Grossman's (1972) angle.*
3. *Better health resulting from investment in health leads to quality time freed for work resulting increased income quality life (Thomas et al, 2006).*
4. *Better education leads to increased wage rates and productivity.*
5. *There is a cross fertilization of investment in both education and health. Good health generates time benefits for education while at the same time increased education generates benefits for better health (Grossman, 1976).*

Figure 1: Investment in Health

Source: Author

Health, therefore, is regarded as one of the most important things in the basket of individual wellbeing. Good health is a prerequisite for engaging in income earning and educational opportunities and capabilities (see the reviews of Bhalotra & Rawlings, 2013; Thompson, 2014) and therefore is fundamental to wealth creation.

According to Fuchs & Zeckhauser, 1987, health is special commodity. This assertion stems from the fact that health is not transferable from one person to another; it can be increased or decreased; it has a very important element of initial endowment; and that health status is mainly self-produced and can be boosted or otherwise by the consumption of other goods. The implication of these conditions, according to Fuchs and Zeckhauser, is that the value of marginal changes in health will not be the same to everyone.

Semyonov, Lewin-Epstein, & Maskileyson (2013) observed a positive relationship between health and wealth in the sense that health suffers when an individual is low on wealth (Deaton, 2007), and when he is in very poor health may have very low capacity to create wealth (Smith, 2005). In addition, factors such as initial endowment and rate of time preference induce a positive relationship between health and wealth but other factors such as a trade-off between hazardous work and wages will lead to a negative relationship between them. Fuchs and Zeckhauser (1987) therefore attributed inequality in health "partly to results of initial endowments and partly to the result of individual behaviour and random shocks".

Grossman (1972) views health as a durable capital stock with healthy time as its output. Individuals inherit an initial stock of health that depreciates with age. The decline in health can be confronted or arrested by investment in health (boosters).

In a review, Leibowitz (2004) underscored the role of non-medical consumption goods on an individual's health. According to Leibowitz, while non-medical commodities compete with health investments for an individual's time and monetary resources, they directly influence one's health positively or negatively. For example, while smoking may provide some satisfaction to the consumer now and generate unhealthy days in the future, dieting or exercise may generate disutility in early periods but may increase discounted lifetime utility by increasing the number of healthy days in later periods.

Determinants of health

From the foregoing discussion, the determinants of health would include the social and economic elements of the environment (see e.g., Adams, Hurd, McFadden, Merrill, & Ribeiro, 2003; Carrieri, & Jones, 2017; Pollack et al, 2013; Ravesteijn, van Kippersluis, & Van Doorslaer, 2017; Semyonov et al., 2013; Woolf et al, 2015; Zimmerman & Woolf, 2014). The physical environment and a person's individual characteristics and behaviours are other determinants of health (Adams et al., 2003; Fuchs & Zeckhauser, 1987).

Thus, health of individuals, people and their communities are affected by a wide range of contributory factors such as where they live, the state of the environment, Grossman (1972) views health as a durable capital stock with healthy time as its output. Individuals inherit an initial stock of health that depreciates with age. The decline in health can be confronted or arrested by investment in health (boosters).

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Thus, health of individuals, people and their communities are affected by a wide range of contributory factors such as where they live, the state of the environment, genetics, income, education and the relationship with friends and family. Among socioeconomic variables, years of formal schooling completed is probably the most outstanding correlate of good health (Breslow & Klein, 1971; Hinkle et al., 1968; Stockwell, 1963). Again according to Dardanoni and Wagstaff (1990), the demand for medical care will increase in response to increased uncertainty over the *ex ante* level of health.

Although, some researchers implicitly have assumed that persons with higher incomes are in better health primarily because they purchase more medical services (Viscusi, 1993; Woolf et al, 2015), other studies found that medical utilization does not help in determining health among the general population (Adler et al., 1993 & 1994). Ettner (1996) however found a positive correlation between income and health using instrumental variable estimation.

Measurement of Health

Because of the complexity, dynamic, and abstract nature of health, its measurement is very difficult and takes an indirect approach involving several steps (McDowell, 2006). According to McDowell, health measurements could be subjective or objective and can be classified by their functions, the purpose, or application of the method. The subjective measures describe quality rather than quantity of function and often give insights into matters of human concern such as pain, suffering, or depression without physical measurements or laboratory test. In addition, and aside their simplicity and cost effectiveness, subjective measures also provide information about people even if they do not seek care and therefore reveal positive aspects of good health without the invasive procedures of expensive laboratory analyses.

The major concern of the use of the subjective measures is its susceptibility to bias due to the fact that patients are asked to state their opinion of their state of health coupled with the issue of completeness. However, due to the several methodological advances in survey sampling and data analysis, indices of personal health that relied on subjective measurements have become largely acceptable (McDowell, 2006).

Descriptive classifications focus on their scope, whereas methodological classifications consider technical aspects, such as the methods used to record information. A functional approach could be taken along three lines of purpose for measuring health: diagnostic (e.g., measurement of blood pressures, temperature, among others.), prognostic (e. g. screening tests and measures such as those that predict the likelihood that a patient will be able to live independently following rehabilitation), and evaluative (indexes measure change in a person over time) (Bombardier & Tugwell, 1982; Tugwell & Bombardier, 1982). Kind and Carr-Hill (1987) proposed functional classification which monitors either health status or change in health status for individuals or groups. The clinical interview measures health status of the individual while the change in individual is measured by the use of clinical evaluation. Group health status is measured by means of a survey instrument, but the change in a group makes use of a health index. Health status measures, whether generic or specific, record the presence and severity of symptoms or disabilities.

Environment, Pollution and Health

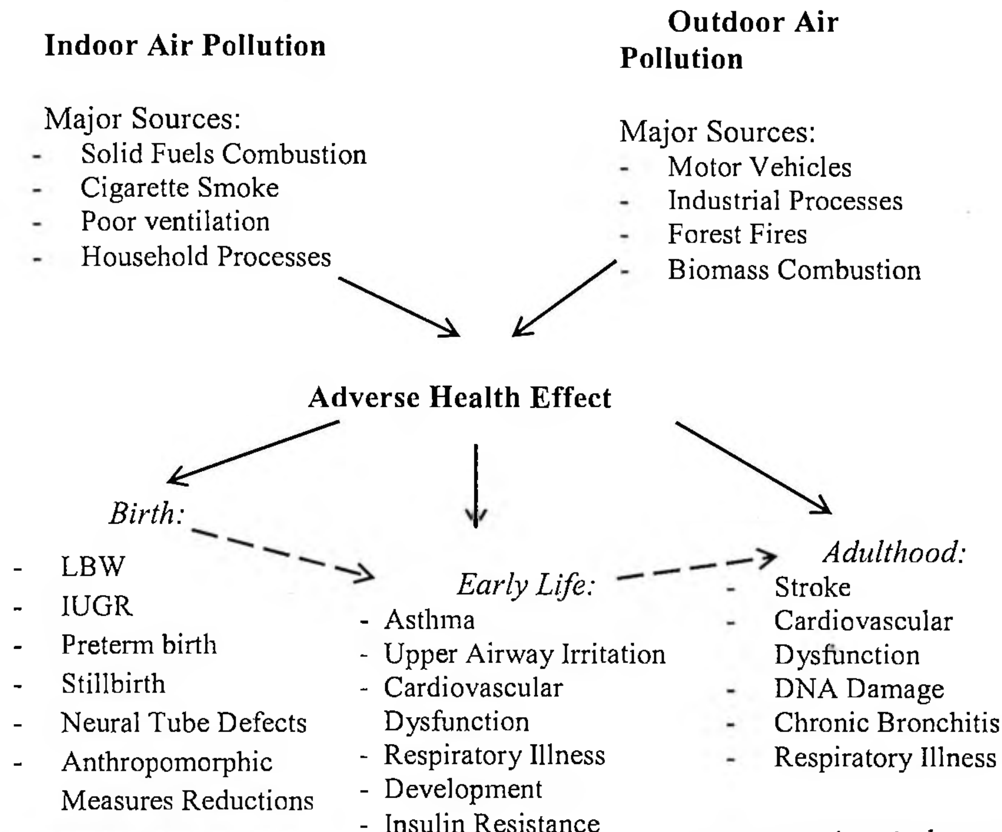
Duruibe, Ogwuegbu and Egwurugwu (2007) defines environment (biophysical) as the totality of circumstances (biotic and abiotic) surrounding an organism or group of organisms, and consequently includes the factors that influence their survival, development and evolution. The environment entails the flora, fauna and the abiotic, and includes the aquatic, terrestrial and atmospheric habitats. To satisfy their basic needs humans interact with the various components of the environment and through this interaction, human well-being is affected (Hanley, Shogren, & White, 2007). For example, due to the huge populations of humans, the elements of human survival are undergoing change through pollution (Duruibe et al, 2007).

A pollutant is any substance in the environment which is harmful and has damaging consequences to the environment, could impinge the quality of life and eventually cause death. Hence, environmental pollution is the presence of a pollutant in the environment; air, water and soil, which may be toxic and will cause harm to living organisms in the contaminated environment. Pollution can take the form of chemical substances or energy, such as noise, heat or light. Pollutants, the components of pollution, can be either foreign substances/energies or naturally occurring contaminants but are considered contaminants when in excess of natural levels. Pollution of air, water, and land results when natural resources are used at rates beyond nature's capacity for replenishment (Tietenberg & Lewis, 2015).

Environmental pollution is a significant contributor to the global burden of disease (Briggs, 2003, Van Houtven, 2014). This fact provides an important reason for the link between human health and the environment. This is because environmental contaminants and exposures are known to cause a wide range of adverse health effects (Van Houtven, 2014), including many respiratory, diarrheal, and cardiovascular illnesses and cancers. Moreover there is strong evidence suggesting that early-life exposure to pollution have long-term consequences later in life (Almond & Currie 2011a,b; Currie, Graff Zivin, Mullins, & Neidell, 2014).

Graff Zivin and Neidell (2013) reviewed the contributions made by economists to the understanding of the relationship between the environment and individual well-being and conclude that pollution indeed has a wide range of adverse effects on individual well-being, even at levels well below current regulatory standards.

Studies also observed strong epidemiological association between acute and chronic exposure to air pollutants and the occurrence of cardiovascular diseases (see e.g., Brook et al., 2004; Farmer et al., 2014; Franchini, & Mannucci, 2007, 2009, 2012; Newby, 2015); Pope III et al., 2004). Figure 2 shows pathways of sources of air pollution and the classification of their adverse health effects. For example, in a comprehensive review of the growing body of epidemiological studies, Farmer et al. (2014) observed adverse health effects of air pollution exposure. These include cardiovascular and respiratory illnesses, asthma, increased risk of out-of-hospital cardiac arrest (OHCA), and myocardial infarctions (MIs).



A... ct categories: indoor and outdoor. Classification of air pollution depends on the source; the fact that outdoor air pollution can influence indoor air quality should also not be overlooked. A number of adverse health effects have been associated with exposure to air pollution throughout life. Adverse health effects caused by foetal exposure to air pollution, both indoor and outdoor, can significantly affect the health of the individual throughout life. While the sources of air pollution vary, the health complications associated with exposure to increased levels of these pollutants seem to be universal. [*LBW = low birth weight; IUGR, = intrauterine growth restriction.*]

Figure 2. Adverse Health Effects Pathways of Air Pollution Exposure

Source: Farmer, et al. (2014).

The literature is replete with the influence of child health on human capital formation (Currie, 2009; Currie and Stabile, 2006; Currie et al., 2014). For example, Case, Fertig and Paxson (2005) found that children who had poor health grew up with significantly lower educational attainment, poorer adult health and lower socio-economic status. Case et al. (2005) argued, using the fetal-origins hypothesis and the life course models, that childhood health and circumstances can determine adult health. For example, nutrition deficiency during pregnancy is linked to the child's chronic health conditions such as coronary heart disease and diabetes in middle age (Barker, 1995; Ravelli et al., 1998). Also illness and deprivation during childhood can have lasting effects on adult health (Kuh & Wadsworth, 1993). Thus, parents with poor health are more likely to have children with poor health (Coneus & Spiess, 2012). Much of these parental poor health effect on children is results of pollution. Figure 2 shows the causal links between air pollution and some of these conditions.

In a comprehensive review, Currie et al. (2014) arrived at the conclusion that there is a direct connection between early childhood exposure to pollution and long-term outcomes such as educational attainment and earnings. In the short-term, Currie *et al.* found that significant reduction in air pollution levels lead to decreases in infant mortality and fetal losses.

Metallic elements that have relatively high density and are toxic or poisonous even at low concentration are referred to as "heavy metals" (Duruibe et al., 2007). The phrase "Heavy metals" is a general collective term, which applies to the group of metals and metalloids with atomic density greater than 4 g/cm^3 , or five times or more, greater than water (Garbarino et al., 1995, Hawkes, 1997). Heavy metals include lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), silver (Ag) chromium (Cr), copper (Cu) iron (Fe), and the platinum group (Armah, Quansah & Luginaah, 2014). Table 1 shows a catalogue of some of these metals and their established human health effects. Heavy metal pollutants freed by mining activities are transported by surface water such as streams and rivers. This action is in the form of sediments, groundwater (through leaching and acid mine drainage), and by air/wind (Agarwal, 2009) as suspended particulate matter. By so doing, these media have themselves become sources of pollution to humans and other living things while soils and water bodies are major areas of deposition of these metals (Coelho, Teixeira & Gonçalves, 2011).

Table 1: Established Human Health Effects of Selected Metals

Toxic chemicals	Established associated health effects
Cadmium	Respiratory tract infections, lung toxicity, bronchitis, kidney damage, gastro-intestinal irritation, nausea, vomiting, diarrhoea, pain, metallic taste in the mouth, reproductive, and developmental toxicity
Copper	Irritation of eyes, mouth, nose; nausea, diarrhoea and abdominal pains; dizziness and drowsiness; headache, liver and kidney effects
Lead	Impaired growth, induces weakness in the fingers, wrist and ankles; increased blood pressure and hypertension; anaemia; damage to kidney; spontaneous abortion in women and damage to male reproductive system leading to sterility, low IQ development
Manganese	Neurotoxin, tremors, lethargy, speech disturbance, mask-like face, psychological disturbance, respiratory effects such as increased incidence of cough and bronchitis and increased susceptibility to infectious lung disease, reproductive/developmental effects such as impotence and loss of libido, low IQ.
Mercury	Kidney damage, low IQ, irritation, nausea, vomiting, pain, ulceration, diarrhoea, toxicity to the brain and nervous system, abdominal pains
Zinc	Gastrointestinal effects, impaired lung functioning, respiratory irritations
Cobalt	Respiratory irritation, diminished pulmonary function, wheezing, asthma, pneumonia, and fibrosis
Platinum	Watering of eyes, sneezing, tightness of the chest, wheezing, breathlessness, cough, eczematous and urticarial skin lesions, signs of mucous membrane inflammation
Arsenic	Cancers of the skin, liver, lung, bladder and blood; upper respiratory infections, damages to the nervous system, skin pigmentation such as hyperpigmentation, keratosis, cerebral neuropathy; gastrointestinal diseases, nausea, vomiting, diarrhoea

Source: Armah et al. (2012)

Empirical Studies on Mining Pollution

Lee, Chon and Jung (2001) investigated the extent and degree of trace element contamination of soils, plants, waters and sediments influenced by mining activity of the Daduk mine. The soil samples were taken from around the mine, from the tailings, uncultivated and high lands, paddy fields and a nearby control area. Random samples of plants were also taken from agricultural land including household gardens and paddy fields while stream waters and sediments were also collected along a small stream. These samples were analysed by inductively coupled plasma–atomic emission spectrometry (ICP-AES) and also through the Korean standard method for chemical analysis of soils. Heavy metal concentrations in stream water and sediments were found to have decreased with increasing distance from the tailings. These materials have been dispersed downslope by both surface erosion and wind action and by effluent draining the mine wastes into lower lying land, mainly used for the growth of paddy rice and garden crops.

Obuasi is a residential town suffering from decades of considerable consequences of poorly regulated mining activities. Several studies show that mining and smelting of gold ores have created soil contamination problems. Fine particles selectively eroded from the mine waste-rock, tailings and slag have the potential to contaminate nearby soils or carried as sediments in surface waters, thereby enlarging the area affected by the mining activities. Sediments in river channels, reservoirs and floodplains are affected by arsenic derived from mining operations (Kumi-Boateng, 2007).

Kumi-Boateng (2007) applied geostatistics to study the hazard posed by arsenic in the Obuasi Municipality and found higher arsenic concentration in soil depths of 0-15cm and lower concentration in deeper depths (15-30cm). The different levels of concentration of arsenic at the respective depths is an indication that deposited soil contains more arsenic than the more stable or undisturbed soil. Higher levels of concentration were found in stream sediments collected within a km of the mine site indicating significant geochemical dispersion of arsenic downstream of the tailings and the retention sumps. The Kumi-Boateng study concludes that arsenic mobilized by streams/rivers are very often deposited on land during flooding and that soils with arsenic concentration also correspond with plants of high arsenic concentration. This is so because farmers have preference for cultivating food crops on floodplains close to rivers/streams. Arsenic in food crops or in water is a health hazard.

Bempa et al. (2013) investigated gold mine tailings dams as a potential source of arsenic and other trace elements contamination and their dissolution into the adjoining environmental media in the Obuasi Municipality. Atomic absorption spectrometer (AAS, Varian Models 240FS) was used to determine the level of concentration of the pollutants. Results showed very high concentration of arsenic (up to 1752mg/kg) and other trace elements in mine tailings in the Obuasi gold mine site. These levels of contamination were much higher than the Netherlands soil protection guideline values. Leaching levels of arsenic were in the range of 0.04–0.56%, presenting high proportions for the total arsenic content in the mine tailings.

Furthermore, Boateng et al. (2012) used geochemical pollution indices to assess possible impact of mine tailings reclamation on the quality of soils from the AngloGold Concession, Obuasi. Soil samples from mine tailings reclamation sites were evaluated for the concentrations of plant nutrients and trace metals. The study found consistently high average concentration values for arsenic with even the least value exceeding the Netherlands soil/sediment intervention guideline value of 55mg/kg. Furthermore, estimates from the geochemical evaluations indicated that arsenic contamination was very high and therefore poses a threat to agricultural land use as well as general environmental quality.

Antwi-Agyei, Hogarh and Foli (2009) also investigated the issue of tailings dams as a potential source of trace elements contamination in soils at the Obuasi gold mine by analysing soil samples taken from depths of up to 12 cm and within a radius of 400 m from the tailings dams (active and decommissioned). Both types of tailings dams impacted adjoining soils with greater concentrations of the trace elements when compared to undisturbed control soils. Arsenic was found to be above the Netherlands intervention value of 55 mg/kg dry weight, even in control soils but highest for soils nearer the decommissioned dams.

Amonoo-Neizer, Nyamah and Bakiamoh (1995) found significant distribution of arsenic and mercury (Hg) in the top soils, plantain, water fern, elephant grass, cassava and mud fish at Obuasi and its environs. Other studies have made various findings regarding the presence of trace elements in water sources, soils and foodstuffs at Obuasi and surrounding areas (Amasa, 1975; Bamford, Osae, Aboh, & Antwi., 1990; Golow, Schlueter, Amihere-Mensah, Granson, & Tetteh, 1995). So far, it appears that arsenic constitutes the major trace element problem in the Obuasi area. This has been linked to the considerable level of naturally occurring arsenic at Obuasi, as well as liberations from arsenic bearing gold ores during gold extraction (Ahmad & Carboo, 2000; Amonoo-Neizer et al., 1995; Asiam, 1996; Kumi-Boateng, 2007; Smedley, 1996; Smedley, Edmunds, & Pelig-Ba., 1996).

Armah et al. (2012) found the mean concentrations of As, Cd, Pb, Hg, and Mn were elevated up to 20-fold higher in the blood of resident adults and children in Tarkwa Nsuaem Municipality/Prestea-Huni Valley District (mining communities) than in Cape Coast Metropolis. The risk of acute respiratory infections in the exposed populations of Tarkwa Nsuaem Municipality/Prestea-Huni Valley District were approximately 41- and 12-fold greater than the unexposed group. The risk of diabetes mellitus in the exposed populations of Tarkwa Nsuaem Municipality/Prestea-Huni Valley District were also approximately 20- and four-fold higher than the unexposed group. What is however, uncertain is the proportion of anthropogenic contribution to the levels of these metals in the blood (Armah et al., 2012).

In another study, Armah et al. (2011) spatially assess the distribution of heavy metals within the catchment of the Tarkwa mining area using interpolation techniques in a geographical information systems environment. The authors examined water quality trends for 84 sites for fourteen parameters—pH, conductivity, Total Dissolved Solids (TDS), turbidity, nitrates, sulphates, Chemical Oxygen Demand (COD), total cyanides, arsenic (As), cadmium (Cd), iron (Fe), manganese (Mn), nickel (Ni) and lead (Pb)). The results showed that surface and groundwater was contaminated by As, Cd, Fe, Mn and Pb with the average concentrations exceeding World Health Organization guideline values. The contamination of drinking water sources has health implications for human exposure within the catchment of the Tarkwa mining area. The elevated levels of toxic heavy metals demonstrate lack of adequate controls in the use of hazardous and toxic chemicals within the Tarkwa mining area.

From the results of empirical studies discussed so far, it is cear that gold mining areas in Ghana are heavily polluted by mining pollutants and the health hazards posed by these pollutants are not in doubt. What is, however, not known is the extent to which the pollution is impacting and will continue to impact the health of residents. In other words the economic value of the health risks posed to residents is not known.

Economic Methods for Measuring Environmental Change

Understanding how the environment affects human health and how these threats can be best managed has become a matter of priority for many researchers and policymakers. Van Houtven (2014) identifies four main components for valuing (in monetary terms) the relationship between health and the environment. According to Van Houtven a given change in environmental conditions may result in changes in:

- averting/defensive expenditures;

- mitigating (e.g., medical) expenditures;
- productivity losses (e.g., lost income/wages due to illness); and
- disutility from pain and suffering.

Some of the valuation approaches used by health and environmental economists for estimating one or more of these components are cost of illness methods; averting behaviour; survey-based stated preference approaches, such as contingent valuation or choice experiment; and revealed preference methods such as hedonic models (Dickie, 2017).

Cost of illness methods focus on direct medical and other treatment costs (mitigating expenditures) and in other cases on indirect costs (productivity losses) (Dickie 2017). This method is widely used due to data availability (Van Houtven, 2014). The cost of illness approach relies heavily on the idea that people are producers where costs of health services are seen as investments. The investment in health is seen as improving people as productive agents. The benefit for improvements in health is the labour product created plus any savings in health care expenditures due to any reduction in disease (see Mushkin, 1962; Drummond, 1992). The costs of health degradation are the damages caused by the disease (or accident). Studies employing the cost of illness approach include Weisbrod (1971), Cooper and Rice (1976), and Mushkin (1979).

Averting behaviour methods focus on the averting/defensive expenditures if they only measure changes in averting expenditures, and are therefore, like the cost of illness method, limited in scope. However, if they are used with mitigating expenditures to estimate a health production function, then they are capable of incorporating all four components of value (Van Houtven, 2014). This combined approach, according to Van Houtven, has rarely been used due to its relatively difficult data and technical requirements value.

In health value applications, survey-based stated preference approaches, such as contingent valuation or choice experiments methods are also applied (Dickie, 2017). In this method survey respondents are presented with hypothetical scenarios involving trade-offs between money and health. Responses are then used to estimate respondents' willingness to pay for better health-related conditions. They have a major advantage of capturing all the four components of value. Their only weakness however, is the hypothetical nature of the trade-offs and the resulting difficulty in confirming responses.

In addition to using stated preference methods, a variety of revealed preference methods have also been used to explore individuals' trade-offs between money and health risks. Hedonic wage-risk studies, for example, use evidence from labour markets to determine the amount of additional compensation individuals require for taking jobs with higher risks of death (See e.g., Taylor, 2017).

There is also a large variety of health outcomes associated with environmental exposure (see e.g., Armah et al., 2012; Farmer et al., 2014; Satarug, Garrett, Sens, & Sens, 2011; Sly et al, 2016). These outcomes may vary cost of illness method, limited in scope. However, if they are used with mitigating expenditures to estimate a health production function, then they are capable of incorporating all four components of value (Van Houtven, 2014). This combined approach, according to Van Houtven, has rarely been used due to its relatively difficult data and technical requirements value.

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There is also a large variety of health outcomes associated with environmental exposure (see e.g., Armah et al., 2012; Farmer et al., 2014; Satarug, Garrett, Sens, & Sens, 2011; Sly et al, 2016). These outcomes may vary according to duration, frequency, latency, and severity of illness (Graff Zivin & Neidell, 2013). Another dimension is that environmental exposures often result in risk of illness, rather than the certainty of illness, for exposed individuals (Van Houtven, 2014). Hence, a lot of studies on mining pollution report on health risks of exposure. Therefore environmental contaminant abatement policies tend to reduce only the risks for individuals, but not the duration, severity or other attributes of illness.

General Overview of Economic Methods for Measuring Environmental and Resource Values

Economists have devised several approaches for valuing non-market environmental goods (see Birol, Karousakis, Koundouri, 2006; Segerson, 2017). These valuation methods can be classified into two broad methodologies: stated preference and revealed preference methods (Carson & Louviere, 2011). Each of these broad classifications of methods is further classified under direct and indirect techniques as catalogued in Table 2.

Table 2: Economic Methods for Measuring Environmental and Resource Values

Method	Revealed Preference	Stated Preference
Direct	Market Price	Contingent Valuation
	Simulated Markets	
Indirect	Travel Cost	Attributes-Based Models
	Hedonic Property Values	Conjoint Analysis
	Hedonic Wage Values	Choice Experiments
	Avoidance Expenditures	Contingent Ranking

Source: Tietenberg and Lewis (2015)

Stated Preference Methods

Stated preference methods, sometimes simply called willingness-to-pay surveys (Haab & Whitehead, 2014), are not based on observed behaviour and therefore use survey techniques to elicit willingness to pay for a marginal improvement or for avoiding a marginal loss (see e.g., Boyle, 2017; Mitchell & Carson 1989; Bateman et al., 2004).

