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Working conditions of male and female artisanal and small-scale goldminers in Ghana: Examining existing disparities

Frederick Ato Armah[a,*], Sheila A. Boamah[b], Reginald Quansah[c], Samuel Obiri[d], Isaac Luginaah[e]

[a] Department of Environmental Science, University of Cape Coast, Ghana
[b] Arthur Labatt Family School of Nursing, Health Sciences Addition, University of Western Ontario, Canada
[c] Biological, Environmental & Occupational Health Sciences, School of Public Health, University of Ghana, Legon, Ghana
[d] Council for Scientific and Industrial Research-Water Research Institute, P.O. Box AN 40, Accra, Ghana
[e] Department of Geography, University of Western Ontario, London, Canada

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ABSTRACT

Artisanal and small scale mining (ASM) provides a livelihood to more than 100 million men and women worldwide, mostly in the global south. Although the sector is male-dominated, the number of women engaged in its activities has increased dramatically in recent years, underscoring the need for critical assessment of their environmental, health and safety working conditions. Based on a cross-sectional survey of 482 male and 106 female artisanal and small-scale goldminers in Ghana, this study examines the disparities in the mean scores of the environment, health, safety and economic working conditions between male and female goldminers. Using four counterfactual decomposition techniques, inequality in working conditions was disaggregated according to group differences in the magnitudes of the determinants and group differences in the effects of the determinants. The difference in the mean values of the estimated coefficients accounts for much of the difference in environment, health, safety, and economic working conditions between the male and female artisanal and small-scale goldminers. This implies that the gap in working conditions between the two groups may be attributed to discrimination, but it may also emanate from the influence of unobserved variables. Gender-specific differences exist for the artisanal and small-scale goldminers surveyed: age and years of experience are salient for men, whereas education and number of years lived in the community are more important for women.

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1. Introduction

Artisanal and small-scale mining (ASM) occurs in 80 countries, across which, collectively, the total number of people engaged in the activity has grown from 10 million in 1999 to potentially more than 20–30 million today (Buxton, 2013). Artisanal and small-scale miners account for 80% of global sapphire, 20% of global gold and up to 20% of world diamond production (World Bank, 2009). They are found scattered across sub-Saharan Africa, Asia, Oceania, and Central and South America. Although their largely-informal and, on the whole, relatively un-mechanized, nature generally results in low productivity, the sector is an important livelihood and income source for a host of impoverished individuals (Banchirigah and Hilson, 2010; Hilson and McQuilken, 2014). Worldwide, at least 100 million people – workers and their families – depend on ASM, compared to only seven million people in the case of industrial mining (World Bank, 2009).

It is a complex industry that is highly-important economically in at least 23 countries in sub-Saharan Africa. There is growing recognition that ASM is the most significant economic activity in many of the region's rural settings (see Banchirigah and Hilson, 2010; Hilson and McQuilken, 2014). Here, most ASM activities are dynamic, populated by individuals who carry out different tasks, responsibilities which are often determined by gender (Hinton et al., 2003). In most artisanal and small-scale gold mining communities in sub-Saharan Africa, men undertake jobs related to actual ore extraction, such as digging, blasting, crushing stones and loading and transporting ore (Armah et al., 2013a). They are less present in the processing stage, and play a relatively minimal role in the delivery of auxiliary services. Women, on the other hand, tend to dominate processing (panning, preparing the processing plant) and the provision of auxiliary services (cooking, cleaning,

* Corresponding author.
E-mail addresses: farmah@ucc.edu.gh (F.A. Armah), sboamah@uwo.ca (S.A. Boamah), yaw121@yahoo.co.uk (R. Quansah), obirisamuel@gmail.com (S. Obiri), iluginaa@uwo.ca (I. Luginaah).

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buying gold). The former features high levels of manual activity to extract mineral remnants from tailings; women form ‘human chains’, each carrying large buckets of tailings on their heads, and panning and sluicing mud and sand to recover particles of gold. It is not uncommon to see children by their sides. Women’s tasks are the most labour-intensive yet yield the lowest economic returns. Given the nature of ore processing, they and their children commonly inhale dust, which can lead to respiratory disease. Moreover, they often become exposed to mercury and in some cases, toxic cyanide, when it is used to reprocess tailings. But they also haul ore with windlasses, sort stones/tailings, and bag ore (Armah et al., 2013a). The general gender division of labour reflects the perceived appropriateness of tasks for both women and men (Heemskerk, 2003).

In sub-Saharan Africa, overall, the majority of benefits from small-scale gold mining accrue to men, while most of the occupational health risks and vulnerabilities associated with this activity are borne by women (see Jenkins, 2014; Gier and Mercier, 2006). Across the region, large numbers of women participate in the – largely-informal – small-scale gold mining economy, which also supports multiple dependents through allied livelihoods. Yet, little is known about the working conditions of both its male and female operators, and how these vary systematically with educational level, age, and years of experience on the job. It is no secret that artisanal and small-scale miners often operate in hazardous working conditions. Major health risks associated with artisanal mining include exposure to dust (silicosis, mesothelioma); exposure to mercury, zinc vapour, cyanide, acids, and other chemicals (Obiri et al., 2010); and over-exertion, problems arising from working in an inadequate workspace and complications associated with using inappropriate equipment. Due to a lack of engineering expertise and capital, there are many accidents at sites, mostly caused by rock falls and subsidence, a lack of ventilation, misuse of explosives, and obsolete and poorly-maintained equipment (Lahiri-Dutt, 2008). It has been suggested that women bear the brunt of these impacts because of their dual roles as primary carers and being responsible for the health of their families (Hinton et al., 2003; Jenkins, 2014). They are vulnerable to contamination from mercury and other heavy metals in water and the work environment; mercury exposure is known to severely impair foetal development (Hinton et al., 2003). Notwithstanding this, it is unclear how length of stay of artisanal and small-scale goldminers in the community mediates the relationship between working conditions and the compositional attributes of these individuals.

This paper aims to address these gaps by examining the disparities between the working conditions of male and female artisanal and small-scale goldminers. The analysis focuses on Ghana, where the number of artisanal and small-scale goldminers has risen sharply since the 1990s (Armah et al., 2013b). Ghana is the second largest African gold producer and the ninth largest globally; artisanal and small-scale miners account for a significant amount of this production (Wilson et al., 2015). Based on official statistics from the Ghana Extractive Industries Transparency Initiative (GHEITI), in 2013 and 2014, gold from ASM accounted for approximately 34% of total gold production (MOF, 2014).

