UNIVERSITY OF GHANA, LEGON

PERI-URBAN ENVIRONMENT, SANITATION AND HEALTH - ASSOCIATED HEALTH RISKS IN WASTE HANDLING IN PRAMPRAM, GHANA

BY

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DECLARATION

Candidate's Declaration

I declare that apart from references to other researchers' works which have been duly cited, this research is my original work carried out in the Department of Biological Environmental and Occupational Health Sciences (BEOHS), School of Public Health (SPH), College of Health Sciences (CHS), University of Ghana (UG), Legon, Department of Parasitology, Noguchi Memorial Institute for Medical Research (NMIMR), CHS, University of Ghana, Legon, Department of Bacteriology, NMIMR, CHS, University of Ghana, Legon and the Department of Immunology, Microbiology and International Health, Copenhagen School of Global Health, University of Copenhagen, Denmark, under the supervision of Dr. M. Dzodzomenyo and Dr. I. Ayi.

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Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of a thesis laid down by the University of Ghana, Legon.

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ABSTRACT

The peri-urban community of Prampram is characterized by filthy and choked open drains, indiscriminate waste disposal and open defecation. Waste handlers engage in different types of activities such as sweeping, collection, transportation and disposal with little or no personal protection and thus are often confronted with serious public health problems related to their work.

The purpose for this study was to assess the different degrees of health risks associated with different activities in waste handling in the peri-urban community of Prampram, Ghana.

This study used a mixed method design to quantitatively investigate 280 waste handlers with respect to the activities performed, exposure surfaces to waste, use of personal protective working gear and self reported health outcomes. A qualitative phase of the study involving 22 waste handlers explored the perceptions about health risks associated with waste work. The rationale for including the qualitative phase was to triangulate and complement the quantitative phase of the study. Laboratory methods were also used to investigate faecal contamination of hands by the detection of faecal indicator *E. coli*/Coliforms as well as to determine the incidence rate and intensity of helminthes infections 3 and 6 months post-treatment.

The most common self-reported health problems were bodily pains (56.4%), headache (38.6%), fever (35.7%) and diarrhoea (11.4%). There was an association between working with smelling/odorous waste material and reported fever ($p < 0.05$) as well as contact of exposed bodily surfaces to waste with reported skin disease ($p < 0.05$). The perception about reporting health problems due to working

with smelling waste material was corroborated by one 35-years old female waste handler who collected human faeces from the beach each morning when she explained how inhalation of 'bad air' could lead to health problems such as nausea.

Waste handlers whose hands were directly exposed to waste material were 4.2 times (95%CI: AOR 1.4-10.0) more probable to report cough symptoms than those whose hands were not exposed. The odds of reporting upper back pain among waste handlers who performed three activities a day (sweeping, collection and disposal) was 4.1 times (95%CI AOR: 1.6-11.0) greater than those who only swept every day. Waste handlers who swept every day have 70% less risk of developing upper back pain compared to those who performed two activities per day (disposal and collection). The odds of reporting upper back pain was 2.2 times (95%CI AOR: 0.6-8.0) higher among those who transport waste compared to those who sweep.

There was a significant difference ($p < 0.0001$) in the level of faecal contamination of the hands of waste handlers before and after engaging in waste handling activities, by detection of both indicator *E. coli* and Coliforms. The proportion of waste handlers that tested positive to faecal indicator *E. coli* was 23.2% (95%CI: 18.4-28.8). The mean log concentrations/level of indicator *E. coli* among waste handlers was 0.079 ± 1.6 CFU/50ml. There was also a significant difference ($\chi^2 = 18.8$, $p = 0.0086$) in the mean log concentration/level of faecal indicator *E. coli* among the types of waste handling activities. There was a significant difference ($p = 0.0083$) in the level of faecal indicator *E. coli* among waste handlers who only engaged in sweeping every day and those who performed two or more waste management activities such as sweeping, collection and disposal.

Helminthes infections among waste handlers correlated with the type of waste handling activities based on the likelihood ratio Chi-square test statistic (LR=15.3, p = 0.033). The mean intensity of helminthes infection among waste handlers 6 months post-treatment with Albendazole (400mg) single oral dosage was 2.8 egg/gram, indicating light intensity whilst the incidence rate of helminthes infections was 1.46% per month. The proportion of waste handlers who experienced light intensity helminthes infection was 4.3% after 6 months post-treatment. Waste handlers who used rubber gloves during work were 80% less likely to acquire helminthes infections compared with those who did not use gloves. The detection of faecal indicator *E. coli* on hands of waste handlers was corelated with helminthes infections ($p < 0.0001$) and nine waste handlers (3.2%) tested positive for both indicator *E. coli* and helminthes.

There is an increasing number of waste handlers in the peri-urban community of Prampram engaged in different types of waste handling activities, who also belong to different waste management organizations. These waste handlers have different levels of exposures to waste and reported with different degrees of health outcomes. It was clearly demonstrated by this study that using bare hands to perform waste handling activities increases the likelihood of reported health problems, contamination of hands by faecal material and infection with *Trichiuris trichiura*. Thus waste handlers experience a burden of disease which is likely to be consequences of their occupation. Private companies and government institutions employing waste handlers in the peri-urban community of Prampram must ensure periodic anti-helminthic treatment of waste handlers (at least every 6 months), provide adequate hand washing and hygiene facilities (soap and water) as well as suitable and affordable personal protective working gear to waste handlers and supervise their use during work.

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DEDICATION

This work is dedicated to God the Father, Son and Holy Spirit.

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LIST OF ABREVIATIONS

ACI – Azongtaba Cottage Industry

CBOs – Community-based organizations

CEO – Chief Executive Officer

CFUs – Colony Forming Units

CHF – Cooperative Housing Foundation

DHRC – Dodowa Health Research Centre

DWD – Dangme West District

ENVIROCON – Environmental Consciousness Club

EPA – Environmental Protection Agency

Epg – Egg per gram

ERC – Ethical Review Committee

ESPA – Environmental Services Providers Association

GCA – Ghana Clean Advocacy

GDP – Gross Domestic Product

GFWSC – Ghana Fair Wages and Salaries Commission

GHC - Ghana Cedis

GHS – Ghana Health Service

GSS – Ghana Statistical Service

HDSS – Health and Demographic Surveillance Site

ILO – International Labour Organization

IRB – Institutional Review Board

JMP – Joint Monitoring Programme

MDAs – Ministries Departments and Agencies

MDGs – Millennium Development Goals

MLGRD – Ministry of Local Government and Rural Development

MMDAs – Metropolitan, Municipal and District Assemblies

NACONWAM – National Coalition of NGOs in Waste Management

NESP – National Environmental Sanitation Policy

NESSAP – National Environmental Sanitation Strategy and Action Plan

NGOs – Non-governmental organizations

NYEP – National Youth Employment Programme

PPG - Personal Protective Gear

SIM – Sulphur Indole Motility media

SUSA – Sustainable Sanitation

TNTC – Too Numerous to Count

TSI – Triple Sugar Iron

UNICEF – United Nations Children Fund

USD – United Sates Dollar

WHO – World Health Organization

WMO – Waste Management Organization

ZL – Zoom Lion

DEFINITION OF TERMS

Waste handlers were defined as those who either worked for waste management companies and institutions or as volunteers who directly handle waste materials along the waste management chain. Waste handlers included sweepers, collectors, transporters and disposers of waste. The type of *waste* managed included solid waste; solid waste mixed with fresh and decomposed human faeces or effluents from domestic waste pipes and septic sludge from tanks emptied into open drains.

Peri-urban area was defined as an interface between rural and urban setting, having a high population density, high prevalence of open defecation and inadequate sanitation infrastructure.

1.0 CHAPTER ONE – INTRODUCTION

1.1 BACKGROUND TO STUDY

The world is faced with increasing challenges regarding the provision of sustainable sanitation and waste management, especially in Africa and other developing countries. Proper solid waste management is an important component of sound environmental sanitation and sustainability. A combination of sustainable environment, sanitation and improved waste management offers opportunities to reduce health hazards and to reduce the chances of acquiring sanitation-related diseases.

It is well known that sanitation related diseases, to a large extent, have the potential of crippling productivity, reducing manpower and for this reason are generally understood to weaken national and local economies. The World Health Organization (WHO) estimates that 7% of the world's deaths and 8% of global disease burden are caused by sanitation related diseases. Poor sanitation is also a major risk factor for diarrhoeal diseases, causing high morbidity and mortality (WHO, 2008). Ghana faces similar waste management and sanitation challenges and as such, a wide range of approaches is being considered in order to improve sanitation and waste management in the Ghanaian communities.

In Prampram in the Dangme West District (DWD) of the Greater Accra Region of Ghana, the solid waste management situation is worsened by poverty, poor infrastructure, lack of awareness and inadequate human resources. Thus Prampram, the largest peri-urban area in the DWD, is faced with several waste management and sanitation problems. A large proportion (about 73 per cent) of households in the Prampram community has no toilet facilities and the residents therefore use the

bush, beach or field for open defecation (Asante and Oduro, 2006). Most toilet facilities in the district do not meet the standards of improved toilets and waste disposal methods are not environmentally safe or hygienic. Defecation in the open is a common practice. There is therefore high concentration of both liquid and solid waste, mixed with human faecal matter all over the Prampram township (SUSA Baseline Report, 2011).

Though waste generation is inevitable, only few people within peri-urban settings properly adhere to conventional waste management practices. Waste management practices such as sweeping, collection, transportation and disposal are usually carried out at Prampram with little or no personal protection by waste handlers. Persons engaged in waste handling practices are therefore confronted with serious public health problems related to sanitation/waste handling. They may be at risk of acquiring sanitation related diseases such as diarrhoea through ingestion of helminthes eggs, respiratory tract problems (coughing and occupational asthma) through inhalation of poisonous gases/dust, skin infections through direct skin contact with contaminants in solid waste. Information from the Dangme West District Health Administration has indicated that respiratory tract infections (including coughing) and diarrhoea are among the top three diseases reported at health facilities in the District.

Zerbock (2003) reported that due to lack of sanitation facilities in most peri-urban areas, human faecal matter is always found mixed with solid waste which exposes waste handlers to high risk of faecal contamination. Direct exposure of body surfaces to faecal matter is associated with increased health risks, especially among waste handlers (Cointreau, 2006; Waddington, 2009). As reported by the Sustainable Sanitation (SUSA) baseline report (2011), health risk factors among waste handlers may be attributable to the following: the lack of appropriate protective working gear and/or their

improper usage among waste handlers: lack of access to sanitation and hygiene facilities by majority of the trekking population during working hours; or lack of awareness of the health risks in poor hygiene and sanitation behaviour. All these factors may be associated with health risks such as helminthes infections and contamination of hands with faecal matter among waste handlers.

Intestinal helminthes infections are very common in peri-urban communities in Ghana largely due to poor sanitation, poor hygiene and direct physical contact of unprotected skin with faeces-contaminated soil or solid waste material in which helminthes or their infective agents reside (Ghana National Drugs Programme, Standard Treatment Guidelines, 2011). Even though waste handlers may not be showing symptoms of clinical helminthiasis, they may yet be at risk of acquiring helminthes infections and become sources of transmission to members of the community.

The level of faecal contamination of hands during waste handling may lead to transmission of faeco-oral pathogens and its associated health risks. The level of contamination of the hands by *E. coli*/Coliforms is a common indicator of transmission of sanitation related diseases and commonly used to assess exposure among health-care workers and food handlers (de Wit and Rombouts, 1992; Pickering *et al.*, 2010; Todd *et al.*, 2010; Pickering *et al.*, 2011). However, there is no published data on the degree of contamination of hands by *E.* coli/Coliforms among waste handlers in Ghana.

Meanwhile, due to open defecation and presence of human faecal matter in peri-urban solid waste (Zerbock, 2003), the risk of contamination of hands by faecal matter among waste handlers in peri-urban communities of Prampram may be more widespread compared with health care workers or food handlers. The concentration of faecal contamination of hands among waste handlers may

indicate the level of associated health risks and can be used as an indicator to monitor changes in exposure levels over time.