The most direct approach, called contingent valuation method (CVM or CV method), is a survey-based approach used to estimate amenities and recreational and other behaviours related to environmental and natural resources. It can be used to estimate both use and non-use values. Just as it is the most widely used method for estimating non-use (also known variously as "passive use value", "existence value" and "stewardship value", it is also the most controversial of the non-market valuation methods (Johnston et al., 2017). Since it is not based on any observable behaviour, the contingent valuation survey approach creates a hypothetical market for hypothetically prescribed environmental good or service and solicits from respondents how much they would be willing to pay for it (Carson, 2012). The specified non-market services could be an improved health. In some cases the experiment is designed to solicit amount of compensation respondents would be willing to accept for a given health condition brought about by a particular environmental 'bad' such as air pollution or its incremental damage. It is called "contingent" valuation, because people are asked to state their willingness to pay, depending on a specific hypothetical scenario and description of the environmental service. In the health literature, contingent valuation methods have been used to elicit values for both morbidity and mortality (Johnson, Fries & Banzhaf, 1997).

CV methods are however, differentiated by the way they elicit WTP. Respondents are commonly asked to state their maximum WTP (an "open-ended" CVM question) (as by e.g., Brookshire, Eubanks, Randall, 1983; Samples & Hollyer, 1990; Stevens et al., 1991; and Loomis and Larson, 1994). Another format is to ask respondents to choose the amount they are willing to pay from a list of values. This is referred to as a "payment card" CVM question as by Hagemann (1985), Solomon, Corey-Luse and Halvorsen, (2004). Finally, respondents may be asked to accept or reject a specific amount. This last format is known as "referendum", or discrete-choice, CVM question (e.g., Boyle & Bishop, 1987; Bell, Huppert and Johnson., 2003).

The controversies of the contingent valuation method have to do with the potential for respondents to give biased answers. One of the major points of criticism is hypothetical bias. The premise is that, since respondents will not actually have to pay the estimated value, the respondent may treat the survey casually and provide implausibly large or inflated responses (see Harrison & Rutström, 2008). Sometimes the bias comes from the researcher not taking into consideration cultural and ethical values of respondents in the design of the contingent valuation questions (e.g. Whittington, 1998).

Another area of controversy is that Willingness to accept (WTA) is usually substantially higher than willingness to pay (WTP) (Horowitz & McConnell, 2002). Many contingent valuation studies have found respondents reporting much higher values for questions asking respondents the amount of compensation they would be willing to accept in order to give something up than for questions asking for the amount they would be willing to pay for an incremental improvement in the same good or service (Tietenberg & Lewis, 2015). This sounds contrary to economic theory which suggests that the difference should be negligible. Georgantzís and Navarro-Martínez (2010) and Biel, Johansson-Stenman and Nilsson (2011) attribute the disparity between WTA and WTP to psychological complexities which are rarely taken into account by researchers on the subject. These potential biases can conspire to render the contingent valuation data invalid and/or unreliable.

Johnston et al. (2017) present contemporary guidance for stated-preference studies, including CV, that addresses all common applications, not just the estimation of passive use values for litigation. This follows the broader recommendation made by of the NOAA Panel Report, which also includes a set of guidelines for conducting such CV studies (see Carson, 2012).

Hoyos & Mariel, 2010 classified the evolution of the CVM into three distinct periods. The first period spanned the origin of the method in 1943 up to 1989, the Exxon Valdez accident. During this period, it was used as an alternative to the revealed preference methods such as the travel cost method TCM). The method was first mooted by Bowen (1943) and Ciriacy-Wantrup (1947). The second period covering 1989 to 1992, characterised by extensive debate following the Exxon Valdez oil spill, stimulated further research on the theory and empirics of stated preferences for non-market valuation techniques. The third period, from 1992 onwards, denotes the consolidation of the CVM as a non-market valuation method.

To demonstrate the meticulousness of a contingent valuation survey, let us take Berger Berger, Blomquist, Kenkel, & Tolley (1987) who conducted a contingent market valuation study to explore the WTP for morbidity improvements and alternative measures. Through a survey interview, individuals were endowed with additional symptom days and were asked to purchase reductions in certain light symptoms contingent upon the existence of a market for doing so. The survey instrument was developed to make use of accepted techniques, and improve upon them where possible, in eliciting individual's bids. Individuals were asked about the number of symptom days experienced in the previous year and the costs associated with each symptom. They were asked to rank the symptoms with respect to undesirability, state their values for additional symptom-free days and summarise their values on a tally sheet. A total of 131 people were interviewed in Denver and Chicago using door-to-door and mall-intercept methods. Berger et al found that their estimates for seven light symptoms show that consumer surplus exceeds cost of living with no strong indication of moving together in a systematic fashion.

Other stated preference presentations, albeit indirect and extensions of the CV methods, are attribute-based models, conjoint analysis, choice experiments and contingent ranking models. Choice experiments employ series of questions with more than two alternatives that are designed to elicit responses that allow the estimation of preferences over attributes of an environmental state. It has been used in the estimation of transportation, marketing and psychological problems. Choice experiments, with a long history in marketing and transportation fields (Louviere, 1992), are consistent with random utility theory and are useful as a method of eliciting passive use values (Adamowicz, Baxall, Williams, & Louviere, 1998). Choice experiments are noted particularly for their flexibility in estimating the economic benefits resulting from a wide range of policy scenarios (Lipton et al., 2014) and also for allowing the estimation of marginal values for other attributes related to, for example, the species protection to be estimated. Choice experiments are also noted for their ability to minimize accepting a bid amount regardless of one's preferences by eliminating the take-it-or-leave-it choice encountered in the more traditional CV study (Ajzen, Brown, & Rosenthal, 1996; Hanley et al., 1998). Some of the recent uses of the choice experiment approach to value recreational activities include Lew and Larson (2012), Lew and Seung (2010), Carter and Liese (2012), and Lew and Larson (2014).

Some Empirical Studies on Stated Preference Methods - Willingness to Pay

Yu et al. (2015) investigated and distinguished between the objective and subjective measures of atmospheric visibility in addition to the effect on the people's behavioural intentions on air pollution in China. The authors adopted a mixed method, combining lab experiments to measure objective atmospheric visibility with a questionnaire survey of 569 respondents to measure subjective atmospheric visibility. The regression results show that while people's perception of atmospheric visibility is based on objective information about the ambient air (Relative Humidity, PM2.5, Atmospheric Visibility) their perception of visibility has a significant effect on either their willingness-to accept (WTA) the visibility or on their willingness-to-pay (WTP) for improving the air quality. Yu et al. (2015) found positive environmental attitude to positively influence people's willingness to pay to improve the air quality, and this effect is much stronger than the effect of perception.

Johnson et al. (1997) estimated a general valuation function combining a meta-analysis of Morbidity valuation studies and the QWB health-status index. The morbidity values come from five CV studies up to 1988 to which QWB score was assigned. Results showed that the WTP estimates appear to be logically and statistically consistent. In line with theory, WTP for the reduction or avoidance of a health condition increases at an increasing rate as the health status worsens and also increases with duration.

Viscusi, Huber and Bell (2012) estimated the stated preference values for reducing the morbidity risks from drinking water among US households. The data used was a nationally representative U.S. sample of 3,585 respondents, aged 18 and above, with valid answers to the willingness-to-pay question. The survey was administered in a web-based panel constructed using probability sampling of the U.S. population. The estimates were referenced on the average annual gastrointestinal (GI) illness risk from drinking water. Using interval and quantile regressions, the authors found considerable heterogeneity in the values which they attribute to differences in attitudes towards risk and price sensitivity.

Wang and Hong (2015) undertook a study to find out pharmacists' acceptable level of compensation for a given "medication therapy management" (MTM) session. The authors used contingent valuation method by asking a series of double-bounded, closed-ended, binary discrete choice questions to elicit pharmacists' willingness to accept (WTA) the prescribed compensations for the given MTM services. The data was from a cross-sectional survey of 1524 active phamarcists in Tennessee, USA in 2009. A Kaplan-Meier approach was employed to analyse pharmacists' WTA, and Cox's proportional hazards model was used to examine the effects of pharmacists' characteristics on their WTA. The authors found that pharmacists' WTA compensation for the given MTM session was higher than the current Medicare MTM programs' compensation levels and patients' willingness to pay. Furthermore, pharmacists' characteristics were found to have statistically significant association with their WTA rates.

Grutters et al. (2008) used a discrete choice experiment to compare willingness to accept (WTA) and willingness to pay (WTP) for hearing aid provision and also explored whether income and endowment effects could be the possible explanations for the disparity between WTA and WTP. The data came from a face-face interview of 300 hard of hearing people on the provision of hearing aid. Two versions of the questionnaire—one on WTA and the other one was on WTP—were designed and therefore, 150 participants completed each one. The authors found that WTA exceeds WTP and the disparity was higher in the high income group. Moreover no proof of an endowment effect was found.

Martín-Fernández et al. (2010) evaluated the perceptions of patients about the service provided by their family physicians using the WTA/WTP ratio. The payment card was used to measure the WTP and WTA in interviews involving 451 subjects at six health centres with different socioeconomic characteristics. An explicative model was constructed to study the WTA/WTP relationship. Results showed the WTA/WTP ratio increases with age particularly in low-income areas. The ratio was however found to have decreased in professional groups with more specialized activities, with growing family income, and in the chronically ill.

Manan, Ali, Khan and Jafarian (2015) evaluated the characteristics and commitment of methadone therapy patient's in terms of out of pocket (OOP) cost, Willingness-To-Pay (WTP) and Willingness-To-Accept (WTA) concepts. Treatment is fully subsidized by the government and so the study was designed to see if financial constraint could lead to patients being made to pay for inconvenience of the therapy or be incentivised. Patients (all from an urban area) were grouped into three income groups. The average OOP cost per month was about 35% of employed patient's monthly income with a wide variation attributable to high inter-individual and significant differences between patients in terms of transport, times taken to clinic, cost per trip and weekly household income. Results show that patients in the lowest income group, showed the highest tendency to pay for treatment, asked for the least money for inconvenience, and many are unwilling to accept any payments. From these findings Manan et al. deduced that WTP and WTA is less of a concern for patients in the low-income group and that OOP payment is not a treatment barrier for most of the urban of methadone therapy patients.

Sarigiannis, Karakitsios and Kermenidou (2015) assessed the health impact and the respective economic cost of particulate matter (PM) emitted into the atmosphere through the burning of biomass for space heating in Thessaloniki (Greece). Particular attention was paid to differences between the warm and cold seasons in 2011-2012 and 2012-2013. Sarigiannis et al. (2015) also based their assessment on estimated exposure levels and the use of established WHO concentration-response functions (CRFs) for all-cause mortality, infant mortality, new chronic bronchitis cases, respiratory and cardiac hospital admissions. It involves monetary valuation of the willingness-to-pay to avoid welfare loss associated with illness or willingness to accept compensate for the loss of welfare associated with illness. Results showed increase in long term mortality by 200 excess deaths out of the nearly 900,000 inhabitants during the winter of 2012-2013. This is equivalent to 3540 years of life lost and an economic cost of almost 200-250m€. New chronic bronchitis cases were found to dominate morbidity estimates while health and monetary impacts are more severe during the cold season, notwithstanding its smaller duration.

Orgill, Shaheed, Brown and Jeuland (2013) investigated household demand for water in peri-urban Cambodia with a focus on the influence of water quality on willingness to pay (WTP). The authors analysed responses to a contingent valuation scenario that account for subjective perceptions of water quality. A multivariate logit regression technique was employed. The mean household WTP for improved water quality was found to be US$3 (roughly 1.2% of mean income) per month. In addition, most of the households believe their in-house water was safe for drinking after treatment and storage. Again, beliefs about existing levels of water quality have a significant impact on WTP for improved water quality even though actual water quality was not correlated with these perceptions of water quality. Orgill et al. (2013) suggest that underlying perceptions of water quality should be considered interventions aimed at increasing the adoption of water treatment programmes.

Revealed Preference Methods

Revealed preference methods are based on actual observable choices that allow resource values to be directly inferred from those choices (Boyle, 2003; Tietenberg & Lewis, 2015). This is referred to as market price or simulated markets method. However, indirectly calculating the value of an environmental risk, such as some exposure to a substance that could pose some health risk, entails making use of hedonic, travel cost or averting behaviour methods.

The averting behaviour measures economic value by observing how people spend on things that they perceive will make them escape effects of pollution or diminish the damage that they are likely to go through when faced with a threat of harm from environmental hazards (Dickie, M. (2017). For example, people may want to stay indoors or adjust their daily activities to lessen exposure to ambient air pollution. Also, people may spend more by switching to consumption of bottled or sachet water to avoid consuming polluted water. Again residents may resort to the use of medication or medical treatment to avoid or minimise damage caused by a given amount of pollution exposure. According to Dickie (2014), glossing over averting behaviour can bias estimates of pollution damage and therefore need to be considered when estimating pollution damage by looking into what people do to obviate pollution hazards.

Hedonic regression or hedonic demand theory is another revealed preference method of estimating demand or value. Within the housing market context, hedonic methods have been employed to estimate the value of many types of environmental amenities (Birol et al., 2006) such as improvements in air quality; access to beaches, parks, and other types of open space and land use patterns (Acharya & Bennett, 2001; Bockstael, 1996; Geoghegan, Wainger & Bockstael., 1997); dams and rivers (Bohlen & Lewis 2009). Others are brownfields, desirable views, tree cover on a property or in the neighbourhood, industries, Weiss, Maier and Gerking (1986) found the probability of a fatal accident to be 40 times more in "high-risk" industries compared with "low-risk" ones. Other works on wage-risk trade-off include Dillingham and Smith (1983), Freeman and Medoff (1985), and Moore and Viscusi (1988). Hersch and Viscusi (1990) found individual differences in health-related activities important in determining the wage-risk trade-offs that workers receive.

Li, Folmer, Jianhong and Xue (2014) designed a structural equation model of happiness to measure how perceived risk due to (i) intensity of exposure to polluted air, and (ii) hazard of pollutants influence on happiness. Proximity to the pollution source was used as the measure of objective risk. Li et al. (2014) found both types of perceived risk negatively and significantly influence people's happiness, although in absolute terms, the total perceived risk effect is less than the (positive) effect of ability, measured by income and education. Other important determinants of happiness according to Li et al. (2014) are family size, age, proximity to the pollution source, work environment and current health condition.

According to Whitehead, Noonan and Marquardt (2014), both stated preference and revealed preference methods have their limitations. While revealed preference data are limited to historical variation in prices and quality, stated preference data are accused of being hypothetical and often biased in favour of good intentions (Whitehead, Pattanayak, Van Houtven & Gelso, 2008). Whitehead et al. (2008) are of the view that combining revealed preference and stated preference data can leverage both types' strengths such as grounding results from stated preference surveys in the reality of revealed preference while allowing variation beyond the range of prices and quality constrained by history. The validity of the stated preference data, however, remains a limiting factor. Whitehead et al. (2014) combine revealed preference and stated preference data from a contingent behaviour survey of a regional concert series. Results show evidence of predictive validity.

Ambient particulate matter is commonly used as a proxy for air pollution in hedonic analysis (Gyourko, Kahn & Tracy, 1999). For example, Chay & Greenstone (2005) investigated the capitalization of air quality into housing values. The study was motivated by the air pollution reductions brought about by the Clean Air Act Amendments. The authors found evidence suggesting that total suspended particulates (TSPs) nonattainment status is causally related to both air pollution declines and housing price increases during the 1970s.

Kim, Phipps and Anselin (2003), in an attempt at improving the hedonic price methodology for spatial data, developed a spatial-econometric hedonic housing price and used it to estimate the marginal value of improvements in sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) concentrations for the Seoul metropolitan area. Results showed that SO_2 pollution levels had a significant impact on housing prices while NO_2 pollution did not. The authors attribute this differential impact to the relatively higher levels of SO_2 pollution relative to pollution standards and also to, now emerging, NO_2 pollution. Marginal WTP for a four percent improvement in mean SO_2 concentrations is about \$2333 or 1.4% of the mean housing price.

Health Status

Rumsfeld (2002) defines health status as "the impact of disease on patient function as reported by the patient" and also, from the clinician point of view, as the range of manifestation of disease in a given patient involving symptoms, functional limitation, and quality of life. Quality of life here is the difference between actual and desired function. Health status is also defined as the state of health of a person or population assessed with reference to morbidity, impairment, mortality and indicators of functional status and quality of life. Health status is therefore a holistic concept that is determined by more than the presence or absence of any disease. It is often summarised by measures of life expectancy or self-assessed health status, and more broadly includes measures of functioning, physical illness, and mental wellbeing. Health status is an important determinant of an individual's economic and social well-being. A healthy individual will be more productive, will contribute more towards a nation's economy, and all things being equal, will have a better quality of life than will a sick individual (Wolfe, 1986).

Individual health status may be measured by an observer (e.g., a physician), through an investigation and rating the individual along any of several dimensions such as risk factors for premature death, presence or absence of life-threatening illness, severity of disease, and overall health (Krabbe, 2017). Individual health status can also be assessed by the person's own health perceptions in the domains of interest, such as physical functioning, emotional well-being, pain or discomfort, and overall perception of health.

Health status measures include functional, global, disease-specific or utility measures. Due to their social importance, most measures of functional health status are subjective measures (Garcia & McCarthy, 1996). Measures which attempt to capture the nature of health status and, indeed, the whole range of physical, mental and social functioning are referred to as global measures. Global measures are of two kinds: profiles where an individual's conditions are analysed using a series of dimensions or aggregate measures in which case a single number is used to capture health status (e.g. the Rosser matrix used in calculating Quality-Adjusted Life Years (QALYs)). While disease-specific measures are important for clinical decision-making (e.g. Arthritis Impact Measurement Scale), utility measures or value scales are employed when the outcomes cannot be measured in natural units as commonly used in QALYs (Garcia & McCarthy, 1996).

Following the acknowledgement of the importance of perceived health status in the prediction of the need for, and utilisation of health services, Hunt et al. (1980) developed and tested indicators which assess subjective rather than objective health problems. A test of validity of the instrument on four groups of elderly people differing in health status was performed. The results showed that perceived health status of these elderly people was in sync with objective health status.

Healthcare is the prevention, treatment, and management of illness and the preservation of mental and physical well-being through the services offered by the medical and allied health professionals (The American Heritage Medical Dictionary, 2007). The mechanism through which healthcare is delivered is referred to as a health care system.

Dardanoni & Wagstaff (1990) examined the uncertainty surrounding the incidence of illness and the uncertainty surrounding the effectiveness of medical care. Results show an increase in uncertainty surrounding the incidence of illness or reduction in the expected basic level of health results in an increase in demand for medical care. Furthermore, an increase in the expected effectiveness of medical care is found to reduce the demand for medical care. In this case, the demand for medical care will increase when uncertainty surrounding the effectiveness of medical care increases. Picone, Uribe and Wilson (1998) also found the stock of health capital to increase with increments in uncertainty.

Health Expenditure

Ill health does not only cause pain and suffering but can also be economically detrimental to patients and their families (Dagenais, Caro, & Haldeman, 2008). The economic costs of illness include increased health care costs and income losses due to reduced labour supply and productivity (Gertler & Gruber, 2002; Smith, 1999). Majority of the few health expenditure studies on Africa are at the macro level. As such they used per capita real GDP and per capita national health expenditure. For example, Murthy and Okunade (2009) employed econometric analysis on a cross-sectional data for 2001 from 44 countries in Africa to estimate the determinants of health expenditure. Their results show that per capita real GDP is a major determinant of health care expenduture in Africa. Other studies that employed similar approaches include Gbesemete and Gertham (1992), Okunade (1985), Murthy (2004), Okunade (2005).

Most studies on health expenditure at the micro level are on household out of pocket and catastrophic health expenditure and did not consider the productivity losses at work due to illness or injury of a household member. For example, Mugisha, Kouyate, Gbangou and Sauerborn (2002) examined household out-of-pocket expenditure on health care particularly malaria treatment in rural Burkina Faso and found households spent less on malaria because they feel confident to self-treat malaria. They also found more than 80% of out-of-pocket household health expenditure was allocated to drugs and more was spent on health care from qualified health workers than from self-medication and traditional healers.

In another study on Africa, Goudge et al (2009) also measured the direct cost of health care expenditure as a percentage of total household expenditure (direct cost burdens) for households in rural South Africa. Goudge et al used cross-sectional survey data of 280 households on illness events, treatment patterns and health expenditure in the previous month. Results show that households experiencing illness incurred a direct cost burden of 4.5% of total household expenditure.

O'Donnell et al. (2005) investigated sources of variation in the incidence of catastrophic expenditure on health care across six Asian countries using household surveys on out-of-pocket household expenditure. They found that with the exception of India and Sri Lanka, larger households are more likely to incur catastrophic health expenditure with higher incidence in rural areas and lower among households with a sanitary toilet and safe drinking water. O'Donnell et al also reported that household total consumption positively correlated with the incidence of catastrophic payments and that having a highly educated household head, insurance coverage and living in an urban area lessen the risk of incurring catastrophic health expenditure.

Buigut, Ettarh and Amendah (2015) examine the incidence and determinants of catastrophic health expenditure among urban slum communities in Kenya using multivariate logistic regression analysis on a data set on informal settlement residents. They found that while the proportion of households facing catastrophic health expenditure ranges from 1.52% to 28.38% depending on the threshold used, the number of working adults in a household and membership in a social safety net appear to reduce the risk of catastrophic health expenditure. However, seeking care in a public or private hospital increases the risk.

Brown, Hole and Kilic (2014) explored the risk factors associated with experiencing catastrophic health expenditure at the household level in Turkey using a sample selection approach based on Sartori (2003) to allow for the potential selection problem which may arise if poor households choose not to seek health care due to concerns regarding its affordability. Their results suggest that poor households are less likely to seek health care relative to non-poor households, which highlights the vulnerability of poor households in terms of health care availability and implies that special attention should be devoted to overcoming the health care barriers faced by poor households in Turkey.

Kim and Yang (2011) compared the compositions of health expenditures between households with and without catastrophic health expenditures; the relationships between catastrophic health expenditures and household income; as well as the relationship between catastrophic expenditures and expenditure patterns in South Korea. Kim and Yang used data of 90,696 households from the 2006 South Korean Household Income & Expenditure Survey to assess the presence of catastrophic health expenditure. The double-hurdle model was used to assess income sources and expenditure categories. Their results showed, after adjusting for household characteristics, that catastrophic health expenditure positively correlated with total income, however, earned incomes were significantly lower, while transfer and loan incomes were significantly higher in households with catastrophic health expenditures than in those without catastrophic health expenditures.

Parker and Wong (1997) examined the determinants of household health monetary expenditures in Mexico with a focus on the impact of household income on health expenditures using the economic and demographic characteristics of the household as covariates. Parker and Wong used the Mexican National Survey of potential selection problem which may arise if poor households choose not to seek health care due to concerns regarding its affordability. Their results suggest that poor households are less likely to seek health care relative to non-poor households, which highlights the vulnerability of poor households in terms of health care availability and implies that special attention should be devoted to overcoming the health care barriers faced by poor households in Turkey.

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Income and Expenditures of 1989. They employed multiple regressions with the Heckman correction for selectivity bias. They found monetary health expenditures by Mexican households to be sensitive to changes in household income levels.

In one of the extensions to the Grossman model, Galama & Kapteyn (2011) used a generalized solution to Grossman's model of health capital and found that, when measured across the healthy and unhealthy, health decreased with the cost of medical goods/services and with environmental factors that are detrimental to health (e.g., working conditions) and increase with education. Galama & Kapteyn were however inconclusive on the effect of income on health because results deferred among different subgroups.

Again, Ettner (1996) used data from three sources—the National Survey of Families and Household, the survey of Incomes and Program Participation, and the National Health Interview Survey—to estimate the structural impact of income on, among others, self-assessed Health status. The results of both ordinary least square and instrumental variable regressions showed that income significantly improved mental and physical health.

At the macro level, Wolfe (1986), and Wolfe and Gabay (1987) found evidence which suggests that health care expenditures have a positive relationship with health status. Using cross-national health and life-style data from the OECD, Wolfe (1986) found, after controlling for life-style that have impact on health and adjusting for inflation and population size, the existence of a positive link between medical expenditures and health status. Wolfe (1986) was confirmed by, Wolfe and Gabay (1987) who used data spanning 20 years from 22 countries with a simultaneous equation model. The proxies for health status were infant mortality, live birth weight and life expectancy and a variety of indicators for life style. These findings are also in line with Nixon and Ulmann (2006).

Intergenerational Transmission of Health

According to Thompson (2014), a strong relationship between parent and child socioeconomic outcomes has implications for the notion of equal opportunities.

Various aspects of the influence of child health on human capital formation have been observed in the literature (Currie, 2009; Currie & Stabile, 2006). For example Case, Fertig and Paxson (2005), Case, Lubotsky and Paxson (2002), and Currie and Stabile (2004) found that children who have poor health also have significantly lower educational attainment, poorer adult health and lower socio-economic status. In the context of these socioeconomic indicators, intergenerational mobility of health plays no mean role. However, very few of the studies on child health have probed intergenerational correlations in health.

According to Coneus and Spiess (2012) intergenerational health can be transmitted in three main ways. These are the shared environment including the modelling behaviour by children of their parents (see Levy et al., 2000) or the power of example (Lefgren, Sims, & Lindquist, 2012); hereditary; and socioeconomic factors such as investment in health, income, education of parents and other household decisions of which the parents are big role players (Sacerdote, 2007; Osmani & Sen, 2003). These mechanisms interact in complex ways in connecting parental health to child health (Coneus & Spiess, 2012). The lack of sufficient knowledge of the extent of the contribution of each set of these factors has forced economists to attempt decomposing intergenerational correlation estimates into causal components. Such decomposition would help to identify factors that promote or retard mobility and also identify possible paths for government intervention. The major impediment however, is the difficulty in measuring health.

This measurement problem, according to Ahlburg (1998), could be attributed to the concept of health being multidimensional with different aspects of it having different effects on well-being, productivity, and other labour-market outcomes as well as its dynamic nature. Some of the measures used in the economics literature include anthropometric measures (Thompson, 2014). These include, for example, height (e. g., Bhalotra & Rawlings, 2011, 2013; Venkataramani, 2011); birth weight (e. g., Currie & Lin, 2007; Currie & Moretti, 2007; Emanuel et al., 1992; Royer, 2009); body mass index (BMI) (e.g., Classen, 2010; Classen & Hokayem, 2005). Subjective measures such as respondents' self-reported health status (e.g., Case et al., 2002; Coneus & Spiess, 2012; Trannoy et al., 2010) are also used. Despite being subject to measurement errors, the subjective measures are the most widely used measure of health in the empirical literature (Strauss & Thomas, 1996).

Most of these studies focus on how early life health shocks affect adult health. Few, however, looked at the link between parental health and the health of its progeny at all stages of life.