In Ghana, as in many parts of sub-Saharan Africa, women often experience discrimination at small-scale gold mines. Employment and training opportunities are typically prioritised for men and women are only allowed to work in the most menial, low-paid positions (Tallichet et al., 2006). Maternity leave may not be granted and women returning from childbirth or caring for children may struggle to regain employment. According to Tolonen (2014), our understanding of the welfare effects of natural resource use, in general, and by extension, gold extraction, is rather limited, especially at the local level. The 2010 Ghana Population and Housing Census figures on gender participation proportion in mining stood at 0.6% for females compared to 2% for males (Ghana Statistical Service, 2010; Rufai et al., 2014).

2. Theoretical context

Artisanal and small-scale miners face a number of environmental and health-related threats, most of which have been examined extensively in the literature. Complications can arise from overexposure to the very fine mineral dust particles generated from blasting and drilling. These particles can accumulate in the lungs, causing pneumoconiosis (Castilhos et al., 2015; Long et al., 2015), as well as the irreversible disease silicosis, which is induced by excessive inhalation of crystalline silica or quartz (Gottesfeld et al., 2015; Oni and Ehrlich, 2015). In ASM, exposure to mercury is of critical concern. This heavy metal is found in about 25 organic mineral compounds. Workers can inhale, swallow or absorb mercury through their skin. Even exposure to small quantities can, over time, cause severe poisoning. Symptoms of mercury poisoning include weakness, mouth ulcers, bleeding gums and loose teeth, tremors, nausea, abdominal pain, headaches, diarrhoea and cardiac weakness (Long et al., 2015; Rajaee et al., 2015). In addition, small-scale mine production features noisy process, and unfiltered noise emanating from equipment, such as drills, crushers and engines can lead to temporary or permanent hearing loss, speech interference and eardrum rupture (Green et al., 2015; Long et al., 2015). Back injuries from lifting and shovelling as well as slips and falls are additional health and safety risks facing artisanal and small-scale miners. There are, however, gender-based heterogeneities evident in the exposure to these hazards.

Gender is a fundamental marker of social and economic stratification linked to exclusion. In the context of this paper, unless otherwise stated, gender refers explicitly to the behaviour, attitudes, values and beliefs that a particular sociocultural group considers appropriate for males and females. It is often suggested that gender roles are fluid and can shift over time, space and in different contexts (see Butler, 1990; Hinton et al., 2003). Notwithstanding one’s socioeconomic class, there can be systematic gender differences in material wellbeing, although the degree of inequality varies across countries and over time (Meinzen-Dick et al., 2014). Gender inequality is prevalent in most societies, with males on average better positioned in social, economic, and political hierarchies (Meinzen-Dick et al., 2014; Ridgeway, 2011).

The accentuation of the complexities in the social relationships that shape our understanding of what it means to be male and female – both individually and collectively, and the notion of agency, or conscious choice – distinguish the model of the social construction of gender from all others (Davis et al., 2006; Lorber, 1994; Risman et al., 2012). Gender defines and determines roles, rights, responsibilities, and obligations in a society. The innate biological differences between females and males form the basis of social norms that define appropriate behaviour for women and men and determine the differential social, economic, and political power between the sexes (O’Shaughnessy and Krogman, 2011; Ridgeway and Correll, 2004). At the beginning of the twenty-first century, these differing norms still mostly favour men and boys, giving them more access than women and girls to the capabilities, resources, and opportunities that are important for the enjoyment of social, economic, and political power and well-being (Meinzen-Dick et al., 2014; Ridgeway, 2011).

In the literature (see Meinzen-Dick et al., 2014; UN Millennium Project, 2005), the systematic disadvantage women face is framed in terms of capabilities, access to resources and security dimensions. Capabilities (Anand et al., 2010) are basic human abilities as measured by education, health, and nutrition. These are fundamental to individual well-being and are the means through which individuals access other forms of well-being. The access to resources domain refers primarily to equality in the opportunity to use or apply basic capabilities through access to economic assets (such as land, property) and resources (such as income and employment). Without access to resources, women are unable to use their capabilities to ensure their well-being and the well-being of their families, communities and societies (see Nussbaum, 2001; Robeyns, 2005; Sen, 1989; UN Millennium Project, 2005). The security domain is defined here as reduced vulnerability to violence and conflict, which can lead to physical and psychological harm and constrict individuals, households, and communities from fulfilling their potential (see Nussbaum, 2001; Robeyns, 2005; Sen, 1989; UN Millennium Project, 2005). These three domains are interrelated, and change in all three is critical to achieving Millennium Development Goal 3, which seeks to promote gender equality and empower women. Due to the historical legacy of disadvantage women have suffered, they are still frequently referred to as a vulnerable minority. In most countries, however, women are a majority, with the potential to accumulate enormous power. Given the total size of the female population in most poor countries, interventions to improve their lives will affect national outcomes.

3. Materials and method

This study was conducted from January to September 2011 under the auspices of the Natural Resource and Environmental Governance (NREG) Programme in Ghana. The NREG programme was initiated to address governance issues relating to natural resources and environment and to facilitate sustainable economic growth, poverty reduction, increase revenues and improve environmental protection. Mining in Ghana has been characterized by divergent interests including lack of clarity over legal compensation and the distribution of benefits, cultural conflicts and tensions between local communities and migrants, and lack of trust between communities, industry and Government (Armah et al., 2014). With the rise in the gold price and government strategy to attract more foreign investment, the number of disputes have increased. These conflicts emanate from a lack of sufficient consultation and community engagement, a lack of accurate information on mining impacts, differing expectations of social and economic benefits, environmental concerns, and disputes over land use and economic compensation (see Armah et al., 2013a, 2014). Moreover, large-scale mining operations often cause involuntary resettlement, resulting in a loss of land, livelihoods and resources for local communities. Another area of concern has been the environmental damage resulting from mining activities, especially unregulated artisanal and small-scale gold mining. Conscious of these challenges, the Government of Ghana and its development partners crafted a modern policy and regulatory framework under the NREG to tackle social issues in mining communities.

3.1. Study area

The study site was selected because it is one of the oldest surface mining areas in Ghana, and covers perhaps its most significant gold mining localities, namely the Tarkwa Nsuaem and Prestea Huni Valley Districts in the southwest of the country. This area includes three of the country's largest surface mine concessions: Bogoso–Prestea, Tarkwa, and Damang. It lies within an important gold belt, which stretches from the town of Konongo to the northeast through Tarkwa to Axim in the southwest, thus making mining the main industrial activity in the area (Kuma and Younger, 2004). Inhabitants of Tarkwa and its environs have a long history of alluvial mining, which is locally referred to as *galamsey*. The geology of the area makes it highly attractive for mining and several concessions have been granted to both large-scale and small-scale mining companies. Surface gold mining concessions are frequently granted in areas containing settlements and farmland, sparking conflicts between mining enterprises and local communities. The area also has one of highest per capita concentrations of artisanal and small-scale goldminers in Ghana, and thus offers unique opportunities to better understand gold mining's effects on local livelihoods and human health.

