

# On-Site Personal Protective Equipment Signage and Use by Road Construction Workers in Ghana: A Comparative Study of Foreign- and Locally-Owned Companies

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## Research article

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# Abstract

**Background:** Road construction work has its own specific set of risks and safety issues. It has not been adequately addressed in most low- and middle-income countries, especially in Africa. The objective of this study was to determine the prevalence of personal protective equipment (PPE) use during road construction activities by workers in foreign-owned against locally-owned road construction companies in Ghana.

**Methods:** An institution-based cross-sectional survey was undertaken during January – March, 2020 to study 389 road construction workers who were actively working on site. They were unobtrusively observed to capture whether or not they wore the appropriate PPE at the time of the survey. The PPE of interest were: hard hat, goggles, shoes, nose masks, hearing protection, gloves, and reflective vests/apparel. On-site posted PPE signage was also checked.

**Results:** Majority of workers were labourers (53.5%) and males (96.9%). Similar numbers of workers in foreign-owned (194) and locally-owned (195) companies were studied. Use of PPE varied considerably by type: goggles (11.3%), hard hat (27.0%), safety shoes (78.7%), gloves (30.6%), hearing protection (10.8%), reflective vest (44.5%) and nose mask (17.2%). For all types of PPE, use was higher among workers in foreign-owned companies compared with locally-owned companies: goggles (Odds ratio [OR] 55.2), hard hat (OR 20.2), safety shoes (OR 4.1), gloves (OR 23.7), hearing protection (OR 52.0), reflective vest (OR 5.3) and nose mask (OR 17.8) ( $p < 0.001$  for all ORs). No site had any signage to promote PPE use.

**Conclusions:** Majority of workers used safety shoes. Less than half of workers used other types of PPE and use of some types (goggles and hearing protection) was minimal. Workers in foreign-owned companies were significantly more likely to use all of the types of PPE. Although there is still room for improvement in foreign-owned companies, locally-owned companies should be able to attain similar PPE use to that in foreign-owned companies. Road construction companies should place a premium on health and safety issues by hiring safety managers with professional training, providing staff with PPE, and training them on proper usage, as well as adopting safety protocols.

## 1.0 Background

Occupational injuries cause approximately 360,000 deaths per year globally. An additional 340 million workers suffer non-fatal injuries [1]. Construction work is especially dangerous [1]. Data are not well known globally, but in high-income countries construction-related deaths account for around 15–20% of all occupational injury deaths [2, 3]. Hence, safety for construction workers is an especially significant issue.

Road construction has its own specific set of safety issues such as different risk exposures, different safety management strategies, and different personal protective equipment (PPE). The work takes place mostly in open environments, exposing the workers to bad weather conditions such as cold, windy, or hot

environments. Many jobs are done by small and short-lived firms, working in constantly changing worksites, which makes monitoring of hazards and injuries more difficult [4–6].

Occupational safety and health is less developed in low- and middle income countries (LMICs) than in high income countries [7]. In particular as regards construction safety in Africa, there have been only a small number of studies, primarily from East Africa and on building construction [8–12]. Gebremeskel and Yimer found a high annual prevalence of injury (33%), but also found that safety training and use of PPE lowered risk of injury [9]. Two studies looked at self-reported PPE use by construction workers in Uganda and Ethiopia, finding rates of use of any PPE of 16–38% [8, 12]. Izudi *et al.* found that PPE use was increased among female workers, permanent employees (as opposed to temporary or casual workers), and among people with previous knowledge of safety.

In one of the few studies on safety for road construction workers in Africa, Nyende-Byakika found that use of PPE was only 14% in Uganda. Most contractors interviewed in the study thought investing in PPE was a waste of money. However, subjectively, there was a greater emphasis on safety on bigger projects, especially those that had international involvement [13].

In order to address the gap in knowledge on safety for road construction workers in Africa, we sought to determine the prevalence of several specific items of PPE among road construction workers. We also sought to determine whether posted PPE signage was adequate. Finally, we sought to determine whether type of company (locally-owned or foreign-owned) was associated with differences in PPE signage or use.