Non-communicable conditions such as injuries and musculoskeletal pains could also differ among waste handlers performing different activities in Prampram compared to the general population. Solid waste handling activities such as sweeping, collection, transportation or disposal of waste materials involve vigorous physical body movements in pushing, pulling, bending, or carrying heavy objects. Such activities predispose waste handlers to physical body injuries and musculoskeletal pains such as neck, wrist and back pains (Palmer, 2003; Quansah, 2005; Fejer *et al.*, 2006; Mehrad *et al.*, 2008; Tiwari, 2008; Kanchanomai *et al.*, 2015).

Furthermore, inhalation of poisonous gas through burning of solid waste material or through working in close proximity to dumping sites or toilet facilities and lack of nose masks may contribute to respiratory tract diseases. Similarly, lack of proper protective clothing and exposure of bare skin to waste contaminants may lead to skin diseases among waste handlers. An analysis of self-reported waste handling related injuries, musculoskeletal pains, respiratory and skin diseases among waste handlers in the peri-urban community of Prampram is essential in estimating health risk factors associated with different solid waste handling activities.

Even though the magnitude of health risks may be attributed to one's own beliefs, others perceive that health risks associated with one's occupation are unavoidable (Mutha *et al.*, 1999). There is the need to explore experience and perception of health risks among waste handlers in Prampram specifically relating to exposure to waste material, personal protection as well as access to sanitation and hygiene facilities during waste handling. It is also imperative that indigenous experience and

perceptions about health risks in waste handling should be incorporated in evaluating programs aimed at reducing these risks and improving public health among waste handlers (Tate *et al.*, 2003).

1.2 Problem Statement

Rapid population growth, increased migration and the resultant increase in population density, places enormous pressure on the already few existing sanitation and waste management facilities within the peri-urban community of Prampram. The community is therefore faced with critical sanitation and waste management challenges. According to the SUSA baseline report (2011), Prampram is characterized by filthy and choked open drains, indiscriminate waste disposal, huge waste pile-up and open defecation. There is therefore high concentration of human faecal matter within the communities and faecal matter is almost always present in solid waste materials.

Waste workers handling such wastes are constantly exposed to biological and physical hazards, and may suffer severe health consequences arising from waste handling. Even though the Environmental and Sanitation Directorate of the local Municipal and District Assemblies as well as some private waste management organizations support waste handlers by providing rudimentary equipment and personal protective working gear, these interventions are woefully insufficient. The lack of education and training of waste handlers, lack of provision of hygiene facilities by employers and the overwhelming task of removal of huge waste pile-up in Prampram, may all contribute to the burden of exposure to health risks in waste handling.

Waste handlers are therefore at risk of infections not only with soil transmissible helminthes, but also from other biological agents including bacteria, through contamination of the hands with human

faecal matter. In addition, waste handlers are at risk of developing musculoskeletal pains due to strenuous bodily movements during waste handling and removal. Respiratory tract infections may arise due to the inhalation of gaseous and particulate contaminants in waste and skin diseases due to direct physical contact with same, among other non-specific symptoms of diseases.

Even though there is available information on occupational health risks faced by waste handlers in North America (Rendleman and Feldstein, 1997) and Brazil (Gutberlet *et al.*, 2013), there is limited published research on health risks to waste handlers in Ghana with none focusing on those in peri-urban communities. Again, existing studies on waste management in Ghana report mainly on the nuisance aspects of waste pile-up due to poor management (Fobil *et al.*, 2008; Ampofo 2013) and not direct health risk factors that solid waste handlers are exposed to and associated disease problems.

The health problems resulting from the handling of solid waste and associated health risks in urban and rural settlements have been well documented (Johannessen *et. al.*, 2000; Jenkins, 2005; Porta *et. al.*, 2009). However in peri-urban communities, the existence of higher population densities as compared with rural areas, widespread open defecation and the lack of and/or inadequate basic sanitation services, threatens the health of waste handlers in these settings. According to a survey conducted in Accra by Boadi (2004), the evidence of open defecation in an urban setting was 2.5% compared with 77% in the peri-urban community of Prampram as reported by the SUSA baseline study (2011). Peri-urban communities have a mixture of both rural and urban characteristics; therefore understanding the health risks among waste handlers in such transitory communities and populations, would be of immense public health significance. Thus, being the largest peri-urban community in the Dangme West District, understanding the health risks associated with waste

handling activities in Prampram would be critical in designing environmental sanitation programs aimed at health promotion in these settings in Ghana.

1.2.1 Research Questions

This research therefore sought to answer the following questions;

1. What is the effect of exposure of bodily surfaces and use of personal protective working gear on self-reported health problems among waste handlers in Prampram?
2. How does waste handling activities correlate with specific self-reported health problems, contamination of hands with human faeces and incidence of helminthes infections in Prampram?
3. What is the measure of contamination of hands by faecal matter among persons engaged in waste handling?
4. What is the incidence rate and intensity of helminthes infections among waste handlers performing different waste management activities three and six months post treatment with an anti-helminthic drug?

1.3 Justification

Prampram is characterized by weak waste management systems and inadequate sanitation facilities. Widespread defecation by residents in open spaces poses environmental and public health risks, particularly to waste handlers in this community (Zerbock, 2003). Direct physical exposure of bare bodily parts to waste contaminants among waste handlers is a risk factor for acquiring microbial infections, especially helminthes infections. The vigorous and strenuous bodily movements

associated with the handling and removal of huge waste pile-up also expose waste handlers to various musculoskeletal bodily pains and injuries, in addition to other non-specific health problems.

The need therefore to assess health risks associated with waste handling within the peri-urban community of Prampram, to classify the waste handlers based on type of activity, type and level of exposure to health risk factors and use of personal protective working gear; investigate self reported health problems associated with waste handling, as well as contamination of hands and determination of incidence rates and intensity of helminthes infection all become very necessary.

The information generated from carrying out this research would help to improve knowledge and address the increasing challenges of health risks associated with waste handling in peri-urban communities in Ghana.

1.4 Main Objective

To investigate the different degrees of health risks associated with different activities in waste handling in the peri-urban community of Prampram, Ghana.

1.4.1 Specific Objectives

1. To assess the effect of exposure of bodily surfaces and use of personal protective working gear on self-reported health problems among persons engaged in waste handling in Prampram
2. To assess the extent to which waste handling activities correlate with specific self-reported health problems, contamination of hands with human faeces and incidence of helminthes infections in Prampram.
3. To determine levels of contamination of hands by faecal material among persons engaged in different waste handling activities in Prampram.
4. To determine the incidence rate and intensity of helminthes infections among persons engaged in waste handling in Prampram.

1.6 Conceptualized Framework

Waste handlers perform different activities which may include sweeping, collection, transportation or disposal during waste handling. Frequently, it is the manner in which faecal matter is mixed with solid waste (biological hazard), strenuous bodily movements during pushing, pulling and lifting of waste bins (physical hazards) or the exertion of awkward bodily postures (ergonomics) that serve as sources of health hazards to waste handlers. Weak administrative interventions such as the lack or inaquate provision and supervised use of personal protective equipment for waste handlers may also predispose workers to acquire health problems.

The exposure of waste handlers to microbial or pathogenic agents in waste materials coupled with other health conditions such as musculoskeletal pain, respiratory tract or skin diseases may differ

according to the different types of activities in waste handling. Such differences in waste handling activities may further predispose waste handlers to different risk levels for acquiring microbial infections. This study therefore focused on the incidence and intensity of helminthes infections as well as risk of faecal contamination of hands which may be associated with the different waste handling practices in Prampram. The different waste handling activities may also be risk factors for acquiring musculoskeletal pains, respiratory and skin diseases as well as other non-specific health problems among waste handlers. The conceptual framework is as presented in Figure 1.1.

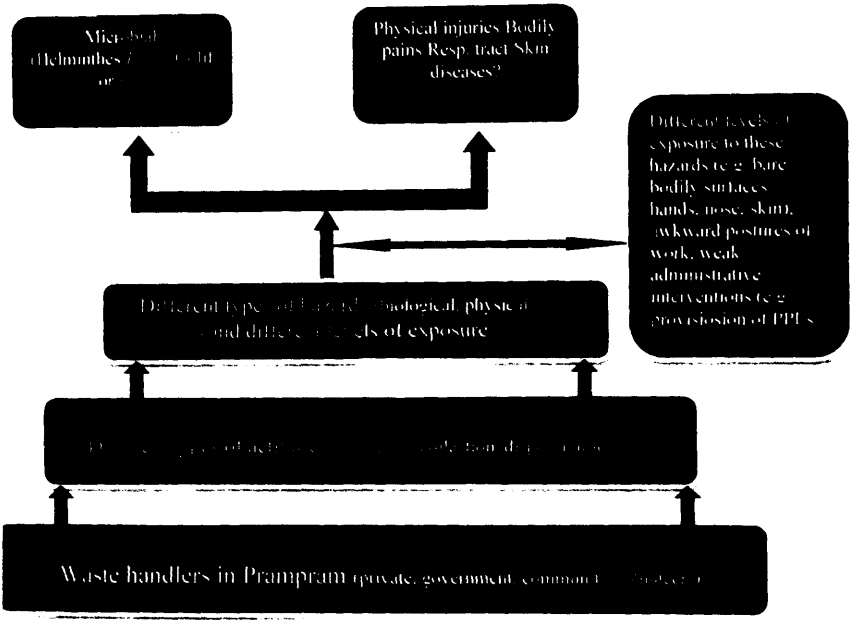

FIGURE 1.1: CONCEPTUAL FRAMEWORK

1.7 HYPOTHESES

The study hypothesized the following:

1. The degree of health risks associated with waste handling among waste handlers in Prampram differ significantly according to different types of activities carried out.
2. The concentration of faecal indicator *E. coli* and Coliforms on hands of waste handlers before work differ significantly according to different types of activities after work.
3. The incidence rate and intensity of helminthes infections 3 and 6 months post-treatment with Albendazole (single oral dose) are significantly different across different waste handling activities.

2. 0 CHAPTER TWO – LITERATURE REVIEW

2.1 GENERAL OVERVIEW OF WASTE MANAGEMENT IN GHANA

The basic objectives of waste management are to protect public health, reduce health risks to those involved and preserve the natural environment against waste pollution (Hardoy *et al.*, 2001; Pacione, 2005). Thus, waste management encompasses all the activities undertaken to reduce the volumes of accumulated waste and its adverse impact on public health and the environment (Gladding, 2002). Waste management processes may include collection, transportation, treatment, recycle or re-use and final disposal (Tchobanoglous *et al.*, 1993; Ackerman, 2000; Ackerman, 2005; Bogner *et al.*, 2007).

In Ghana, increasing population and rapid urbanization have led to increased waste generation and waste management problems (Boadi, 2003; Fobil *et al.*, 2008). In 2010, the Ghana National Environmental Sanitation Strategy and Action Plan (NESSAP) reported that 25.9% of households in Ghana dump their waste in unapproved dumping sites (gutters, streams, drains, lagoons) whilst more than 70% of Ghanaians practice indiscriminate waste disposal. The effect of indiscriminate dumping of waste leads to accumulation of huge volumes of waste piled up in public open spaces, along streets, beaches, and in open drains both in urban and peri-urban communities both in Ghana and other African countries (Momoh and Oladebeye, 2000; Tsiboe and Marbell, 2004; Butu and Mshelia, 2014).