Climatic factors provide a contextual background to the agriculture-dependent livelihoods that co-exist with gold mining in the study area. Some artisanal and small-scale goldminers in Ghana seldom abandon agriculture completely given that their activities may be seasonal and influenced by external factors such as the price of gold on the world market. Two climatic regions border the Tarkwa Nsuaem and Prestea Huni Valley Districts: the southern portion falls in the southwestern equatorial climatic region and the northern part has a wet semi-equatorial climate (Benneh and Dickson, 2004). The rainfall pattern generally follows the northward advance and the southward retreat of the inter-tropical convergence zone that separates dry air from the Sahara and moisture-monsoon air from the Atlantic Ocean. The area experiences two distinct rainy periods (double rainfall maxima). The first and larger peak occurs in June, while the second and smaller peak occurs in October. The mean annual rainfall exceeds 1750 mm with around 54% of rainfall in the region falling between March and July. The area is very humid and warm with temperatures between 26–30 °C (Dickson and Benneh, 2004).

3.2. Data collection

The study was entirely quantitative and data were obtained using a structured questionnaire, which was tested among 15 participants with similar socioeconomic background to ensure its feasibility. The pilot group was first asked to complete the questionnaire, and comment on the comprehensibility of the questions; this led to minor modifications of the questionnaire to improve understanding. The questionnaire was structured into four sections: socio-demographic, knowledge of health effects of mercury intoxication, and occupation-related quality measures. The demographic aspects include the number of people engaged in mining and ancillary activities, types of human habitats and proximity to the pits, sex, age, marital status, ethnic origin, education, religion, income, and work shifts. This section also includes an assessment of social behaviour in the ASM community. The section on knowledge of health effects provided a detailed description of the overall gold production process, which focused on the use of mercury in gold amalgamation, amount of mercury used and activities linked to artisanal and small-scale production (e.g. mercury selling, gold trading, and catering for miners). Occupation-related quality measures include artisanal and small-scale miners' self-ratings on environmental, safety, health and economic conditions within the employment setting, which is the focal variable in this paper.

Artisanal and small-scale goldminers who were 18 years or older at the time of the survey and had continuously lived in the mining community for at least one year were eligible to participate in the study. Potential participants were excluded if they had been absent from work in the past one year (to reduce recall bias), had been engaged in artisanal and small-scale gold mining for less than one month or had shifted permanently from artisanal and small-scale gold mining to another occupation (petty trading, large scale mining, etc.). Sampling for the study was systematic: all individuals meeting the inclusion criteria were approached. A general introduction to the study was given each morning by theresearch team. After screening for eligibility, individuals provided written consent to participate in the study. A total of 603 participants were recruited however, 15 individuals (nine males and six females) declined participation because of time constraints due to work schedule and domestic activities, personal disinterest and apathy due to unmet expectations of previous researchers. According to the artisanal and small-scale goldminers who declined to participate in the study, some researchers promised that their research findings would inform government on the need for their inclusion in the formal economy. However, several years thereafter, this has not happened. In fact, they contend that their plight has rather worsened, thus warranting their decision not to participate in ongoing and future studies. Moreover, some of miners indicated that, in the past, after they had granted interviews to researchers, government and security officials often invaded their mine sites. The propinquity of these events motivates them to think that it cannot be coincidental. Based on the inclusion and exclusion criteria as well as non-participation, a sample size of 588 consisting of 482 males and 106 females was obtained. Participants were resident in Prestea, Asamankakraba, Kamporasi, Tarkwa, Akoon, Abontoako, New Atoano, Kofi Gyan, Cyanide, Brahabobom, Teberebie, and Low Cost. Others were resident in Huni Valley, Nsuta, Tamso, Simpa, Dompim, Nzemaline, Wassa Nkran, Efuanta, Damang, Dumasi, Dwabeng, Bogoso and Bankyim.

3.3. Measures

3.3.1. Response variable

The focal response/dependent variable was working conditions of artisanal and small-scale miners. In a series of questions, respondents were asked to evaluate their working conditions in terms of the environment, health, safety and economy. In the context of this study, unless otherwise stated, the term "economic working conditions" includes wages or income, employment benefits, incentives and workload that cumulatively influence the productivity of artisanal and small-scale goldminers. Environment is broadly defined and encompasses both physical and social dimensions. These include the resources that artisanal miners have in their physical surroundings, their perceptions of the quality of their workspace and occupational setting, space availability (e.g. overcrowding) and material circumstances as well as the nature and extent of their personal social networks at the workplace. Health refers to the functional status of artisanal goldminers, and comprises physical fitness, emotional wellbeing, activities of daily living, social activities, change in health status and overall health (see Huber et al., 2011). Safety refers to the existence and operationalization of precautions such as disposal of hazardous materials, required personal safety equipment such as safety goggles, gloves, protective apparel, permitted noise levels and fall protection. Each of the four working conditions was rated as poor (1), fair (2), good (3), very good (4), and excellent (5). A composite variable, environment, health, safety and economic working condition, was then derived using principal component and factor analysis. Scale reliability was ascertained prior to the generation of the composite score. The Cronbach's α (scale reliability coefficient) was 0.71.

As shown in Table 1, only one factor had an Eigenvalue greater than 1, indicating that all the items loaded on a single construct. Based on Kaiser's criterion, we retained this factor which also explained almost 55% of the variance in the response variable. Higher scores on the response variable correspond to better working conditions. The likelihood ratio test indicated a good model fit.

Table 1
Principal component factor loadings, unique variances and scoring coefficients.

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor 1	2.19868	1.31767	0.5497	0.5497
Factor 2	0.88101	0.3301	0.2203	0.7699
Factor 3	0.55091	0.18151	0.1377	0.9076
Factor 4	0.3694		0.0924	1

Variable	Factor 1	Uniqueness	Scoring coefficients
Health working conditions	0.8146	0.3364	0.3705
Environment working conditions	0.8565	0.2663	0.38957
Safety working conditions	0.7750	0.3994	0.35246
Economic working conditions	0.4482	0.7991	0.20384

3.3.2. Independent variables

The independent variables were selected based on theoretical relevance and practical importance. Age of respondent at interview was subsequently categorized into discrete periods 18–24; 25–34; 35–54; and 55 years and above. The reference group is 18–24 years because it is the low point of a worker's "legal" entry into artisanal and small-scale gold mining. Highest educational attainment of respondent was grouped as no education (reference), primary, secondary, or tertiary education. Length of stay of respondent in the community at the time of interview and experience on the job are continuous variables measured in years.