## 2.0 Methods

### 2.1 Setting

An institution-based cross-sectional study was conducted between 27th January and 4th March, 2020. The study was conducted in Ghana, a West African country of approximately 30 million people with Gross National Income of US\$2,220 per capita [14]. Eighteen construction companies actively working on 19 different roads were purposively selected from three regions, namely, Ashanti, Ahafo and Western North. The study sites selected were mostly unpaved roads with the dominant activities being construction of drains and bridges, excavation works, steel cutting and bending as well as fixing, survey activities, grading of road, hauling of laterite and boulders, road surfacing and compaction, demolition works, watering of roads, and bituminous surfacing-related activities among others (Table 1).

Table 1  
Study sites.

Road Visited	Road Type	Purpose
<b>Foreign-Owned Construction Company Sites</b>		
Ahensan to Chirapatre	Urban road	Rehabilitation and upgrading
Terchire to Adrobaa	Feeder road	Gravel to bitumen
Mpasatia to Bedaabout	Feeder road	Gravel to bitumen
Kentinkrono township	Urban road	Gravel to bitumen
Onwe-Achinakrom-Deduako-Kwaso to Donyina	Urban road	Gravel to bitumen
<b>Locally-Owned Construction Company Sites</b>		
Kumasi Airport roundabout to Buokrom	Urban road	Rehabilitation
Fumesua township	Urban road	Gravel to bitumen
Sefwi Wiawso township	Urban road	Rehabilitation
Chirano to Akoti Junction	Feeder road	Gravel to bitumen
Wiawso College of Education area roads	Urban road	Gravel to bitumen
Daban to Ampeyoo	Urban road	Rehabilitation
Pemenase to Ankaase Lakeside	Feeder road	Gravel to bitumen
Kokofu through Amakom to Lake Bosomtwe	Feeder road	Gravel to bitumen
Ahenkro to Tetrem	Feeder road	Gravel to bitumen
Bekwai township	Urban road	Upgrading
Krapa township	Urban road	Gravel to bitumen
Achinakrom area	Feeder road	Gravel to bitumen
Main Nyinahin road to Adobewura	Feeder road	Gravel to bitumen
KNUST Police Station area roads	Urban road	Rehabilitation

## 2.2 Profile of Study Participants

Workers at each construction companies' sites who were working in the following crafts were selected: excavation/earth works, steel bending/erection/fixing, masons, carpenters, welders/electricians, drivers/operators, mechanics, daily labourers, site supervisors, safety officers, architects, quantity surveyors, land surveyors and civil engineers. All workers in each craft were included in the study. A total

of 389 road construction workers who were actively working on site were purposively observed unobtrusively.

### **2.3 Data Collection Procedure**

Road construction workers of foreign- and locally-owned companies were observed without their knowledge with a checklist to capture whether or not they wore the appropriate personal protective equipment (PPE) on site. Research assistants stood on the roadside or sat in cars parked near the construction sites. These were public sites with other passing traffic of vehicles and people and hence the observations could be accomplished without attracting attention. The PPE of interest were hard hat, goggles, safety shoes, nose masks, hearing protection, gloves, and reflective vests/apparel. Safety shoes implied any closed toe shoes as opposed to sandals or other open toe shoes or bare feet. On-site posted cautionary signage was also checked. Posted safety signs on welding arc flash, scaffold safety, safety shoes, no smoking, open trench, machine safety, truck safety, keep away, open trench and fall protection, and signs advising PPE were checked. Data were collected on tablets using Open Data Kit (ODK) software. Data collectors were people with a bachelor's degrees who were given 3 days of training before the project. They were directly supervised on site by the principal investigator (IKY). Data collected were checked for accuracy, completeness and uniformity by the principal investigator at the end of each day's activity.