In peri-urban communities, where relatively larger numbers of people aggregate in smaller areas (unlike in rural settings) with inadequate waste management systems, the problem of indiscriminate dumping of solid waste in public open spaces is worsened (Ahmed and Ali, 2004; Rathi, 2006; Fobil *et al.*, 2008). In most Ghanaian peri-urban communities, the major problem with waste management

is the way human excreta is mixed with solid waste (Sam, 2002; Asante and Oduro, 2006; Rotich *et al.*, 2006). Waste handlers, like sweepers, engage in removal of waste within the communities, regardless of associated health problems that waste handlers may face. Contamination of the waste stream by human excreta has led to over 90% of people in peri-urban communities in Ghana infected with sanitation-related biological agents (Zerbock, 2003; NESSAP 2010; Mara and Evans, 2011).

Published review papers in Asia (Zhang *et al.*, 2010), Europe (Magrinho *et al.*, 2006), America (Louis, 2004) and Africa (Getahun *et al.*, 2012) reveal that waste handlers perform activities including sweeping, collection, transportation and disposal of waste to reduce the volumes of accumulated waste whilst improving the general aesthetics of the environment. However the occupational health risks associated with each of these waste handling practices, especially in peri-urban communities have not been fully investigated.

Previous studies conducted on health risk factors among waste handlers have mainly focused on non-communicable health problems like musculoskeletal pains, cancer and occupational asthma in urban settings (Abou-ElWaf *et al.*, 2012; Norman *et al.*, 2013; Kanchanomai *et al.*, 2015). Research on the risk of acquiring faecal oral infections, including soil transmissible helminthes, among waste handlers is very scanty, with none published in peri-urban settings in Ghana. This research seeks to classify waste handling activities in a large coastal peri-urban community in Ghana and describe the associated health risk factors (both communicable and non-communicable) among the waste handling workforce.

To achieve the goal of adequate removal of waste from communities, studies in India (Srivastava *et al.*, 2005; Kuriah, 2006), Tanzania (Mbuligwe, 2004), and Ghana (Fobil *et al.*, 2008) have suggested that the involvement of multiple stakeholders is critical.

2.1.1 Stakeholders in waste management in Ghana

Stakeholders in waste management are those who take part in various components of the waste management chain, from the generation of waste to its final disposal (Van Dijk, 2006; Cointreau, 2001). Major stakeholders in waste management in Ghana, include the national and local governments (Tsiboe and Marbell, 2004; Asase *et al.*, 2009; Boamah, 2011), private sector (Post, 1999; Obiri-Opare and Post, 2002), non-governmental organizations (Nuno-Amarteifio, 1995; Post *et al.*, 2001), community-based organizations (Heyman, and Langendijk, 1997; Oduro-Kwarteng *et al.*, 2006), and professional waste handlers (Norman *et al.*, 2013). Though some variations may exist with respect to governance, supervision or mode of service delivery, studies have shown in developing countries including India (Srivastava *et al.*, 2005; Kuriah, 2006), Tanzania (Chinamo, 2003; Mbuligwe, 2004), and Ghana (Fobil *et al.*, 2008) that corporation and partnerships among the various actors in waste management is critical to achieve adequate removal of waste from communities.

The national government is responsible for the establishment of institutional and legal framework for solid waste management in Ghana. It also supports and ensures that local governments (e.g. Metropolitan, Municipal and District Assemblies – MMDAs) have the authority, power and capacity to effectively discharge their roles in waste management. It is therefore expected of the government to make laws, enact policies and provide leadership and supervision for effective solid waste

management in Ghana. Even though no distinct law has been identified for the management of solid waste, some key policy documents exist in Ghana. Key national policy documents relevant to solid waste management are the National Environmental Sanitation Policy (NESP), guidelines for landfills and the Manual for the Preparation of District Waste Management Plans in Ghana.

The NESP was prepared by the Ministry of Local Government and Rural Development (MLGRD) in 1999 and revised in 2010 to develop and maintain clean, safe and pleasant environment for human settlements. The Guideline for Landfills was prepared by the Environmental Protection Agency (EPA) to establish standards for design, construction and management of waste disposal systems to protect public health and the environment in Ghana. The Manual for the Preparation of District Solid Waste Management Plans was however prepared by the Metropolitan, Municipal and District Assemblies (MMDAs) to enable the local government, through District Assemblies, enact bye-laws and to enforce the implementation of the NESP for effective solid waste management in the respective Districts and Municipal Areas in Ghana. Thus, the MMDAs work directly with local District Waste Management, Environmental Health and Sanitation Departments to achieve the national objective on waste management in Ghana (Tsiboe and Marbell, 2004; Asase *et al.*, 2009; Boamah, 2011).

Private sector participation in solid waste management became prominent when the government of Ghana changed its policy towards private sector-led development for all sectors of the economy. Local private solid waste management organizations either partner with government in private-public partnerships (e.g. Zoom Lion Ghana Limited and Azongtaba Cottage Industry – ACI) or with other private organizations in private-private partnerships (e.g. Zoom Alliance) to deliver solid waste management services in Ghana.

In private-public partnership agreements, private waste management organizations recruit waste handlers to provide waste management services to the communities, whilst their salaries are paid by the local government. These private partnership involvements in waste management in Ghana have increased over the past two decades. In peri-urban communities in Ghana, the high number of waste handlers confirms the increasing participation of the private sector in solid waste management (Post, 1999; Obiri-Opare and Post, 2002; Ogawa, 2005; Fobil *et al.*, 2008; Oteng-Ababio, 2009; Oduro-Kwateng and vanDijk, 2013). The massive involvement of the private sector in solid waste management in Ghana has introduced more efficiency (ability to achieve desired results) and effectiveness (ability to provide a particular service at low cost) in solid waste management, than two decades before (Ahmed and Ali, 2002; Fobil *et al.*, 2008; Oduro-Kwateng and vanDijk, 2013), similar to claims by several authors in other parts of Africa (Cointreau-Levine and Coad, 2000; Massoud and El-Fadel, 2002; Post *et al.*, 2003).

Non-governmental organizations (NGOs) participate in waste management activities, aside their primary goal of executing several other projects, for the concern of the deplorable environments within which their beneficiaries may live. In Ghana, NGOs have contributed to solid waste management through creation of public awareness on negative impacts associated with inappropriate solid waste management (Nuno-Amarteifio, 1995; Post *et al.*, 2001; Ahmed and Ali, 2002). In addition, NGOs also participate actively in solid waste handling activities within communities, conduct waste management related research and help to introduce new solid waste management technologies.

The National Coalition of NGOs in Waste Management (NACONWAM), the Environmental Services Providers Association (ESPA), the Environmental Consciousness Club (ENVIROCON), the

Ghana Clean Advocacy (GCA) as well as the Cooperative Housing Foundation (CHF) International are some examples of major NGOs in Ghana which also engage in waste management activities. The NGOs usually work closely with community residents and community-based organizations to successfully implement solid waste management services within Ghanaian communities. The activities of NGOs in solid waste management is more pronounced in urban than in peri-urban and rural communities in Ghana.

Community-based organizations (CBOs) play significant roles in responding to poor environmental conditions within their localities by initiating waste management activities, primarily street sweeping and collection of refuse. These CBOs advocate for alternative and beneficial solid waste management options that are suited within the context of the local communities (Heyman, and Langendijk, 1997; Ahmed and Ali, 2002; Oduro-Kwarteng *et al.*, 2006). The CBOs also promote the need for waste producers to separate waste at source before disposal and assist local District Assemblies, Town Councils and Unit Committees for their efforts in safe disposal of solid wastes (NESP, 2010). The activities of CBOs are more dominant in rural and peri-urban settings than in classical urban communities.

Waste handlers in Ghana perform either day to day or occasional waste handling activities at the community level (Norman *et al.*, 2013). They may belong to different groups of waste management companies (in government or private) or community-led voluntary groups. Waste handlers employed by government or private waste management companies are paid monthly salaries whilst the community participatory groups do not earn salaries. The current research defines waste handlers as those engaged in either day to day or occasional waste management activities with or without

monetary profit but who work under supervision. Routine domestic waste handlers and pupils engaged in waste handling are therefore not discussed in this literature.

There is the need for the different stakeholders in the waste management sector to collaborate at the community levels to improve the state of the environment, sanitation and health in peri-urban communities in Ghana. One of the objectives of this research is to identify, classify and describe the characteristics of the waste handling workforce and their activities in peri-urban communities in Prampram, Ghana.

2.2 Status of sanitation in Ghana

The level of sanitation coverage is low throughout Ghana. Poor sanitation has a major negative impact on public health. Improving sanitation is a key remedy to sanitation related diseases worldwide (WHO, 2008). Currently, Ghana is placed 48th out of 51 African countries with national sanitation coverage of 14% (WHO/UNICEF, 2012). Thus only 14% of Ghanaians use acceptable (improved) toilet facilities. Sanitation, as defined by the WHO (Joint Monitoring Programme – JMP), generally refers to the provision of facilities and services for safe disposal of human faeces (JMP, 2010). In Ghana, sanitation also includes solid waste management (Porter *et al.*, 2011). However, improved sanitation is one that hygienically separates human faeces from human contact and does not include the use of shared toilet facilities (JMP, 2010).

Shared facilities are defined as sanitation facilities of an otherwise acceptable type but are shared between two or more households, including public toilets (WHO/UNICEF, 2012). The JMP argues that it is only the users of improved sanitation facilities that are considered as having access to

sanitation on condition that the facility is not shared by neither multiple households nor the public. The JMP (2010) again reports that about 67% of people in Ghana use shared sanitation facilities. However, for Ghana to achieve its MDGs for sanitation by 2015, the number of people who use shared facilities will have to decrease significantly.

Ghana aims at achieving 54% coverage for sanitation by the year 2015. Yet, in 2008, access to improved sanitation in urban areas was only 18% while rural access was 7% (WHO/UNICEF, 2010). With the current rate of sanitation coverage it will be difficult to achieve improved sanitation by 2015 according to the JMP (2010). Thus currently, Ghana is not on track for attaining the MDG for sanitation.

Another major problem with the poor state of sanitation in Ghana is defecation in the open. According to the WHO/UNICEF (2012), it is the lack of sanitation facilities that forces people to defecate in the open. With open defecation, there is no separation between the person practicing the act and faeces, and the associated environmental pollution increases with population density, as experienced in peri-urban communities in Ghana. In places of open defecations, human faeces are disposed of in fields, bushes, open water bodies, forests, beaches or other open spaces or disposed of together with solid waste (Potter *et al.*, 2011). Whilst the sanitation coverage between 2008 and 2010 increased, the rate of open defecation decreased in both urban and rural areas in all the regions of Ghana (thus 23% in 2010 to 19% in 2012) (WHO/UNICEF, 2012).

Throughout the WHO/UNICEF (2012) report, the information about sanitation is mainly focused on urban and rural disparities with very little information on peri-urban situations. Similarly, the status of sanitation in urban and rural communities in Ghana has been very much described by Osumanu *et*

al., (2010) and Lau, (2011) respectively. However the situation in peri-urban areas remains scantly researched. The Sustainable Sanitation (SUSA) project, of which this research is part, therefore sought to conduct research to find lasting solutions to peri-urban sanitation problems and generate information that will help address the poor state of sanitation in such settings in Ghana.

2.3 WASTE HANDLING PRACTICES AND FAECAL EXPOSURE

Unlike sparsely settled rural areas, peri-urban settlements have moderately higher population densities. Coupled with the lack of adequate sanitation infrastructure, peri-urban areas are the largest source of faecal contamination in Ghana (Asante and Oduro, 2006). Human faeces are always present in the solid waste stream in peri-urban communities in Ghana which makes it a health risk to waste handlers (Zerbock, 2003; Asante and Oduro, 2006). Direct physical exposure to human faeces and associated health risks among waste handlers in Prampram may be due to the lack of appropriate protective working gear/their improper usage, lack of access to sanitation and hygiene facilities during working hours or lack of awareness.