3.3.3. Statistical analysis (counterfactual decomposition techniques)

Counterfactual decomposition techniques (see Armah et al., 2016; Oaxaca 1973; Jann, 2008; O'Donnell et al., 2008) were used to study gender-based discrimination in the work environment of artisanal and small-scale goldminers. Generally, the aim of the Blinder–Oaxaca decomposition is to determine how much of the difference in mean outcomes across two groups is due to group differences in the levels of explanatory variables, and how much is due to differences in the magnitude of regression coefficients (Hlavac, 2014). In particular, the disparities in the mean scores of the environment, health, safety and economic working conditions between male and female artisanal and small-scale goldminers in Ghana were evaluated. The inequality in working conditions was disaggregated into a fraction which is due to group differences in the magnitudes of the determinants on the one hand, and another fraction consisting of group differences in the effects of these determinants, on the other hand. For example, female artisanal and small-scale goldminers may be less favoured in the gold mining workplace not only because they periodically require maternity leave but also because they are less knowledgeable about how to handle, for example, mercury in the amalgamation process.

Environment, health, safety and economic working conditions scores (y_i) is our response variable of interest. There are two groups, namely females and the males. There is an assumption that the work condition score is explained by a vector of determinants, x, according to a regression model:

$$y_i = \begin{cases} \beta^{\text{woman}} x_i + \varepsilon_i^{\text{woman}} \text{if woman} \\ \beta^{\text{man}} x_i + \varepsilon_i^{\text{man}} \text{if man} \end{cases} \tag{1}$$

where the vectors of β parameters include intercepts. The males are assumed to have a more advantageous regression line (higher scores on working conditions) than the females. Moreover, the males are assumed to have a higher mean of x. Exogeneity was assumed; consequently, the conditional expectations of the error terms in Eq. (1) are zero. The gap in work condition scores between the females (y^{women}) and males (y^{men}) is given by:

$$y^{\text{women}} - y^{\text{men}} = \beta^{\text{women}} x^{\text{women}} - \beta^{\text{men}} x^{\text{men}} \tag{2}$$

where x^{women} and x^{men} are vectors of the independent variables evaluated at the means for the females and males, respectively. For the set of independent variables, the following holds:

$$\begin{aligned} y^{women} - y^{men} &= ({\beta_0}^{women} - {\beta_0}^{men}) \\ &+ ({\beta_1}^{women}{x_1}^{women} - {\beta_1}^{men}{x_1}^{men}) \\ &+ ({\beta_2}^{women}{x_2}^{women} - {\beta_2}^{men}{x_2}^{men})\ldots \\ &+ \ldots({\beta_n}^{women}{x_n}^{women} - {\beta_n}^{men}{x_n}^{men}) \\ &= G_0 + G_1 + G_2 \ldots + \ldots G_n \end{aligned} \quad (3)$$

so that the gap in environment, health, safety and economic work condition scores between females and the males can be thought of as being due in part to (i) differences in the intercepts (G_0), (ii) differences in x_1 and β_1 (G_1), and (iii) differences in x_2 and β_2 (G_2). For example, G_1 might measure the part of the gap in mean score of environment, health, safety and economic working conditions (y) due to differences in educational attainment (x_1) and the effects of educational attainment (β_1), and G_2 might measure the part of the gap due to the gap in age of respondents (x_2) and differences in the effects of age of respondents (β_2). Estimates of the difference in the gap in mean work condition score can be obtained by substituting sample means of the xs and estimates of the parameters β's into Eq. (2).

It is further estimated how much of the overall gap or the gap specific to any one of the xs (e.g. G_1 or G_2) is attributable to (i) differences in the xs (sometimes called the explained component) rather than (ii) differences in the β's (sometimes called the unexplained component). In doing so, two options were considered. In the first, the differences in the xs were weighted by the coefficients of the female group and the differences in the coefficients were weighted by the xs of the male group, whereas in the second, the differences in the xs were weighted by the coefficients of the male group and the differences in the coefficients were weighted by the xs of the female group. In both cases, there is a way of partitioning the gap in outcomes between the females and males into a part attributable to the fact that the females have worse xs than the males, and a part attributable to the fact that *ex hypothesi* they have worse β's than the males. These formulations are expressed as follows:

$$y^{women} - y^{men} = \Delta x\beta^{women} + \Delta\beta x^{women} + \Delta x\Delta\beta = E + C + CE \quad (4)$$

From Eq. (4), the gap in mean score of environment, health, safety and economic working conditions can be thought of as deriving from a gap in xs or endowments (E), a gap in β's or coefficients (C), and a gap arising from the interaction of endowments and coefficients (CE). So, in effect, Eq. (5) places the interaction in the unexplained part, whereas the Eq. (6) places it in the explained part. The rationale for this is that the decompositions were formulated to examine discrimination in the gold mining workplace. The unexplained portion of the mean outcome gap has often been attributed to discrimination, but may also result from the influence of unobserved variables. In the first decomposition, the presumption is that it is women who are paid according to their characteristics, whereas men receive unduly generous working conditions. In the second decomposition, the presumption is that men are paid according to their characteristics, and it is women who are discriminated against.

$$y^{women} - y^{women} = \Delta x\beta^{women} + \Delta\beta x^{men} = E + (CE + C) \quad (5)$$

Triangles denote differences between groups. The difference in the β's includes not only the difference in slopes but also in constants. Mean outcomes in environment, health, safety and economic working conditions between male and female miners are represented in Fig. 1. But this is only one way of writing the difference between male and female artisanal and small-scale goldminers, as shown below.

$$y^{women} - y^{men} = \Delta x\beta^{men} + \Delta\beta x^{women} = E + CE + C \quad (6)$$

In Fig. 1, the differences in the xs are weighted by the coefficients of the female subgroup and the differences in the coefficients are weighted by the xs of the males subgroup, whereas in Fig. 2, the differences in the xs are weighted by the coefficients of the males subgroup and the differences in the coefficients are weighted by the xs of the female subgroup.

The Oaxaca's decomposition as a unique case of another equation may also be formulated as

$$\begin{aligned} y^{females} - y^{males} &= \Delta x\left[D\beta^{female} + (I - D)\beta^{male}\right] \\ &+ \Delta\beta\left[x^{female}(I - D) + x^{male}D\right] \end{aligned} \quad (7)$$

where I is the identity matrix and D is a matrix of weights. In the simple case, where x is a scalar rather than a vector, I is equal to one and D is a weight. In this case, $D = 0$ in Eq. (5), and $D = 1$ in Eq. (6).