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Genetic epidemiologists who studied intergenerational mobility of health have generally sought associations between gene and specific diseases such as cancer and Alzhemer's disease. Studies also looked at lifespan, which, according to Ahlburg (1998) is the ultimate output of the health production function. Estimates of the correlation of the lifespan between generations have been used to support a strong genetic component of longevity (Yashin & lachine, 1997). While some interpret this correlation as support for a strong genetic component of longevity, others have argued it suggests an environmental nature to the lifespan correlation. Geneticists distinguish between two types of environmental effects: shared and non-shared environmental effects. Yashin and Iachine (1997) have suggested that rather than use data on lifespans it may be more beneficial to base models directly on the genetics of susceptibility to disease. This focus is certainly closer to the concept of health which economists concerned with investments in human capital worry about.

Levy et al. (2000) examined the specificity of the effects of the intergenerational transmission of gastrointestinal illness behaviour by (a) comparing the children of Irritable Bowel Syndrome (IBS) patients to control children whose parents did not have IBS, and (b) statistically controlling for differences between the IBS parents and non-IBS parents in the frequency of non-gastrointestinal health care visits. Their findings support earlier studies that children copy the illness behaviour exhibited by parents during illness in order that they (children) can avoid unpleasant tasks and expect special consideration (see Lowman et al., 1987; Whitehead et al., 1982, Whitehead et al., 1994).

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In a recent but more comprehensive study, Thompson (2014) assesses the role of genetic transmission mechanisms in generating intergenerational associations. Thompson compares the strength of transmission among adopted versus biological children, and found that genetic transmission accounts for approximately only 20-30% of intergenerational associations in most health conditions. Again, Thompson (2014) found that controlling for potential environmental mediators does not substantively reduce intergenerational health transmission estimates. Thompson (2014) suggests that since intergenerational transmission of health is a significant inhibitor of overall socioeconomic mobility, interventions which target environmental conditions should mitigate the transmission of health across generations and promote equality of opportunity (Thompson, 2014).

Pascual and Cantarero (2009) found evidence suggesting sons' reported health depended significantly on the self-assessed health of their fathers in Spain. Using grandmother fixed effects models on a data set of California births, Currie and Moretti (2007) found that if a mother was low birth weight, her children are more likely to be low birth weight at birth, even for comparisons between mothers who are sisters, and stronger for mothers living in known poverty zones. What this seems to establish is that a low birth weight woman—whose low birth weight could be the result of environmental factors of the mother or the mother herself being of low birth weight at her birth—has a higher probability of bringing forth a low birth weight child. Classen and Hokayem (2005) also found significant intergenerational correlation between mother's BMI index and that of their children in the US.

Coneus and Spiess (2012) examined intergenerational relationships between parent and child health based on data from the Mother and Child Questionnaires of the German Socio-Economic Panel (SOEP). Various health measures such as anthropometric and ''self-rated'' health measures were used. Results showed significant relationships between parental and child health during the first three years of life. Again, Coneus and Spiess (2012) found parents with poor health are more likely to have children with poor health after controlling for parental income, education, and family composition.

Canta and Dubois (2015) found the respiratory health of children to be negatively affected if both parents smoked after controlling for total tobacco consumption of parents.

Despite the importance of the study and the existence of a growing literature on health mobility and the multiplicity of measures of health, few attempts have been made to measure intergenerational mobility (Coneus & Spiess, 2012; Pascual & Cantarero, 2009). In this sense, we still know very little about intergenerational health mobility particularly, in developing countries. Moreover most of these studies do not look at the impact of parental health on their adult offspring and rather concentrated on children and most focus on income gradient of child health (Coneus & Spiess, 2012).

Mining and Water Pollution

Mining affects fresh water through heavy use of water in processing ore, and through water pollution from discharged mine effluent and seepage from tailings and waste rock impoundments (Duruibe et al., 2007). There is growing awareness of the environmental legacy of mining activities that have been undertaken with little concern for the environment. Mining by its nature consumes, diverts and can seriously pollute water bodies (Garbarino et al., 1995; Institute of Environmental Conservation and Research [INECAR], 2000).

Ore is mineralized rock containing a valued metal such as gold. After excavating the mineral-rich rock, it is crushed into finely milled tailings for processing with various chemicals and separating processes to extract the final product (Peplow, 1999; Lenntech, 2004; UNEP/GPA, 2004). This generates several tonnes of waste (Lenntech, 2004). It is estimated that on average 99 tonnes of waste material made up of soil, waste rock and the finely ground tailings is generated for every tonne of copper extracted in Canada. This waste is the potential source of water pollution.

Water pollution from tailings and mine waste may need to be managed for decades after closure (Peplow (1999). The severity of these impacts however depend on a variety of factors, such as the structure of minerals being mined, sensitivity of the local terrain, the kind of technology employed, the skill, knowledge and eco-friendliness of the company, and finally, the ability to monitor and enforce compliance with environmental regulations (Armah et al., 2014).

There are four main types of mining impacts on water quality: acid mine drainage, heavy metal contamination and leaching, processing chemicals pollution, and Erosion and Sedimentation. Acid Mine Drainage (AMD) is the process whereby large quantities of rock containing sulphide minerals excavated, either from open pits or opened up in underground mines, reacts with water and oxygen to create sulphuric acid. At a certain level of water acidity a bacteria called *Thiobacillus ferroxidans* accelerates the oxidation and acidification processes, and leaching. This process continues for as long as sulphides and the other ingredients are present – even thousands of years. The leachate is carried off the mine site by rainwater or surface drainage and deposited into nearby streams, rivers, lakes and groundwater (Duruibe et al., 2007). AMD not only severely degrades water quality but can also kill aquatic life and make water virtually unusable (Stevens, Kooroshy, Lahn & Lee, 2013).

Heavy metal pollution is caused when metals such as arsenic, cobalt, copper, cadmium, lead, silver and zinc contained in excavated rock or exposed in an underground mine come in contact with water (Duruibe et al., 2007). The percolated metals are carried downstream as water washes over the rock surface (Habashi, 1992). This kind of pollution occurs through the seepage of chemical agents such as the cyanide used by miners to pluck off the target mineral from the mineralised ore into water bodies. These chemicals adversely affect water quality and can be highly toxic to wildlife and humans directly and through the food chain (Duruibe et al., 2007; Habashi, 1992; Garbarino et al., 1995; Horsfall & Spiff, 1999; Peplow, 1999).

In the process of constructing and maintaining roads, open pits, and waste impoundments, the soil and rocks are loosened. Erosion of the exposed earth carries significant amounts of sediment into streams, rivers and lakes. Excessive sediment can choke riverbeds and destroy watershed vegetation, wildlife habitat and aquatic organisms.

In a nutshell, mine wastes laden with heavy metals are transported in either dissolved form as suspended sediments, through rivers and streams, stored in river beds or leached and contaminate water from underground sources such as wells and boreholes. The extent of groundwater contamination however will depend on the proximity of the well to the mining site (Duruibe et al., 2007). However, sediments water can be carried and deposited far away from the mine site. Mining therefore can destroy surface water and groundwater supplies (Mensah et al., 2015). In addition, mining uses a great deal of water and therefore diminishes surface water and groundwater supplies and lower the water table (Mensah et al., 2015). Groundwater withdrawals may damage or destroy streamside habitat, including humans many miles away from the actual mine site (Eisler & Wiemeyer, 2004).

Potable Water and Pollution

It is estimated that more than 30% of the world's population is without access to clean water while large proportions have to spend hours daily to collect water (Briscoe and de Ferranti 1988; Churchill et al., 1987). About 44% of the world's population, majority of whom live in Sub-Saharan Africa and Southern

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Asia, had to leave their homes to fetch the water needed for their day-to-day domestic use - drinking, cooking, washing and bathing (Pickering & Davis, 2012). In many less developed countries, getting water for household use from such sources located outside the home consumes households' money and time. People have to pay to access, process, and store water from community sources and also travel to collect it (Whittington, Jeuland, Barker & Yuen. 2012, UNICEF & WHO, 2012).

The water challenge engenders adverse consequences for productivity, health, and quality of life. There are also significant health concerns related to these practices, given that such water is generally untreated, polluted from a variety of natural and man-made contaminants such as mining, and difficult to manage hygienically following collection, even when water at the point of collection is of very high quality (Shaheed, Orgill, Montgomery, Jeuland & Brown, 2014). Water pollution is one of the greatest dangers to human health (Jeuland, Pattanayak, & Bluffstone, 2015). In fact, human survival is impossible without water, and people can become morbid from drinking contaminated water. In addition to negatively affecting personal hygiene, water insecurity also gives rise to household interpersonal conflicts (Kujinga, Vanderpost, Mmopelwa and Masamba, (2014).

According to the Ghana Statistical Service [GSS] (2014b), 8.6% of households collected drinking water from a source with arsenic above the Ghana standard of 10 ppb, and 5.6% of the households had drinking water that exceeded the standard limit at the point of consumption.

Smedley et al. (1996) found that arsenic in drinking water from streams, shallow wells and boreholes in the Obuasi gold-mining area of Ghana vary between 2 and 175 μgl^{-1}. According to Smedley et al. (1996), the main sources of arsenic in drinking water are mine pollution and natural oxidation of sulphide minerals. Stream waters were found to be the most affected by mining activity and contain some of the highest arsenic concentrations observed while its concentrations in ground waters reaches up to 64 μgl^{-1}. In addition, Smedley et al. (1996) found that the median concentrations of inorganic urinary arsenic from sample populations in two villages, one a rural stream water drinking community and the other a suburb of Obuasi using groundwater supply, were 42 μgl^{-1} and 18 μgl^{-1} respectively. Other studies confirming the presence of arsenic in surface and ground water include Bell (1998), Smedley, Nicolli, Macdonald, Barros and Tullio (2002), and Sarkordie, Nyamah and Amonoo-Niezer, (1997).

Arsenic poisoning results in skin infections, multiple nerve inflammation, bronchitis, gastroenteritis, rhinitis, and cancer (Ogola, Mitullah & Omulo, 2002). It can result in skin and lung cancer, 20–30 years after the first occurrence of symptoms (Harada, 1996). Other effects include cardiovascular and cerebrovascular diseases, diabetes with malignant neoplasm including Bowen's disease. The potential health effects of drinking water containing arsenic include skin damage, circulatory system problems, and increased risk of cancer and infant mortality (Chen et al., 1995).

Ghana, the second largest gold producer in Africa also happens to be the second most buruli ulcer endemic country worldwide (WHO, 2017). The Buruli

Ulcer disease has assumed public health importance in Ghana since 1993. Severe cases came from the Amansie West district of Ashanti Region (Amofah et al., 2002; Amofah, Sagoe-Moses, Adjei-Acquah & Frimpong, 1993; WHO, 2000). The Amansie West District, which tops the buruli ulcer cases in Ghana also happened to contain highest levels of arsenic, possibly released into rivers and lakes and ground water by intensive gold mining activities (Bell, 1998).). This confirms Duker, Carranza and Hale's (2004) assertion that arsenic may be a big role player in the spatial distribution of buruli ulcer. Water pollution by mining is a major cause of contamination of fresh water sources.

In Africa, where access to potable water is particularly limited, it is estimated that more than one-half of the population lacks access although ninety-six percent of the renewable water resources are not utilized (Banerjee et al., 2008; UNICEF & WHO, 2012).. This is typically due to lack of infrastructure to access and transport the water resources (Banerjee et al., 2008). A number of studies, including one covering several countries in sub-Saharan Africa (SSA), have found that improving water access by reducing the travel time to water sources significantly improves child health (Pickering & Davis, 2012; Wang & Hunter, 2010; and Vidyasagar, 2007). Specifically, Pickering and Davis (2012) found that a 5-min decrease in walk time to source water was associated with a 14% average relative decline in two-week diarrhoea cases and an average increase of 0.2 in the WAZ score for an under five-year old child. Again, a fifteen-minute decrease in one-way walk time to water decreases the average relative risk of diarrhoea by 41%. Several studies have also found strong positive correlation between access to potable water and incidence of water borne diseases (Paul, Hunter, MacDonald, & Carter, 2010; Wright, Gundry & Conroy, 2004).

Although there are, undoubtedly, benefits associated with extending water services to households (Lule et al., 2005; Paul et al., 2010), such water projects involve high sunk costs requiring careful assessment of users' willingness and ability to pay for the services. Paradoxically, there exists ample evidence of neglect of water facilities by beneficiaries, especially in rural communities where potable water is rather scarce (MacRae & Whittington, 1988; Merrett, 2007:116; Therkildsen 1988). It is therefore critical to get the price of water right, especially if markets are partially or completely absent. Besides meeting fairness and efficiency considerations, water prices should be at a level to induce efficient usage of water services (Dalhuisen, Florax, De Groot, & Nijkamp, 2003; Klawitter, 2003; Worthington & Hoffman, 2008).

Several households in both rural and urban communities in Africa spend considerable amounts of time traveling to water sources and queuing to collect it, implying that the price of water at the point of collection may not reflect its true value. Existing works made attempts at obtaining the true value of improved water services or quality by creating hypothetical water market or use situations and asking households to state their preferences (see e.g., Whittington et al., 2002). Other studies have used experimental methods such as randomized control trials (Kremer, Null, Miguel & Zwane, 2008; Nauges & Whittington, 2009). Furthermore, a number of papers employed hedonic pricing methods based on the assumption that improved water services are embedded in higher housing prices, all else being equal, (see e.g., Nauges & Whittington, 2009).

There is general unanimity in the literature that the notion of access to water supply should incorporate some measure of associated time cost and/or physical burden (Ho, Russel & Davis, 2014). The problem however has to do with the focus of measurement, as well as the best indicators to employ for regular monitoring. Though, much more commonly used (Demeke, 2009; ICF International, 2011; WHO & UNICEF, 2006), evidence adduced by Ho et al. (2014) points to the use of self-reported indicators of water fetching distance as non-optimal. In a study conducted in a relatively low-lying terrain among Mozambican households, Ho et al. (2014) found high correlation between straight-line distance and route distance implying that the straight-line distance could be good proxy for water fetching distance. It, however, significantly under-estimates the actual distance travelled to fetch water. The straight line distance may perform poorly in rugged and mountainous terrains (Noor et al., 2006; Perry & Gesler, 2000; and Sorenson, Morssink & Campos, 2011).

Most water demand studies conducted in industrialised countries are not suitable for replication in developing countries. This is because, unlike industrialised countries, developing countries' water demand situation is much more complicated (Briscoe et al., 1990). These complications are brought about by the extended family situation and other exogenous social, economic and psychological characteristics. Briscoe et al. (1990) underscored the need for sufficient background information on the kind of service or services people want when designing rural water supply system in developing countries.

Household Water Supply in Ghana

Nearly one-third (32.3%) of households in Ghana have their main source of drinking water from wells (including boreholes), while 28.9% have pipe-borne water as their source of drinking water (GSS, 2014). Nine percent (9.0%) have natural sources as their main source of drinking water while nearly twenty-seven percent (26.7%) use other sources of water, which includes sachet water (28.0%) as the largest proportion. In the urban areas of Ghana, sachet water (44.5%) constitutes the major source of drinking water for households followed by pipe-borne water (38.6%) and well (13.9%). This is in sharp contrast to rural areas where nearly three-quarters (73.9%) of households use either well (55.3%) or natural sources (18.6%) as their main source of drinking water.

For general household use, 42 percent of households use pipe-borne water, 40.4 percent use water from wells, while 12.1 percent and 5.3 percent of households use water from natural and other sources respectively. The main source of water for general use by households in urban areas is pipe-borne water accounting for more than sixty percent (62.3%) while a little over a quarter (25.9%) use water from well. Water from natural and other sources is utilized by only four percent and 7.9 percent of households respectively. In rural Ghana, the well (58.5%) and natural sources (22.1%) are the major sources of water for general use.

Conclusion

The chapter reviewed the related relevant literature for the study. As a result, the literature on the concept and measurement of health were reviewed. These were linked to the literature on environmental pollution and health. This includes various methods of measurement of environmental change such as revealed and stated preference methods. The chapter also took a critical look at pollution of the environment including water bodies by mining activities. The literature on intergenerational health transmission was also reviewed. Empirical studies on revealed and stated preference methods and intergenerational transmission of health and other socioeconomic variables were also reviewed.

The study applies the instrumental variable hedonic (revealed preference) model to estimate the impact of mining pollution on health expenditure; Intergenerational income transmissions methods to estimate the link between gold mining pollution and intergenerational transmission of disease; and Marshallian demand models (stated preference) to estimate the effect of gold mining pollution on water consumption. Studies measure the health hazards posed to humans by gold mining pollution. Most of these studies, especially on Africa, however, fail to measure how these health risks translate into healthcare cost and how gold mining pollution could lead to potable water scarcity and transmission of disease across generations among households living close to the source of the pollution. The main measure of gold mining pollution, in this study, is the shortest distance between the household and the major mine or tailing site.

CHAPTER THREE

THEORETICAL FRAMEWORK

Introduction

The previous chapter was devoted to the review of relevant literature related to the study. This chapter focuses on the philosophy and the theoretical framework of the study. The philosophy of the study is based on egalitarian anthropocentrism drawn from environmental economic philosophy. The theory of the study is based on demand theory in which stated and revealed preference models were employed.

Philosophy of the Study

Mining and its attendant health risks to residents of adjacent communities are elements of environmental pollution, degradation or change. Since the study is about the pollution related health consequences of gold mining, the study can claim its association with egalitarian anthropocentrism of Environmental Economics which focuses on human equality and maintenance of minimum standard of living as against utilitarianism which focuses on maximizing total human happiness with less concern for how it is distributed among people. Anthropocentrism rejects the biocentrism in which both humans and nonhuman species are said to have inherent value and the value of humans is not given special status relative to the value of nonhuman species.

Theoretical Model of the Study

The task at this stage is to develop a theoretical framework for the determinants of household health expenditure, daily household water consumption and intergenerational health mobility when such a household is exposed to pollution from gold mining activities. In the first part of this section a hedonic model of the behaviour of a utility-maximizing household's effort to maintain a healthy household or prevent the household from 'bad' health in the face of mining pollution was developed. This is followed by a demand for water model showing how mining pollution can influence water use. The section concludes on how paternal socio-demographic characteristics and environmental risks affect intergenerational health transmission.

The Hedonic Model

The theoretical model for the first objective of the study is an extension of the work of Chang and Trivedi (2003). Their model formalizes self-medication, which is a risky investment, by assuming that a rational utility maximizing agent balances the benefits and costs associated with self-medication. Like Chang and Trivedi (2003), it is assumed that a rational agent maximizes an expected utility function that depends on health status (h) and consumption of a composite good (x), subject to a budget constraint. Let the utility function be defined as:

$$u = u(x,h), \tag{3.1}$$

with $u_x > 0$, $u_h > 0$, $u_{xh} = u_{hx} > 0$ and $u_{xx}, u_{hh} < 0$. Chang and Trivedi (2003) assumes that improvement in health status is through either professional care, which is risk-free, or self-medication, which is risky. In this study, it is assumed that health status depends on investment in health (M), which is a derived demand. The returns to such an investment are partly deterministic and partly stochastic due to some exogenous environmental factors. The stochastic component is assumed to have a one-sided distribution. The uncertain health outcome could be due to several factors including misdiagnosis and reinfection resulting from repeated emission of dangerous gases from the mines or leakages of heavy metals in water for domestic use. As noted earlier, tons of inorganic mercury and high concentrations of arsenic are present at areas close to gold mines (see e.g., Smedley, 1996; and Telmer & Veiga, 2009). The health status is therefore defined as:

$$h = h_o + (r - \varepsilon)M \tag{3.2}$$

where h_0 is the initial or "endowed" health status; $r - \varepsilon$ is the return to health care investment: with r and ε being the deterministic and stochastic marginal returns to the investment in health, respectively. Suppose the price of the composite good x is normalized to one, the agent's budget constraint is:

$$B = x + M \tag{3.3}$$

where B is the budget in real terms. The agent's corresponding expected utility function is:

$$Eu(x,h) = Eu\left(B - M, h_o + (r - \varepsilon)M\right) \tag{3.4}$$

Following Chang and Trivedi (2003), let the utility function be additive and separable in x and h, so that:

$$u(x,h) = u(x) + v(h), \tag{3.5}$$

Also let $v(h)$ be of the specific form:

$$v(h) = -\frac{(\rho - h)^2}{2}, \quad \text{with } 0 \leq h \leq \rho \tag{3.6}$$

Using equations (3.5) and (3.6), we can rewrite equation (3.4) as:

$$Eu(x,h) = u(B - M) - E\left(\frac{\left(\rho - h_o - (r - \varepsilon)M\right)^2}{2}\right) \tag{3.7}$$

Let $\mu = E(r-\varepsilon)$ be the expected returns on health care investment and $\sigma^2 = E(r-\varepsilon-\mu)^2$ be the variance of $(r-\varepsilon)$. The mean-variance formulation of (3.7) is:

$$Eu(\bullet) = u(B-M) - \frac{(\rho - h_0 - \mu M)^2}{2} - \frac{\sigma^2 M^2}{2} \quad (3.8)$$

Maximizing equation (3.8) with respect to the choice variable (i.e., M) yields the following first order condition:

$$u_M(B-M) + (\rho - h_o - \mu M).\mu - \sigma^2 M = 0 \quad (3.9)$$

Equation (3.9) stipulates that at equilibrium the marginal health benefit from an increased investment in health (i.e., $(\rho - h_o - \mu M).\mu - \sigma^2 M$) must balance the marginal utility cost of the investment (i.e., $u_M(B-M)$). It can easily be shown that M decreases in h_o and σ^2, but increases in B. Thus, $dM/dh_0 < 0$, $dM/d\mu > 0$, $dM/d\sigma^2 < 0$ and $dM/dB > 0$ (see equations B1 to B4 in Appendix B).

Finally, let the stochastic component of the health outcome depend on exposure to mining externalities, such as cyanide spillage, as well as a vector of individual characteristics ($\mathbf{A}$). That is, $\mu = \mu(\mathbf{z};\mathbf{A})$ and $\sigma = \sigma(\mathbf{z};\mathbf{A})$, where $\mathbf{z}$ is a vector of mining externalities (e.g., nearness to the mining site, which is a proxy for exposure to pollution, and noise pollution due to blasting, among others). It is hypothesized that increased pollution decreases the expected returns to health expenditure but the variance increases in pollution (i.e., $\mu_{\mathbf{z}} < 0$ and $\sigma_{\mathbf{z}}^2 > 0$) so that ${dM}/{dz} < 0$. We can then specify the general form of health care investment equation as:

$$M = f(h_o, B, \mathbf{z}; \mathbf{A}) \tag{3.10}$$

The empirical specification of equations (3.10) is presented in Chapter 5.

Household Water Demand

Here we develop the theoretical model for our second objective.

Households in developing countries usually travel long distances and also spend time waiting or queuing to haul water for domestic use. The issue becomes complicated when the ground water is polluted thus bringing increased health risks to residents. Moreover, a study by Whittington, Lauria and Mu (1991) found that the opportunity cost of the travel time to haul water could be valued at say the prevailing wage rate. Therefore, it is surmised that the shadow price of water is the sum of the actual price paid at the point of collection and the opportunity cost of travel and queuing time, valued at full or a fraction of wage rate. This shadow price therefore denotes the individual's willingness to pay for water connection to the household. To formalize this, suppose that an individual's indirect utility function (U) is defined as:

$$U = \psi(\mathbf{p}, B, A; \mathbf{s}), \tag{3.11}$$

where $\mathbf{p}$ is the price of a composite commodity, A is the quantity of water used, B is income or expenditure, and $\mathbf{s}$ is a vector of socio-economic characteristics that could shift the indirect utility function. Note that water usage is in the indirect utility function because it does not have an explicit price. Following Charemza (1990), Lee and Pitt (1986) and Lee (1986), the expression for the shadow price (Marshallian virtual price) of water is equation 3.12.

$$\rho_w = \frac{\partial \psi(\bullet)/\partial A}{\partial \psi(\bullet)/\partial B} = \rho + \tau_w, \tag{3.12}$$

where ρ_w is the shadow price (or virtual price) of water, $\partial \psi(\bullet)/\partial A$ is the partial derivative of the indirect utility function with respect to water usage, ρ is the price paid for the water at the point of collection, and τ_w is individual's subjective valuation of the traveling and waiting time to collect the water.

Empirical specification of equations (3.12) is presented in Chapter Six.

Intergenerational Health Transmission

Under this subsection, the theoretical model for the third objective is specified.

Understanding the nature of the intergenerational correlations in health is crucial for formulating appropriate policy responses (Fitzgerald, 2011). A parent may transmit an ailment to an offspring genetically or through infection. Taking a cue from the theoretical model of Lefgren et al. (2012), which establishes a relationship between the income of a father and his son, let the intergenerational health relationship between a parent and an offspring be of the following form:

$$H_s = \beta_0 + \beta_1 H_p + \beta_2 S_s + \beta_3 E + \varepsilon_s \qquad (3.13)$$

where H_s and H_p are the health conditions of offspring and parent respectively, S_s is the socio-demographic characteristics of the offspring, E denotes the environmental conditions including neighbourhood characteristics and almost all measures of health, and ε_s is a residual term. Finally, β_1 measures the persistence of health status across the generation. Suppose fathers differ in terms of health and socio-demographic factors.

Parental health is a function of parent's socio-economic, environmental, genetic and other idiosyncratic factors. We write this relationship as:

$$H_p = \gamma_0 + \gamma_1 H^*_{pp} + \gamma_2 S_p + \gamma_3 E + \eta_p \tag{3.14}$$

where S_p represents socio-demographic characteristics of parent and/or household including education, income, wealth, specific health conditions, physical functioning, and mortality, among others; H^*_{pp} denotes any genetic inheritance from parent, and η_p captures variation in paternal health due to idiosyncratic factors that are orthogonal to socio-demographic factors such as accident or injury.

It is the intention of every parent to produce or nurture healthy children as measured by health conditions. Substituting (3.14) into (3.13) gives:

$$H_s = \lambda_0 + \lambda_1 S_p + \beta_2 S_s + \lambda_2 H^*_{pp} + \lambda_3 E + \upsilon_s \tag{3.15}$$

Note that $\lambda_0 = \beta_0 + \beta_1\gamma_0$, $\lambda_1 = \beta_1\gamma_1$, $\lambda_2 = \beta_1\gamma_2$, $\lambda_3 = \beta_1\gamma_3 + \beta_3$ and $\upsilon = \beta_1\eta_p + \varepsilon_p$. More specifically, λ_1 corresponds to the fraction of investment in child health multiplied by the genetic inheritance component for his grandfather. Meanwhile λ_2 captures the degree to which parental health and socio-demographic factors are directly transferable to children. λ_3 denotes the contribution of environmental conditions including pollution to intergenerational health persistence.