Waste handlers are repeatedly exposed to biological agents in faecal contaminated waste during a day's work, through direct physical contact with solid waste (Cointreau, 2006; Waddington, 2009). These biological agents may include bacteria, fungi, protozoa, helminthes and viruses (Bunger *et al.*, 2000; Dumont *et al.*, 2001; Krajewski *et al.*, 2002; Lavoie *et al.*, 2006), some of which can be acquired from faecal contaminated soil and solid wastes (Esrey *et al.*, 2001). The long survival rates for some of these biological agents in human faecal contaminated environments may also increase the risk to which waste handlers are exposed to them (Schonning *et al.*, 2007; Jensen *et al.*, 2009; Tay *et al.*, 2010).

The exposure to biological agents during solid waste handling may thus result in clinical manifestation of poor sanitation related diseases like diarrhoea and helminthiasis (Avotri and Walters, 1999; Rushton, 2003; Ackerson and Awuah, 2010). Indeed information from the Dangme West District Health Administration suggests that diarrhoea and helminthiasis are among the top three diseases reported at the local health facility in Prampram.

2.4 HEALTH RISKS IN WASTE HANDLING

Waste handlers all over the world are at risk of work-related health problems which account for about 4 per cent total loss of the world's Gross Domestic Product (Takala, 2002). In 2005 the International Labour Organization (ILO) estimated that 1.7 million people in the world die each year as a result of occupational health problems. Again, the WHO clearly stated that poor occupational health and reduced working capacity of workers lead to economic loss of up to 10-20 per cent of Gross Domestic Product (GDP) of any country (WHO, 1994).

In Ghana as in other developing countries, waste handlers constitute a relatively large proportion of the workforce in the waste management sector. With the rapid increase in population densities and solid waste generation in peri-urban communities, waste handlers now also have to deal with the removal huge volumes of waste piles, but using antiquated waste removal technology. These waste handlers may therefore be predisposed to several health risks. Gaining a better insight into occupational health risks among the waste handling workforce is critical to be able to establish public health measures that would curb the impact of these health problems in peri-urban communities in Prampram, Ghana.

Waste handling activities require extensive physical exertion due to lifting and carting of heavy waste materials. Such activities have been reported to predispose waste handlers to physical body injuries and musculoskeletal pains such as neck, wrist and back pains (Palmer, 2003; Quansah, 2005; Fejer *et al.*, 2006; Mehrad *et al.*, 2008; Tiwari, 2008; Abou-ElWaf *et al.*, 2012; Kanchanomai *et al.*, 2015). Other studies from both developed and developing countries have reported occupational asthma from organic dust inhalation as well as headaches, and dizziness from non-specific waste handling activities (Avotri and Walters, 1999; Sigsgaard, 1999; Fielder *et al.*, 2000; Pukkala and Ponka, 2001).

Psychosocial health risk factors among waste handlers from Africa (Oke and Awofeso, 2006) and Europe (Engkvist, 2010) have also been reported to adversely affect physical and emotional well-being of the workers. The sources of such as psychosocial risk factors, may include nuisance from inhaling bad smells/odour and air laden with microorganisms or particulate matter of solid waste mixed with human excreta, increased stress-related behaviours such as smoking, anxiety, feeling of powerlessness and alienation, decrease in self esteem and social stigmatization due to waste handling (Dorevitch and Marder, 2001).

Extensive open defecation in peri-urban communities in Prampram, Ghana, may increase the likelihood of high human faecal content in solid waste (Asante and Oduro, 2006), thereby exposing the waste handling workforce to biological agents including *E. coli*/coliforms and helminthes. Helminthes that are mostly associated with waste handling related gastrointestinal problems include *Ascaris lumbricoides*, *Trichuris trichiura*, *Necator americanus*, *Ancylostoma duodenale*, and *Schistosma mansoni* (Filip *et al.* 1988; WHO, 2006). The infective stages (eggs or larvae) of these

helminthes reside in faecal contaminated soil and they can be transmitted through direct faeco-oral ingestion or direct skin penetration.

Even though there is available information on occupational health risks to waste handlers in developed (Rendleman and Feldstein, 1997) and developing (Gutberlet, 2013) countries, there remains paucity of published research on these health risks to waste handlers in Africa and particularly Ghana with none focusing on those in peri-urban communities. To reduce the health risks involved, waste handlers may have to adopt proper waste handling practices that limit physical exposure to human faecal matter and limit extreme physical exertion on lifting and carting of waste. This study seeks to determine the levels of self reported and actual occupational health risks among waste handlers in peri-urban communities in Prampram, Ghana.

2.4.1 MAGNITUDE AND REDUCTION OF HEALTH RISKS AMONG WASTE HANDLERS

Health risks exist in every step of the processes of waste handling, from collection to final disposal. Waste handling is therefore considered to be a risky occupation (Campbell 1994, Kitsantas *et al.*, 2000). Health risks in waste management can be perceived as low or high. The extent of an individual's susceptibility to health risk factors in waste handling may be influenced by level of protection and exposure to hazards (Mutha *et al.*, 1999). The type and magnitude of health risks reported among waste handlers are also likely to be influenced by culture and behaviour within local contexts under which waste handlers work (Whitelaw *et al.*, 2001; Tate *et al.*, 2003; Gutberlet, 2008).

Previous studies have described health risks among waste handlers and found health problems including bodily pains (Norman *et al.*, 2013), eye, skin, and gastrointestinal problems that were associated with waste handling (Dorevitch and Marder, 2001; Rushton, 2003). Common ways suggested to reduce exposure to health risks in waste handling include the use of personal protective gear (PPG) (Tjoe Nij *et al.*, 2003). The use of proper PPG may prevent direct exposure of body parts waste handlers to waste, which often is faecally contaminated, and also prevent cuts and injuries during waste handling activities. Additionally, the availability and use of hygiene/sanitation facilities or waste handling equipment during work may catalyze reduction of poor health risk factors among waste handlers. A study on sanitation and hygiene by Yacoob *et al.*, (1992) suggests that the health and safety of waste handlers in peri-urban areas require changes in hygiene behaviour, improvements in sanitation facilities and the use of appropriate waste handling logistics or equipment.

The information about the magnitude of health risk factors is important to gain insight and to recommend public health measures that would curb the impact of these risk factors among solid waste handlers in rapidly developing peri-urban communities, e.g. in less developed countries like Ghana. For instance, past research about health risk factors among waste handlers have been used to predict actual health effects relating to waste management (Rushton, 2003), and have been useful in the evaluation of programs aimed at improving health status among waste handlers within local contexts (Whitelaw *et al.*, 2001; Tate *et al.*, 2003). However, existing studies on waste management in Ghana report mainly nuisance aspects of solid waste pile-up due to poor management (Fobil *et al.*, 2008; Ampofo, 2013) and not on the magnitude of health risk factors that solid waste handlers are exposed to and associated disease problems.

2.4.2 Risk factors associated with helminthes infections

Helminthes infections are one of the most common health problems associated with poor sanitation and improper handling of solid waste contaminated with human faecal matter. Studies in Ghana and other developing countries have shown that residents in peri-urban communities have higher risks for helminthes infections than in urban communities because of the higher proportions of poverty, poor environmental hygiene, inadequate sanitation, open defecation and inadequate waste management systems (Arinola and Fawole, 1995; Cornish *et al.*, 1999; Phiri *et al.*, 2000; Zerbock, 2003; Rosewell, 2010; Flores *et al.*, 2011; Mara and Evans, 2011). These factors perpetuate the continued existence of helminthes in peri-urban communities.

The infective stages of helminthes persist for longer periods in faecal polluted environments and can survive a wide range of physical and chemical conditions, thereby posing the highest health risks to waste handlers, compared with other biological agents in waste (Feachem *et al.*, 1983, Gaspard *et al.*, 1997; Nelson *et al.*, 2004; Sanguinetti *et al.*, 2005; Kone *et al.*, 2007). Adequate warmth and moisture in tropical countries, including Ghana also favour the survival of helminthes eggs and increases the risk of transmission to waste handlers (Brooker and Michael 2000). Researchers have reported persistence of helminthes eggs in salty beaches in Brazil (da Silva *et al.*, 2009; Rocha *et al.*, 2011) and Portugal (Scaini *et al.*, 2003) due to faecal contamination of the soil.

According to de Silva *et al.*, (2003), Hotez *et al.*, (2009) and the WHO (2013), the most important species of soil transmissible helminthes that infect people are the human roundworm (*Ascaris lumbricoides*), the human whipworm (*Trichuris trichiura*) and the hookworms (*Necator americanus* and *Ancylostoma duodenale*). These groups of soil-transmitted helminthes do not require

intermediate hosts in their life cycle. One of the major modes of transmission is through direct faecal-oral ingestion of the eggs/ova (*Ascaris lumbricoides* and *Trichuris trichiura*) (Santamaria & Toranzos, 2003; Vandemark *et al.*, 2010) but also through direct penetration of the larvae (hookworms) through exposed parts of the body (Esrey *et al.*, 1991; Carr and Strauss, 2001). Though several studies have been conducted in Ghana on the prevalence and intensity of helminthes infections in children of school going age (Annan *et al.*, 1986; Soares Magalhães *et al.*, 2011; van Mens *et al.*, 2013), research on adult populations (Ayeh-Kumi *et al.*, 2009; Humphries *et al.*, 2011) and among other occupational groups in peri-urban communities in Ghana are very limited.

2.4.3 Risk factors associated with faecal contamination of human hands

The level of contamination of hands by human faecal matter among waste handlers may be used as an indication of risk of transmission of faecal-oral pathogens and its associated health problems. A study among the adult household population in Tanzania has shown that the use of toilet as well as sweeping and cleaning human faeces are risk factors for increased levels of faecal indicator bacteria on the hands (Pickering *et al.*, 2011). Similar studies conducted in Britain (Judah *et al.*, 2010; Dodrill *et al.*, 2011) Malawi (Taulo *et al.*, 2009) and Ethiopia (Andargie *et al.*, 2008), assessing microbiological contamination of the hands among adult commuters and food handlers also revealed presence of faecal indicator bacteria.

The levels of non-pathogenic *E. coli*/Coliforms on the hands of trekking populations, food handlers but also health-care workers have thus been used as common indicators to assess exposure of the hands to faecal pollution (de Wit and Rombouts, 1992; Pickering *et al.*, 2010; Todd *et al.*, 2010). Meanwhile, the presence of high levels of human faecal content in solid waste piles in peri-urban

communities of Prampram and the lack of adequate protection of the hands during waste handling may worsen contamination of the hands by human faeces among waste handlers.

Currently, there is very little research on the degree of contamination of hands by *E. coli*/Coliforms among waste handlers in Ghana. Assessment of the level of faecal contamination of hands among waste handlers would indicate the level of associated health risks factors and can be used as an indicator to monitor changes in exposure levels over time.

2.4.3.1 Use of *E. coli*/Coliforms as indicators of faecal contamination

Non-pathogenic *E. coli*/Coliforms are well accepted as indicators of pollution by human faecal matter in both temperate (Leclerc *et al.*, 2001, Payment *et al.*, 2003) and tropical (Isobe *et al.*, 2004) climates. Even though faecal enteroccoci have also been used to monitor levels of faecal pollution of hands, a study on their natural ecology by Wilson (2005) revealed that faecal enteroccoci occur in lower numbers than *E. coli*/Coliforms.

Faecal indicator *E. coli*/Coliforms in water samples can grow on microbiological growth media incubated at 44.5°C for 24 hours under laboratory conditions (Cabral, 2010). The indicator *E. coli*/Coliforms can be detected by using substrate based tests that function on the enzymatic activity of ß-glucuronidase, produced by the faecal indicators when incubated at 44.5°C in the laboratory (Van Poucke and Nelis, 2000; Payment *et al.*, 2003).

The enzyme β-galactosidase cleaves lactose in glucose and galactose, and can be detected by using colored or fluorescent markers that change colour after enzyme action in a chromogenic media

(Manafi, 2000). Phenotypic tests including citrate utilization, production of hydrogen sulphide (H_2S) and hydrolysis of urea can be used to confirm and differentiate growth of faecal indicator *E. coli* from Coliforms. Whilst the cells of faecal indicator *E. coli* do not use citrate, do not produce H_2S, and do not hydrolyze urea, cells of Coliforms do (Holt *et al.*, 1994).