### **2.4 Data Analysis**

The dependent variables in this study were use of various types of PPE (hard hats, goggles, shoes, nose masks, hearing protection, gloves, and reflective vests/apparel wearing). The independent variables were type of company (foreign-owned vs. locally-owned) and profession of worker. The data collection was done using the ODK App. Data were cleaned and analysed using Stata 16.0 statistical software. Descriptive statistics such as frequency distribution and percentage calculations were derived from the independent variables. Statistical significance was set at  $p < 0.05$ . Relationship of categorical variables was assessed using Chi-square test and Fisher's exact test, where expected values were less than 5. Stratified analysis for the effect of company type on PPE, stratified by type of profession, was performed using Epi Info 7.1.4 statistical software.

### **2.5 Ethical Considerations**

The Kwame Nkrumah University of Science and Technology/Komfo Anokye Teaching Hospital Committee on Human Research, Publications and Ethics (CHRPE), approved the study. Agencies under the Ministry of Roads and Highways (MRH), namely, the Ghana Highway Authority (GHA), the Department of Urban Roads (DUR) and the Department of Feeder Roads (DFR) as well as the construction companies also gave approval for the conduct of the study at their construction sites. Information collected through the observations was anonymous and did not include name or any other identifying information on the workers.

## **3.0 Results**

Data were obtained from 19 sites, 14 run by locally-owned companies and 5 run by foreign-owned companies (Table 1), but primarily hiring Ghanaian workers. There were no personal protective safety signage at any site studied. A total of 389 workers who were actively working on site were observed unobtrusively. Labourers formed the majority of the workers (53.5%), followed by masons (17.5%) and drivers (9.0%) (Table 2). The two most common professions of workers were the same for both types of companies, with minimal differences in proportions of the other professions. There were 12 (3.1%) females and 377 (96.9%) males. The professions of the females were flagsmen (2), labourers (6), supervisors (3) and safety officers (3).

Table 2  
Frequency of Workers by Profession and Company Type

Profession	Foreign Owned		Ghanaian-Owned		Total	
	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent
Carpenters	11	5.7	9	4.6	20	5.1
Concrete Mixer Operator	0	0	1	0.5	1	0.3
Drivers	13	6.7	22	11.3	35	9.00
Flagsmen	4	2.1	0	0	4	1.0
Labourers	88	45.4	120	61.5	208	53.5
Masons	41	21.1	27	13.9	68	17.5
Mechanics	7	3.6	3	1.5	10	2.6
Safety Officers	3	1.6	0	0	3	0.8
Steel Benders	18	9.3	6	3.1	24	6.2
Supervisors	6	3.1	7	3.6	13	3.3
Surveyors	3	1.6	0	0	3	0.8
<b>Total</b>	<b>194</b>	<b>100%</b>	<b>195</b>	<b>100%</b>	<b>389</b>	<b>100.00</b>

For all workers, use of PPE ranged from 78.7% for safety shoes to 10.8% for hearing protection (Table 3). There were notable differences in use of PPE between the two types of companies. For workers in foreign-owned companies, use of PPE ranged from 89.7% for safety shoes to 21.1% for hearing protection. For workers in locally-owned companies, use of PPE ranged from 67.7% for safety shoes to 0.5% for each of hearing protection and goggles. Use of all categories of PPE was significantly higher among workers in foreign-owned companies ( $p < 0.001$  for all categories of PPE, Table 3).

Table 3  
Percentage Personal Protective Equipment Use by Company Type

	<b>N</b>	<b>Goggles</b>	<b>Hard Hat</b>	<b>Safety Shoes</b>	<b>Gloves</b>	<b>Hearing Protection</b>	<b>Reflective Vest</b>	<b>Nose Mask</b>
Foreign-owned	194	22.2%	49.5%	89.7%	56.2%	21.1%	63.9%	32.0%
Locally-owned	195	0.5%	4.6%	67.7%	5.1%	0.5%	25.1%	2.6%
Total	389	11.3%	27.0%	78.7%	30.6%	10.8%	44.5%	17.2%
Odds Ratio		55.2	20.2	4.1	23.7	52.0	5.3	17.8
<i>p-value</i>		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
95% CI		7.5-405.8	9.8-41.8	2.4-7.2	11.8-47.6	7.1-382.2	3.4-8.2	7.0-45.6