Analytical Approach

Hedonic model (Objective 1)

In the previous section, I specified the theoretical model and arrived at equation (3.10). Equation (3.10) is a *hedonic-type* equation, for which economic cost of healthcare (both preventive and curative) depends on the level of the environmental hazards (z) that an individual is exposed to after controlling for other social, economic, and biophysical characteristics.

The goal is to estimate the hedonic health expenditure function for mining pollution and empirically assess whether healthcare expenditure rises with mining pollution concentration. The difficulty of consistently estimating the hedonic health expenditure function in equation (3.10) lies in the probable existence of unobserved factors that co-vary with both mining pollution and health expenditure. For example, areas with higher levels of air pollution may follow the direction of the wind but may also be the location of residences of the more educated (and therefore, higher per-capita income-earning) mineworkers or tend to be more urbanized and have higher population densities. Again as a result of acid mine drainage, streams and water bodies may carry pollutants far away from the mine site (Sumi & Gestring, 2013). Consequently, cross-sectional estimates of the health expenditure–mining pollution gradient may be severely biased due to effects of omitted causes in the model. In other words the model is miss-specified. Another source of bias in estimation of the average marginal WTA compensation for mining pollution is when the population is self-selected to locations based on preferences. It is important to control for these problems if they exist. In equation

3.10, clearly health status, h_0 , and income, B , are suspected to be endogenous due to their likely reverse causal relationship with M . If this is true, it would cause the error term to be biased. Thus, some of the regressors, $X_i = f(h_{0i} B_i)$, are endogenous, so that $E(X_i \mu_i) \neq 0$. I propose to find appropriate instrumental variables to address the suspected potential sources of endogeneity in the income and health status variables. For example, let the structural equation be:

$$M_i = f_i(\hat{h}_0, \hat{B}, \mathbf{z}; \mathbf{A}) + \mu_i \qquad (3.16)$$

Where $\hat{h}_0$ and $\hat{B}$ are the instrumented endogenous variables. The reduced form equation is:

$$X_{ij} = g_{ij}(\mathbf{z}, \kappa; \mathbf{A}) + \varepsilon_{ij} \qquad (3.17)$$

Where X is the set of endogenous variables and $j = 1, 2, \ldots\ldots, m$ indexes the m endogenous variables. The symbol, $\boldsymbol{\kappa}$, is a vector of instrumental variables, and ε_{ij} is the error term. The thrust of a good instrument is that it should not correlate with the error term but should be sufficiently and strongly correlated with the endogenous variable once the other independent variables are controlled for.

Functional Form

The specific functional form of hedonic models varies considerably in the literature. In reality, the specification that fits the data best depends on the issues under consideration and the data actually available. For example, in applying the model to pricing housing attributes, some studies have found that linear specifications best fit the data (see, e.g., Cropper, Deck & McConnell, 1988; Rosen, 1974), while others have found non-linear relationships (see, e.g. Cassel &

Mendohlsson, 1985; Colwell & Munneke, 1999; Halvorsen & Pollakowski, 1981). Nonetheless, some studies advocate the use of nonparametric methods to avoid imposing *a priori* restrictions on the distribution of the error terms in such models (see, e.g., Meese & Wallace, 1991; Redfearn, 2009; Stock, 1989; Thorsnes & McMillen, 1998). These hints from the literature and the kind of data available were considered in fashioning our empirical equation of the relationship between healthcare cost and the quality of the environment.

Demand for water model (Objective 2)

The objective here is to construct a model that efficiently estimates residential water demand in the Obuasi Municipality and investigate the determinants of households' value of time spent on water collection as leisure time.

From equation 3.12, the virtual price of water can simply be interpreted as an individual's incremental value of water usage. If water had a substitute, which is traded in a competitive market, it would have been straightforward to derive its shadow price if a function that links the two commodities exists. Since this is not the case, information on the value of water could either be (1) indirectly obtained by valuing the travel time and queuing time to haul water (τ_w), which could then be added to the price paid at the point of collection (ρ); or (2) directly obtained by eliciting the individual's willingness to pay for a given quantity of water ($\rho+\tau_w$). So far, the former has been widely used but not without drawbacks (see e.g., Kremer, Miguel, Leino, & Zwane, 2011; Whittington, Mu, & Roche, 1990;

Whittington et al. 1991). The most critical challenge is whether water collection is considered by individuals as leisure/social activity or work (i.e., $\tau_w \leq 0$ or $\tau_w > 0$).

It may be erroneous to cost time for household chores without careful empirical investigations. This is because such activities could be considered by a household as either leisure or work. While some studies have used values equivalent to minimum wage of unskilled labour (polyvalent worker), others have valued it as a proportion of or full hourly income of households (see e.g., Eom & Larson, 2006; Kremer et al., 2011; Whittington et al., 1990; Whittington et al. 1991). In addition, water projects in developing countries often suffer neglect (see e.g., Therkildsen 1988; MacRae and Whittington 1988; Merrett, 2007) implying that beneficiary communities do not place high values on them.

Using the virtual price information, two empirical models are estimated: (1) a water demand equation that uses wage rate to value the travel and waiting time, as well as use WTP for water as the true price of water; (2) a Logit model that explores determinants of negative willingness to pay for the travel and waiting time. These models are specified in the next two sections.

Generally, there are problems of endogeneity resulting from the nature of data on water pricing. Data on water pricing range from a single volumetric price to more complex types of discontinued tariff structures in which fixed access charge could be combined with decreasing or increasing volumetric rates. In some of these pricing methods as consumers select the quantity of water to be demanded, they also select the price – a bi-causal relationship. This may yield biased and inconsistent estimates especially when the more common ordinary least squares technique is used (Worthington & Hoffman, 2008). As a result, other econometric techniques have been employed to improve reliability of the estimates (Agthe & Billing, 1987; Agthe, Billing, Dobra & Raffiee, 1986; Barkatullah, 1996; Hewitt & Hanemann, 1995; Higgs & Worthington, 2001). These include generalized least squares (GLS), two-stage least squares, logit and IV techniques were employed on cross-sectional data. The choice of technique depends on the type of data used (Arbués, García-Valiñas & Martínez-Espiñeira, 2003). Other techniques employing a variety of functional forms including nonlinear forms have been used – log-log and semi-log (Schleich & Hillernbrand, 2009). The Cobb-Douglass water demand equations are also widely used in the literature (Foster & Beattie, 1981; Hewitt & Hanemann, 1995; Nieswiadomy & Cobb, 1993). Another non-linear model used is the Stone-Geary utility function (Dharmaratna, & Harris, 2012; Gaudin, Griffin, & Sickles, 2001; Martinez-Espiñeira & Nausges, 2004).

Despite the varied techniques, most of these studies follow the form $Q_d = f(P, Z)$ where Q_d is the quantity of residential water demanded or consumed, P is some measure of water price and Z represents other independent variables that could impact residential water demand (Worthington and Hoffman, 2008). These variables usually include income, household structure and size, property characteristics, non-price water restrictions and so on (Arbués et al., 2003).

I proceed from the premise that household demand for water in Ghana is a composite demand consisting of the water demanded for drinking purposes and for other household activities such as cooking, cleaning, washing and body hygiene. The fact that only 38.6% of urban dwellers in Ghana use pipe-borne water for drinking while as much as 44.5% use sachet water (GSS, 2014b) is an indication that households do not have access to a reliable flow of potable water. It also shows that households have to travel varying distances in search of water from less reliable but more expensive sources, including sachet water. This problem is further compounded in mining communities where water bodies are polluted and government and community operated water services are perceived to be contaminated by mining activities. As a result, block pricing of water hardly works realistically. Meanwhile, the shadow price of water comprises the value of travel and waiting time plus the price of water paid at the point of collection.

From the forgoing, the water demand equation is specified as equation (3.18).

$$\ln A_i = \theta + \mathbf{bs}_i + a_1 \ln M_i - a_2 \rho_{wi} + \varepsilon_i \tag{3.18}$$

where A is the quantity of water used; s is a vector of socio-economic characteristics that could shift the indirect utility function; M is income or expenditure; and ρ_w is the shadow price of water. The respective parameters to be estimated are $\theta, \mathbf{b}, a_1, a_2 > 0$; i is household specific index; and ε_i is independent and identically distributed (iid) error term.

For the second model, let i index individual household and WTP denote household's willingness to pay for potable water delivered at its doorstep. If p is the actual price paid for water per unit, then $WTP_i - p_i = WTA_i$ is the value of time the individual household places on water collection. This brings us to our second proposed empirical equation as expressed in equation (4.8). The dependent variable is the Willingness to Accept (WTA) compensation not to travel to the point of collecting the water. The model is specified as:

$$WTA_i = \begin{cases} 1 & if \ WTA_i^* = f(\mathbf{z};\gamma)_i + \upsilon_i > 0 \\ 0 & otherwise \end{cases}, \qquad (3.19)$$

where f is a functional notation, $\mathbf{z}$ is a vector of individual characteristics, γ is a vector of coefficients to be estimated, and υ_i is a disturbance term, which is logistically distributed.

Logit Regression Model and Intergenerational Health Mobility (Objective 3)

This subsection is a prelude to the estimation of a binary logistic regression model which seeks to measure the intergenerational associations in a particular health condition (the categorical dependent variable). Thus, let H_i denote individual i who could suffer a particular disease such that $H_i = 1$ if individual i shows positive signs of the diseases and zero otherwise. More formally,

$$\text{Let } H_i = \begin{cases} 1 & \text{if the individual suffered the deasese} \\ 0 & \text{otherwise} \end{cases} \qquad (3.20)$$

Then probability p_i of suffering the disease is defined as

$$p_i \equiv \Pr[H_i = 1|\mathbf{x}] = F(\mathbf{x}_i'\boldsymbol{\beta}) = \frac{e^{\mathbf{x}_i'\boldsymbol{\beta}}}{1 + e^{\mathbf{x}_i'\boldsymbol{\beta}}} \tag{3.21}$$

where $F(\cdot)$ is a cumulative distribution function (cdf) of the logistic distribution, $\mathbf{x}_i$ is a vector of regressors with their corresponding coefficients denoted by $\boldsymbol{\beta}$.

It is noteworthy at this stage to explain how the method of computing the disease variables was done. The questions were designed to ask each household member whether s/he experienced the symptoms in a set of symptoms known to be indicative of a certain disease. The determination of symptoms of a disease was done through the Delphi technique. The Delphi technique is a routine where a group of experts (in this case, medical doctors), anonymous to each other but known only to the coordinator, are used to evaluate an idea or problem in order to reach a consensus (Hsu & Sandford, 2007). The coordinator poses questions to the experts individually, returns to analyse the responses and goes back to the experts armed with a set of questions resulting from the evaluation of the responses. This back and forth goes on until a consensus is reached. The same technique was used in diagnosing whether a particular household member suffered a particular disease or not. For example, for lower respiratory tract infections, cough plus any other one of the listed symptoms is an indication that the person suffered a lower respiratory tract infection.

Summary

The focus of this chapter is to explain the philosophy, conceptual and theoretical frameworks of the study. The study espouses the egalitarian anthropocentrism drawn from environmental economics philosophy while the theory of the study is based on demand theory in which stated and revealed preference models were employed. Specifically a *hedonic-type* equation in which economic cost of healthcare depended on the level of the environmental hazards that an individual is exposed to, after controlling for other social, economic, and biophysical characteristics was developed. These environmental hazards also featured in the residential water demand and intergenerational health transmission models later in the chapter. My argument is that environmental hazards could affect access to potable water, socio-cultural factors regarding water collection, and it is a source of diseases that could not only affect the current generation but generations yet unborn.

The chapter closed with the discussion of the analytical approaches for transforming the theoretical models into econometric models to which the data were applied to realise the research objectives

CHAPTER FOUR

METHODOLOGY

Introduction

This chapter discusses the philosophical assumptions and also the design strategies of the study. Common philosophical assumptions were reviewed and the positivist paradigm was identified for the framework of the study. The research design for this study is an explanatory type and for that matter, the quantitative (statistical and econometric) methods of analysis were used. A questionnaire was used in a survey conducted to generate the data. Furthermore, the justification for each of the data collection methods used in the study was discussed.

Study Area

The study area is the Obuasi Municipality in the Ashanti Region of Ghana. It is located between latitudes 6 °08N and 6 °14N, and longitudes 1°30W and 1°50W. While the Ghana Statistical Service [GSS] (2014a) estimates the total land area covered by the Municipality at 220.7 square kilometres, the Obuasi Municipal Assembly (2014) puts it at 162 square kilometres. The Municipality lies 64km south of Kumasi, the Regional capital and 320km (by road) north-west of Accra, the Capital of Ghana. The Municipality was carved out of the former Adansi West District in 2004. It shares boundaries with Adansi North District to the north and east, Adansi South district to the south, and Amansie Central District to the west (Obuasi Municipal Assembly, 2014). See Figure 3 for the map of the study area.

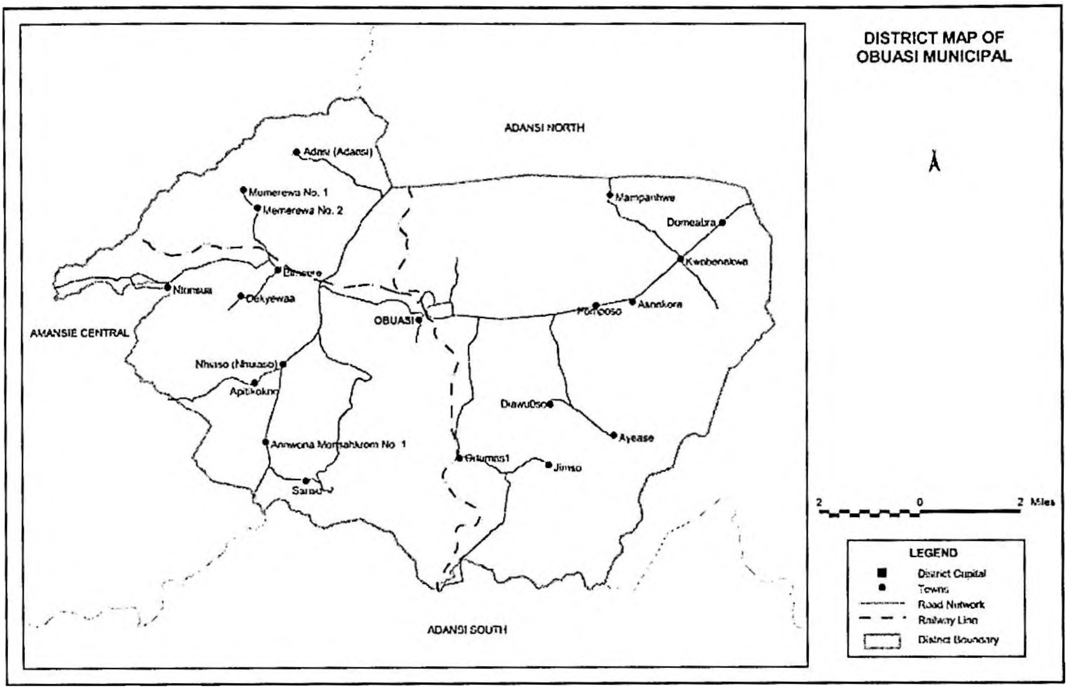

Figure 3 Map of Obuasi Municipality
Source: Ghana Statistical Service (GSS) 2014a

Located within the Obuasi municipality is the famous Obuasi mine. It is one of two AngloGold Ashanti (AGA) operations in Ghana and is wholly owned and managed by AGA. AngloGold Ashanti acquired the mine from Ashanti Goldfields Company Limited of Ghana in April 2004. The mine has been in operation since 1895 (Gough & Yankson, 2012). The mine is located on a total mining concession covering an area of 47,500ha enveloping about eighty communities. Approximately 250,000 people, who are mostly engaged in subsistence farming, reside within a 30km radius of the mine.

Mining operations are primarily underground, mining to a depth of 1.5km with six shafts for man transport and rock hoisting. Some surface mining in the form of open pit and tailings reclamation occurs. Obuasi currently treats sulphide ores from underground at the south plant, following the decommissioning of the tailings treatment plant in October 2010. The south plant also treats sulphide tailings and has a monthly capacity of 360,000t.

In choosing the study area, I took note of a few issues. There are 10 major gold mining companies operating in Ghana by 2012. Of the ten, three (3) are relatively new. Out of the remaining seven (7), four (4) comprising AngloGold Ashanti – Obuasi, Gold Fields Ghana – Damang, Golden Star Prestea/Bogoso and Chirano Gold Mines are noted for both underground and open pit mining but AngloGold Ashanti – Obuasi has placed open pit mining on hold for some time now. The remaining three (3) operate the open pit mining only. The Obuasi mine being the oldest mine operating in Ghana, has a rich historical amplitude and has passed through old and modern methods of mining and so would have left in its trail an endemic concentration of pollutants accumulated over the years. Though a relatively small area, the Obuasi Municipality could, nonetheless, provide a good source of data to satisfy the research objectives.

The Municipality has a rather undulating topography and a semi-equatorial type of climate with a double rainfall regime. Mean annual rainfall ranges between 1250mm and 1750mm. Mean average annual temperature is 25.5°C and relative humidity is 75% - 80% in the wet season. The vegetation is predominantly a degraded and semi-deciduous forest. The forest consists of limited species of hardwood which are harvested as lumber. The Municipality has nice scenery due to the hilly nature of the environment.

According to the Obuasi Municipal Assembly (2014), there are seven (7) hospitals, two health centres, eight (8) clinics, four (4) maternity homes and one (1) Community-based Health Planning and Services (CHPS) centre. There are twenty-one (21) doctors supplemented by one hundred and sixty–five (165) nurses and two hundred and twenty-three (223) paramedics in the Municipality in 2013. The doctor/population ratio stands at 1:10,250 (Obuasi Municipal Assembly, 2014).

In terms of water coverage, thirty (30) communities have their sources of water from either boreholes or hand-dug well. Thirty-three (33) communities have 100% pipe borne water coverage. However, pipe-borne water utilization is very low and limited to washing and other domestic uses instead of drinking purposes due to the fact that the water is contaminated by mining activities especially illegal mining and domestic waste (Obuasi Municipal Assembly, 2014). This confirms the claims of Rademeyer (2013), Hadadin, Qaqish, Akawwi and Bdour (2010) and Kujinga et al. (2014) that access to improved water may not guarantee availability of clean water in most developing countries.

Research Design

According to Blanche, Blanche, Durrheim, & Painter (2006), paradigms are systems of interrelated ontological, epistemological, and methodological assumptions. They act as viewpoints that provide the basis for a particular research and inform the methods of data gathering, observation, and interpretation (Blanche et al., 2006).

Ontology and epistemology are about people's worldview of the nature of reality or being and the constituents of acceptable knowledge of reality respectively. Methodology, however, defines the practical approach to studying whatever the researcher believes can be known. For example, the world could be seen through the window of objectivism, constructivism, or interpretivism as shown in Table 3. Though, none of these views can claim superiority over the other different ways of seeing the world, they have implications in most academic areas. Each may be appropriate for some purposes and insufficient or overly complex for other purposes.

Table 3: Positivist, Interpretive, and Constructionist Paradigms

	Ontology	Epistemology	Methodology
Positivist	• Stable external reality • Law-like	• Objective • Detached observer	• Experimental • Quantitative • Hypothesis testing
Interpretive	• Internal reality of subjective experience	• Empathetic • Observer subjectivity	• Interactional • Interpretation • Qualitative
Constructionist	• Socially constructed reality • Discourse	• Suspicious • Political • Observer constructing	• Deconstruction • Textual analysis • Discourse analysis

	• Power	versions	

Source: Blanche et al. (2006)

From Table 3, a positivist researcher who prefers or believes in working with an observable social reality could then have an end product of such a research as law-like generalisations similar to those produced by the physical or natural scientist (Saunders, Lewis & Thornhill, 2009). Such a researcher has most probably used experimental or explanatory methodology.

Furthermore, Saunders et al. (2009) classified the purpose of research into three categories—Exploratory, Descriptive and explanatory studies—from which research strategies are adopted. Exploratory studies are useful for seeking out new insights and are particularly useful for clarifying people's understanding of a problem. Exploratory study can be conducted by literature search, interviewing of expert or through focus group discussion. Descriptive studies are used to give precise profile of individuals, situations, events and processes (Robson & McCartan, 2016). However, if the purpose of the research is to establish a causal relationship between variables, then one is in the realm of explanatory research.

In adopting any or a mix of the above three purposes of study, one can use any or a mixture of the following strategies: experiment, survey, case study, or action research. Experiments tend to be used more in exploratory and explanatory research to answer 'how' and 'why' questions. Because they use control and experimental groups, experiments have the advantage of internal validity but a drawback of external validity (Saunders et al., 2009). According to Saunder et al., a survey strategy is usually associated with the deductive approach and most frequently used to answer who, what, where how much and how many questions. The survey strategy tends to be used in exploratory and descriptive research and allows the collection of quantitative data. The quantitative data can be analysed by means of descriptive and inferential statistics. The case study strategy is used for research involving the empirical investigation of a phenomenon within its real-life context with evidence from multiple sources (Saunders et al., 2009).

Study Design

This study makes use of the objectivist approach as exemplified by positive economics—a branch of economics that focuses on the description and explanation of economic phenomena, as well as their casual relationships (Mäki, 2009. The study is an explanatory research since the focus is on investigating the relationship between mining pollution, on the one hand, and household health expenditure, household demand for water and intergenerational associations in health on the other. It (the study) therefore, used the quantitative methods emphasizing objective measurements, and the statistical and econometric analysis of data. Both primary and secondary data were used. The primary data was obtained from a survey of households in the Obuasi Municipality through questionnaire administered by experienced interviewers. The data was collected during the months of June and July 2014 mainly covering the twelve months prior to the enumeration period. The secondary data used came from Aragón and Rud

(2016). The secondary data was used to confirm that distance from households to the mine is an appropriate proxy for mining pollution.

Study Population

As of March 2010, the population of the Obuasi Municipality was 168,641 (GSS, 2012). It is the most populous after Kumasi Metropolitan Assembly area in the Ashanti Region. The population of the Obuasi Municipality, with 41,312 households (in 2010) and a household size of four, consists of 81,015 males and 87,626 females. Again, of the total population of the municipality, 24,997 or 14.8% is rural. This is an indication that the Municipality is largely urban.

Mining and its related activities constitute the main industrial activity of the municipality and employs about 35% of the working population. This is followed by commercial and agricultural sectors employing 25% each. Services employ about 20% of the work force.

The unit of analysis in the study is the Household. The study adopts the Ghana Statistical Service (2012) definition of a household as person or a group of persons who lived together in the same house or compound and shared the same housekeeping arrangements. The study population therefore consists of all the households in the Obuasi municipality.

Sample Size

Six hundred households from the Municipality were selected for the study. The selection was done through cluster sampling of 92 (33.3%) out of the Municipality's 275 Enumeration Areas (EAs). The sample represents approximately, 1.5% of the 41,312 households of the Obuasi Municipality. The statistical formula by the United Nations Statistical Division (2008) was used in the determination of the sample size. I used the Ghana Living Standards Survey Round Six (GLSS6) as my reference. The United Nations Statistical Division's (2008) sample size formula is given by

$$n_h = \frac{(z^2)(r)(1-r)(f)(k)}{(p)(\tilde{n})(e^2)} \tag{4.1}$$

Where n_h is the sample size, i.e. the number of households to be selected;

z is the statistic that defines the level of confidence 95% in this case;

r is an estimated proportion of people who fell ill or injured within a two-week period prior to GLSS6 survey date (i.e., 14%);

f is the sample design effect or clustering effect. I used the default value of 0.2 (United Nations Statistical Division, 2008);

k is a multiplier accounting for the anticipated rate of non-response. I used seven percent, the nonresponse rate in the GLSS6;

p is the proportion of the total population accounted for by the target population and upon which the parameter, r, is based. Just like the GLSS6 (whose target pupation is all the households in Ghana (see GSS 2014b, p. ii)), our target population is all the households of the Obuasi Municipality and therefore, $p = 1$. (According to the United Nations Statistical Division, 2008, p can be set equal to one if the target population is the same as the total population);

$\bar{n}$ is the average household size (number of persons per household). In Ghana, the average household size is four in this case (GSS, 2012);

e is the margin of error to be attained and is taken to be 10% of r (i.e., $\frac{1}{10}r$)

Substituting for these values in the formula, the sample size, therefore, is

$$n_h = \frac{(1.96^2)(0.14)(0.86)(1.2)(1.07)}{(4)(0.10)^2(0.14)^2(1)} = 757.51 \qquad (4.2)$$

Based on the percentage of people who fell ill or injured within a two-week period prior to the GLSS6 survey reference date, i.e., $r = 0.14$, the calculation reveals a sample size of 758 households. The reference period for the GLSS6 was only two weeks. The proportion of the population that fell ill, r, would have been higher if the reference period were longer than two weeks. In this study, the reference period is 52 weeks. This implies a higher proportion of people falling ill or experiencing injury than in a two-week period. Using a higher reference period (more than 2 weeks) will drastically reduce the sample size. For example, if 14% of the population fell ill or was injured in two weeks, then in four months at most 28% would have fallen ill or injured. Using 28% for r is 0.28, assuming that repetitions are counted, the sample size would have reduced to 317 as in equation 4.3.

$$n_h = \frac{(1.96^2)(0.28)(0.86)(1.2)(1.07)}{(4)(0.10)^2(0.28)^2(1)} = 317.1 \qquad (4.3)$$

Clearly, the sample size would reduce to below 317 if the proportion of people reporting ill or injured, r, is higher than 28%—as would be the case for longer reference period. This implies that our sample size should be below 317. However, having precision of the data in mind, the sample size was set at 600 such that each sample cluster contributes approximately, one for every 25 household. Therefore, the smallest cluster, made up of 39 households, contributed two households to the sample. Likewise, the largest cluster of 962 households contributed 39.

Sampling Technique

According to the United Nations's Statistical Division (2008), probability sampling requires each element of the target population to have a known positive non-zero and numerically calculable mathematical chance of being selected into the sample. United Nations's Statistical Division argues that probability sampling is the foundation upon which the sample estimates can be inferred to represent the total population from which the sample was drawn. To satisfy the requirements for using probability sampling entails knowledge of the target population and its subdivisions.