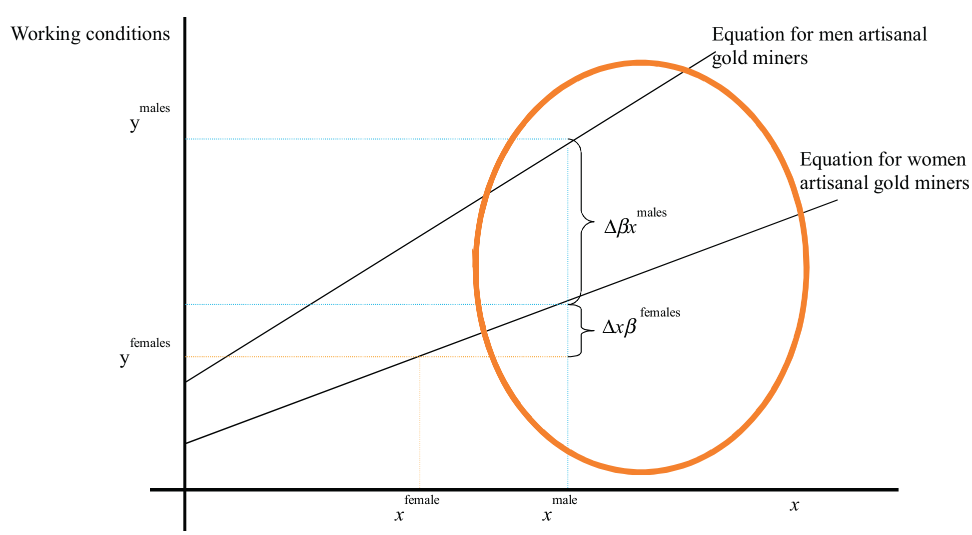

Fig. 1. Female artisanal and small-scale goldminers are paid according to their characteristics and men receive unduly generous working conditions.

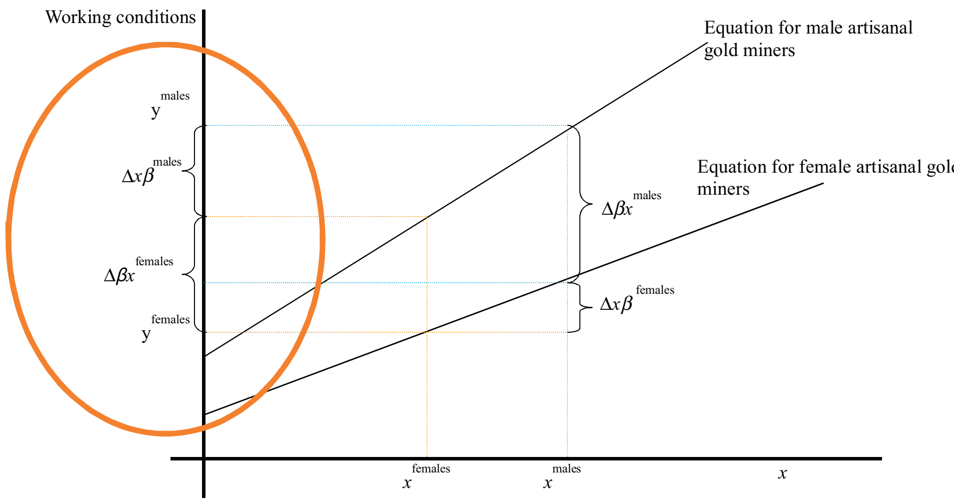

Fig. 2. Male artisanal and small-scale goldminers are rewarded according to their characteristics and females are discriminated against.

In addition to the above formulations, three more formulations were considered. Cotton (1988) suggested weighting the differences in the xs by the mean of the coefficient vectors, which yields

$\mathrm{diag}(D) = 0.5$ (Cotton)(8)where diag (D) is the diagonal of D. Reimers (1983) suggested weighting the coefficient vectors by the proportions in the two groups, so that if f_{NP} is the sample fraction in the males group, the following is obtained:

$\mathrm{diag}(D) = f_{\mathrm{NP}}$(Reimers)(9)

Finally, the decomposition proposed by Neumark (1988) was included, which makes use of the coefficients obtained from the pooled data regression, β^{P}:

$$y^{\mathrm{females}} - y^{\mathrm{males}} = \Delta x\beta^{\mathrm{P}} + \left[x^{\mathrm{female}}\left(\beta^{\mathrm{female}} - \beta^{\mathrm{P}}\right) + x^{\mathrm{male}}\left(\beta^{\mathrm{P}} - \beta^{\mathrm{male}}\right)\right] \quad \text{(Neumark)} \qquad (10)$$

The foregoing equations were implemented in STATA 13SE software. The detailed Blinder–Oaxaca decomposition of work condition differentials is not invariant to the choice of reference group when a set of dummy variables is used. When dummy variable(s) are used as predictors then the detailed coefficients effect attributed to individual variables is not invariant to the choice of left-out group(s). This invariance or identification problem is well documented in the literature. The "normalized" regression equation, where the estimate is simply the average of three sets of estimates with varying reference groups, has been proposed to address this problem. In this study, current employment status and site of the gold mining were the dummy variables. For this reason, the oaxaca.ado and mvdcmp.ado file in STATA 13 (StataCorp, College Station, TX, USA) SE were operationalized to address this issue.

Table 2
Distribution of sample by gender ($n = 588$).

Respondent characteristics	Male (%)	Female (%)	Inferential statistics
Marital status			chi^2 (3) = 20.6533 Pr = 0.000
Single	88.9	11.1	Cramér's V = 0.1874
Married	77.5	22.5	
Divorced	65.0	35.0	
Widow/widower	100.0	0.0	
Educational attainment			chi^2 (3) = 13.2926 Pr = 0.004
No education	100.0	0.0	Cramér's V = 0.1504
Primary education	80.4	19.6	
Secondary education	87.3	12.7	
Tertiary education	68.2	31.8	
Age			chi^2 (3) = 2.0537 Pr = 0.561
18–24	83.3	16.7	Cramér's V = 0.0591
25–34	80.6	19.4	
35–54	84.4	15.7	
55 or more	75.0	25.0	
Currently working			chi^2 (1) = 10.5328 Pr = 0.001
No	74.5	25.5	Cramér's V = −0.1338
Yes	85.5	14.5	
Occupational health problems			Pearson chi^2 (1) = 0.1741 Pr = 0.677
No	80.8	19.2	Cramér's V = −0.0172
Yes	82.4	17.7	
Years of experience			
Mean	7.0	4.0	
S.D	7.2	4.2	
Range	1–44	1–20	
Years of residence			
Mean	26.3	25.7	
S.D	13.9	13.4	
Range	1–60	4–60	

4. Results

4.1. Characteristics of male and female artisanal and small-scale goldminers

Non parametric Pearson's chi-square test of independence for the two categorical distributions (female versus male) was calculated. The chi-squared statistic report rejects the hypotheses that marital status, educational attainment, and current employment status measures are independent of the gender measure (Table 2). However, the Cramer's V statistic indicate weak associations. The chi-squared statistic failed to reject the null hypotheses that age and occupational health problem measures are independent of gender.