CI: Confidence intervals

There were also differences in use of PPE by different type of professions, with significant differences among the professions for all types of PPE (Table 4). Flagsmen and safety officers had 100% use of several types of PPE (hard hats, safety shoes, and reflective vests). The only concrete mixer observed was using only safety shoes and no other PPE. As a whole, labourers had less than 50% use of all types of PPE, except for safety shoes. Given the different nature of the work for the different professions, one would not expect every profession to use every PPE all of the time. However, one would expect everyone to wear safety shoes and hard hats and, as the works sites were at road sides, one would expect all workers to wear reflective vests. Use of safety shoes was over 90% for all professions, except for labourers and masons, each of which had around a third of workers not wearing safety shoes. Only two of the 11 professions had 90% or greater use of hard hats and only three of the professions had 90% or greater use of reflective vests. In terms of specific occupations with specific PPE needs, one would especially expect use of gloves among steel benders, but use was only 20.8%. Likewise, one would expect use of hearing protection among mechanics and concrete mixer operators, for which use was only 40.0% and 0% respectively.

Table 4  
Percentage Personal Protective Equipment Use by Profession

	N	Goggles (%)	Hard Hat (%)	Shoes (%)	Gloves (%)	Hearing Protection (%)	Reflective Vest (%)	Nose Mask (%)
Carpenters	20	15.0	25.0	95.0	55.0	15.0	60.0	35.0
Concrete Mixer Operator	1	0.0	0.0	100	0.0	0.0	0.0	0.0
Drivers	35	11.0	20.0	94.3	14.0	8.6	65.0	11.0
Flagsmen	4	75.0	100	100	75.0	50.0	100	75.0
Labourers	208	7.7	22.6	71.2	23.1	7.2	34.6	13.0
Mechanics	10	40.0	50.0	100	60.0	40.0	90.0	40.0
Masons	68	16.2	29.4	73.5	33.8	17.6	50.0	22.1
Safety Officers	3	66.7	100	100	66.7	66.7	100	100
Steel Benders	24	4.2	33.3	100	20.8	0.0	70.8	25.0
Supervisors	13	7.7%	30.8	92.3	30.8	7.7	61.5	7.7
Surveyors	3	0.0	66.7	66.7	0.0	0.0	33.0	0.0
<i>p-value</i>		<i>&lt; 0.001</i>	<i>0.002</i>	<i>&lt; 0.001</i>	<i>0.01</i>	<i>&lt; 0.001</i>	<i>&lt; 0.001</i>	<i>0.005</i>
<b>Total</b>	<b>389</b>							

Given the fact that labourers had less PPE use than most other professions (Table 4) and that labourers were more common in locally-owned companies than in foreign-owned companies (Table 2), it is possible that the difference we observed in PPE use between company types might be explained by the higher percentage of labourers working in locally-owned companies. Hence, we further evaluated PPE use by company type, looking at the differences stratified by labourers vs. all other professions (Table 5). The differences between companies persisted, with statistically higher use of all types of PPE by workers in foreign-owned companies than in locally-owned companies, both for labourers and for all other professions. Odds ratios adjusted for type of profession were significantly higher than one for all types of PPE and were minimally different from the univariate odds ratios (Table 3).

Table 5  
Use of Personal Protective Equipment by Type of Company and Category of Worker.