2.4.3.2 Methods of recovery and growth of *E. coli*/Coliform as faecal indicators from hands

Hands contaminated by human faeces play an important role in transferring faecal organisms from person to person (Curtis and Cairncross, 2003). A waste handler who does not practice sufficient hand hygiene after work can transfer pathogens to other persons through direct physical contact, contamination of inanimate objects and surfaces, and through food preparation (Curtis *et al.*, 2000; Curtis *et al.*, 2003). Although hand hygiene has been described for years as a primary means to prevent the spread of faecal organisms, literature describing the quantity and quality of faecal indicators on hands of waste handlers is scanty. Different microbiological techniques have been used to elute faecal indicator organisms from hands to identity and enumerate these organisms. Some of the commonly used methods described in literature include the hand-impression (i.e. direct finger imprints on agar plates), hand-swabs (i.e using sterile swab in 1% peptone buffer), and the hand-rinse method (i.e. sterile bag technique) (Table 2.1). The methods that allow recovery of relatively more bacteria in Total Plate Count (TPC) on microbiological growth media from both human and inanimate surfaces are preferred and applied for microbiological research purposes (Sanders, 2012; Lambrechts *et al.*, 2014). The applied methods require varying degrees of microbiological expertise, budgets and logistics, and accompanied by inherent merits and demerits (Table 2.1). Considering all the advantages and disadvantages of the different methods reviewed, the sterile bag-technique (hand-rinse method) seemed to be most appropriate option suitable for recovery and estimation of the level

of contamination of hands by faecal material among waste handlers (Lambrechts *et al.*, 2014; Mattioli *et al.*, 2014; Mattioli *et al.*, 2015). However, the hand-rinse method needed to be validated against other standard methods such as the hand-impression and hand-swab (in 1% peptone buffer) to confirm its suitability or otherwise for the current study in Prampram.

Table 2.1: Frequently used techniques for recovering *E. coli/Coliforms* on hands

echnique	Representative studies	Purpose of technique	Advantages of technique	Disadvantages of technique
irect nger nprints nto agar late (hand-npression)	Larson, 1985; Henry and Rahim, 1990; Hansen, and Knochel, 2003; Luby *et al.*, 2007; Devamani *et al.*, 2014.	Screening for gross levels of hand contamination, especially in community settings.	Least expensive, technically simple.	Not quantitative, very insensitive; colonies may be very close, difficult to count and identify; air-borne contamination of agar.
land swab n 1% eptone uffer)	Han *et al.*, 1986; De Alwis *et al.*, 2012; Naeem *et al.*, 2015.	Quantitative analysis of small areas of skin.	Permits quantitation and identification of surface organisms.	Permits sampling of only small areas at one time; cannot readily estimate bacterial population of a larger surface area, such as entire hand.
land-rinse sterile bag)	Pickering *et al.*, 2010; Davis *et al.*, 2011; Lambrechts *et al.*, 2014; Mattioli *et al.*, 2014; Mattioli *et al.*, 2015.	Quantitation of microorganisms of total hand surface.	Permits sampling of larger surface area of hands at one time compared with direct impression of fingers onto agar plate and swabbing of palm. Risk of air-borne contamination of sampling fluid is reduced.	More complicated procedure; initial dilution in sampling fluid may reduce sensitivity.

2.5 Prevention and reduction of exposure to health risks in waste handling

Health risks accompany different activities in waste handling (Cointreau, 2006). However taking the appropriate preventive measures can reduce the exposure to health risk factors in waste handling activities. Reduction in exposure to health risks can be achieved by preventive treatment with anti-helminthic drugs, adequate sanitation and good hygiene practices as well as using appropriate equipment and personal protective working gears in waste handling. Health education, change in health behaviour and periodic training in waste handling may also be necessary preventive steps in reducing health risks among waste handlers in peri-urban communities in Ghana.

The use of preventive anti-helminthic drugs is the current global strategy in controlling soil transmissible helminthes infections among at risk populations, like waste handlers (WHO, 2006, WHO, 2010). In endemic countries like Ghana, Albendazole (400mg) and Mebendazole (500mg) are the anti-helminthic drugs of choice for the treatment of soil transmissible helminthes infections (Crompton *et al.*, 2003; Jamison *et al.*, 2006; Lopez *et al.*, 2006; Ghana Health Service, 2008).

Albendazole and Mebendazole have undergone extensive safety and efficacy testing and have been used in millions of people globally with only few and minor side-effects (Lubis *et al.*, 2012). Both drugs are effective broad-spectrum anti-helminthics, inexpensive and are easily administered by trained non-medical personnel. However, unlike Mebendazole, Albendazole (400mg) is administered as a single oral dosage which makes it easier to monitor treatment by direct observation by researcher (Hall and Chan 1994; Farmer *et al.*, 2001; WHO, 2013).

The problem with preventive treatment with anti-helminthic drugs to at risk populations is the inability to prevent re-infections after a short period (Luong, 2003; Bethony *et al.*, 2006; Singer and de Castro, 2007; Jia *et al.*, 2012).

Adequate sanitation and good personal hygiene practices are essential to reduce risk factors for helminthes infections among waste handlers. Good hygiene practices may also reduce the growth of other biological agents on the hands of waste handlers; a result of exposure to human faecal matter during waste handling. The use of appropriate waste handling equipment may reduce health risks associated with labour intensive activities for instance in lifting and carting heavy waste materials and walking long distances to disposal sites. Wearing of appropriate personal protective working gear during waste handling serves as a barrier to prevent direct physical contact with biological agents in solid waste. This may not only reduce the impact of direct transmission of biological agents, but also minimize mechanical injury to the waste handlers.

Promotion of health education among waste handlers about healthy behaviours, including hand washing with soap after engaging in waste handling activities or after defecation and before eating may help to reduce transmission and re-infection of helminthes and other faecal related biological agents. Organizing periodic training about the use of appropriate waste handling equipment and protective gear may also be necessary preventive steps in reducing occupational health risk factors among waste handlers.

2.5.1 Use of personal protective working gear (PPG) in waste handling

The risks of acquiring infections or injuries associated with waste handling begin with an exposure to waste materials containing infectious agents or direct contact with waste handling equipment respectively. By wearing appropriate protective clothing, waste handlers would be able to prevent the direct physical contact with waste materials, thereby minimizing the impact of exposure of body surfaces to waste. Occupational injuries in waste handling would be curbed if adequate personal protective working gears are properly worn during waste handling activities (Boadi *et al.*, 2005).

For example, the risk of respiratory infection or allergic response to organic dusts can be greatly reduced if waste handlers wear nose masks or mouth covers during waste handling (Cointreau, 2006). Similarly, the risk of developing diarrhoea or hand injuries can be greatly reduced if waste handlers wear appropriate hand gloves during waste handling.

The appropriate protective gears that are expected to be worn by waste handlers during waste handling activities should include but not limited to over-all gowns/apron/vests, wellington boots, nose/mouth masks, gloves, head gear and goggles for their personal safety and protection from occupational health hazards. Waste handlers in peri-urban communities in Ghana receive little or no protective clothing from the waste management organizations which engage their services. Even those who own some of these protective gears sometimes do not wear them during waste handling or use them inappropriately, resulting in inadequate physical protection during work. According to Boadi and Kuitunene (2003), waste handlers may suffer exposure to injuries and infectious agents due to inadequate use of personal protective gear.

3.0 CHAPTER THREE – MATERIALS AND METHODS

3.1 STUDY AREA

The Greater Accra region of Ghana is politically divided into six (6) Districts which includes the Dangme West District (DWD). The DWD is situated in the Southeastern part of Ghana, Dodowa being its District Administrative capital. The District lies between latitude 5° 45' South and 6° 05' North and Longitude 0° 05' East and 0° 20' West. With a total land area of 1,442 square kilometres, the DWD is the largest in the Greater Accra Region, covering about 41.5% of the land area of the region (DWD, Republic of Ghana, 2008; Ghana portal, www.ghana.gov.gh). The Dangme West District Assembly serves as the local government authority and functions in collaboration with other Ministries, Departments and Agencies (MDAs) like the District Health Directorate and the Dodowa Health Research Centre to implement government health policies at the local level. The District is sub-divided into four (4) administrative sub-districts, namely, Shai, Osudoku, Ningo and Prampram.

There are four (4) health centres, one (1) in each of the 4 sub-districts, and six (6) community clinics which are scattered throughout the district. The two (2) major health centres include the District Hospital and Health Research Centre located in Dodowa. The Dodowa Health Research Centre (DHRC) is one of the three (3) Health Research Centres of the Ghana Health Service (GHS) and conducts health research focusing on the needs of the health sector in the Southern part of Ghana. The DHRC is strongly connected with the District Health Directorate and the Local Government Authority of the DWD. It houses the Health and Demographic Surveillance Site (HDSS) of the District and conducts periodic research focusing on development and evaluation of community and District based health interventions. The HDSS is used to collect research information aimed at improving the process of health service delivery, planning and policy formulation in the Ghana

Health Service (GHS) (dhrc-ghs.org). For these reasons and more, the DWD was chosen by the Sustainable Sanitation (SUSA) Ghana project to conduct health research on finding sustainable sanitation solutions in the District, particularly in Prampram.

Prampram is the largest settlement in the DWD and found within the vicinity of Tema, about 30 minutes drive away by car. As a coastal peri-urban community, the primary occupations of residents are fishing and fish selling, but also subsistence farming and small scale artisans. Being peri-urban, the communities within Prampram have been experiencing rapid urbanization within the past decade resulting in large numbers of people congregating around relatively smaller areas. The few sanitation facilities within Prampram are outstretched and there are inadequate waste management systems to cater for the removal of huge accumulated waste (www.ghanadistricts.com). The only healthcare facility, the Prampram Health Centre, provides healthcare solutions to local residents, about 80% of who report with poor sanitation related diseases (Ansah, 2011).

There are four (4) main communities within Prampram (Fig. 3.2) selected for this study, in addition to three (3) other surrounding communities which had waste handlers under direct supervision from Prampram. Thus in all, seven (7) communities were selected namely, Kley, Olowe, Lower East, Lower West, Abia, Abbey and Yeduekorfe. The last three communities (Abia, Abbey and Yeduekorfe) were the additional three communities. Further information about the characteristics and population of the selected communities for the study are described in sections 3.2 and 3.3 respectively.

Figure 3.1 shows the 4 main communities in the study area; two Upper towns; Kley, Olowe and two Lower towns; Lower East and Lower West.

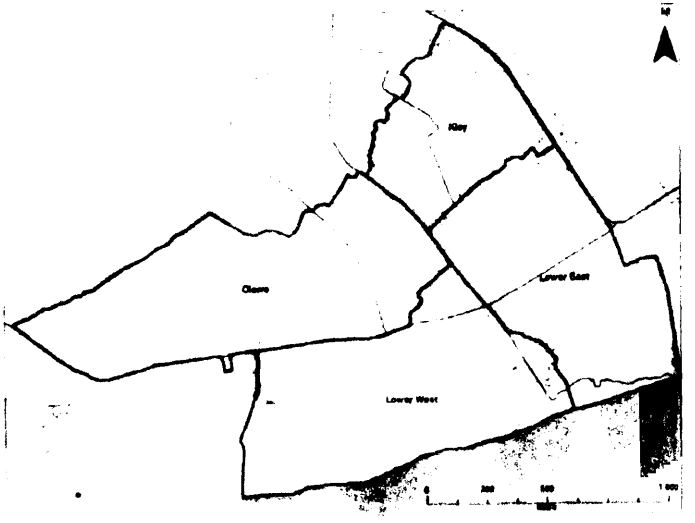

FIGURE 3.1: MAP OF PRAMPRAM SHOWING THE FOUR MAIN COMMUNITIES IN THE STUDY AREA

(Source: SUSA-Ghana, 2011).