For females, the number of years of engagement in artisanal and small-scale goldmining ranges between 1 and 20 years (mean = 4.04, S.D = 4.20). For males, the number of years of engagement in artisanal and small-scale gold mining ranges between 1 and 44 years (mean = 7.05, S.D = 7.22). Duration of residence in the community ranges between 4 and 60 years (mean = 25.69, S.D = 13.39) for females and between 1 and 60 years (mean = 26.30, S.D = 13.98) for males.

Table 3 displays the mean values for environment, health, safety and economic working conditions of males and females, and the difference between them. The contribution attributable to the gaps in endowments (E), the coefficients (C), and the interaction (CE) are also shown. Table 3 is the threefold Blinder–Oaxaca decomposition of the mean outcome difference. The endowments term represents the contribution of differences in the explanatory variables across groups (male and female), and the coefficients term is the part that is due to group differences in the estimated coefficients. The interaction term accounts for the fact that cross-group differences in explanatory variables and coefficients can occur at the same time. In this study, the gap in estimated coefficients (unexplained component) accounts for the great bulk of the gap in environment, health, safety and economic working conditions between males and females.

Table 4 indicates how the explained and unexplained portions of the gap in environment, health, safety and economic working conditions vary depending on the decomposition used. The first and second columns correspond to the Oaxaca decomposition in equations 5 and 6, where $D = 0$ and $D = I$, respectively. The third and fourth columns correspond to Cotton's and Reimers' decompositions, where the diagonal of D equals 0.5 and $f_{NP} = 0.820$, respectively. The final column labelled "*" is Neumark's decomposition. Several variations of computing counterfactual do not alter the main results qualitatively. Regardless of the decomposition used, it is evidently the difference in the mean values of the estimated coefficients or β's (unexplained component) that accounts for much of the difference in environment health, safety, and economic working conditions between male and female artisanal and small-scale goldminers in Tarkwa, Prestea and Damang in Southwestern Ghana. From the results of the Oaxaca decomposition, the unexplained component or estimated coefficient accounts for 68.3% of the differences in environment, health, safety, and economic working conditions between male and female artisanal and small-scale goldminers. Based on Cotton's decomposition, differences in the mean values of β's (gaps in coefficients) explain 87.7% of the differentials in environment, health, safety, and economic working conditions between male and female artisanal and small-scale goldminers. About 75% and 69% of the differentials in environment, health, safety, and economic working conditions between male and female artisanal and small-scale goldminers are explained by the mean values of β's based on the Reimer's and Neumark's decompositions, respectively.

Table 3
Summary of decomposition results between male and female artisanal and small-scale goldminers ($n = 588$).

Summary of decomposition results: High: sex = male Low: sex = female	
Mean prediction high (H)	0.036
Mean prediction low (L)	−0.164
Raw differentials (R) {H − L}	0.200
due to endowments (E)	−0.014
due to coefficients (C)	0.136
due to interaction (CE)	0.078

Table 4
Proportion of explained and unexplained components ($n = 588$).

D	0	1	0.5	0.820	[a]
Unexplained (U) $\{C + (1 - D)CE\}$	0.214	0.136	0.175	0.15	0.138
Explained (V) $\{E + D \times CE\}$	−0.014	0.063	0.024	0.049	0.062
% Unexplained {U/R}	107.2	68.3	87.7	**75.3**	**69.2**
% Explained {V/R}	−7.2	31.7	12.3	24.7	30.8

[a] Reference = pooled model over both categories.

In Table 5, the gaps in individual estimated coefficients β's contribute to the overall unexplained gap are shown. For example, focusing on the second column corresponding to the estimated coefficients, it is recognized that the gaps in the three variables (i.e. education, residence time, and experience of health problems at work) actually favour the females whereas the gaps in age, years of experience and current employment status disfavour the females. Of the latter, it is the gap in age that accounts for the bulk of the unexplained gap. It is not so much the levels of explanatory variables that account for inequalities in environment, health, safety, and economic working conditions between male and female artisanal and small-scale goldminers in Southwestern Ghana; it is rather due to discrimination and unobserved heterogeneities.

The coefficient estimates, means, and predictions of each variable for each group, the "high group" in this case being the males and the "low group" being the females. For the first Oaxaca decomposition (Eq. (5)), column 3 of Table 5 enables us to identify how the gap in each of the β's contributes to the overall unexplained gap. For the other decompositions, the contributions of the individual β's can be found by subtracting the explained part given in Table 5 from the group difference in the variable specific predictions given in Table 6. It is emphasized that the unimportance overall of the explained portion is due to offsetting effects from the different xs. The net contribution of the predictors to the gap in working conditions between male and female artisanal and small-scale goldminers is shown in Fig. 3.

5. Discussion

In this study, four counterfactual decomposition techniques were used to evaluate disparities in mean outcomes for environment, health, safety and economic working conditions across two groups—male and female artisanal and small-scale goldminers in Ghana. Artisanal and small-scale goldminers' assessment of the state and trends of working conditions in their workplace, health and safety at work, including the experience of work-related health problems or accidents were considered. Knowledge of the health effects of working conditions in low-income countries is extremely scarce due to the lack of systematic research and the difficulties involved in setting up databases. It is, however, well known that most women in low-income countries still shoulder extremely heavy physical workloads in the household and at the workplace.

Table 5
Decomposition results for variables ($n=588$).