	N	Goggles	Hard Hat	Shoes	Gloves	Hearing Protection	Reflective Vest	Nose Mask
Labourer								
Foreign-owned	88	17.0%	45.5%	87.5%	61.4%	15.9%	61.4%	26.1%
Locally-owned	120	0.8%	5.8%	59.2%	5.0%	0%	15.0%	3.3%
<i>p value</i>		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Total	208							
All other professions								
Foreign-owned	106	26.4%	52.8%	91.5%	51.9%	25.5%	66.0%	36.8%
Locally-owned	75	0%	2.7%	81.3%	5.3%	1.3%	41.3%	1.3%
<i>p value</i>		< 0.001	< 0.001	0.043	< 0.001	< 0.001	< 0.001	< 0.001
Total	181							
Adjusted Odds Ratio*		57.5	20.4	3.8	24.3	43.8	4.8	17.8
95% CI		7.3-451.8	9.8-42.8	2.2-6.6	11.9-49.4	6.2-311.3	3.1-7.4	6.8-46.2
<i>p value</i>		< 0.001	< 0.001	0.043	< 0.001	< 0.001	< 0.001	< 0.001

\*Mantel-Haenszel adjusted odds ratio for the effect of company type (foreign-owned vs locally-owned) on use of personal protective equipment, adjusted for type of profession (labourer vs. all other professions).

CI: Confidence intervals

## 4.0 Discussion

This study sought to determine the prevalence of use of seven types of PPE by road construction workers in Ghana. It also sought to determine the presence or absence of signage related to use of PPE. No site had any type of signage cautioning workers to use PPE of any kind. PPE use was moderate and ranged from most workers using safety shoes to very few workers using goggles or hearing protection. PPE use varied among the professions, being higher among flagmen and safety officers and lower among labourers. PPE use varied dramatically by type of company. Workers in foreign-owned companies used all of the seven types of PPE significantly more often than workers in locally-owned companies.

This is one of the first studies to address PPE use by road construction workers in Africa. In one of the few prior studies on this topic, Nyende-Byakika studied four road construction sites in Uganda [13]. Interviews with workers and managers were conducted. Self-reported use of PPE ranged from 0–20% for the different sites, averaging 14%. Subjectively, many contractors indicated that they felt investing in PPE was not warranted. There have been several other studies that reported PPE use and other aspects of safety among building construction workers in Africa [8–12]. Alemu *et al.* interviewed 206 building construction workers in Addis Ababa, Ethiopia. They reported 38% use of PPE. Main reasons stated for not using PPE were lack of availability and lack of orientation to how to use it [12]. Izudi *et al.* interviewed 385 building construction workers in Kampala, Uganda. Self-reported use of PPE in the past two days was 15.6%. Factors associated with PPE use were previous knowledge of safety measures, status as a permanent employee (as opposed to temporary employees or casual workers with no contract), and female sex. Twenty percent of the workers they studied were female [8]. Although construction work is usually considered as male dominated [15], the proportion of female construction workers in the other studies in East Africa ranged from 24–48% [9, 11, 12]. The current study had a much smaller proportion of women (3.1%). The distribution of interviewees was not reported by sex in the road construction study from Uganda noted above [13].

This study thus adds to the literature on PPE use by construction workers in Africa, and especially by road construction workers. It uses direct observation of PPE use, in comparison to the self-report used by the above studies and it reports on use of specific types of PPE. The types of PPE evaluated in the current study protect against injuries (e.g. hard hats and safety boots), as well as lung damage from dust and silica inhalation (e.g. nose masks), and hearing loss (e.g. hearing protection). The effectiveness of the various types of PPE is well documented [16, 17]. It is also notable that one of the above studies from Ethiopia reported an annual prevalence of injury of 32.6%. This was decreased by half by both PPE use and safety training [9].

It is also notable that the current study showed a large difference between foreign-owned and locally-owned companies. This was partly because in Ghana, in general, workers of foreign owned companies are mostly supplied with PPE by their employers and refusal to wear it attracts sanctions. On the other hand, workers of locally-owned construction companies are largely expected to procure their own PPE and there are no sanctions for not using it. To our knowledge, this is the first study showing such a difference in PPE use among different types of construction companies, especially in Africa. There have been several reports of the effect of different management practices. For example, in Addis Ababa, Ethiopia, Alemu *et al.* reported that prior training in PPE use and presence of on-site supervisors both increased use of PPE around five-fold each [12]. Nyende-Byakika looking specifically at road construction workers in Uganda reported that, subjectively, workers felt that there was a bigger emphasis on safety by the same companies on bigger projects that had international involvement [13]. A study conducted in Kenya by Mitullah *et al.* revealed differences in safety practices depending on the type of worker. About 70% of casual workers were not provided with welfare-related facilities and safety materials at most project sites [18].