For an appropriate sampling frame, the study therefore, adopted and used the 2010 Population and Housing Census Enumeration Areas (EAs). The Obuasi Municipality has been segmented into 275 mutually exclusive and exhaustive EAs for the 2010 census (see GSS, 2014a). Sampling from the whole Municipality would be costly. Therefore I decided to use the 275 EAs as clusters from which to sample the households for the survey. However, having precision and a good spatial distribution of the households across the municipality in mind, I decided to choose one out of every three EAs, that is, sampling from a third of the total number of EAs in the Municipality. Therefore, 92 EAs were selected as the sample clusters using simple random sampling. The 92 selected EAs are listed in Table 15 in Appendix C. From the 92 EAs I sampled 600 (as discussed in the previous section) households such that each contributed approximately four percent of its households to the sample. In other words, each cluster contributed 1 in every 25 households to the sample. Therefore, the probability of recruiting a particular household in the Obuasi Municipality for the survey is

$$\frac{92}{275} \text{ x } \frac{1}{25} = \frac{1}{75} \text{ or } 0.013$$

Data Collection Instruments

The survey was conducted using a structured questionnaire. The questionnaire was classified into six sections. Section one is the household roaster which identifies every member of the household, their marital status, age, years of formal education, and length of stay in the community. This section also asks of the relationship of each member to the head of the household. Other information solicited by this section includes distance between residence and nearest major gold mine. Section two asks of the general health condition of every household member within the previous 12 months. The questions include illnesses and injuries, duration of illness, hospital attendance, admissions, expenditure on the medication, travel to the health centres and whether or not the illness has affected the normal work activities of any household member. Section three is on specific health conditions. Here, symptoms of various diseases were presented for the respondent to indicate which of them he or she has experienced and number of times during the period under consideration. Section four is on utilities, that is, water and fuel. While section four is on the consumption of certain food items grown or harvested from the environment, section six is on general expenditure.

The questionnaire was pre-tested in the Obuasi Municipality using some of the EAs outside the 92 EAs selected for the study. Problems noted were rectified and clarifications given to portions of the questionnaire that were not understood by the interviewers.

Method of Data Collection

To help in the identification of the location of the EAs I applied and obtained maps of all the 92 EAs from the Ghana Statistical Service (see Figure 9 in Appendix C for a copy of a EA sample map) including the description of EA boundaries (see a sample in Figure 10, Appendix C). Again, with the help of staff of the Ghana Statistical Service, six experienced interviewers were recruited and trained and used as field assistants. One of the field assistants of the rank of District Statistical Officer was made the field supervisor.

The field supervisor also provided technical assistance such as helping to locate the boundaries of the EAs. The training culminated in the pre-testing of the questionnaire and issues such as the appropriate translation of the questionnaire into the language of the respondent were addressed through peer review. The questionnaire was also reviewed and changes made after the pre-testing.

Armed with the questionnaire and maps of the 92 EAs, the researcher, the field supervisor and the five field assistants moved into the selected EAs of the Obuasi Municipality to have a-face-face interview with the selected households' members. The training and pre-testing took place in April and May 2014 while the actual data collection took place from June to July including a mopping up exercise.

Of 600 households, 42, either did not complete the questionnaire or they were not properly answered and the mopping exercise could not correct the problem. This resulted in 558 completed questionnaires—a seven percent nonresponse. The non-response rate is similar to the GLSS6 nonresponse rate.

The data was entered using a CSPro 5.0 template I designed while the main analysis was done using STATA 13. Wolfram Mathematica was also used to evaluate some mathematical equations and to draw some graphs. To validate the data, I provided key summary statistics of the study data along with the corresponding mean values (urban areas) of the Ghana Living Standard Survey Round 6 (GLSS 6) on Table 14 (Appendix C). Detailed descriptive statistics from the data are provided in Tables 4, 8 and 11 of Chapters Five, Six and Seven respectively.

CHAPTER FIVE

GOLD MINING POLLUTION AND PRIVATE HEALTH CARE EXPENDITURE

Introduction

This chapter empirically provides the link between private healthcare expenditure (preventive and curative) and exposure to pollution from gold mining activities in the Obuasi Municipality of Ghana. It begins by estimating the determinants of health care costs in the study area and used that to compute the minimum compensation in health care expenditure that is acceptable to victims of mining pollution within the municipality. Finally, we provide a link between health expenditure and pollution.

Empirical Hedonic Model

Taking a cue from the literature (and based on the data available), as discussed in the data analysis part of Chapter Four, the following empirical equation is proposed; assuming the relationship between healthcare expenditure and the quality of the environment can be linearized:

$$\ln(M_i) = f_i\left(h_o, B, \mathbf{z}, \mathbf{A}\right) + \mu_i = \alpha_0 + \alpha_1 h_{0_i} + \alpha_2 \ln\left(B_i\right) + \boldsymbol{\theta}'\mathbf{z}_i + \boldsymbol{\gamma}'\mathbf{A}_i + \mu_i \quad (5.1)$$

with $\alpha_1 < 0$, $\alpha_2 > 0$, and $\boldsymbol{\theta} < 0$ (based on equations B1-4 at Appendix B); where M_i is investment in health proxied by per capita private health care expenditure of household i, and μ_i is a normally distributed error term (i.e., $\mu_i \sim N(0, \sigma_\mu^2)$. The private health care expenditure is calculated as household out-of-pocket expenditure on health care plus opportunity cost of lost productivity and healthcare related travel cost. The figure is then divided by the household size to arrive at M_i. As noted by Chang and Trivedi (2003) the variable h_{0i} is measured by the long-term health status of the individual. However, due to lack of data they used variables reflecting current health status, e.g., illness and injuries. In this study, I proxy the variable by the respondent's subjective evaluation of the typical health conditions of household members, and current health conditions. The variable B_i is per capita household income, and the vector $\mathbf{A}_i$ includes diseases incidence of household members, the age of household head, gender of the household head, years of education of household head, and the marital status of the household head. The shortest distance between the household and a major mine site has been used as a proxy for the variable $\mathbf{z}_i$. Instrumental variable (IV) regression is estimated and the results are provided along with ordinary least squares (OLS) estimates.

Data Description, Results and Discussion

Data description

The descriptive statistics of the data used for the empirical analysis is presented in Table 4. The average distance between the residents of the respondents and the mining sites is 1.4km, with a standard deviation of 1.7, which is relatively high. This implies that some of the houses are much farther away from the mining sites than others. As noted earlier, it is expected that the distance from the dwellings to the mining sites correlates positively with households' exposure to pollution. According to Aragón and Rud (2016), the main gas pollutant within the mining communities is nitrogen dioxide (NO_2). Using their limited but highly correlated data points we regressed NO_2 on distance and found an elasticity coefficient of -1.87, with an adjusted R-squared of 88% (see Table 7). Thus, a percentage increase in the distance to the mine decreases the concentration of the gas by approximately 1.9%. The results were bootstrapped and found to be consistent even after 1000 replications.

Nearly one-half (47%) of the households interviewed had incidence of LRTIs, and on average the recurrence of skin diseases per household is 1.1. In other words a skin infection recurs at least once in a household. The mean per capita household out of pocket healthcare expenditure plus opportunity cost of lost productivity and healthcare related travel cost is approximately Gh¢56, with a standard deviation of 49. The per capita out of pocket healthcare expenditure alone in Ghana is GH¢49.74 while the per capita total household expenditure is Gh¢3,117 (GSS, 2014). The corresponding figure for urban areas, which is higher

Table 4: Descriptive Statistics of Variables Used in the Analysis

Description	Mean	Standard deviation
Distance from residence to major mine in km	1.448	1.705
Mean annual per capita health expenditure (Gh¢)	55.51	48.94
Per capita household health status (%)	80.47	6.705
Household size	3.14	1.77
Household Incidence of LRTI per capita	0.47	0.399
Per capita household incidence of diabetes	0.109	0.245
Per capita household incidence of cardiovascular diseases	0.193	0.296
Per capita household incidence of neurological disorders	0.348	0.363
Skin infections recurrence per household	1.088	2.294
Age of household head	40.677	11.044
Male (1,0 otherwise)	0.79	
Years of education of household head	10.98	4.001
Per capital household expenditure (Gh¢)	3,876.41	1,999.44
Greater portion of hospital bills paid by non-household member (1,0)	0.134	
Household Head is Married (1, 0)	0.668	
Per capita household work force	0.606	0.308
Exercise (1/0)	0 343	

Source: Field data (2014)

than rural arrears, is Gh¢3,926 (GSS, 2014b). From our data collected in a predominantly urban area, the per capita household expenditure is about Gh¢3,872.

The respondents were asked to subjectively evaluate their health status on a scale of 0 to 100. Studies have found that when health information is lacking, individuals' subjective health (SH) assessment is considered a legitimate indicator of overall health status (see e.g., Brook et al., 1979; Ferraro, Farmer and Wybraniec, 1997). Furthermore, the choice of a scale of 0–100 is based on previous studies in similar communities in Ghana, which, upon several pre-tests found that respondents were comfortable at expressing subjective evaluation of a number of variables on such a scale (see e.g., Akpalu, 2008 and Akpalu, 2011). Also, previous studies on regulatory compliance in fisheries, for example, have employed a similar scale (see e.g., Kuperan and Sutinen, 1998; Eggert and Lokina, 2010). The mean health status is found to be 80.5%, which is quite high.

Only 21% of the households interviewed were headed by females and the average age of the household head is 41 years, with a standard deviation of 11. The (GSS 2014a) puts the female-head household ratio of the Obuasi Municipality at 34%, same as the national estimate (GSS 2012). However, the more recent GLSS6 report (GSS 2014b) puts it at 30%. Only one-thirds of the household heads are unmarried and the average number of years of education is 11 years, implying most of them have at least a secondary school education. Finally, only 19% of households had most of their hospital bills paid by a non-member of the household.

Respondents were also asked what measures they take to keep themselves healthy. This variable is computed as 'Take measures to keep healthy'. Approximately 34% of respondents make conscious effort to keep (themselves) healthy. Again, respondents were to choose from a list of who pays the greater portion hospital bills of respondents. As result, 13.4% of respondents reported that 'Greater portion of hospital bills paid by non-household member'. Per capita household work force computed as the proportion of adults between 18 and 60 years divided by household size. This reflects the household workforce as required by the laws of Ghana. It also represent the carrying capacity of a household and is recorded as 0.6 per person per household.

In Addition, each household member also indicated whether he/she had experienced any symptoms out of a list of symptoms of respiratory tract infections, diabetes, skin diseases, cardiovascular diseases and neurological disorders during the period. Out of the responses and using Delphi technique, each household member was diagnosed as possibly suffering from any of the diseases. These are then computed to give incidence of the disease in every household. The incidence per household is divided by the household size to give the per capita household incidence. Therefore, the per capita incidence of LRTI, Diabetes, cardiovascular diseases and neurological disorders respectively are 0.47, 0.11, 0.19, and 0.34.

Regression Results and Discussion

Two sets of regression equations are estimated: two-staged least squares compared with ordinary least squares regressions. Since it is possible that one's health care spending could impact health status while, at the same time, a good long-term health status could reduce health expenditure, a bi-causal relationship between per capita household health status and per capita household health expenditure is suspected. I also suspected a bi-causal relationship between per capita household expenditure and per capita household health expenditure. As a result, I estimated an instrumental variable (IV) regression or two-staged least squares (2SLS) regression. The following instruments are used: per capita incidences of lower respiratory tract infections, diabetes, cardiovascular diseases, neurological disorders; the recurrence of skin infections, years of formal education, per capita household workforce and a dummy variable for a collection of activities undertaken to prevent ill-health or maintain good health.

Results of the determinants of per capita household health expenditure within the mining community selected for the study is shown in Table 5 and Table 6. Table 5 shows only the first stage of the instrumental variable (IV) estimation while Table 6 shows both OLS and IV or 2SLS regression results. All the instruments are significant, an indication that they are correlated with the excluded or endogenous variables. The Shea's adjusted partial R-squared for per capital household health status and per capita household expenditure are 0.175 and 0.191 respectively. The F-statistics reveals the lines are a good fit at one percent significance level (P<0.00)

Table 5: First Stage Results of Instrumental Variable Regression

Variable	Coefficients	
	Per capita household health status%	Log(per capita household expenditure)
Log(distance between house and the nearest major mine pollutant)	-0.418 (0.255)	-0.053 (0.019)***
Male (1,0)	-1.905 (0.747)**	0.026 (0.055)
Household head is Married (1,0)	0.555 (0.669)	-0.154 (0.049)***
Age of household head	-0.151 (0.024)***	-0.003 (0.002)
Greater portion of hospital bills paid by non-household member (1,0)	0.688 (0.683)	0.149 (.05)***
Household Incidence of lower respiratory tract infections (LRTI) per capita†	-1.434 (0.84)*	0.057 (0.061)
Per capita household incidence of diabetes †	-1.704 (0.908)*	0.105 (0.066)
Per capita household incidence of cardiovascular diseases†	-3.972 (1.046)***	-0.009 (0.076)
Per capita household incidence of neurological disorders†	-1.693 (0.915)*	-0.06 (0.067)
Skin infections recurrence per household†	-0.304 (0.114)***	-0.024 (0.008)***
Per capita household labour force†	1.244 (0.938)	0.624 (0.069)***
Exercise†	-1.813 (0.564)***	0.087 (0.041)**
Years of education of household head†	0.147 (0.069)**	0.014 (0.005)***
_cons	88.58 (1.482)***	7.739 (0.108)***
N	545	545
Adjusted R-squared	0.175	0.191
F(13, 531) = 14.51 Prob > F	0.000	

F(13, 531) = 18.84	Prob > F		0.000

Standard errors in parentheses; * significance at 10%; **significance at 5%; *** significance at 1%

† Instrumental variable

Moreover, the IV results (Table 6) show improved coefficients, compared to the OLS results, and the Sargan's score with a p-value of 0.42 indicates that the instruments are uncorrelated with the error term and also the IV equation is not miss-specified. This means the excluded variables need not be included in the structural equation. The minimum eigenvalue of 14.73 is greater than the 10% critical value for the 2SLS relative bias of 10.22, an implication that we cannot reject the null hypothesis that the instruments are weak. These conditions conspire to indicate that the IV estimation is better than the OLS estimates.

The estimated coefficients of the following variables are statistically significant at five percent level, or better: distance from residence to the major mining site, per capita household health status, per capita household expenditure, age of household head and the dummy variable representing whether or not the household pays most hospital bills.

Table 6: Regressions Results of Determinants of Per Capita Household Health Expenditure

log of Per capita Household health expenditure	Coefficients OLS	IV	Elasticity IV
Log(per capita household expenditure)	0.167 (0.064)**	0.413 (0.178)**	0.413
Per capita household health status (0-100%)	-0.043 (0.005)***	-0.128 (0.014)***	-0.128
Log(distance between house and the nearest major mine)	-0.119 (0.031)***	-0.118 (0.042)***	-0.118
Male (1/0)	0.006 (0.088)	-0.167 (0.116)	-0.132
Household head is Married (1/0)	-0.057 (0.079)	0.082 (0.11)	0.055
Age of household head	-0.005 (0.003)*	-0.018 (0.004)***	-0.737
Greater portion of hospital bills paid by non-household member (1/0)	-0.283 (0.082)***	-0.246 (0.107)**	-0.044
_cons	6.154 (0.690)***	11.528 (1.803)***	
N	545	545	
Adj R-squared	0.184		
Goodness of fit [Prob > F]	0.000	0.000	
Ramsey RESET test F(3, 534) = 0.72 Prob > F	0.543		
Breusch-Pagan/Cook-Weisberg het test.	0.416		
First stage:			
Shea's Adj Partial R-sq			
Health Status		0.175	
Total Household Expenditure		0.191	
Minimum eigenvalue statistic		14.73	
10% Critical values for 2SLS relative bias		10.22	
# of endogenous regressors		2	
# of excluded instruments		8	
Sargan's (score) Chi^2(6) = 5.99		p = 0.424	
Basmann Chi^2(6) = 5.901		P = 0.434	

Standard errors in parentheses

* significance at 10%; **significance at 5%; *** significance at 1%

The coefficient of perceived health status is negative and statistically significant at one percent level. Thus, as predicted by our theoretical construct and in line with Wolfe (1986), and Wolfe and Gabay (1987), individuals with better general health status, all else being equal, spend less on health care. The corresponding elasticity coefficient is -0.13 (inelastic), which indicates that health care expenditure is not very sensitive to perceived health status. With regards to policy making, improving the health status of the residents may have positive feedback effect on health care expenditure.

Also confirmed is our hypothesis that higher income earning households, all things being equal, spend more on health care. The positive relationship between healthcare spending and real income has also been found for an African-wide study (Murthy and Okunade, 2009). It is also in line with Kim and Yang (2011); Parker and Wong (1997).The coefficient is significant at five percent level with an elasticity coefficient of 0.41. This suggests that healthcare is a normal good. Since mining communities in Ghana are bedevilled with high poverty rates, public policy aimed at improving the incomes of the residents within the mining communities are likely to promote good health.

The critical hypothesis that distance to the nearest major mining site, which is a proxy for exposure to pollution, is positively related to health care expenditure is supported by the data. The coefficient of the variable is statistically significant at one pecent level and the corresponding elasticity coefficient is -0.12. This implies that health care expenditure may increase by 0.12% as a result of a percentage decrease in the average distance from the residence to the mining site.

Conversely, the marginal willingness to accept compensation for health care expenditure (curative and preventive) due to exposure to pollution from the mining activities, all else being equal, is higher for households that are closer to the mining sites. This amply confirms existing biochemical studies in Ghana that have found significant health impacts of hazardous substances such as arsenic, mercury, cadmium and lead (see Armah et al., 2012; Essumang, 2009; Voegborlo et al., 2010).

Furthermore, households with relatively older heads spend less on health care compared to their counterparts that have younger heads. This may be indicative of the income or earnings of the household heads. Older household heads, all else being equal may have less income and assets and for that matter have less money to spend on health care. Surprisingly, the variable has the highest elasticity coefficient of -0.74. This is quite intriguing and may appear surprising, since older individuals are expected to have greater health needs. However, the findings from the literature indicate that pure age effect on healthcare spending is an open empirical question, which cannot be determined a priori. A cross country study on Africa found that national healthcare expenditure is not significantly determined by the proportion of the older population within a country (Murthy and Okunade, 2009). Also, as argued by Zhang and Imai (2007), it is the ageing process and the likelihood of death as one ages that leads to increased healthcare spending not the age of an individual. It is therefore unclear whether this finding is indicative of the income or earnings of the household heads (i.e., older household heads, all else being equal, have less income and assets and, for that reason, have less money to spend on healthcare). If income poverty is the driving force of the low spending, then public policy may be required to support older people.

Finally, due to the problem of recall, the respondents were not asked to provide the exact health care expenditure of his/her employer or health insurance. The respondent was rather asked to indicate whether or not someone other than a household member pays a bigger share of a household member's health care expenses. The regression results has shown that a respondent whose employer or health insurance pays a greater portion of his/her hospital bill made less private health care expenditure on the average, compared to his/her counterpart who carries a bigger burden of his/her health care cost. The corresponding elasticity coefficient is 0.04, which is quite low (i.e., highly inelastic). This is an indication that specialised health insurance and health subsidies could be employed as a mechanism of supplementing or solving the problem.

The Willingness to Accept (WTA) compensation for Mining Pollution

As noted earlier, the minimum compensation in health care expenditure that is acceptable to victims of mining pollution within the municipality decreases with the distance from the residence to the major mining sites. Using equation 5.1, the negative relationship between the two variables, if all other explanatory variables are evaluated at their mean values could be illustrated by Figure 4. The households residing closest to a major mining site (0.02km) are willing to accept a minimum of GhS68.79 per annum per household member, while the counterpart who resides farthest away from the mine (10km) requires a compensation of GhS33.27 per annum.

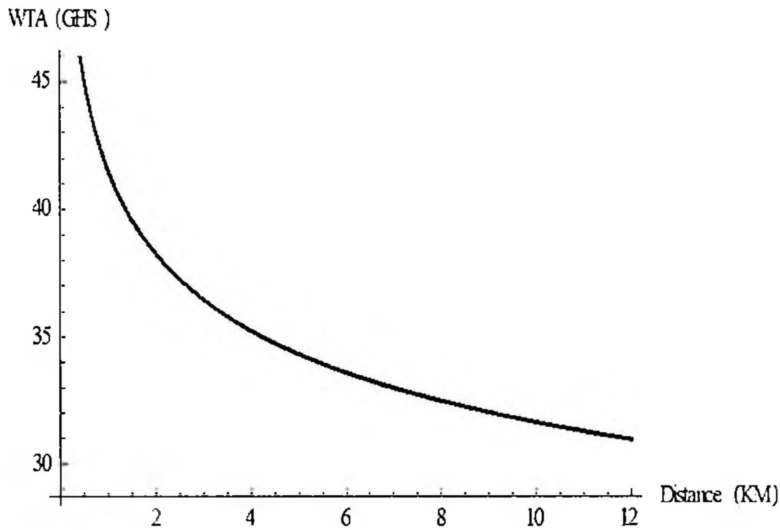

Figure 4: WTA Compensation: the Proximity-Health Expenditure Trade-Off

The Total Willingness to Accept (WTA) compensation is obtained by multiplying the frequencies of the distances by the WTA and summing up the outcomes. The computed value for the total number of respondents is about GHS 70,505.56 per annum. The corresponding mean WTA is GHs41.20.

WTP and NO2 Concentration

According to the World Health Organization (WHO), generally, a strong correlation exists between concentrations of NO_2 and other toxic pollutants

(WHO, 2006). As a result, NO_2 is often used as a proxy or surrogate for the pollutant mixture as a whole since it is easier to measure. Following this assertion, it is straightforward to estimate WTA compensation elasticity with respect to the pollution concentration, which is the product of WTP compensation elasticity with respect to distance and distance elasticity with respect to NO_2.[1] Using the corresponding figures from Table 7 (i.e.,-1.87^{-1}) and Table 7 (i.e., -0.118), the elasticity coefficient is 0.06. Thus, a 10% increase in NO_2 concentration will increase the WTA compensation by 0.6%.

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[1] Note that if $y = f(x(v))$, then the elasticity of y with respect to v is

$$\eta_{yz} = \left(\frac{f_x . x}{f}\right) \bullet \left(\frac{x_v . v}{x}\right).$$

Table 7: Regression Results of Bootstrap Data of Effect of Distance (km) on Nitrogen Dioxide (NO_2) Concentration

Number of replications	100	500	1000
Distance (Km)	-0.022	-0.022	-0.022
	0.006)***	(0.007)***	(0.007)***
_cons	0.825	0.825	0.825
	(0.139)***	(0.209)***	(0.202)***
Elasticity	-1.87	-1.87	-1.87
No. of Observations (4)			
Wald chi2(1)	13.85	9.10	9.63
Prob> chi2	0.000	0.003	0.002
Adj R-squared	0.876	0.876	0.876

Bootstrapped standard error in parentheses; * significant at 10%, ** significant at 5%, ***significant at 1%. Source: Data Aragón and Rud (2016)

Conclusion

This chapter employed a simple hedonic-type model developed earlier to estimate the relationship between household health expenditure and mining pollution. The results confirm that exposure to gold mining pollution affects private household health care expenditure, after controlling for a number of variables including current and long-term health status.

However, the chapter found an inverse relationship between the age of household head and health care spending. This calls for further research to enrich public policy. Thus, it is unclear whether this is due to asset ownership effect or that younger individuals in the mining community are generally in poorer health condition compared to their older counterparts, as mining pollution has intensified over time.

Secondly, private health expenditure of residents in mining communities may decline if policies that promote good health are promoted. This may include preventive measures that minimize exposure to pollutants.

Furthermore, the finding that wealthier households spend more on healthcare than their poorer counterparts suggests that public policies that create jobs and improved earnings may promote good health among residents of mining communities, as most live in poverty.

Finally, by directly estimating effect of mining pollution on healthcare spending, compensation for exposure to such pollution could be calculated and victims better compensated. Thus, the distance to the tailings could be the yardstick for determining compensation for people residing in mining communities, all else being equal. For example while a person staying within one-half of a kilometre of the mine could be compensated with Gh¢45, those within 2 kilometres of the mine could claim a health expenditure compensation of Gh¢38. In the same vein a policy could be enacted to prevent people from settling within a certain distance of the mine, especially in the case of new mines, after looking at the cost-benefit analysis of allowing the people to settle within that perimeter.

This chapter of the study, though intriguing, is not without shortcomings primarily related to data. The reliance on subjective assessment of health status of the respondents, although employed by other studies, could suffer from human errors. In addition, as indicated, data from an earlier bio-physical study was employed to draw the link between distance to tailings and pollution concentration within the mining communities. Furthermore, the study uses a historical mining community in Ghana, where exposure has lasted for over a century as a case. The findings may therefore not strictly hold for recent mining areas. Future extensions of this work should consider these limitations and employ physical and biochemical data to enrich the analysis.

CHAPTER SIX

RESIDENTIAL WATER DEMAND: VALUING TRAVEL AND WAITING TIME COST

Introduction

In this chapter I estimate demand for water and how it is affected by mining pollution in the Obuasi Municipality and looks for determinants of valuing travel and waiting time in collecting residential water as leisure time. The chapter is premised on the fact that residents in developing countries usually travel long distances and also spend time waiting their turn to fetch water for domestic use. This issue could become more complicated if the environment is polluted by gold mining activities. As discussed in Chapter Three, the shadow price of water consists of the actual price paid for water plus value of time spend travelling and waiting to haul the water. From the literature and as discussed earlier, the travel and waiting time could be valued at the wage rate. The mathematical expression of the shadow price of water is equation 3.12 in Chapter Three.

Empirical Model

Two empirical equations are estimated. The first is a two-staged least squares water demand model. The structural and reduced form equations of the model are specified in equations 6.1 and 6.2 respectively. Each of the two equations represents three regressions represented by $j = 1, 2$ and 3 respectively.

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$$lpcqntpd_{ij} = \beta_0 + \beta_1 shd_{ij} + \beta_2 lpch\exp_i + \beta_3 \text{lstay}_i + \beta_4 male_i + \beta_5 mar_i + \beta_6 ldist_i + \beta_7 drnkslf_i + \beta_8 drnkcm_i + \beta_9 pfml_i + \varepsilon_{ij} \quad (6.1)$$

$$lpch\exp_i = \gamma_0 + \gamma_1 shd_{ij} + \gamma_2 \text{lstay}_i + \gamma_3 male_i + \gamma_4 mar_i + \gamma_5 ldist_i + \gamma_6 drnkslf_i + \gamma_7 drnkcm_i + \gamma_8 pfml_i + \gamma_9 mwrk_i + e_{ij} \quad (6.2)$$

where $lpcqntpd$ is log of quantity of water used per day by a typical household member; shd is shadow price of water; $lpch\exp$ is the log of per capital household expenditure; lstay is the length of stay of the household head in the community; $ldist$ is the distance between household's location and the nearest major mine site or treatment plant; $pfml$ is the proportion of female in a household; and $mwrk$ is the proportion of adults aged between 18 and 60 years. The rest: $male$, mar, $drnkslf$, $drnkcm$, are dummies for male, marital status, whether drinking water source is self-operated, community-operated or operated by other means respectively and ε is the error term. The symbol, i, is a household identifier while $j = 1,2,3$ identifies the three regressions in which the travel and waiting time portions of the shadow price of water in *Regressions 1* and *2* are computed at seven (7) and one hundred (100) percent of the household expenditure respectively[2]. In the third regression (*Regression 3*) the amount the household is willing to pay (WTP) for water is used as the shadow price of water.