Variables	E (D = 0)	C	CE	Explained: D			
				1	0.5	0.820	*
Education	−0.004	−0.42	0.003	−0.001	−0.002	−0.001	−0.001
Age of artisanal and small-scale gold miner	0.007	0.482	−0.012	−0.005	0.001	−0.003	−0.003
Years of experience	−0.04	0.083	0.062	0.022	−0.009	0.011	0.022
Site of gold mining	−0.002	0.056	0.004	0.003	0.001	0.002	0.003
Residence time	−0.003	−0.291	−0.007	−0.009	−0.006	−0.008	−0.009
Current employment status	0.025	**0.119**	0.035	0.06	0.043	0.054	0.055
Experienced health problems at work	0.001	−0.300	−0.008	−0.007	−0.003	−0.005	−0.005
Constant	0.000	0.407	0.000	0.000	0.000	0.000	0.000
Total	−0.014	0.136	0.078	0.063	0.024	0.049	0.062

Table 6
Coefficients, means and predictions ($n=588$).

Variables	High model (men)			Low model (women)			Pooled
	Coef.	Mean	Predicted	Coef.	Mean	Predicted	Coef.
Education	0.056	1.311	0.074	0.374	1.321	0.494	**0.081**
Age of artisanal and small-scale gold miner	0.097	1.948	**0.189**	−0.144	2.000	−0.288	**0.058**
Years of experience	0.007	7.054	0.051	−0.013	4.038	−0.054	0.007
Site of gold mining	0.005	7.025	0.038	−0.003	6.509	−0.021	0.006
Residence time	−0.016	26.303	−0.413	−0.004	25.698	−0.112	−0.015
Current employment status	0.372	0.710	**0.264**	0.155	0.547	**0.085**	**0.336**
Experienced health problems at work	−0.345	0.755	−0.26	0.062	0.736	**0.046**	−0.256
Constant	0.094	1.000	0.094	−0.313	1.000	−0.313	0.045
Total			0.036			−0.164	

The gap in working conditions between the two groups of goldminers was disaggregated into a part that is due to group differences in the levels of explanatory variables, and a part that is due to differential magnitudes of the regression coefficients. Overall, the gap in environment, health, safety and economic working conditions between male and female artisanal and small-scale goldminers can be largely attributed to differential magnitudes of regression coefficients (*unexplained component*) rather than the levels of explanatory variables (*explained component*). By and large, this implies that the unexplained portion of the mean gap in environment, health, safety and economic working conditions between male and female artisanal and small-scale goldminers may be attributed to discrimination, but it may also emanate from the influence of unobserved variables. Gender-specific differences exist in the important factors that contribute to discrimination in working conditions of the artisanal and small-scale goldminers. In this context, age and years of experience are salient for male artisanal and small-scale goldminers whereas education and number of years lived in the community were more important for women artisanal and small-scale goldminers. Based on the Oaxaca, Cotton, Reimers and Neumark decompositions only 32%, 12%, 25% and 31%, respectively, was accounted for by the productive characteristics of male and female artisanal and small-scale goldminers. This means that regardless of the decomposition technique used, less than a third of this gap is explained by the differences in the productive characteristics of women and men artisanal and small-scale goldminers, such as the level of education reached, the experience accumulated, or the number of hours worked.

In this study, men were over-represented in the sample (82%), indicating that artisanal and small-scale gold mining in the study area is male-dominated. While it is difficult to document the existence of prejudice and gender stereotypes in this study, there are indications that, in some workplaces, such as traditionally male-dominated sectors or sectors where non-standard jobs tend to be concentrated, discriminatory practices towards women exist (Botha and Cronjé, 2015; Rufai et al., 2014; Vincent, 2013).

The gender-based inequality in environment, health, safety and economic working conditions of artisanal and small-scale goldminers identified in this study may culminate in disparities in adverse health outcomes including work-related morbidity and mortality. According to Fletcher et al. (2011), there is a cumulative negative effect of performing a physically demanding or environmentally hazardous job on worker's health, but the effects vary substantially across age and education groups as well as experience. The World Health Organization recognizes fair employment and decent work as a cornerstone of health, and advocates for fair minimum wages, full employment, and occupational health and safety standards (WHO, 2009). Because disparities are socially generated they should, in principle, be correctable. Gender inequities do not only emanate from income disparities; gender is also linked to differential access to health services, unequal obligations to provide unpaid family care duties, and to disparities in nutrition (Berkman and Kawachi, 2000). In the artisanal and small-scale gold mining sector, gender disparities in exposure to environmental and health hazards have been identified as important factors (Heemskerk, 2003; Hinton et al., 2003). For this reason, Veiga et al. (2006) suggest special attention be given to educational and gender issues and opportunities in the artisanal and small-scale gold mining sector.

Gender differences in exposure to risk factors and psychology as well as biological (sex-related) factors and varying social situations produce gender-specific patterns of occupational health problems. Individuals who work in jobs with the worst conditions experience declines in their health (Fletcher et al., 2011). Job characteristics are more detrimental to the health of females and older workers than to men or younger workers, and the adverse health effects increase with the length of exposure to job conditions (Fletcher et al., 2011).