Caveat: *It is also worth mentioning that Prampram is now the District Administrative Capital of the newly created Ningo-Prampam District, which has been carved from the then Dangme West District, since 2012. Relevant information about its geographical, demographic and other features is very scanty as the new District, in collaboration with the Dangme West District is currently in the process of collecting and updating such information about the District (www.ghanadistricts.com).*

3.2 CHARACTERISTICS AND SELECTION OF STUDY SITE

About 73 per cent of households in the Prampram community has no toilet facility and the residents use the bush, beach or field for outdoor defecation (Asante and Oduro, 2006). According to the Dodowa HDSS, about 85% of residents in the coastal community of Prampram, especially Lower East and Lower West, practice open-air defecation in bush or beach (DHRC, 2010). Most toilet facilities in Prampram do not meet the standards of improved toilets and waste disposal methods are not environmentally safe (Keraita *et al.*, 2009). There is high concentration of both liquid and solid waste, mixed with human faecal matter scattered all over Prampram Township. The presence of accumulated solid and human faecal waste may pose health risks to those who occupationally engage in solid waste removal.

The selection of the 4 main communities for this study was informed by the objectives of the SUSA Ghana project, which focused on sanitation problems in peri-urban townships with high population densities. The Dodowa HDSS used a combination of population density and sanitation usage data in the DWD to select five cluster communities including Prampram (Lower East and Lower West), Dodowa, Mataheko, and Ayikuma. After transect walks by a field site selection team from the DHRC, the Prampram Township was selected as the field site for this study. In the Dodowa HDSS, the Prampram Township was divided into four clusters namely, Kley, Olowe, Lower East and Lower West. These clusters were finally selected for inclusion in the SUSA Ghana project because of three main reasons: geographically, they were in proximity to one another, collectively, they represented the highest population density of any township in the DWD and finally, they contained high proportions of "***unimproved***" sanitation practices, compared with the three other previously selected sites (HDSS, 2011). Abia, Abbey and Yeduekorfe were added to the 4 main study sites because of

presence of waste handlers who were also being supervised by the District waste management authority and specifically from Prampram.

3.3 STUDY POPULATION

The population of the DWD was estimated to be 122,836 at an annual growth rate of 2.1, according to the 2010 Ghana population and housing census (GSS, 2013). The estimated populations of the four major communities in the study area of Prampram were 1,446 (Kley), 1,507 (Olowe), 2,837 (Lower East), and 1,413 (Lower West), according to the Dodowa HDSS, report (2011). As at the time of data collection, information on the population of Abia, Abbey and Yeduekorfe were not available by the Dodowa HDSS. However these were smaller communities, compared with Kley, Olowe, Lower East and Lower West.

3.5 OPERATIONAL DEFINITION OF STUDY PARTICIPANTS AND WASTE

Waste handlers were defined as sweepers, collectors, transporters and disposers of waste who either worked for waste management companies and institutions or as volunteers directly handling waste materials along the waste management chain. The type of waste managed included solid waste mixed with fresh and decomposed human faeces or effluents from domestic waste pipes and septic sludge from tanks emptied into open drains. Peri-urban area was defined as an interface between rural and urban setting, having high population density, high prevalence of open defecation and inadequate sanitation infrastructure.

3.6 Recruitment of study participants

The objective of this study was to collect research information on health risks among waste handlers at the community level, as such routine waste handlings by households and school pupils were not considered. Participants for this study were identified after transect walk and observation of waste handling activities within Prampram. After conducting a short survey, all the participants who directly handled waste by performing the following activities; sweeping, collection, transportation, disposal or a combination of these activities were recruited. After obtaining informed consent from them, data was then collected from all 288 respondents of which 280 were waste handlers and eight (8) government stakeholders who supervised waste management activities in Prampram. Because this was an intensive descriptive study of health risks among waste handlers in Prampram, sample size was not calculated to determine minimum sample size. As such, all the estimated 280 waste handlers in the Prampram study area were purposefully recruited into the study, in addition to the eight (8) government stakeholders.

3.7 Study design and methods of data collection

The study design was community-based prospective cohort study of waste handlers (i.e. to assess level of contamination of hands as well as determine incidence rate and intensity of helminthes infections). The mixed methods approach (Johnson and Onwuegbuzie, 2004; Ulin *et al.*, 2005; McBurney and White, 2009) including qualitative, quantitative as well as laboratory protocols were used in data collection (as described in sections 3.8.1-4, 3.9.1-3 and 3.10.2-3). The anti-helminthic drug, Albendazole (400mg) was administered to waste handlers at baseline of quantitative data collection and followed three (3) and six (6) months post-treatment to determine incidence rate and intensity of helminthes infections. All the respondents were recruited based on specific waste

handling activities they performed in the study area. Both the field and laboratory aspects of this study were conducted between October, 2011 and July, 2013.

Structured questionnaire was administered to all 280 waste handlers (as described in section 3.8.3) to generate information about exposure of body surfaces to waste, personal protection by use of protective working gear and self reported health problems in waste handling. In-depth interviews were conducted with 22 out of the 280 waste handlers to obtain in-depth information on perceptions and experiences of waste work (as described in section 3.8.4). Stakeholder interviews were conducted with eight (8) selected government supervisors of waste handlers in the Prampram study area (as described in section 3.8.1).

Hand rinse samples were collected from waste handlers to assess presence of faecal indicator *E. coli*/Coliforms (as described in section 3.9.1). Albendazole (400mg) was administered to 261 out of the 280 waste handlers at baseline (as described in section 3.9.3) and stool samples were collected from 257 out of the 261 waste handlers three months (3) after baseline treatment, whilst 250 stool samples were collected out of 261, six (6) months post-treatment (please see section 3.9.3).

3.8 Data collection methods for description of waste handling activities and self reported health problems

Stakeholder interviews, observations during transect walk, researcher-administered questionnaire and in-depth interviews were used to collect information about the waste handling workforce; activities performed and self reported health problems as described individually below.

3.8.1 Stakeholder Interviews

The purpose for the stakeholder interviews (Varvasovszky and Brugha, 2000) was primarily to obtain information on what waste management organizations were operating within the four (4) main communities in Prampram, how many waste handlers were there, what specific activities they performed and what different types of wastes they handled.

The main criteria used for the selection of stakeholders were that the specific stakeholder undertook oversight responsibility, direct supervision or offered employment to waste handlers in the study area. The interviews were conducted in English using a semi-structured interview guide. Each voice recorded interview lasted between 30 and 45minutes which took place at the offices of the stakeholders. The stakeholder interviewees included three (3) district managers in sanitation, waste management and environmental health, four (4) local assembly members and one (1) local council coordinator for public toilet managers and waste transporters. (Please find stakeholder interview guide attached in appendix 8.2.1).

3.8.2 Observations

Observations were conducted by taking transect walks (Rifkin and Pridmore, 2009) through the study communities in Prampram, starting from the outskirts of the community and gradually narrowed towards the centre. The purpose of observation and transect walk was to familiarize researcher with the study area about the state of waste management, hygiene and sanitation facilities, identify specific sites where waste handlings occurred and map out these locations. Waste handling sites observed included open drains by the road-sides, around ponds, dumping sites, beaches, around waste containers, public toilet facilities and other open spaces within the peri-urban community

where waste was disposed, collected and handled by waste workers. In addition, the types of protective gears worn, (e.g. over-all gowns, footwear, oral-nasal masks, gloves etc.) and bare parts of waste handlers directly exposed to waste whilst engaged in a day's waste handling activities (e.g. such as nose/mouth, hands, arms, feet or head) were also observed. The observations were systematically recorded using observational guides and into field notes. (Please find observational checklist attached in appendix 8.2.4).

3.8.3 Administration of Questionnaire

All the 280 waste handlers identified based on their activities, were interviewed using a close-ended questionnaire comprising about twenty (20) questions. The questionnaire was adopted from Mbeng *et al.*, (2009) and Ifegbesan (2010) and modified within the context of the current waste handling practices at the study site. Information was collected to classify and describe types of activities undertaken and to identify exposure surfaces to waste, the use of personal protective working gear as well as self reported health problems among waste handlers. The waste handlers were identified and questioned on the site where they carried out waste work.

The questionnaire was divided into five (5) sections, with each section addressing a specific group of research questions.

A summary of the research questions under each section is provided below:

- Section A: demographic information – age, sex, educational level, waste management organization
- Section B: socio-economic status – average monthly income

- Section C: Job information – specific waste handling tasks performed in a day, number of years engaged in waste handling and number of hours spent per day.
- Section D: level of protection and exposure to waste –protective gear worn during work, exposed body surfaces directly in contact to waste.
- Section E: waste handling and self reported health problems – how many times in the past two weeks a waste handler reported health problem, specific things about waste perceived to cause sickness.

Respondents were given between 2 to 10 optional responses to the questions from which they could choose from. For questions that required multiple responses, the respondents chose more than one response. The questionnaire was administered on one-on-one basis by the researcher after waste handlers had finished engaging in a day's waste handling activities (between 10am and 12 noon).

The waste handlers were identified on site, where waste handlings took place. The interviews were conducted in English or in the local Ga or Dangme languages, depending on the language the respondent spoke most fluently. Each questionnaire interview lasted for about an hour. The data collected were checked for correctness, coded, classified and entered into statistical software prior to analysis.

3.8.4 In-depth Interviews

In total 22 waste handlers, representing a diversity of all the different types of waste workers, were interviewed with the purpose of understanding their work conditions, perceptions of common health problems, and the use of Personal Protective Gear (PPG). A face-to-face in-depth interview approach

was adopted to allow an open communication which could expand on some of the observations made at the waste sites (Sturges and Hanrahan 2004). The in-depth interviews were conducted in a neutral venue away from the work place of waste handlers to create a relaxed interview atmosphere.

The local dialect, Dangme, was used during the interviews which were recorded using a digital audio device and continued until practically no new information was added (saturation point). Each in-depth interview lasted between 45 minutes to one hour using semi-structured interview guide. The questions asked during the interview mainly focused on (but not limited to) perceptions and experiences about: common health problems in waste handling, exposure to occupational hazards, personal protection from health hazards as well as access to hygiene facilities during work. Further probing questions were asked following each major question asked during the interview. Additional memos on any other relevant information obtained or observations made during the interviewing process were also recorded as field notes. (Please find interview guide in appendix 8.2.2).

3.9 Description of Laboratory Procedures

Laboratory procedures were used to measure the levels of faecal indicator *E. coli* and Coliforms in hand rinse collected from waste handlers before and after engaging in waste handling activities and also to detect presence/absence of helminthes eggs in stool samples collected. The *E. coli* and Coliforms were used as indicators to determine the level of faecal contamination of hands whilst presence of helminthes eggs predicted incidence of infection three and six months post-treatment with Albendazole. Details of these procedures are described in sections 3.9.1-5 below.