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[2] These are lower and upper bounds of the value time spent on water collection. While Kremer et al. (2011) found the value of the travel time to be about seven percent of wage rates, Whittington et al (1991) found the value to be equivalent to the wage rate. Other studies (e.g., Eom & Larson, 2006) found values that fall within this range.

The detailed descriptive statistics of the variables used in the estimation can be found in Table 8. It can be seen that all the variables in equation 6.2 are found in equation 6.1 with exception of *mwrk* which is an instrumental variable for per capita household expenditure ($pch\exp$).

The second empirical equation estimated is a Logit model (equation 6.3). The dependent variable is Willingness to Accept (WTA) compensation not to travel to the point of collecting the water. The empirical model is specified as:

$$\begin{aligned} WTA_i = {} & \beta_0 + \beta_1 lh\exp_i + \beta_2 hhsize_i + \beta_3 qntpd_i + \beta_4 mar_i + \beta_5 male_i + \\ & \beta_6 yed_i + \beta_7 lstay_i + \beta_8 rural_i + \beta_9 drnkslf_i + \beta_{10} drnkcm_i + \\ & \beta_{11} wgnsscm_i + \beta_{12} wgnssslf_i + \beta_{13} drnkppb_i + \beta_{14} drnkbhl_i + \\ & \beta_{15} drnkwll_i + \beta_{16} ldist_i + \beta_{17} mndstpp_i + \beta_{18} mndstbhl_i + \\ & \beta_{19} mndstwll_i + \beta_{20} ttrtwtr_i + \beta_{21} tmwt_i + \upsilon_i \end{aligned} \tag{6.3}$$

where independent variables are $lh\exp$, the log of household expenditure; *hhsize* signifies household size; *qntpd* is quantity of water used per day; years of education of household head is denoted by *yed* ; *rural* is a dummy for rural household; whether the source of water for general use is community-operated, *wgnsscm*, or self-operated, *wgnssslf* . Dummy variables *drnkppb* , *drnkbhl* , and *drnkwll* , in that order, represent whether drinking water is pipe-borne, borehole or well. There are also interactions between mine distance and drinking water sources – pipe-borne, borehole and well – denoted by *mndstbhl* , *mndstwll*, and *mndstpp* respectively. We also have travel time and waiting time denoted by *ttrtwtr* and *tmwt* respectively while *mar* , *male* , *lstay* *drnkslf* , *drnkcm*, and *ldist* maintain the same connotation as in equation 6.1. As usual, i, is a household identifier while υ is the error term.

Data Description, Results and Discussion

Data Description

The data for the statistical analysis are obtained from a survey of households in the Obuasi Municipality in Ghana. The survey was conducted between May and July 2014. The data contain detailed household characteristics, including demographic characteristics, educational attainment, employment status, household expenditure, water sources and usage, time spent on water collection, and distance travelled to collect water. The total sample size is 600 households within 92 (out of 275) enumeration areas. Of the total number, 558 households were successfully interviewed. However, as a result of missing values in the data, 545 households are used in the analysis. The descriptive statistics of the data for the estimation is presented in Table 8.

Table 8. Descriptive Statistics of Variables Used for Estimating the Demand for Water in Ghana (540 observations)

Variable	Description	Mean	SD
pcqntpd	Water usage per day per household member in litres	29.1	15.458
ppw	Price Paid for Water (GH¢/15L)	0.142	0.545
Shd_3	Amount willing to Pay for Water (Gh¢/15L bucket)	0.527	1.687
shd_2	Shadow Price of Water (Travel Cost +Waiting cost+ Price Paid for Water) (GH¢), valued at 100% of household expenditure	1.530	2.235
Shd_1	Shadow Price of Water (Travel Cost+ Waiting cost + Price Paid for Water) (GH¢), valued at 7% of household expenditure	0.239	0.561
	Household size	3.15	1.762
pchexp	Per Capita household expenditure (GH¢)	3881.53	2001.27
hexp	Household expenditure (GH¢)	10279.58	5343.01
dsttrav	Distance Travel to Haul Water (in metres)	217.76	644.06
mar	Married (1/0)	0.67	
wttm	Waiting time in minutes	11.057	13.72
	Male(1/0)	0.791	
lstay	Length of stay in the community in years	27.378	14.22
dist	Distance between household location from major mine site	1.458	1.71
drnkslf	Drinking water source self-operated (1/0)	0.389	
drnkcm	Drinking water source community operated (1/0)	0.059	
drnkoth	Drinking water source operated by other means (1/0).	0.552	
mwrk	Household workforce	0.607	0.307
pfml	Proportion of females in household	0.443	0.297

Source: Field Survey data (2014)

The variable, *pcqntpd*, denotes water usage in liters is measured by the quantity of water per head within each household and the mean water usage per

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Source: Field Survey data (2014)

The variable, *pcqntpd*, denotes water usage in liters is measured by the quantity of water per head within each household and the mean water usage per capita is approximately 29 litres. Price paid for water denotes amount paid for water at the point of collection. The average price paid for a 15-litre bucket is 14.20 Ghana pesewas. This does not include the travel cost to haul the water. The shadow price of water (shd) is the sum of the price paid at the point of collection plus the value of travel time and waiting time. To obtain the imputed cost of travel time, respondents were asked to state how long they take to walk from residence to the nearest major mine or treatment plant. They were also asked to state the same distance in kilometers. The two dimensions of distance were converted into time rates (minutes per meter). This rate is used to convert the travelling distance in metres into travel time in minutes. The travel and waiting costs are then valued at the expenditure rate of the household. Drawing on the findings of Whittington et al. (1991) and Kremer, et al. (2011), the travel time is valued at approximately the household expenditure (shd_2) rate and seven percent of the household expenditure (shd_1), respectively. This provides us with upper and lower bounds of our estimates. Also included in the data, as an alternative shadow price, is the maximum amount a household is willing to pay for a bucket of water delivered to the doorstep of the household (shd_3). On the average, individuals travel about a fifth of a kilometer to haul water with a spread of 660metres.

The per capita household expenditure is the total expenditure of the household divided by the number of members of the household ($pch\exp$). The expenditure of the household is computed as the sum of total annual food and nonfood household expenditures including expenditure on health, transport, clothing, furniture and household appliances. Also included is information on the proportion of females in the household (*pfml*), length of stay of household head in the community (*lstay*), distance from household to the nearest major mine site or treatment plant (*dist*), and whether the household's drinking water source is self-operated (*drnkslf*) , community-operated (*drnkcm*) or is operated by other means (*drnkoth*).

From the data, the average quantity of water used per person is 29.1 liters (1.95 buckets) with a standard deviation of 15.5 liters. The mean shadow prices per bucket of water are Gh¢0.24, Gh¢0.53, and Gh¢1.53[3] for the shadow price valued at seven percent household expenditure, the alternative shadow price (maximum amount the consumer is willing to pay) and the shadow price valued at 100% of household expenditure respectively. The per capita average household annual expenditure is approximately GH¢3,881. Males head 80 percent of the households. The average length of stay of household head in the community is approximately 27 years while the distance of the household from the mine or treatment plant is about 1.5km. The length of stay variable is included here as an environmental variable which could indicate the household's brush with gold mining pollution.

According to the data only six percent of households' drinking water source is community operated while that of almost 39 percent of the households' is self-operated. 55 percent is operated through other means. Over 80 percent of households whose main drinking water source is operated by other means use

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[3] At the time of the data collection, GH¢3.20 was approximately US$1.00.

sachet/bottled water. Of those who operated their own drinking water source, over seventy percent (70%) use borehole or inside standpipe. The average proportion of adults to household population aged between 18 and 60 years is 62 percent and the proportion of females to household population is 44 percent.

Results and Discussion

The two-staged least squares (2SLS) estimation method has been employed to investigate the determinants of demand for water and the results are presented in Table 9. The 2SLS method was used because the ordinary least square (OLS) technique did not yield consistent estimates for *Regressions 1* and *2* reported in Table 9. The first stage F statistics are 20.65 and 20.20 respectively which are different from zero (prob>F = 0.000) and the weak identification statistic of approximately 96 is far in excess of the 10% critical value of 16.38. These are indications that the excluded exogenous variable is a valid instrument and sufficiently correlated with the included endogenous regressor but uncorrelated with the error term. They also signify that regression is well specified. The test of endogeneity values of 0.023 and 0.059 confirm that the per capita household expenditure is actually endogenous. *Regression 1* values the travel and waiting time to haul water at seven percent of average hourly expenditure within the household while *Regression 2* values it at full (100%) hourly expenditure; *Regression 3* uses the maximum WTP for water for the price of water. The seven percent and 100% give us the lower and upper bounds of the estimated coefficients, respectively. The F-statistics for the three regressions indicate that each line is a good fit.

Table 9: IV Estimation of Determinants of Quantity of Water Used per Person per Household per Day

Variables	Regression 1		Regression 2		Regression 3	
	(Opportunity Cost of Travel and Waiting Time = 7% of Household Hourly Expenditure)		(Opportunity Cost of Travel and Waiting Time= 100% of Household Hourly Expenditure		Opportunity Cost of Water = Maximum Amount Willing to Pay	
	Coefficient	**Elasticity**	**Coefficients**	**Elasticity**	**Coefficients**	**Elasticity**
Travel Distance and Waiting Costs + Price of Water	-0.335 (0.132)**	-0.08	-0.039 (0.016)**	-0.059		
Amount Willing to Pay/15L bucket					-0.057 (0.027)**	-0.030
Log (Per capita household expenditure)	0.548 (0.103)***	0.548	0.507 (0.111)***	0.507	0.559 (0.11)***	0.559
Length of stay in years	0.004 (0.002)**	0.113	0.004 (0.002)**	0.116	0.005 (0.002)***	0.124
Male (1/0)	0.091 (0.10)	0.072	0.134 (0.111)	0.106	0.089 (0.114)	0.070
Head is married(1/0)	-0.096 (0.066)	-0.06	-0.119 (0.075)	-0.079	-0.107 (0.075)	-0.072
Log(Distance of residence from mine area)	0.202 (0.030)***	0.202	0.188 (0.031)***	0.188	0.202 (0.031)***	0.202
Drinking water system is self-operated (1/0)	-0.159 (0.057)***	-0.062	-0.175 (0.059)***	-0.068	-0.186 (0.056)***	-0.072
Drinking water system is community	0.169	0.01	0.195	0.012	0.155	0.009

operated (1/0)	(0.089)*		(0.091)**		(0.094)*	
Proportion of females in household	0.193	0.085	0.224	0.099	0.181	0.08
	(0.107)*		(0.112)**		(0.119)	
Constant	-1.29		-1.013		-1.413	
	(0.870)		(0.924)		(0.919)	
First stage F(9, 530)	20.65		20.20		20.55	
Prob >F	0.000		0.000		0.000	
Weak Identification test statistic	97.72		96.138		97.83	
10% Weak ID teat critical value	16.38		16.38		16.38	
Test of endogeneity of endogenous regressors (p-value)	0.016		0.082		0.023	
Observations	540		540		540	

* Significant at 10percent; ** Significant at 5percent; *** Significant at 1percent. Robust standard errors in parentheses

Source: Analysis of Field Survey Data (2014)

From the three regressions the residential water use obeys the basic law of demand: i.e., the price of water negatively correlates with the quantity of water used. In addition, household expenditure per head, the proxy for income (Basani, Isham & Reilly, 2008), has a positive effect on the quantity of water used. This implies that the water for residential use is considered a normal commodity. The price elasticity coefficients indicate inelastic demand, with the elasticity coefficients ranging from -0.08 to -0.06 for the lower and upper bounds of the opportunity costs of time respectively (i.e., in *Regressions. 1* and *2*, respectively). The results, based on the maximum WTP, suggest a much stronger inelastic demand condition for water than the first two regressions, with the corresponding elasticity coefficient of -0.03. The inelastic demand emphasizes that the water sources are spatially limited and also reflects the Obuasi Municipal Assembly's (2014) view of low pipe-borne water access and utilization for drinking due to perceptions of contamination resulting from mining activities. These (low) elasticities are, however, similar to those of Carver and Boland (1980); Thomas and Syme (1988); Barkatullah (1996); and Martinez-Espinera and Nauges (2004) in the developed countries. It is also in line with Nauges & Whittington's (2009) assertion that household demand for potable water services in developing countries is very inelastic. In addition, the relatively high value of the income elasticity (i.e., between 0.51 and 0.56) in each of the three regressions means that residential water use is less constrained by own-price than by household income. One major implication of the relatively high income elasticity is that since mining is the mainstay of the economy of Obuasi, in periods of mine shutdowns resulting in layoffs, household water consumption per head will decrease or residents may resort to the use of water from more polluted sources leading to health complications even under increasing cost of water production.

Households whose heads stayed relatively longer in the community use more water. The length of stay variable which is highly correlated with age of household head is significant at five percent or better with elasticity 0.12. Long stay in the community probably entails knowledge of sources of quality water and may even influence choice of location. This finding is however in line with Cheesman, Bennett, and Son (2008) that more permanent residents consume more water especially from a piped network.

Households who draw water from community operated water sources are found to use more water, on the average, than those who collect water from the two other sources (self-operated and other private sources), all else being equal. Moreover, of the three sources, self-operated drinking water source households consume the least quantity of water. This is hard to explain, but anecdotal evidence suggests that the average water quality differs across the three sources.

Furthermore, gender representation within a household explains water usage within it. The results specifically reveal that a percentage increase in the proportion of females in a household increases water usage by 8-10%, on the average, all else being equal. This finding is consistent with gender roles within households in Ghana. Compared to their male counterparts, women are more likely to engage in cooking, washing and other household chores that require frequent use of water.

Perhaps an interesting finding is a positive relationship between the distance to a major mining site and water usage within households. The corresponding elasticity is 0.2, and statistically significant at one percent level. Existing studies have found high concentration of heavy metals at tailing sites. As a result, households nearer to the sites may be reducing their water usage in order to avoid excessive contamination. It also reflects water scarcity and pollution of ground water due to acid mine drainage (Duruibe et al., 2007; (Garbarino et al., 1995).

Logit Regression Results

The results of the Logit model, which characterizes households according to whether or not they value time for collecting water as leisure time, are reported in Table 10. This is measured by the difference between WTP for portable water brought to one's doorstep minus the actual price paid for water. I refer to this as the WTA compensation not to travel to point of collecting water. The Wald chi-square test indicates the line is a good fit at one percent significant level, and the Linktest confirms that the model is well specified. The factors that explain subjective evaluation of the travel and waiting time as leisure time include household expenditure, daily water usage, the household head's years of formal education, marital status, length of stay in the community, distance travelled to haul water for residential use, time spent queuing to collect water, water usage within the household, whether or not the drinking water source is self-operated, and type of drinking water (pipe-borne, borehole, well, or processed water). These factors are discussed in turns.

Table 10: Logit Regression of WTA not to Travel to Point of Collecting Water (Difference between WTP and Actual Price Paid per Unit of Water)

Variable	Coefficient (with interaction terms)	Marginal effects	Coefficient (without interaction terms)	Marginal effects
Log(Household expenditure)	0.911 (0.426)**	0.000	0.973 (0.41) **	0.000
Household size	-0.042(0.141)	-0.003	-0.053 (0.013)	-0.004
Quantity of Water used per day	-0.015(0.005)***	-0.001	-0.015 (0.006)***	-0.001
Head is Married (1/0)	-0.71(0.393)*	-0.055	-0.655 (0.37)*	-0.051
Head is male (1/0)	0.187(0.395)	0.012	0.142 (0.392)	0.01
Years of education of Head	-0.083(0.04)**	-0.006	-0.091 (0.039)**	-0.006
Length of stay	-0.03(0.012)**	-0.002	-0.03 (0.012)**	-0.002
Located in rural area (1/0)	-0.574(0.575)	-0.034	-0.793 (0.58)	-0.045
Drinking water source system self-operated (1/0)	1.262(0.541)**	0.106	1.512 (0.522)***	0.134
Drinking water source system community-operated (1/0)	0.414(1.482)	0.034	0.369 (1.501)	0.03
Water for general use source system community-operated (1/0)	-0.705(0.93)	-0.039	-0.75 (0.948)	-0.042
Water for general use source system self-operated (1/0)	0.266(0.473)	0.019	0.197 (0.464)	0.014
Drinking water is pipe-borne (1/0)	-0.751(0.606)	-0.043	-0.725 (0.481)	-0.042
Drinking water is Sachet/bottled (1/0)				
Drinking water is borehole (1/0)	-3.051(0.879)***	-0.131	-3.536 (0.783)***	-0.149
Drinking water is well (1/0)	-2.219(0.842)***	-0.073	-2.37 (0.795)***	-0.076
Log(distance to mine)	-0.744(0.42)*	-0.036	-0.133 (0.208)	-0.007
Interaction: Mine distance and drinking water sources - pipe-borne	1.234(0.529)**	0.086		

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Interaction: Mine distance and drinking water sources - sachet/bottled water				
Interaction: Mine distance and drinking water sources - Borehole	0.482(0.628)	0.034		
Interaction: Mine distance drinking water sources - well	0.1(0.589)	0.007		
Time travelled to fetch water	-0.002(0.003)	-0.00	-0.002(0.003)	-0.00
Time spent waiting for water	0.014(0.011)	0.001	0.017(0.011)	0.001
Constant	-7.284(3.523)**		-7.417(3.402)**	
Wald chi-squared	60.01		52.89	
Prob > Chi-squared	0.000		0.000	
Linktest	0.616		0.933	
Number of observations	494		494	

* Significant at 10percent; *** Significant at 1percent. Robust standard errors in parentheses

Source: Analysis of Field Survey Data (2014)

Households that are relatively well-off are more likely to consider water collection as a leisure activity, and therefore would like to be compensated in order to have the water delivered to their residence. The income effect on household chores has also been found in the literature: Couples are found to allocate more time to childcare as their household income increases (Fernádez & Sevilla-Sanz, 2006).

Households who operate their own drinking water source systems as, compared to using community-operated and 'other means, are more likely to demand compensation to have the water delivered to their residence.

On the other hand, households that use more water a day, on the average, place a non-negative value on the travel and waiting time for collecting water. This may be due to decreasing returns to the value of time invested in building social capital outside of the home. Also, households that have married heads and those that have lasted longer in the community, on the average, are less likely to consider water collection as a leisure activity. The likely explanation is that such households already have strong social ties within and outside the home and therefore consider time spent on such outside activities as a cost. Married people have less incentive to seek pleasure outside (Lee & Bhargava, 2004). This is also in line with Thrane (2000) who reported a negative relationship between being married and leisure time, and (Robinson & Godbey, 1999) who found married people had less time for leisure compared with the unmarried. Age and length of stay in the community are highly correlated. Lee and Bhargava (2004) and Robinson and Godbey (1999) also found that as respondents' age increased, they spent more time on leisure activities. But this will compete with water fetching time also seen as leisure.

Furthermore, households headed by individuals with more years of schooling place positive value on time use for collecting water and hence less likely to ask for compensation in order to bring water to the residence. Opportunity cost of time for the more educated is high: higher education increases time spent on housework and child care (Hill & Stafford, 1980; Sousa-Poza, Schmid, & Widmer, 2001). Water fetching time therefore competes with the little time devoted to housework.

Finally, those who obtained drinking water from hand dug wells, and boreholes are less likely to place a positive value on the opportunity cost of time than those who use pipe-borne and sachet water.

Summary

In this chapter we considered works in which the opportunity cost of time spent hauling water was valued using the full wage rate or a fraction of it. In addition to valuing the opportunity cost of time at seven percent and 100 percent, as has been done in the literature, households were asked to provide their maximum WTP for the waiting and queuing time. Interestingly, a number of the households valued the water collection as a leisure activity and therefore were rather willing to accept compensation for the time. This has interesting implications for public policy on water management, and perhaps explains why water development programs have failed in several rural communities. This lends support to the finding in the literature that only a very small proportion of time saved from household chores are allocated to work activities, such as faming.

Further, our finding that water demand for residential water use has inelastic demand condition and is a normal good is consistent with the literature. The relatively low price elasticity coefficient compared to those frequently reported is very likely due to the limited availability of potable water within the mining community, where much of the water bodies are heavily polluted with heavy metals. The result that households that are farther away from the tailing sites use more water appear to suggest that relative scarcity and quality of water may differ across concentric zones around the mines. It is possible that households that operate their own water systems are better informed about the quality of their water and hence use less water than their counterparts who obtain the water from community and other private operated sources. Further research is nevertheless needed to substantiate this assertion.

Further, the finding that a significant proportion of households with certain characteristics consider water collection as a leisure activity indicates that social norms and values, as well as other psychological factors must be considered when making a decision to extend water infrastructure to communities. Thus, there is the need to explore further social and psychological factors that could influence people's behaviour regarding water collection and usage.

CHAPTER SEVEN

GOLD MINING POLLUTION AND INTERGENERATIONAL HEALTH TRANSMISSION

Introduction

In Chapter Five, we established a positive relationship between mining pollution and health care cost indicating the former is a contributor to certain ailments that afflict people of communities where gold mining takes place. In this chapter we try to see whether and how mining pollution is linked to the transmission of these ailments across generations. The premise is that environmental change caused by say, gold mining pollution, not only degrade the natural environment but also come with health risks to residents (Adei et al., 2011; Ansa-Asare et al., 2014; Quansah et al., 2015; Kumar & Sahu, 2007; Obiri et al., 2006; Thayer el al., 2012). Some of these health problems can be passed on from parent to progeny (Farmer et al. (2014). In addition, a connection between early childhood exposure and long-term effects had been established (Currie et al., 2014). Meanwhile, intergenerational health is a very important determinant of socioeconomic status (Thompson, 2014). However, very few studies on child health, especially in Africa, have looked at the role of intergenerational persistence in health.

Empirical Specification

From equation (4.9) and (4.10) the empirical model is specified as follows:

$$\ln\left(\frac{disc_{ij}}{1-disc_{ij}}\right) = \beta_0 + \beta_i disp_{ij} + \beta_2 agech_i + \beta_3 yeduc_i + \beta_4 ageduc_i + \beta_5 \ln(dist_i) + \beta_6 pocc_i + \beta_7 pbnwat_i + \beta_8 bhole_i + \beta_9 welriv_i + \varepsilon_i \quad \text{........(7.1)}$$

where $disc_{ij}$ and $discp_{ij}$ represent offspring i 's disease condition j and the corresponding parent i 's health condition j respectively; the health condition denoted by j are cardiovascular disease, Asthma, LRTI, diabetes, and neurological disorder; $agech$ is offspring's age; $yeduc$ represents years of education of parent; ln(dist) is log of distance from household to the nearest mine site. The interaction between child's age and years of parent's education is denoted $ageduc$. The nature of parent's occupation is denoted $pocc$, while $bhole$, $welriv$ and $pbnwat$ stand for borehole, well, and pipe borne water dummies respectively.

Data Description, Estimation Results and Discussion

Data

The data for the empirical analysis were extracted from data collected through cluster sampling of 600 households in the Obuasi Municipality of the Ashanti Region of Ghana between May and July 2014. The extract consists of 340 households where the household head has an offspring(s) as a member of the household.

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In the main survey, a questionnaire was administered to each selected household in a face-to-face interview after assuring each respondent of absolute confidentiality of the information to be provided. The questionnaire included questions on demographic characteristics (e.g., age and level of education), location of residence, and the household's main source of drinking water. There were also questions on the general health condition of each household member (e.g., illnesses and injuries suffered, duration of illness and its effect on normal activities, and physician consultations during the previous 12 months). Each household member also indicated whether he/she had experienced any symptoms out of a list of symptoms of respiratory tract infections, diabetes, skin diseases, cardiovascular diseases and neurological disorders during the period. The symptoms for each disease condition were analysed for each household member in order to arrive at a decision of whether or not the individual may have suffered or was suffering from the given diseases. Out of these, the descriptive statistics shown in Table 11 were compiled and used for the empirical analysis.

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Data Description

Table 11: Descriptive Statistics of Variables Used in the Analysis

Description	Mean	s.d
Offspring's cardiovascular disease status (1/0)	0.143	
Parent's cardiovascular disease status (1/0)	0.443	
Offspring's asthma status (1/0)	0.064	
Parent's asthma disease status (1/0)	0.159	
Offspring had lower respiratory tract infection (1/0)	0.345	
Parent had lower respiratory tract infection (1/0)	0.554	
Offspring's diabetes status (1/0)	0.047	
Parent's diabetes disease status (1/0)	0.276	
Offspring suffered neurological disorder (1/0)	0.134	
Parent suffered neurological disorder (1/0)	0.360	
Distance from residence to major mine in km	1.781	1.993
Offspring's Age (years)	26.54	13.93
Parent's Years of Education (years)	9.94	4.284
Parent engaged in physically exerting occupation (1/0)	0.554	
Main Source of Drinking Water		
Pipe-borne (1/0)	0.089	
Borehole (1/0)	0.27	
Well or River (1/0)	0.089	
Sachet/bottled (1/0)	0.051	
Number of Observations (N)	722	

Source: Field data (2014)

In all, there are 722 offspring of household heads from the 340 households. Single member households and households in which the head has no offspring are excluded. From Table 11, approximately 14% of offspring showed symptoms of cardiovascular diseases as against 44% of their parents (same as household head). The mean age of offspring is approximately

27years with a standard deviation of approximately 14years. While 35% and 55% of offspring and parents respectively suffered LRTIs, 6.4% and 16% of offspring and parents respectively suffered asthma attacks. As noted earlier, we expected to find positive correlation between parents and their offspring' disease conditions.

As high as 51% of sampled households use sachet or bottled water (which is several times more expensive) as their main source of drinking water against the corresponding values of nine percent and 27% for pipe borne water and borehole water respectively. The low utilisation of the pine borne water for drinking is due to its contamination by mining activities (Obuasi Municipal Assembly, 2014). The average distance between the residences of the respondents and the mining sites is 1.8km, with a standard deviation of two. We expected to find the distance from the residences to the mining site to correlate positively with households' exposure to pollution expressed in the offspring's disease condition.