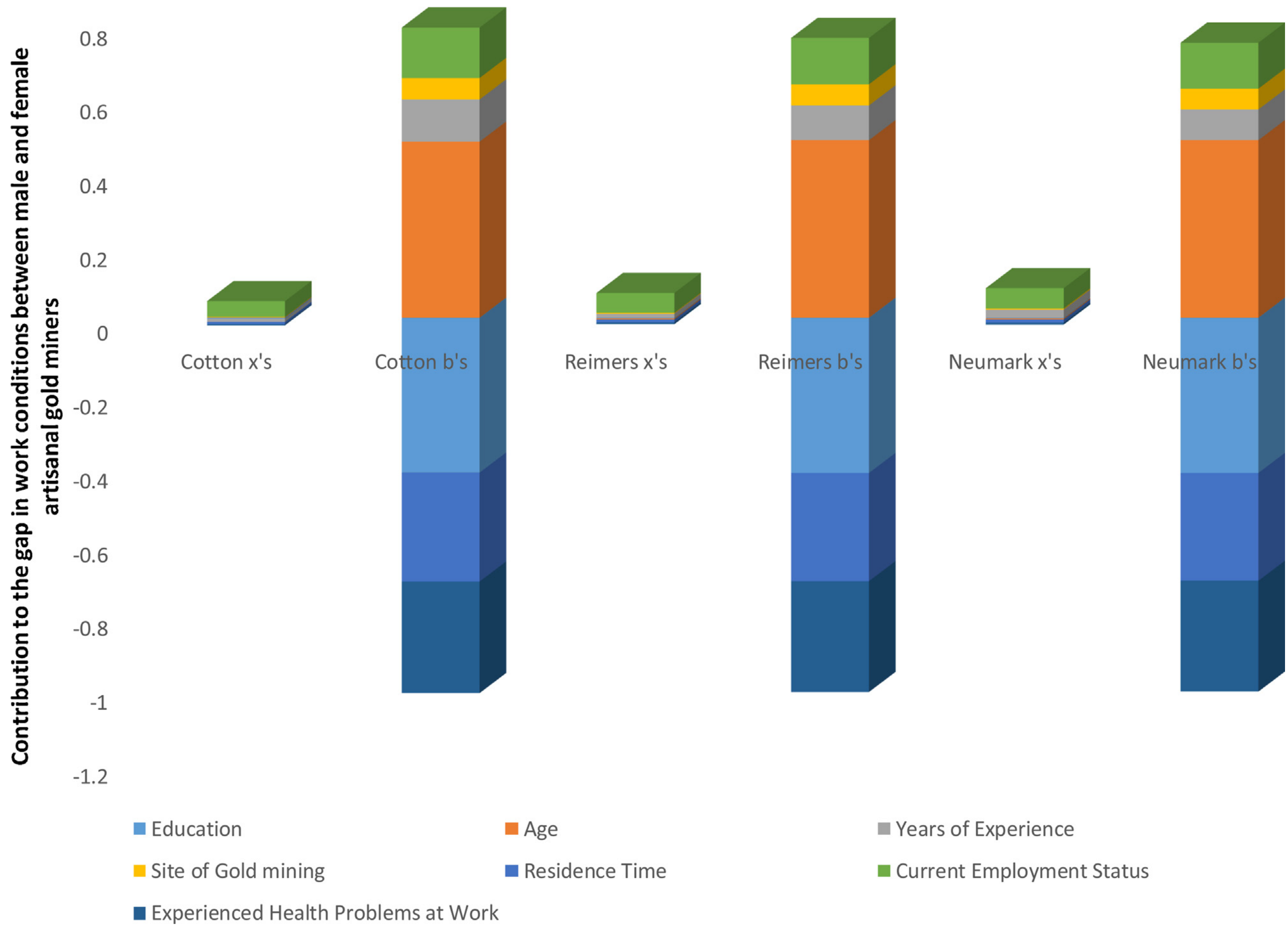

Fig. 3. Contribution to the gap in environment, health, safety and economic working conditions between male and female artisanal and small-scale goldminers.

In particular, education, age, length of residency and experience are known to influence the type of work environment within which people are likely to work. For instance, educational attainment influences the level at which an artisanal and small-scale gold miner will enter the job, the access to work-related resources, and the working conditions. People with more education are more likely to live and work in safe and health-promoting environments. More education generally means a greater likelihood of being employed, and having a job with healthier working conditions, better employment-based benefits and higher wages (RWJF, 2009). Workers with less formal education and training are more likely to hold lower-paying jobs with more occupational hazards, including environmental and chemical exposures (e.g. mercury) and poor working conditions (e.g. shift work with few breaks, potentially harmful tools) that put them at higher risk of injury and fatality (Cubbin et al., 2000). Less-educated workers are also likely to experience more psychosocial stress at work (Almeida, 2005; Fletcher et al., 2011; Grzywacz et al., 2004) and have jobs that make high demands and offer few opportunities for control and skill utilization. Such psychosocial aspects of work, including perceived balance between a worker's efforts and rewards, perceived justice and discrimination in the workplace, and social support among co-workers, have both short- and longer-term impacts on health (RWJF, 2009). Less-educated workers in lower wage jobs also are less likely to have health-related benefits including paid sick and personal leave, workplace wellness programs, and retirement benefits, in addition to employer-sponsored health insurance (Gabel et al., 2002). In contrast, more experienced workers are likely to have better working conditions (Kahya, 2007) and experience is a function of age.

The different determinants of environment, health, safety and economic working conditions frequently manifest at both the individual and community levels. For instance, a person with little education is likely to have an unsatisfactory, poorly paid job and live in poor housing. At the community level, the neighbourhood in which this person lives is likely to be undesirable, perhaps near an artisanal and small-scale gold mine close to water bodies. This complexity makes it difficult to tease out the individual determinants that are linked with individual health outcomes of artisanal and small-scale goldminers. Furthermore, the different determinants can create feedback loops. For instance, overcrowding of workers in gold mining sites may cause increased transmission of infection, which can lead to increased absenteeism and decreased income which forces people to live in overcrowded housing.

This paper advances knowledge by: (1) focusing on environmental, health, safety and economic work conditions, reflecting the importance of cumulative impacts of adverse work conditions on health; (2) adjusting for productive characteristics of women and men artisanal and small-scale goldminers, which helps to understand the relative contribution of productive characteristics and discrimination to the inequality in working conditions between men and women goldminers; and (3) examining subgroup differences in response to working conditions. While this study contributes to the literature by using a cross sectional survey dataset and measuring the joint effects of various dimensions of working conditions (environment, health, safety, economic), there are several limitations with our approach. Endogeneity of the predictors and working conditions do not allow our estimates to have a causal interpretation, although endogenous switching out of work with harsh conditions in order to mitigate negative effects on health suggests our estimates could be lower bounds. In fact, it is likely that individuals for whom artisanal and small-scale gold mining is a means of survival may not switch jobs even though they are conscious of deleterious working conditions. There is also limited information in the data on whether artisanal and small-scale goldminers invest in their health to offset the decrements caused by poor working conditions, which would also make our estimates conservative. Use of self-reported working conditions is both strength and a weakness: it is a comprehensive measure but is not an objective measure.

6. Conclusion

This study assessed the differences in the environment, health, safety and economic working conditions between male and female artisanal and small-scale goldminers operating in Ghana, using four counterfactual decomposition techniques. The inequality in working conditions was disaggregated into a part that is due to group differences in the levels of explanatory variables and a part that is due to differential magnitudes in the regression coefficients. Overall, the gap in environment, health, safety and economic working conditions between male and female artisanal and small-scale goldminers can be predominantly ascribed to differential magnitudes of regression coefficients (*unexplained component*) rather than the levels of explanatory variables (*explained component*). Irrespective of the decomposition technique used, less than 33% of this gap, is explained by the differences in the productive characteristics of women and men artisanal and small-scale goldminers, such as the level of education reached, the experience accumulated, or the number of hours worked. Gender-specific disparities exist in the important factors that contribute to discrimination in working conditions of the male and female artisanal and small-scale goldminers. On the whole, age and years of experience were relevant for male artisanal and small-scale goldminers unlike education and number of years lived in the community, which were rather important for women artisanal and small-scale goldminers. The findings of this study are pertinent to gender-specific occupational health policy and legislation in two broad categories: the treatment of sex differences, and the methods for handling gender-based discrimination at the workplace.

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