3.9.1 Collection and transportation of hand-rinse samples

The collection of hand-rinse samples was done according to four protocols used to study hand hygiene in peri-urban communities in Tanzania (Pickering *et al.*, 2010; Davis *et al.*, 2011; Mattioli *et al.*, 2014; Mattioli *et al.*, 2015) with slight modifications. Two hand-rinse samples were collected from the 280 waste handlers, before and after engaging in a day's work. The dominant hand (comprising finger tips, nails, palm and back of the hand, up to the wrist level) of each waste handler was placed in a sterile sampling bag (Lambrechts *et al.*, 2014; Mattioli *et al.*, 2014) and 50 ml sterile distilled water (Pickering *et al.*, 2010; Davis *et al.*, 2011; Mattioli *et al.*, 2015) was poured from falcon tubes onto the hands. The hands were gently massaged for about 60 secs (Fuls *et al.*, 2008) to dislodge faecal indicator bacteria into the water (Figure 3.2) which was carefully poured back into the falcon tubes. The hands of each waste handler were then wiped with tissue paper. The falcon tubes containing the hand rinse samples were placed in a cold box with ice packs which maintained the box at $\leq 10^{o}$C (Ram *et al.*, 2011) and transported (between 45 minutes and 1 hour) to the laboratory for investigation (described in section 3.9.2). The hand-rinse method was validated against other standard methods such as the hand-impression and hand-swab (in 1% peptone buffer) methods of recovery of feacal indicators from hands (Appendix 8.5)

FIGURE 3.2: PICTURE SHOWING HAND-RINSE BEING TAKEN FROM A WASTE HANDLER

3.9.2 DETECTION OF FAECAL INDICATOR E. COLI/*COLIFORM IN HAND-RINSE*

The detection of faecal indicator bacteria in hand-rinse among waste handlers was performed according to the methods outlined by Warburton, (2000) with slight modifications. A serial dilution was prepared using 1ml of the stock hand-rinse solution to obtain four concentrations of faecal indicators, thus Stock, 10^{-1}, 10^{-2}, and 10^{-3}. A 100 µl of each concentration was dispensed into empty but labeled Petri-dishes, and about 20-25ml of molten Brilliance™ *E. coli*/Coliform selective indicator agar at 45°C, was added. Brilliance agar was prepared according to manufacturer's instructions (CM 1046, Oxoid, UK). The plate containing the hand-rinse solution and molten agar was then swirled for even distribution with the hand-rinse containing faecal indicators.

The plates were allowed to set on a bench at room temperature, turned upside down and were incubated at 44°C ± 0.5°C for 24hrs, using the incubator (Yamato, IC-62, Tokyo, Japan). The plates were visually inspected and the number of *E. coli*/Coliform colonies counted using the colony

counter (Gallenkamp. UK) and recorded in a laboratory notebook and later into an excel spreadsheet for analysis. Positive culture for faecal indicator *E. coli* appeared as purplish looking colonies, whilst other faecal Coliforms appeared as pinkish colonies. Isolates were purified and confirmed as indicator *E. coli* using phenotypic tests like citrate production (on Simmon Citrate Agar), acid and gas production (on TSI – Triple Sugar Iron), indole production and motility (on SIM – Sulphur Indole Motility media) and urea production (on Urea agar).

3.9.3 ANTI-HELMINTHIC TREATMENT OF WASTE HANDLERS

Two hundred and sixty one (261) out of the 280 waste handlers were treated with single oral dose of Albendazole (400mg – SmithKline Beecham Laboratoires Pharmaceutiques, France) at baseline of quantitative data collection, using the Directly Observed Treatment strategy (Montresor *et al.*, 1998; Farmer *et al.*, 2001). The waste handlers were treated at baseline according WHO recommendations on anti-helminthic treatment of high occupational risk groups living in endemic communities with previous prevalence of over 20% (WHO, 2006). According to Bonsu *et al.*, (2000), the prevalence rate of helminthes infections within the Ningo-Prampram community was 25.3%. Hence pre-treatment prevalence rate and intensity of helminthes infections among the waste handlers was not determined. Albendazole is effective in treating infected populations but harmless to uninfected populations (WHO, 2006). The treated waste handlers were followed up, three and six months post-treatment, to check their helminthes incidence rate and intensity of infections. Nineteen (19) waste workers were excluded from taking Albendazole (400mg) treatment due to the following reasons given through a short questionnaire:

1. Pregnancy (3 waste handlers)
2. Breastfeeding (12 waste handlers)

3. Having taken de-wormer less than 3 months ago (3waste handlers)
4. Previous experience of adverse reaction to a de-wormer previously taken (1 waste handler)

The Albendazole was administered by the researcher after being trained by a health worker at the Prampram Health Centre (PHC). There was a stand-by public health nurse at the PHC who was officially designated to receive complaints of adverse reactions to the Albendazole. The anticipated complaints were upper gastrointestinal symptoms (e.g. epigastric or abdominal pain, nausea, vomiting) and diarrhoea.

3.9.4 Collection and transportation of stool specimen

One stool sample per waste handler, each at 90 and 180 days post-treatment were collected to determine the incidence rate of intestinal helminthes infections among waste handlers in Prampram. Each waste handler produced an early morning stool which was collected in previously distributed labelled screw-capped stool specimen containers. The stools were placed in a cool box containing ice packs (to prevent decomposition of specimen and eggs from hatching) and transported within 2 hours to the Noguchi Memorial Institute for Medical Research for processing and analysis. The stool specimen were either processed and analyzed immediately or stored in a refrigerator at 4°C until ready to be processed within 7 days (Yatich *et al.*, 2009).

3.9.5 Processing and Analysis of stool specimen by Kato-Katz technique

Each stool specimen was processed and analyzed using the Kato-Katz (cellophane faecal thick smear) procedure as described by Katz *et al.*, (1972) with slight modifications. Briefly, small amount (about 1g) of emulsified stool specimen was placed on a hydrophobic paper in a bio-safety cabinet. A

piece of nylon sieve was pressed on top so that some of the stool specimen sieved through the pores. A spatula was used to scrape the stool across the surface of the nylon sieve to fill the hole in the centre of a card template placed on a microscope slide.

The hole in the template had earlier been calibrated and found to accommodate 41.7 mg of stool specimen (Martin and Beaver, 1968). Excess stool was removed and the template was carefully removed and a cylinder of stool was left on the microscope slide. The stool specimen on the microscope slide was covered with a cellophane strip pre-soaked with malachite green (prepared in glycerol). The slide was then inverted and firmly pressed against a leveled hard and smooth surface to spread the stool uniformly. The prepared slide was left in a dust-free area in the laboratory at room temperature (25-30°C) to clear for at least 30 minutes and examined under light microscope (x10 objective lens magnification). The presence of any species of helminthes eggs identified were counted and recorded in a laboratory notebook.

The already examined slides were kept for one or more hours to further examine those suspected to contain eggs of *Schistosoma mansoni*. This was to allow better clearing of faecal material to allow for optimal identification of the characteristic lateral spines. The x40 objective lens was used to further confirm morphology and size of helminthes eggs already identified with the x10 objective.
Two slides were prepared for each stool specimen collected. The egg per gram (EPG) of faeces was calculated to obtain the intensity of helminthes infections by multiplying the number of individual eggs by the multiplication factor, 24 (WHO, 2002).

All stool specimen collected were 'formed' and therefore suitable for processing by the Kato Katz protocol. Hardened stool specimens were emulsified with a few drops of normal saline before

processing. About 1g of each processed stool specimen was placed in eppendorf tubes and stored at -80°C for molecular identification of other bacterial, viral or protozoan agents later.

FIGURE 3.3 PICTURE OF SOME SLIDES PREPARED FROM STOOL SPECIMEN BY THE KATO-KATZ FAECAL SMEAR METHOD

(The arrows point to duplicate Kato-Katz slides from a waste handler with identification code and date of preparation).

FIGURE 3.4 PICTURE OF AN EGG OF *TRICHIURIS TRICHIURA* IDENTIFIED IN KATO-KATZ FAECAL SMEAR OF A WASTE HANDLER

(The arrow points at the characteristic terminal plug of the egg of T. trichiura at X10 objective magnification).

3.10 QUALITY CONTROL OF DATA

3.10.1 FIELD QUALITATIVE AND QUANTITATIVE DATA

One qualified field assistant with relevant background and experience was recruited to assist in questionnaire administration. Two days training was conducted for the field assistant to familiarize with the questionnaire and to avoid interviewer bias to responses prior to commencement of data collection. The in-depth interview guide was translated and back translated from English to Dangme and from Dangme to English to check for accuracy and consistency with the original meaning in English, by a qualified bi-lingual speaker before it was administered on the field to the waste handlers.

The questionnaire, in-depth and stakeholder interview guides were pre-tested among fifteen (15) waste handlers in a nearby community with similar features/characteristics to ensure quality of data collected. Five (5) out the fifteen waste handlers participated in pre-testing of stakeholder and in-depth interviews. The data collection instruments were then revised and modified to suit the local context. Both stakeholder and in-depth interviews were transcribed by the researcher and field assistant respectively on the day the interviews were conducted.

Transect walk for the observational study were first conducted from the outskirts of the study communities and gradually narrowed towards the centre, in order to ensure adequate coverage of sites where waste handlings took place.

After fieldwork, each questionnaire was checked for completeness before entering directly into SPSS 17.0 for Windows 7 (SPSS, Inc., Chicago, IL.), to minimize errors. Data was later imported into STATA MP Version 13 (Stata Corporation, College Station, USA) for statistical analysis. Blinded double entry of information from questionnaire was done to ensure accuracy of information entered into the computer software.

3.10.2 LABORATORY DATA

The hand-rinse method of recovery of feacal indicator *E. coli* and Coliforms from hands of waste handlers was validated against other standard methods such as the hand-impression and hand-swab (in 1% peptone buffer) methods, described in Appendix 8.5. Two slides were prepared per sample for identification and quantification of helminthes eggs. Where present, the average number of helminthes eggs was used to estimate intensity of infection. Parasite eggs on each positive slide were

confirmed by a senior laboratory technician and microscopist. About 10% of all examined slides were randomly selected and re-examined under the microscope by the senior laboratory technician and microscopist as quality control.

3.11 DATA ANALYSIS

The qualitative and quantitative data were analyzed differently and described separately in sections 3.11.1-2 below.

3.11.1 QUALITATIVE DATA ANALYSIS

In-depth and stakeholder interviews were analyzed using the approach of thematic content analysis through inductive reasoning. The audio-recorded information was transcribed verbatim into computer files. The transcripts were categorized into quotes and coded using a code book. The codes were used to identify and generate emerging themes which were then used to analyze information on experiences and perceptions about common occupational health problems among waste handlers. Additional thematic areas identified included (but not limited to) the waste handlers' perception and experiences of personal protection and access to basic hygiene facilities during work. All the emerging themes from the coded transcripts were used to generate contents which were later discussed. Some of the emerging themes from the stakeholder interviews included types of waste management organizations and classification of activities performed by waste handlers operating within the peri-urban communities in Prampram. The themes were then analyzed and discussed in the context of the specific objectives, using the approach of thematic content analysis through inductive reasoning (Elo and Kyngas, 2008).

3.11.2 QUANTITATIVE DATA ANALYSIS

Data from questionnaire was coded and entered into SPSS 17.0 for Windows 7 (SPSS, Inc., Chicago, IL.) and later imported into STATA MP Version 13 (STATA Corporation, College Station, USA) for statistical analysis. Covariates were found to be significant at the 95% confidence level ($P < 0.05$) in bivariate and univariable analysis stage and these were included in multivariate logistic regression models. In particular, bivariate analysis of factors associated with certain outcome variables were based on likelihood ratio and the Fishers exact test statistic of independence. The statistical technique in the multivariable analysis section was based on the type of distribution of the predictors and outcome variables. Kolmogorov Smirnov Z test was used to test for normality of all quantitative variables. Frequencies, percentages and arithmetic mean were estimated. Three different non-parametric statistical procedures were used (Wilcoxon rank sum test, sign test and Kruskal Wallis).

Quantification of the strength of associations between covariates (including socio-demographic characteristics, waste handling activities, use and type of personal protective working gear, exposure surface of body parts) and key outcome variables (including helminthes infections, faecal contamination of hands as measured by the presence of faecal indicator *E. coli* and Coliform concentrations, specific self-reported health outcomes and self-reported musculoskeletal pains) were assessed by multivariable logistic regression models.

In assessing the effect of exposure surface of body parts, type of waste handling activities, use and type of personal protective gear on the intensity of helminthes infection, log concentration of *E. coli* and Coliform, zero inflated negative binomial regression model was used. Odds ratios and corresponding confidence intervals were computed as measures of strength of association in both the

univariable and multivariable analysis of factors associated with all binary outcome variables of interest.