Finally, the average number of years of education of a parent was 10 years, implying that most of them have at least a secondary school education.

Estimation Results and Discussion

Logit regression equations are estimated for each of the five disease conditions: cardiovascular diseases, asthma, LRTIs, diabetes and neurological disorders. The coefficients of the results of the intergenerational health transmission regressions are presented in Table 12 while the odd ratios are presented in Table 13. Controlling for offspring's age, parent's educational attainment, distance from household to the mine site, and a set of dummies representing the main sources of drinking water, each regression equation predicts relationship between offspring's health condition and that of their parents. Also, specification link test for single-equation models was done and the test results suggest that the models are not miss-specified.

The estimated coefficients of parent's disease conditions in all five equations are positive and statistically significant at one percent level. This, in line with Thompson (2014), Pascual and Cantarero (2009), Coneus and Spiess (2012) is an indication of a strong persistence of intergenerational transmission of disease (health characteristics) from parent to offspring. There is highly significant probability of the transmission of disease from parent to child. The log odds an offspring suffering a cardiovascular disease change by 2.5 for a unit change in parent's cardiovascular disease condition. The odd ratio for cardiovascular disease is 12.5. This means that the chances of an offspring suffering a cardiovascular disease as his/her parent is 12.5 times higher than the chances of an offspring whose parent did not suffer the disease. Again, a unit change (i.e., from zero to one) in the parent's asthma condition results in the log odds of 3.2 and the odds ratio is as high as 25.4. The increase in the log of the odds of an offspring's LRTIs, diabetes status and neurological disorders are 1.8, 2.8 and 5.7 respectively with odds ratios respectively at 5.8, 16.1, and 300.4. These are indications that the chances of an offspring also suffering the parent's disease are at least 5.8 times higher than the probability of an offspring suffering the disease if the parent does not suffer from the disease.

The variable Age is positive for all the disease conditions. However, it is significant at one percent for cardiovascular disease, LRTIs, and neurological disorders. This is an indication that the probability of an offspring suffering cardiovascular disease, LRTIs, and neurological disorders as his/her parent increases with his/her (offspring's) age. An increase in the offspring's age by one year increases the log odds of cardiovascular diseases by 0.096 (i.e., 0.136 - 0.004 x 9.94, LRTI by 0.02 (i.e., 0.041 – 0.002 x 9.94), and neurological disorders by 0.14 (i.e., 0.151 – 0.001 x 9.94). Thus the chances of an offspring suffering these diseases will increase with his age. The positive correlation between age and cardiovascular diseases supports the findings of Ataklte et al. (2015) that hypertension prevalence in Africa increases with age groupings.

Table 12 : Logit Regression Results of Intergenerational Transmission of Disease From Parent to Offspring

Variable	Cardiovascular disease	Asthma	LRTI	Diabetes	Neurological disorder
Parent has condition (1/0)	2.528 (0.373)***	3.233 (0.431)***	1.763 (0.204)***	2.781 (0.509)***	5.705 (0.804)***
Offspring age	0.136 (0.026)***	0.006 (0.018)	0.041 (0.014)***	0.025 (0.020)	0.151 (0.021)***
Years of parent's education	0.095 (0.082)	-0.276 (0.069)***	0.053 (0.045)	-0.306 (0.077)***	0.004 (0.066)
Parent's education and offspring age interaction	-0.004 (0.002)	0.004 (0.002)**	-0.002 (0.001)	0.004 (0.002)*	-0.001 (0.002)
Log(Distance to mine)	-0.273 (0.127)**	-0.488 (0.152)***	-0.178 (0.075)**	-0.216 (0.204)	-0.205 (0.138)
Parent engaged in physically exerting occupation (1/0)	-0.093 (0.258)	-0.45 (0.364)	-0.383 (0.179)**	-0.771 (0.433)*	0.435 (0.341)
Main Source of Drinking water (sachet/bottled water is reference					
Pipe-borne(1/0)	0.290 (0.42)		-0.091 (0.333)	0.163 (0.618)	-1.169 (0.485)**
Borehole(1/0)	0.542 (0.310)*		0.579 (0.205)***	-0.124 (0.463)	-0.436 (0.363)
Well/river(1/0)	1.164 (0.587)**		0.942 (0.371)**		-0.128 (0.625)
Constant	-7.536 (1.021)***	-2.581 (0.73)***	-2.861 (0.531)***	-3.386 (0.859)***	-10.26 (1.349)***
Number of observations	722	722	722	722	722
Linktest_hatsq	0.412	0.12	0.194	0.181	0.247

Table 13: Odd Ratios of the Logit Regression of Intergenerational Transmission of Disease from Parent to Offspring

Variable	Cardiovascular disease	Asthma	LRTI	Diabetes	Neurological disorder
Parent has condition (1/0)	12.526	25.355	5.83	16.141	300.357
Offspring age	1.146	1.006	1.041	1.026	1.162
Years of parent's education	1.1	0.759	1.055	0.736	1.004
Parent's education and offspring age interaction	0.996	1.004	0.998	1.004	0.999
Log(Distance to mine)	0.761	0.614	0.837	0.805	0.814
Parent engaged in physically exerting occupation (1/0)	0.91	0.638	0.682	0.461	1.545
Main Source of Drinking water (sachet/bottled water is reference					
Pipe-borne(1/0)	1.337		0.913	1.177	0.311
Borehole(1/0)	1.72		1.785	0.883	0.646
Well/river(1/0)	3.201		2.564		0.88
Constant	0.001	0.076	0.057	0.034	0.000
Number of observations	722	722	722	722	722
Linktest_hatsq	0.412	0.12	0.194	0.181	0.247

Source: Analysis of Field Survey Data

The coefficient of the education variable is both positive and significant at one percent level for asthma and diabetes. However the evaluation of the education coefficient together with its interaction with age of offspring showed that it is actually negative. This is an indication that parent's level of education reduces the probability of his offspring suffering from asthma and diabetes. Thus, an increase in the level of parent's education by one more year reduces the log odds of an offspring suffering from asthma by 0.169 (i.e., (.004 x 26.54 – 0.275). The corresponding values for diabetes is -0.2.

We now turn to some significant environmental variables. The distance of the household to the nearest major mine site reduces the probability of an offspring having cardiovascular diseases, asthma and lower respiratory tract infections. The distance coefficient for cardiovascular diseases significant at five percent level. These are strong indications that current mining pollution, proxied by the distance variable, is an important contributor to cardiovascular diseases in the Obuasi Municipality. One percentage point decrease in the average distance increases the log odds for cardiovascular diseases, by 0.27. The positive correlation between proximity to the major mine or tailings and cardiovascular disease supports Farmer et al., 2014; Franchini, & Mannucci, 2007, 2009, 2012; and Newby et al's (2015) position that air pollution contributes to the risk of cardiovascular disease and associated mortality. The link between distance—my proxy to gold mining pollution—and NO_2 has been established in chapter five.

The distance variable is also significant for both asthma and lower LRTIs. The coefficients for asthma is significant at one percent level while that of

LRTI is significant at five percent. These are indication that current mining pollution is a significant contributor to asthma, and lower respiratory tract infections in the Obuasi Municipality. One percentage point decrease in the average distance increases the log odds for asthma and LRTI by 0.49, and 0.18 respectively. Again this finding supports Chauhan & Johnston (2003) and Newby et al., (2015) that air pollution contributes to the risk of respiratory illnesses especially in exacerbating symptoms in individuals with pre-existing respiratory conditions such as asthma and chronic obstructive pulmonary diseases.

Finally, drinking from a well/river and borehole is a potential source of cardiovascular diseases and LRTIs. Of the three sources of drinking water, compared with sachet or bottled water, borehole and well/river water are significant sources of cardiovascular diseases and LRTIs. However, well/river is worse than borehole. Furthermore, the odds ratios for cardiovascular diseases of borehole and well/river are 1.7 and 3.2. These are indications that drinking from borehole and well/river are 1.7 and 3.2 times more disease-causing than the use of sachet or bottled water. The corresponding odd rations for LRTIs are 1.78 and 2.56 respectively. With the exception of neurological disorders drinking pipe-borne water appears not to be significantly different from sachet/bottled water.

Summary

The thrust of this chapter was to determine intergenerational health transmission linkages in the mining communities in Ghana and consequently establish the role played by mining pollution in the intergenerational health transmission pathways. The idea was to see the likelihood of an offspring suffering an ailment suffered by his parent while controlling for socio-demographic and environmental factors.

Specifically, logit regression equations were estimated for each of five disease conditions: cardiovascular diseases, asthma, LRTI, diabetes and neurological disorders in the Obuasi Municipality.

All the five disease conditions show significantly high probabilities of being transmitted across generations. While age of offspring constitutes one of the major drivers of the transmission mechanism, parent's years of education played an abating role. The distance between households and the major mine or tailing sites is a significant enabler of cardiovascular diseases, asthma and LRTI. The use of borehole and well or river for drinking are more likely to cause cardiovascular ailments and LRTI than sachet/bottled water and pipe-borne water. Well/river water is, however, worse than borehole. In addition, socioeconomic status, represented by years of education of parent, plays an abating role in asthma, and diabetes.

CHAPTER EIGHT

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This is the concluding chapter of the study. As a result, a brief summary is given including the focus of the study, methodologies used and key results. This is followed by key findings of the study. I also made some policy recommendations. I concluded with the key contribution of the study to knowledge and issues for further research.

Summary

The main focus of the study was to investigate the effects of gold mining on the health of those who live in the mining areas in Ghana. I used the revealed and stated preference approaches to find how household health expenditure relates to mining pollution and how mining pollution affects potable water availability. I also employed intergenerational income models to estimate intergenerational health transmission from parent to offspring. In Chapter Two the relevant literature was reviewed drawing on concepts and empirical insights from reports of scholarly works of health and environmental economists, sociologists, other environmental and health scientists as well as development and environmental agencies. The philosophical and theoretical frameworks of the study were also considered in Chapter Three.

Consequently, the philosophy of the study is the egalitarian anthropocentrism of Environmental Economics. The theoretical models applied were demand theory and the intergenerational income transmission models.

The study adopted the survey research strategy and therefore in a cluster sampling of the Obuasi Municipality, 558 out of 600 households were successfully interviewed. To determine the health impact of gold mining in the Obuasi Municipality, a simple hedonic model was employed to estimate the relationship between household health expenditure and mining pollution. The results were used to compute the WTA compensation for the health expenditure due to mining pollution. The data was also employed in a simple household water demand and logit models to estimate the value of the travel and waiting time for water collection and the determinants of valuing this time as leisure time. Finally, a logit model was used again to estimate intergenerational mobility of health from father or mother to progeny.

The first objective focused on the relationship between health expenditure and mining pollution. The key findings were that:

1. Gold mining pollution, proxied by the shortest distance between the dwelling and the mine/tailing site, increases household health expenditure. A percentage decrease in the average distance between a household's location and the mine site may lead to a 0.12% increase in health care expenditure.
2. The minimum compensation in health care expenditure that is acceptable to victims of mining pollution within the Obuasi

municipality, ranging from Gh¢33 to Gh¢69 per head per annum, decreases with the distance between residence and the major mining/tailing sites. The mean willingness to accept compensation was found to be Gh¢41 per head per annum.

3. Relatively younger households tend to spend more on healthcare. Although, findings from the literature indicate that pure age effect on healthcare spending is an open empirical question, which cannot be determined a priori, this particular finding could be explained by persistence of intergenerational health transmission.
4. Respondents whose employer or health insurance plan paid a greater portion of the households' hospital bill had lower personal healthcare expenditure than their counterparts who bore most of their healthcare costs

The effect of mining pollution on residential water usage was estimated as the second objective, and the following were the main findings:

1. Gold mining pollution negatively affect water consumption. Thus, there is a positive relationship between the distance to a major mining site and water usage within households. A 10% decrease in the distance between the dwelling and the nearest major mine correspondingly decreases water usage by two percent. This is an indication of the increasing relative paucity of potable water as one gets closer to the mine and supports Peplow's (1999) assertion that pollution reduces with increasing distance away from mining sites.

2. Water collection is likely to be regarded as leisure by certain groups in the municipality and, hence, they would rather be compensated to have water delivered to their home. Households that are relatively well-off and operate their own drinking water source are more likely to consider water collection as leisure and would demand compensation for potable water delivered to their homes. On the other hand, households that use more water, have more educated heads and obtained drinking water from hand dug wells, and boreholes are less likely to place a positive value on the opportunity cost of time than those who use bore-holes and sachet water.

The pollution related intergenerational health transmission was also estimated which yielded the key issues listed below:

1. The probability of an offspring having cardiovascular diseases, asthma and lower respiratory tract infections as his/her parent was found to increase with mining pollution concentration. Thus the closer one is to the mine or drink from a well or river the higher the chances of suffering from cardiovascular diseases and LRTIs. These are indications that a child born in an environment polluted by gold mining will be more prone to mining pollution diseases and the likelihood is higher if the parent had suffered those diseases.
2. Those who drink from borehole or well/river are more likely to suffer from cardiovascular diseases and LRTI than those who use sachet/bottled water and pipe-borne water. Since there is significant

difference between sachet/bottled water and pipe-borne water, residents of Obuasi Municipality need not fear using the latter.

3. There is a strong persistence of intergenerational transmission of disease (health characteristics) from father or mother to offspring. For example, the chances of an offspring also suffering a cardiovascular disease as his/her parent is 12.5 times higher than the chances of an offspring whose father or mother did not suffer the disease. Also the chances of an offspring contracting diabetes and neurological disorders are respectively 16.1 and 300.4 times higher for parent who had the disease than one who did not. The values for Asthma and LRTIs are 25.4 and 5.8 respectively. The strong persistence of intergenerational transmission of disease could explain the finding that younger households spend more on healthcare.
4. The chances of suffering cardiovascular disease, LRTI and neurological disorder increases with age. The positive correlation between age and cardiovascular diseases supports the findings of Ataklte et al. (2015) that hypertension prevalence in Africa increases with age.
5. Parent's years of education was found to reduce the chances of suffering from asthma and diabetes.

Conclusions

From the results and findings of the study, the following conclusions can be made:

Households that are more exposed to mining pollution tend to spend more on healthcare as compared to those that are less exposed. This confirms findings, by biochemical researchers, of significant health impacts of hazardous substances such as arsenic, mercury, cadmium and lead in Ghana. In addition, mining concentration decreases with distance from the household to the mine or tailing. Hence, the minimum health care compensation that victims of mining pollution may be willing to accept depends on the relative pollution concentration.

Mining pollution concentration reduces the availability of potable water to residents. Also, consistent with the literature, water for residential use in the Obuasi Municipality is price inelastic and a normal good. While the price elasticity of demand is relatively low the absolute value of income elasticity is rather high. This may be due to the limited availability of potable water within the mining community, where much of the water bodies are heavily polluted with heavy metals. A good proportion of households with certain characteristics consider water collection as a leisure activity. For example, wealthier households and those that operate their own drinking water source are more likely to consider water collection as leisure and would demand compensation for potable water delivery to their homes. Thus decisions that support potable water delivery to homes could have low success rates if the decision makers are composed of high income earners.

The offspring of household heads whose households are more exposed to mining pollution are more likely to suffer cardiovascular diseases, Asthma and lower respiratory tract infections than less exposed households. In addition, the chances of a progeny suffering the same health condition as the parent are significantly higher than the chances of the one whose parent did not have the ailment. These are indications that it will be much easier for future generations to suffer gold mining pollution related ailments than the current generation, if nothing is done about the current situation However, while age of offspring appears to significantly increase the chances of suffering these ailments, years of education of the parent abate these chances. Finally, drinking pine-borne water is not significantly more disease causing than sachet/bottled water, but it is better than borehole and well water. This contradicts the perception of residents that pine-borne water is contaminated by mining pollution.

Mining pollution therefore, contributes to increased healthcare cost, water scarcity and a likely transmitter of cardiovascular and asthma and lower respiratory tract infections across generations in the Obuasi Municipality.

Policy Recommendations

1. By directly estimating effect of gold mining pollution on healthcare spending, compensation for exposure to such pollution could be

calculated and victims better compensated. Thus, the distance to the tailings could be the yardstick for determining compensation for people residing in mining communities, all else being equal.

2. Since pipe-borne water was found not to be significantly different from sachet/bottled water but better than borehole and well/river water, the central government, in collaboration with the mining companies, has to expand pipe-borne water network to all gold mining communities that are not yet covered by the network. This will improve potable water availability to discourage people from patronising borehole and well/river. Residents should also be educated to know that pipe-borne water is just as good as sachet or bottled water.
3. Specialised centres should be established to monitor and combat current health effects of mining pollution in order to prevent it from cascading into socio-economic and health effects of future generations. These could be resourced to undertake long-term data generation, management and analysis as well as monitoring of emission levels. The data generated should be made available to researchers for their work.

Contribution to Knowledge

The study made the following contribution to knowledge

1. The study is a novelty because to the best of my knowledge no study has been done to directly evaluate the effect of exposure to mining pollution on health care cost among residents of gold mining communities.

2. The thesis has, using intergenerational health transmission model, established the link between current gold mining activities and its negative health effect on future generations.
3. Another issue of interest touched by the study is the valuing of time spent hauling water as leisure time

Limitations of Study

The study is not without shortcomings. The mere fact that the study focussed on effect of large-scale mining on health excluding artisanal mining which also plays a big role (and whose effect cannot be isolated) in environmental degradation is in itself a limitation.

The study was restricted to the Obuasi Municipality which is an urban area and does not cover other gold mining communities in Ghana. Furthermore, the study uses a historical mining community in Ghana, where exposure has lasted for over a century as a case. The findings may therefore not strictly hold for recent mining areas.

Another limitation of the study is with regard to data collection. The survey was conducted only once instead of maybe twice at different periods within the year to make more accurate, information such as household expenditure which is an annualised variable. It will also reduce problems of recollection.

The reliance on subjective assessment of health status of the respondents, although employed by other studies, could suffer from human errors. In addition, as indicated, data from an earlier bio-physical study was employed to draw the link between distance to tailings and pollution concentration within the mining communities.

Issues for further research

Further research needs to be done to cover more mining areas and to put the detrimental health effects of mining pollution beyond doubt, non-mining areas should also be included. In addition, Future extensions of this work should employ physical and biochemical data to enrich the analysis.

Further studies should also be done to deepen the understanding of the household water demand situation in the mining communities. While expanding the area of coverage to include more mining communities, the focus should be on estimating separate demand for drinking water, water for general use and a combined estimate of demand for water. There is also the need to explore further social and psychological factors that could influence people's behaviour regarding water collection and usage.

It is recommended that future studies consider intergenerational health transmission through both parents to male and female children with the view to finding out which of the two parents is more resilient to intergenerational health transmission on one hand and whether the male or female offspring will be more receptive in the transmission process on the other.

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APPENDICES

Appendix A

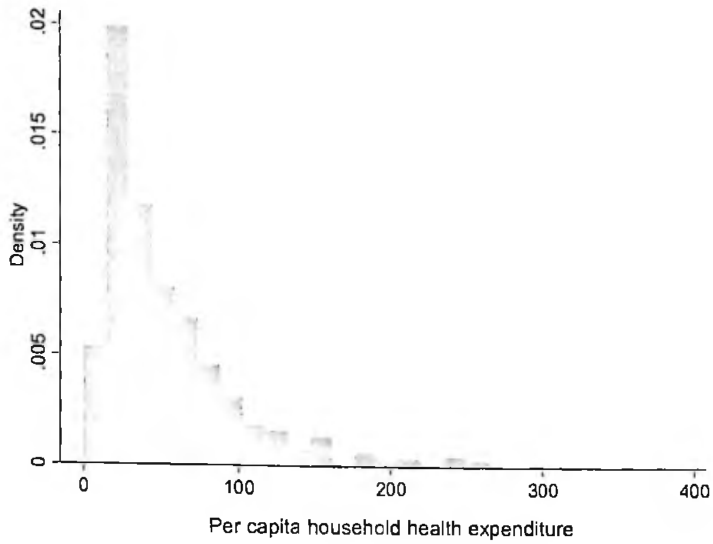

Figure 5: Distribution of Per Capita Household Health Expenditure

Source: Author

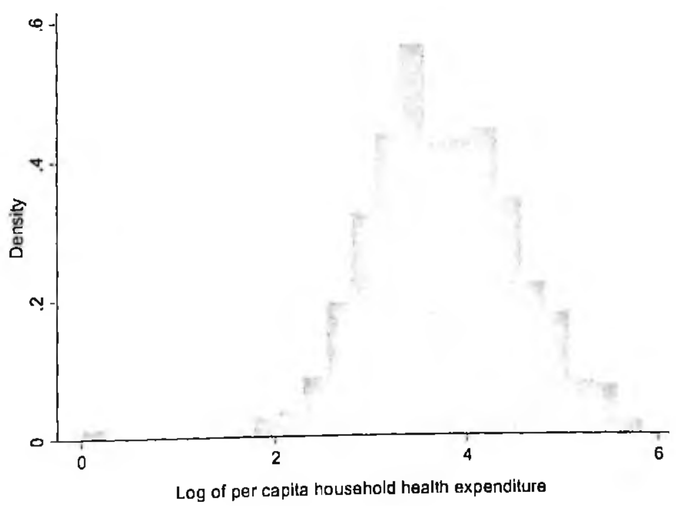

Figure 6: Distribution of Per Capita Household Health Expenditure in Logs

Source: Author

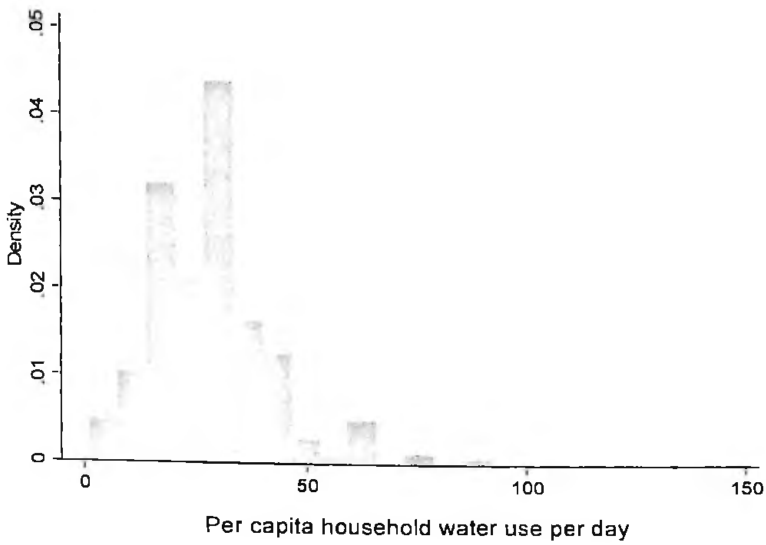

Figure 7: Distribution of Per Capita Household Water Use Per Day

Source: Author

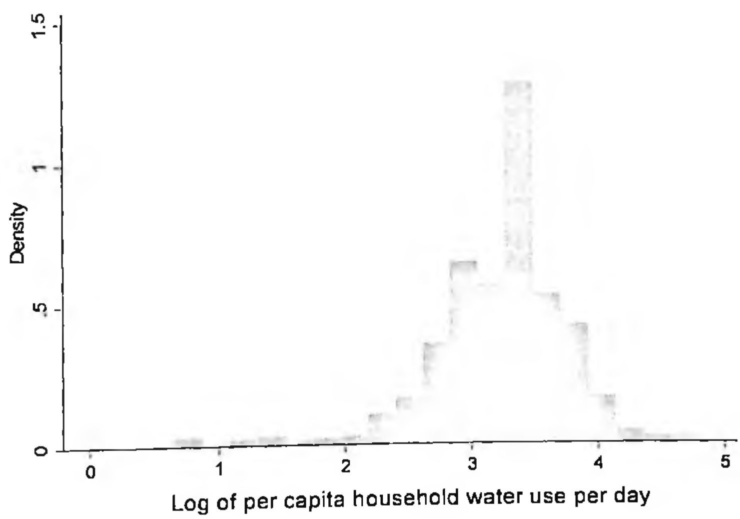

Figure 8: Distribution of Per Capita Household Water Use Per Day in Logs

Source: Author

Appendix B

$$\frac{dM}{dh_0} = \frac{\mu}{\left(u_{MM}(\bullet) - \mu^2 - \sigma^2\right)} < 0 \tag{B1}$$

$$\frac{dM}{d\mu} = \frac{-\left(\rho - h_o - 2\mu M\right)}{\left(u_{MM}(\bullet) - \mu^2 - \sigma^2\right)} > 0 \tag{B2}$$

$$\frac{dM}{d\sigma^2} = \frac{M}{\left(u_{MM}(\bullet) - \mu^2 - \sigma^2\right)} < 0 \tag{B3}$$

$$\frac{dM}{dB} = \frac{u_{MB}(\bullet)}{\left(u_{MM}(\bullet) - \mu^2 - \sigma^2\right)} > 0 \tag{B4}$$

Appendix C

Table 14: Key Summary Statistics of the Study Data and their Corresponding GLSS 6 Values

Variable	Study Data			GLSS 6
	Number of Obs.	Mean	Standard Deviation	Mean
Household Size	558	3.14	1.76	3.6
Age of Household Head	558	40.62	11.06	43.5
Annual Household Expenditure	558	10,205	5,326	9,841
Per Capita Annual Household Expenditure	558	3,872	1,994	3,926
Annual Household Health Expenditure	558	156.9	150.96	148*
Per Capita Annual Household Health Expenditure	558	55.06	48.78	50*

* Cash or out-of-pocket health expenditures only

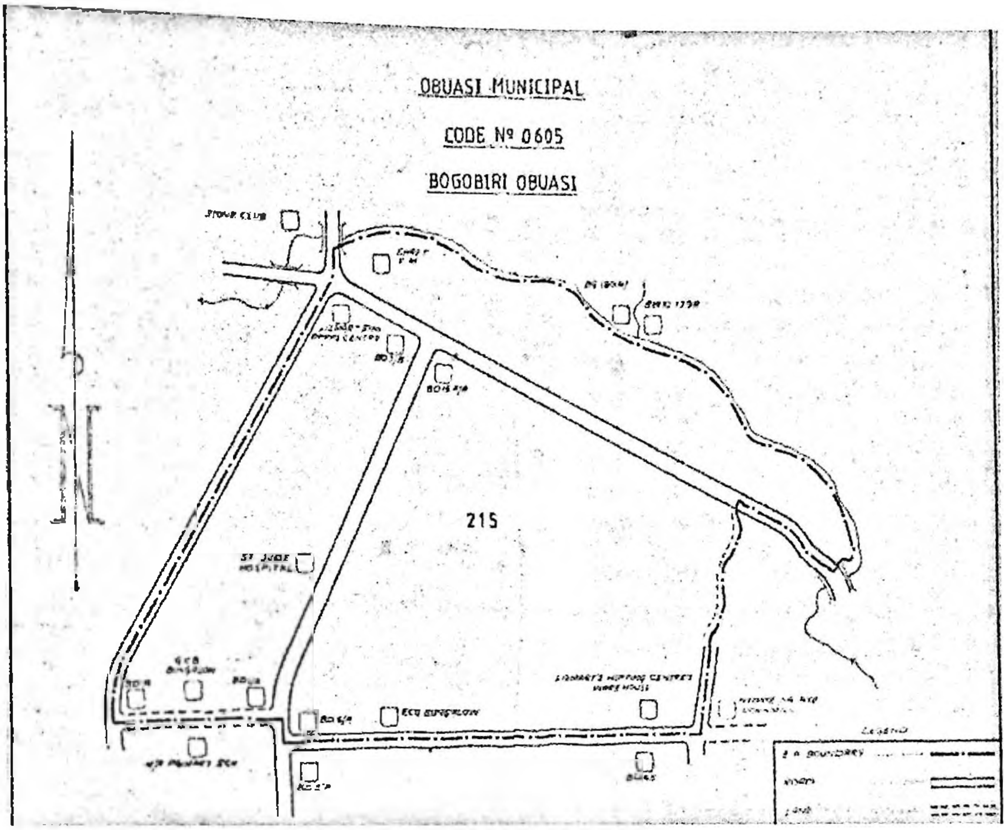

Figure 9: Sample Map of EA No. 215 in the Obuasi Municipality

Source: Ghana Statistical Service

4

GHANA STATISTICAL SERVICE
REPUBLIC OF GHANA

PHC2

Current EA Number 0605200215

2010 POPULATION AND HOUSING CENSUS
GHANA AUTOMATED ENUMERATION AREA INFORMATION SYSTEM (GAEA-INFO)

Selected EA Code . 0605200215

1a. Region:	Ashanti Region	**1b. Region Number:**	06
2a District:	Obuasi Municipal	**2b. District Number:**	05
3b. District Type:	Municipal	**3b. District Type Number:**	2
4a. Sub District Type:	Municipal	**4b. Sub District Number:**	00
5a. 2000 EA Code:	0604001100	**5b. 2010 EA Number (Prov.)**	215
6a. EA Type	One to many (EAs)	**6b. EA Type Number:**	2
7a Locality Name:	BOGOBIRI,OBUASI	**7b. Base Locality Number:**	009
8a. EA Base	SHAFT FM		
8b. EA Base Coord:			

2010 EA Code 0605200215

9. Localities and EA Population Information

Locality Number	Locality/ies in EA	EA Population Information		
		2000 PHC	2010 PHC	2010 PHC
		Enumerated	Estimated (Field)	Enumerated
009	BOGOBIRI,OBUASI SHAFT FM	561	683	0
		561	683	0

10. Enumeration Area (EA) Boundary Description:
Start on the road between the Warehouse for Lizmart Shopping Centre (incl) and Nyame Na Aye Corn Mill (excl) Follow the road; through the footpath, to where it meets the major road Turn right and follow the road to where it crosses the stream Turn left and follow stream; pass BG/180A (excl); to meet the road before Stone Club (excl). Turn left and follow the road to the lane between BD/1A (incl) and M/A Primary Junior High School (excl). Turn left and follow the lane to meet the road after BD/11A (Incl) Turn right and move a little to meet the road between BD/6/A (incl) and BD/5/A (excl). Turn left and follow the road to where it meets the road between Warehouse for Lizmart Shopping Centre and Nyame Na Aye Corn mill; where you started.