The current study showed that none of the 19 sites visited had signage about PPE use. The one other study on PPE use in road construction in Africa in the literature reported that all four sites studied had signage to warn passing vehicles to slow down, but did not comment on signage about PPE [13].

The above discussion has sought to put the current study into context of other African countries. It is also important to note that similar issues on construction safety pertain in many other low- and middle-income countries. For example, a study of 23 building construction companies in Jordan revealed that only nine had safety policies and most construction sites visited had no evidence of health and safety practices in place, such as posted safety signs or PPE in use [19]. In Honduras, interviews with 108 building construction workers and 18 managers revealed that management did not feel it was in their interests to improve safety, only 25% of companies had safety programmes, and workers rarely used PPE [20]. In Indonesia, a study of 200 construction workers at an airport renovation project showed that only 25% used PPE consistently [21].

Before drawing conclusions from the data, the study limitations should be addressed. First, construction sites were selected purposively, rather than randomly. This was necessary as permission from the government highway authorities and the construction companies was needed in advance. Second, as observations were carried out anonymously and unobtrusively with no interactions with the workers, the only information on the worker's characteristics that could be gathered was gender and profession. This limited the ability to analyse associations between other worker characteristics and PPE use. Third, observations of PPE use were one time and it was not possible to ascertain usage over time during the course of a shift. Despite these limitations, the study has the strengths of being one of the first studies to address PPE use in road construction workers in Africa, of having a large sample size, and of using direct observation, which is more reliable than self-report.

## 5.0 Conclusion

This study found that PPE use among road construction workers in Ghana was incomplete and varied with type of PPE and profession of worker. Use ranged from most workers using safety shoes to very few workers using goggles or hearing protection. PPE use was highest among flagsmen and safety officers and lowest among labourers. A notable finding of the study was the large differences in PPE use between different types of companies. Workers in foreign-owned companies used all of the seven types of PPE significantly more often than workers in locally-owned companies. Although foreign-owned companies might be slightly better resourced than locally-owned companies, there is no reason why locally-owned companies should not be able to achieve similar usage of PPE as that achieved by foreign-owned companies. Although there is still room for improvement in PPE use by foreign-owned companies, a feasible next step for occupational safety for road construction in Ghana is to increase use of PPE among locally-owned companies to that in foreign-owned companies. This could be achieved by low-cost and simple means such as companies hiring safety managers who have professional training and by providing needed PPE to workers.

# List Of Abbreviations

CHRPE - Committee on Human Research, Publications and Ethics

DFR - Department of Feeder Roads

DUR - Department of Urban Roads

GHA - Ghana Highway Authority

LMIC - Low- and Middle Income Countries

ODK - Open Data Kit

PPE - Personal Protective Equipment

## Declarations

**Ethics approval and consent to participate.** Approved by the Committee on Human Research, Publications and Ethics (CHRPE) of the Kwame Nkrumah University of Science and Technology. Approval number: CHRPE/AP/544/19. Data were gathered by unobtrusive observation of public behaviour, there was no interaction with participants, and no names or other identifying information were gathered, and hence consent, whether verbal or written, was deemed not to be required by the CHRPE.

**Consent for publication.** Not applicable.

**Availability of data and materials.** The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

**Competing interests.** The authors declare that they have no competing interests"

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**Authors' contributions.** IKY, EOD, CM, PD, FA and EO conceived the study design. IKY gathered and analysed the data and wrote the first draft of the paper. All co-authors provided input to the study design and data analysis, read the paper, revised it critically for important intellectual content, and gave their final approval for the version to be published. The guarantor for the paper is IKY.

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