11. Accessibility Remarks:

Enumerator's Name:.. Phone Number:..

Supervisor's Name:.. Phone Number:..

Report Details: Reports: PHC EA Population Information

Date Printed: 1/12/2012 Entry Series No.: 29325 Time Printed: 4:12.03 PM

Figure 10: Sample Description of EA Map Number 215

Source: Ghana Statistical Service

Table 15: List of Sample EAs Comprising Cluster Size and Sample

EA No.	EA Name	Cluster size	Rural/ Urban	Cluster Sample size	Chances of Selecting a household from Obuasi
002	SANSO	259	R	11	0.013
005	ODUMASI	155	R	6	0.013
008	ODUMASI	220	R	9	0.013
011	KWAME DUAKROM	52	R	2	0.013
014	DIAWUOSO	92	R	4	0.013
017	KWABENAKWA	235	R	10	0.013
020	ASONKORE	200	R	8	0.013
023	POMPOSO	129	R	5	0.013
026	POMPOSO	202	R	8	0.013
029	MAMPANHWE	93	R	4	0.013
032	NYAMESO-OBUASI	265	U	11	0.013
035	ANYINAM, OBUASI	962	U	39	0.013
038	ANYINAM, OBUASI	161	U	7	0.013
041	AHANSO NYEWODEA, OBUASI	200	U	8	0.013
044	AHANSO NYE WODEA, OBUASI	162	U	7	0.013
047	KWABRAFOSU, OBUASI	128	U	5	0.013
050	TUTUKA,OBUASI	185	U	8	0.013
053	TUTUKA,OBUASI	105	U	4	0.013
056	ABOAGYEKROM,OBUASI	200	U	8	0.013
059	BOETE,OBUASI	168	U	7	0.013
062	BRAHABEBOME,OBUASI	311	U	13	0.013
065	BRAHABEBOME,OBUASI	111	U	5	0.013
068	AKAPORISO,OBUASI	123	U	5	0.013
071	BRAHABEBOME, OBUASI	121	U	5	0.013
074	BOETE-OBUASI	191	U	8	0.013
077	TUTUKA,OBUASI	95	U	4	0.013
080	TUTUKA,OBUASI	205	U	8	0.013
083	KWABRAFOSU,OBUASI	382	U	16	0.013
086	ANYINAM,OBUASI	163	U	7	0.013
089	ANYINAM,OBUASI	204	U	8	0.013
092	CAUSU EXT.,OBUASI	153	U	6	0.013
095	NYAMESO,OBUASI	158	U	6	0.013
0098	GAUSU,OBUASI	106	U	4	0.013
101	GAUSU,OBUASI	279	U	11	0.013
104	KOFFEKROM	116	U	5	0.013
107	KOFFEKROM,OBUASI	243	U	10	0.013

110	KULAM,OBUASI	379	U	15	0.013
113	OBUASI ZONGO	136	U	6	0.013
116	OBUASI ZONGO	82	U	3	0.013
119	OBUASI ZONGO	66	U	3	0.013
122	ANTOBOASI,OBUASI	74	U	3	0.013
125	WAWASI,OBUASI	118	U	5	0.013
128	WAWASI,OBUASI	47	U	2	0.013
131	KWABRAFOSU,OBUASI	142	U	6	0.013
134	TUTUKA,OBUASI	240	U	10	0.013
137	TUTUKA,OBUASI	121	U	5	0.013
140	TUTUKA,OBUASI	129	U	5	0.013
143	BOETE,OBUASI	174	U	7	0.013
146	BOETE, OBUASI	121	U	5	0.013
149	BRAHABEBOME,OBUASI	40	U	2	0.013
152	AKAPORISO,OBUASI	115	U	5	0.013
155	AKAPORISO,OBUASI	143	U	6	0.013
158	NEW AKAPORISO,OBUASI	100	U	4	0.013
161	NEW AKAPORISO,OBUASI	155	U	6	0.013
164	BOETE,OBUASI	110	U	4	0.013
167	SAMPSONKROM,OBUASI	133	U	5	0.013
170	KWABRAFOSU,OBUASI	85	U	3	0.013
173	WAWASI,OBUASI	161	U	7	0.013
176	WAWASI,OBUASI	115	U	5	0.013
179	WAWASI,OBUASI	43	U	2	0.013
182	OBUASI CENTRAL	75	U	3	0.013
185	OBUASICENTRAL	82	U	3	0.013
188	NEW NSUTA-OBUASI	120	U	5	0.013
191	BIDIESO,OBUASI	39	U	2	0.013
194	GAUSU,OBUASI	170	U	7	0.013
197	RAMIA,OBUASI	234	U	10	0.013
200	GAUSU,OBUASI	112	U	5	0.013
203	BOGOBIRI,OBUASI	187	U	8	0.013
206	KUNKA,OBUASI	160	U	7	0.013
209	KUNKA, OBUASI	169	U	7	0.013
212	BOGOBIRI,OBUASI	103	U	4	0.013
215	BOGOBIRI,OBUASI	93	U	4	0.013
218	BIDIESO,OBUASI	79	U	3	0.013
221	BIDIESO,OBUASI	101	U	4	0.013
224	OBUASI ESTATE	141	U	6	0.013
227	OBUASI ESTATE	174	U	7	0.013
230	BIDIESO,OBUASI	209	U	9	0.013
233	BOGOBIRI,OBUASI	110	U	4	0.013

236	ABOMPE OBUASI	371	U	15	0.013
239	OBUASI OLD ESTATE	71	U	3	0.013
242	OBUASI NEW ESTATE	92	U	4	0.013
245	OLD ESTATE,OBUASI	102	U	4	0.013
248	NEW NYAMEBEKYERE OBUASI	276	U	11	0.013
251	NEW NYAMEBEKYERE OBUASI	237	U	10	0.013
254	KOKO TEASUA,OBUASI	115	U	5	0.013
257	KOKOTEASUA,OBUASI	161	U	7	0.013
260	KOKOTEASUA,OBUASI	216	U	9	0.013
263	ABOMPE OBUASI	161	U	7	0.013
266	ABOMPE OBUASI	118	U	5	0.013
269	NTONSUA	128	R	5	0.013
272	BIMSERE	74	R	3	0.013
275	ADASI (ADAASI)	80	R	3	0.013
	Total	14723		600	0.013

Source: Author

APPENDIX D: QUESTIONNAIRE

QUESTIONNAIRE

Health Impact of Gold Mining in Ghana

Interviewer ID .... Household ID ....

Date of Interview: .... Time of Commencement .... Time of Completion.....................

Good Morning /Afternoon/Evening. My name is ....from .... I am here on behalf of Mr. Ametefee Normanyo from the University of Cape Coast to collect data for his PhD thesis on health impact of gold mining in Ghana. Your household has been randomly selected to participate in this survey. The promise is that the information you give will be treated with utmost confidentiality. Your responses will be added to those of other respondents for a general analysis so there will be no way by which your responses will be singled out for reference anywhere. Are you willing to participate in the exercise?

Yes ☐ No ☐

EA CODE ☐

RESPONDENT'S CONTACT ☐

SUPERVISORS' REMARKS ☐

SECTION 1 HOUSEHOLD ROSTER AND DEMOGRAPHIC CHARACTERISTICS

1.1	1.2	1.3		1.4		1.5	1.6	1.7	1.8	1.9	1.10	
ID	SEX Male ..1 Female 2	What is the relationship of (NAME) to the head the of household? Head .... 01 Spouse (Wife/Husband..... 02 Child (Son/Daughter .... 03 Grandchild .... 04 Parent/Parent in-law .... 05 Son/Daughter in-Law. 06 Other relative .... 07 Adopted/Foster/Step child.. 08 Househelp .... 09 Non-relative...................... 10		How old is (NAME)?		What is (NAME'S) present marital status? Married ..... 1 Consensual union .... 2 Separated .. 3 Divorced .. 4 Widowed ... 5 Never married ... 6	How many years formal educational has attained	What is (NAME's) Occupation?	How long has (NAME) stayed in this community?	How long will it take you to walk from your residence to the nearest major gold mine?	How far is your residence from the major gold mine?	
		NAME	CODE	YRS	MO.		YEARS		YEARS	HOURS	KM	M
01												
02												
03												
04												
05												
06												
07												
08												
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11												
12												
13												

SECTION 2: HEALTH, GENERAL

HEALTH CONDITION IN THE PAST TWELVE MONTHS

RESPONDENTS: ALL HOUSEHOLD MEMBERS

I D	ID OF PERSON INTER-VIEWED	2.1 During the past 12 months has (NAME) suffered from either an illness or an injury? Neither .... 1 >>2.4 Illness...... 2 Injury......3 Both.......4	2.2 For how many days during the past 12 months has (NAME) suffered from this condition? DAYS	2.3 For how many days during the past 12 months, did (NAME) have to stop the usual activities because of this condition? DAYS	2.4 During the past 12 months has (NAME) consulted a health practitioner, or dentist or visited a health centre or consulted a traditional healer, etc? Yes.........1 No.........2 >>2.10	2.5 What was the main reason for the most recent visit? Illness... 1 Injury...... 2 Follow-up.. 3 Check-up... 4 Prenatal care.. 5 Postnatal care. 6 Vaccination 7 Other........ 8 (specify)	2.6 How much did (NAME) pay for this consultation? AMOUNT	2.7 How much was spent to travel there and to return? AMOUNT	2.8 How much time did it take to travel to and from the facility? HRS	2.8 MINS	2.9 How much time did (NAME) spend at the health facility? HRS	2.9 MINS	2.10 During the past 12 months did (NAME) use herbal or traditional medication? Yes.........1 No..........2 >>2.12
01													
02													
03													
04													
05													
06													
07													
08													
09													
10													
11													
12													
13													

SECTION 2: HEALTH, GENERAL

HEALTH CONDITION IN THE PAST 12 MONTHS **RESPONDENTS: ALL HOUSEHOLD MEMBERS**

I D	ID OF PERSON INTER-VIEWED	2.12 During the past 12 months was (NAME) admitted to a hospital/ health centre on account of the illness/ injury? (INCLUDE TRADITIONAL HEALTH CENTRES) Yes.............1 No..............2 >>2.15	2.13 How many nights/days did (NAME) stay in hospital/ health centre during the past 12 months NIGHTS	2.14 How much did (NAME) pay for staying in a hospital/ health centre during the past 3 months AMOUNT	2.15 During the past 12 months did (NAME) buy any medicine and medical supplies? Yes........1 No.........2 (>>2.17)	2.16 How much did (NAME) pay altogether for these medicine and medical supplies? AMOUNT	2.17 Who pays for the greatest portions of the health expenses incl. consultations and hospital stays (if any)? Household member....... ID; Other relative.. 80; Employyer........ 81; House member's employer 82; Health insurance.... 83; Other .... 84 (specify)	2.18 Would you say that in general (MANE's health during the past 12 montths has been ...... Excellent? ... 1; very good?... 2; good? .... 3; fair? .... 4; poor? .... 5; Don't know, Not sure 6; Refused..... 7	2.19 Have you experienced any shock from mining activity? (e.g. cracks in walls, appliances falling your farmland or crops destroyed, etc) Yes ....1 No 2

SECTION 2: HEALTH, GENERAL

HEALTH CONDITION IN THE PAST 12 MONTHS

ID OF PERSON INTER-VIEWED	2.20 During the past 12 months has (NAME) visited or consulted a prayer camp or spiritualist for good health or healing? Yes.......... ......1 No..................2 >> 2.26	2.21 If yes how satisfying was it? Not satisfying.... 1 Not very satisfying.... 2 Satisfying... 3 Very satisfying. 4 Don't Know.... 5	2.22 How many times was the visit made during the past 12 months	2.23 How much did (MANE) spend for one consultation or visit?	2.24 How much was spent to travel there? (ONE TRIP)	2.25 How much time on average did (NAME) spend at Prayer camp or healing facility?		2.26 Given that (NAME's) best health status ever is 100%. How does (NAME's) current health status compre with it?	2.27 To what extent will you agree or disagree that mining is impacting negatively on the health of members of your community? strongly agree .1 1 agree ...... 2 Neutral ...... 3 disagee......... 4 strongly disagree...... 5 don't know .. 6	2.28 What effort does (NAME) regularly make in order to prevent illness? Nothing .... 1 Use of herbs.. 2 consumption of food ...... supplements 3 medical check-ups..... 4 praying .... 5 exercise.......... 6	2.29 would you rate your satisfaction with the services you get when you attend health facility/ hospital as very good' 1 good? ..... 2 poor? .... 3 very poor? 4 Don't knov 5
				AMOUNT	AMOUNT	DAYS	HOURS				
01											
02											
03											
04											
05											
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13											

SECTION 3: SPECIFIC HEALTH

PART A: HEALTH CONDITION IN THE PAST 12 MONTHS: Upper Respiratory tract infections

RESPONDENTS: ALL HOUSEHOLD MEMBERS

3.1 During the past 12 months has (NAME) experienced the following conditions and if yes how (often) many times?

I D	ID OF PERSON INTER-VIEWED	(a) Caughs? Yes ..... 1 No 2		(b) Nasal discharge/ congesion? Yes ..... 1 No 2		(c) Sneezing? Yes ..... 1 No 2		(d) sore throat? Yes ..... 1 No 2		(e) Headaches? Yes ..... 1 No 2	
		Y/N	NUMBER	Y/N	NUMBER	N/Y	NUMBER	N/Y	NUMBER	N/Y	NUMBER
01											
02											
03											
04											
05											
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07											
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13											

SECTION 3 : SPECIFIC HEALTH

PART A: HEALTH CONDITION IN THE PAST 12 MONTHS: Lower respiratory tract infections

RESPONDENTS: ALL HOUSEHOLD MEMBERS

3.2 During the past 12 months has (NAME) experienced the following and if yes how (often) many times?

I D	(a)		(b)		(c)		(d)		(e)		(f)	
ID OF PERSON INTER-VIEWED	shortness of breath Yes ..... 1 No 2		cough? Yes ..... 1 No 2		wheezing? (a whistling sound made when breathing) Yes .... 1 No 2		tight feeling in the chest? Yes ..... 1 No 2		Muscle/chest pain? Yes ..... 1 No 2		fever (high temperature) Yes ..... 1 No 2	
	Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER
01												
02												
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13												

SECTION 3: SPECIFIC HEALTH

PART B: HEALTH CONDITION IN THE PAST 12 MONTHS: Diabetes

RESPONDENTS: ALL HOUSEHOLD MEMBERS

		3.3 During the past 12 months has (NAME) experienced					
I D	ID OF PERSON INTER-VIEWED	(a) dryness in the mouth? Yes......1 No........2	(b) urge to drink a lot of water? Yes......1 No........2	(c) the need to urinate very often ? Yes......1 No........2	(d) blurred vision recently? Yes......1 No........2	(e) slow healing of wounds Yes......1 No........2	(f) sexual weakness (in men?) Yes......1 No........2
01							
02							
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08							
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11							
12							
13							

SECTION 3: SPECIFIC HEALTH

PART C: HEALTH CONDITION IN THE PAST 12 MONTHS: Skin diseases

I D	ID OF PERSON INTER-VIEWED	3.4(a) During the past 12 months has (NAME) experienced any skin rashes, growths, boils, sores, etc? Yes………………1 No………………..2	3.4(b) What is the local name for (NAME'S) skin conditon?	3.4(c) which of these pictures looks like the kind of skin problem (NAME) has? 1, 2,3, … None …99	3.4(d) How many times during the past 12 months did (NAME's) skin condition recur ?	3.4(e) During the past 12 month has (NAME) experienced itching of the skin? Yes………..1 No…………..2	3.4(f) How many times during the past 12 months did (NAME's) skin itching condition recur ?

SECTION 3: SPECIFIC HEALTH

PART D: HEALTH CONDITION IN THE PAST 12 MONTHS: Cardiovascular diseases

RESPONDENTS: ALL HOUSEHOLD MEMBERS

I D	ID OF PERSON INTER-VIEWED	3.5 During the past 12 months has (NAME) experienced the following and if yes how (often) many times?												
		(a) irregular heart beats (or a" flip-flop" feeling in your chest? Yes............. No.............		(b) feeling of tiredness and lethargy? Yes..............1 No..............2		(c) swelling of feet? Yes......1 No........2		(d) feeling of pressure or squeezing pain in your chest? Yes......1 No........2		(e) faster heart beat even at rest? Yes......1 No........2		(f) chest pain radiating to shoulders, arms, neck, jaw or back? Yes......1 No........2		(g) breathlessness on lying down feeling for air? Yes......1 No........2
		Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER	NUMBER
01														
02														
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SECTION 3: SPECIFIC HEALTH

PART E: HEALTH CONDITION IN THE PAST 12 MONTHS:

Neurological Disorders

RESPONDENTS: ALL HOUSEHOLD MEMBERS

3.6 During the past 12 months has (NAME) experienced the following and if yes how (often) many times?

ID OF PERSON INTER-VIEWED	(a) Severe anxiety? (excessive, uncontrollable and often irrational worry) Yes......1 No........2		(b) Paranoia? (a condition characterized by an elaborate, overly suspicious system of thinking) Yes......1 No........2		(c) Depressed feeling? (appearing desireless, feeling nothing at all or loss of sensation) Yes ....1 No 2		(d) Sudden mood changes? Yes......1 No........2		(e) Suicidal thoughts? Yes......1 No........2		(f) Displaying stress? Yes......1 No........2		(g) Irritability or anger? Yes......1 No........2
I D	Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER	NUMBER
01													
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SECTION 3: SPECIFIC HEALTH

PART E: HEALTH CONDITION IN THE PAST 12 MONTHS: Neurological Disorders

I D	ID OF PERSON INTER-VIEWED	3.6 During the past 12 months has (NAME) experienced the following and if yes how (often) many times?									
		(h) Hyper-sensitivity to others? Yes.........1 No.........2		(i) seisures? (convulsion and fits) Yes.........1 No.........2		(j) paralysis? Yes...........1 No...........2		(k) muscle weakness? Yes...........1 No...........2		(l) poor coordination? (inability to put things or indivi-duals into har-monious working) order) Yes...........1 No...........2	
		Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER	Y/N	NUMBER
01											
02											
03											
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12											
13											

SECTION 4 UTILITIES : *WATER AND COOKING FUELS*

4.1 What is the main source of water supply for your household?

Indoor plumbing 01
Inside standpipe 02
Water truck/tanker 03
Water vendor..................................04
Pipe in neibouring household.....05
Private outside standpipe/tap....06
Public standpipe..........................07
Sachet/bottled water 08
Borehole 09
Protected well................................10
Unprotected well...........................11
River/stream..................................12
Rain water/spring 13
Dugout/pond/lake/dam 14
Other 15
(specify)

DRINKING [ ]

GENERAL USE [ ]

4.2 How far is this source from your dwelling?

DRINKING DISTANCE [ ]   **DRINKING** DISTANCE CODE [ ]

GENERAL USE DISTANCE [ ]   **GENERAL USE** DISTANCE CODE [ ]

4.3 How regular is your source of water supply?

Daily 1
Weekly 2
Forthnightly 3
Monthly..........................4
Other 5
(specify)

a **DRINKING**
TIME UNIT [ ]   NUMBER [ ]

b **GENERAL USE**
TIME UNIT [ ]   NUMBER [ ]

4.4 How much time do you spend on the average waiting your turn to have water from this source?

DRINKING [ ]   **DRINKING** TIME CODE | Hours | Mins |

GENERAL USE [ ]   **GENERAL USE** TIME CODE | Hours | Mins |

4.5 How much water on the aveage does your household use in a day?

Litre.........................1
Gallon 2
Bucket (No. 34) ...3

QUANTITY [ ]   UNIT [ ]

4.6 How is the source supply system operated?

Self 1
Community operated and managed 2
Community Water and Sanitation Agency .3
Ghana Water Company Ltd 4
NGO 5
Other (Specify) 6
Not applicable 7

DRINKING

GENERAL USE

4.7 Does the household pay a regular bill for this water supply system?

Yes 1
No ....2 >>4. 9

DRINKING

GENERAL USE

4.8 How much did your household pay for water for general use (besides drinking) in the last one month? (Only your part if joint meter or shared bill)

AMOUNT

4.9 How much did your household pay for drinking water in the last one month?

AMOUNT

4.10 If you were to contract someone to provide you with potable water for your household, how much will you pay for it?

AMOUNT

Litre.....................1
Gallon 2
Bucket (No. 14),,3

UNIT

4.11 Did your household sell any water to someone else?

Yes ....1 >> 12
No 2

4.12 How much did your household receive from the water sold in the last one month?

TIME UNITS
Daily 1
Weekly 2
Monthly 4
Quarterly 5
Half yearly 6
Yearly 7

DISTANCE CODE
In house 1
Yard 2
Metre 3
Kilometres..................5
Mile 6

4.13 Please complete the table below on you household's usage of for cooking

During the past one month which of the following fuel types did your household use?

FUEL TYPE (a)	UNIT (b)	QUANTITY (c)	UNIT PRICE (GH¢) (d)	AMOUNT (GHS) (e)	
None....01 Wood....02 Charcoal....03 Gas....04 Electricity....05 Kerosene....06 Crop resdue/ sawdust....07 Animal waste....08 Other....09 (specify)	Bundels...... ....1 Bags....2 Kilogrammes......3 Gallons ....4 Botlles....5 Buckets....6 Other (specify)...7				
CODE	UNIT CODE		GH¢	AMOUNT	

SECTION 5: SUPPLEMENTARY QUESTIONNAIRE

Indicate whether you or any member of your household eat any of the following	Yes = 1 No = 2 >>next item	The last time you or any member of your household ate some, what quantity did each member take?	
1. Wild mushrooms harvested from the environment of your community		.............average size fingers	
2. Snails from this area?		.... average size snails	
3. Crabs from this area?		.... average size crabs	
4. Citrus (oranges, tangerines, etc)		..........................oranges	
5. Tomatoes grown in this area?		.... average size tomatoes	
6. Cocoyam leaves?		.... leaves	
7. Cassava products harvested from farms around this community?		..............................Tubers	
8. Fish from the water bodies in and around this community?		............................singles	
9. Local rice grown in this community?		...............Margerine cups	
10. Cabbages cultivated in this area?		...........................Bulbs	
11. Lettuce cultivated in this area?		......................Singles	
12 Sugarcane cultivated in this municipality?		.... Full sticks	
13. Carrots cltivated in this community?		........................fingers	

SECTION 6: GENERAL EXPENDITURE QUESTIONS

28. On the average what is your daily expenditure on food including the ones you produced and consumed yourself.

29. How much on average do you spend on all non-food items weekly e.g. transportation, phone calls, personal care products and services, etc.?

30. How much did your household spend on clothing during the past 12 months?

....

31. How much did your household spend on furniture during the past 12 months?

....

32. How much did your household spend on household appliances during the past 12 months

....

33. How much did your household spend on other things not considered above?

....