Spearman rank correlation coefficient was used to determine the strength of association between faecal indicator *E. coli* and Coliform concentration among the waste handlers. A Bland-Altman assessment for agreement was used to compare the two faecal contamination indices (*E. coli* and Coliform concentration) and range of agreement was defined as mean bias $\pm 2\,SD$. Significant differences in log concentration of *E. coli* and Coliform among different possible combinations of waste handling activities were based on Kruskal Wallis test. The post-hoc test after Kruskal Wallis was determined by Dunn's test for stochastic dominance among multiple pairwise comparisons based on Bonferroni method of adjustment. Robust standard error (Jackknife) was used to estimate the standard error.

Helminthes egg counts was not normally distributed, however there are biological justifications as to why the mean is preferred to the geometric mean and the median in determining the intensity of helminthes infections as explained by Montresor *et al.*, (2007). The geometric mean was used to normalize the typical over-dispersed distribution of intensity of helminthes infections.

The incidence rate of helminthes infection was estimated using the formula adopted by Brittney *et al.*, (2013) with slight modification within the context of the current study.

$$\frac{\text{Number of new cases of helminthes infections over the period}}{\text{Person-time at risk of helminthes infection over the follow up period}}$$

The person time at risk for helminthes infections was defined as $\left[\frac{\alpha+\beta}{2}\right] \times \Delta t$ where α is number of waste handlers at risk at the beginning of the time interval, β is number of waste handlers at risk at the end of the time interval and Δt is number of time units in the time interval.

Unless otherwise stated significant associations were observed at $p < 0.05$. Data was analyzed using STATA MP Version 13 (STATA Corporation, College Station, USA).

3.12 Ethical considerations and clearance

Ethical clearance was obtained from the Institutional Review Board of the Dodowa Health Research Centre (DHRC-IRB – STUDY NO.01/10/11) and Ghana Health Service Ethical Review Committee (GHS-ERC – 09/07/12) before commencement of data collection. Permission was sought from the District Environmental Health Director and District Waste Manager and Prosecutor of the Dangme West District Assembly, Assembly members, Director of the Prampram Health Centre as well as Leaders of the various waste management organizations operating within peri-urban communities in Prampram. Reconnaissance contacts were established with other stakeholders in the Prampram community who were also involved in the study.

Waste handlers were voluntarily recruited after the objectives of the study were clearly explained and informed written consent obtained from them by signature or thumbprint. Additional verbal consent was sought for stakeholder interviews. The identity of stakeholders and waste handlers who consented to participate in the study was not disclosed whilst the information provided by them was kept confidential. (Please find full text of the informed consent form as well as ethical clearance from the DHRC-IRB and GHS-ERC in appendix 8.1).

4.0 CHAPTER FOUR – RESULTS

4.1 WASTE HANDLERS, WASTE MANAGEMENT PRACTICES AND SANITATION IN PRAMPRAM

Transect walk and observation through the study community to identify waste management practices and general sanitation revealed that waste handlers worked at different locations including waste contaminated open spaces (including human faeces), the beaches, around ponds and refuse containers, public toilet facilities, cemeteries and in open drains containing faecal sludge and domestic waste effluents. Waste handlers were engaged in different waste activities along the waste management chain including sweeping, collection, transportation and disposal as well as a combination of two or more activities (also known as multiple tasking). There was limited access to water, sanitation and hygiene facilities for use during waste handling. Stakeholder interviews and questionnaire indicated that waste handlers worked for five different waste management organizations including; private companies in partnership with Government (e.g. Zoom Lion, ZOIL and Azongtaba Construction Industries – ACI), the community Local Government (e.g. Area Council) and Community Volunteer Groups (e.g. Arise and Shine). Whilst the ACI and ZOIL groups worked mainly at the Lower Communities (specifically at the beaches), Zoom Lion, Area Council and the Community Volunteers worked in the Upper Communities (i.e. in open spaces, gutters, toilet facilities and dumping sites). Figure 4.1 shows a Geographic Information System (GIS) map of Prampram indicating some of the sites waste handlers were identified.

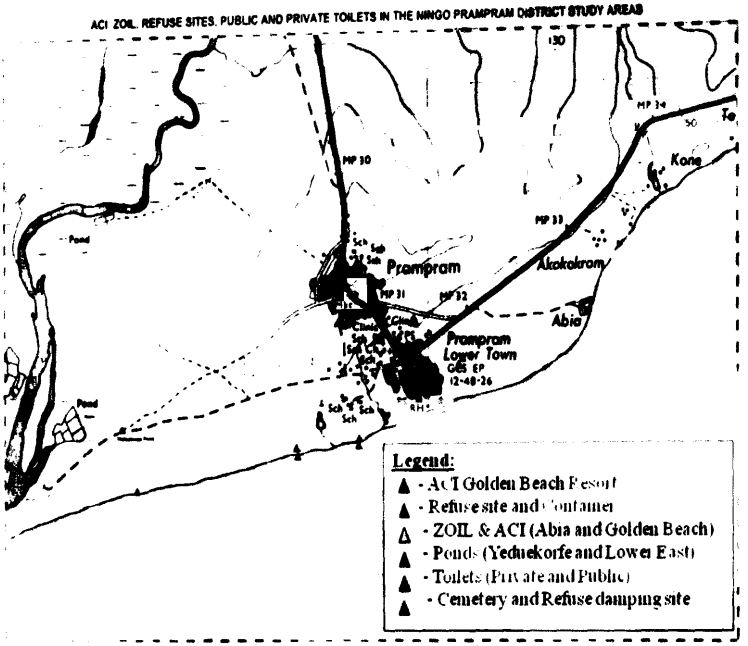

FIGURE 4.1 MAP OF PRAMPRAM SHOWING WASTE HANDLING LOCATIONS

4.1.1 Description of waste handling activities

The different waste handling activities were classified and described through personal observation by transect walk and the by use of questionnaire as illustrated in Box 4.1 below.

Box 4.1: Description of waste handling activities and associated possible health hazards

Waste handling activity	Description	Possible associated health hazards
Sweeping	Using brooms to manually clean and gather wastes from streets, lorry park, beaches, gutters, sanitary facilities (public toilet facilities and dumping sites), waste receptacles, tricycles, around dumping sites and open spaces within the peri-urban communities such as the market place.	Inhalation of dust particles, musculoskeletal problems, faecal contamination of bare hands.
Collection	Using either bare or gloved hands, shovels, brooms, or rakes to pick or remove solid waste from beaches, public amenities, sanitary facilities (public toilet facilities and dumping sites), gutters, fresh water ponds, abandoned grave yards within the peri-urban communities. The waste materials were collected into solid waste receptacles or wheelbarrows and transported to landfill sites, buried or dumped into nearby bushes.	Faecal contamination of bare hands, musculoskeletal problems.
Transportation	The act of moving solid waste from the point of collection to disposal sites using motor-powered waste tricycles, (with attached open tray/caravan for rear loading).	Musculoskeletal problems.
Disposal	Throwing or dumping collected solid waste into waste receptacles, landfill sites or 'unofficial' dumping sites along the beach, around fresh water ponds or in the bush. Waste disposal also involved burning or digging the soil to bury waste materials. Waste materials were usually disposed of in bulk without prior sorting or treatment.	Faecal contamination of bare hands, musculoskeletal problems.
Multiple activities	Performance of two or more of the following activities; sweeping, collection and disposal.	Inhalation of dust particles, musculoskeletal problems, faecal contamination of bare hands.

Scene 4.2.1: Sweeping **Scene 4.2.2:** Collection **Scene 4.2.3:** Disposal **Scene 4.2.4:** Transport

FIGURE 4.2 SCENES OF SOME WASTE HANDLING ACTIVITIES

(The figure showing scenes 4.2.1 to 4.2.4 were some specific waste handling activities captured with digital camera during field observations).

4.2 SOCIO-DEMOGRAPHIC CHARACTERISTICS OF WASTE HANDLERS

The socio-demographic characteristics of waste handlers performing different waste handling activities is shown in Table 4.1. A total number of 280 waste handlers were recruited for this study from five different waste management organizations operating within the study area. The proportion of males and females was 24.6% and 75.4% respectively with a mean age of 42.7 years. The youngest person among the waste handlers was aged 13 years and the oldest was 87 years. Approximately 78% of the study participants worked for 3 to 4 hours a day and more than half (57.9%) of the waste handlers have worked with the waste management organizations for less than a year. In relation to their level of education, 115 (41.1%) had no formal education and 13(4.6%) had secondary education. The proportions of waste handlers performing different activities were as follows: sweeping only (18.2%), disposal only (6.4%), collection only (4.3%), transport (1.8%) only and the number of workers that performed two or more activities (multiple tasking) of the stated activities was 69.3% in total.

TABLE 4.1: SOCIO-DEMOGRAPHIC CHARACTERISTICS

n(%) Socio-demographic characteristics	Waste handling activities							
	S	D	C	T	SD	SC	CD	SCD
Sex								
Male	3(4.4)	12(17.4)	8(12.0)	5(7.3)	2(2.9)	3(4.4)	29(42.0)	7(10.1)
Female	48(23.0)	6(2.8)	4(1.9)	0(0.0)	4(1.9)	3(4.4)	29(42.0)	7(10.1)
Age in years								
<35	15(17.0)	6(7.0)	4(4.4)	1(1.1)	0(0.0)	26(29.0)	10(11.1)	28(31.1)
35 and above	36(19.0)	12(6.3)	8(4.2)	4(2.1)	6(3.2)	43(22.6)	26(14.0)	55(29.0)
Highest Education Level								
None	25(22.0)	7(6.1)	3(2.6)	1(1.0)	3(2.6)	26(22.6)	14(12.2)	36(31.3)
Primary	11(14.1)	4(5.1)	4(5.1)	0(0.0)	0(0.0)	28(35.9)	10(12.8)	21(26.9)
JHS	7(23.3)	3(10.0)	1(3.3)	0(0.0)	1(3.3)	5(17.0)	4(13.3)	9(30.0)
MSLC	6(14.0)	3(6.8)	3(6.8)	3(6.8)	2(5.0)	8(18.2)	5(11.4)	14(31.8)
Secondary	2(15.3)	1(8.0)	1(8.0)	1(8.0)	0(0.0)	2(15.4)	3(23.1)	3(23.1)
No. of Years worked								
< 1 year	16(10.0)	7(4.3)	9(6.0)	1(0.6)	2(1.2)	54(33.3)	22(14.0)	51(31.5)
1-2 years	17(53.1)	3(9.4)	0(0.0)	1(3.1)	0(0.0)	2(6.3)	1(3.1)	8(25.0)
3-4 years	17(22.1)	7(9.1)	3(3.9)	2(2.6)	4(5.2)	11(14.3)	12(16.0)	21(27.3)
5 or more years	1(11.1)	1(11.1)	0(0.0)	1(11.1)	0(0.0)	2(22.2)	1(11.1)	3(33.3)
Current Monthly Salary								
Less than ¢80.0	14(33.0)	7(16.3)	0(0.0)	1(2.3)	3(7.0)	5(11.6)	2(5.0)	11(26.0)
¢80-¢150	37(15.6)	11(4.6)	12(5.1)	4(2.0)	3(1.3)	64(27.0)	34(14.4)	72(30.4)

Legend: S represent sweeping, D (disposal), C (collection), T (Transport), SD (Sweeping and disposal), SC represent sweeping and collection, CD (collection and disposal), SDC (sweeping, collection and disposal), n(%) represent frequency and row percentage

4.3 USE AND TYPE OF PERSONAL PROTECTIVE GEAR (PPG) AND EXPOSURE SURFACES DURING WASTE HANDLING

As shown in Table 4.2, the overall distribution of use and type of personal protective working gear during waste handling was as follows: Wellington boot (61.8%), gloves (57.5%), nose/mouth cover (32.1%) and overall apron (72.9%). The proportion of waste handlers with the highest use of nose/mouth cover were those who swept and collected waste everyday (26.0%). According to Table 4.2, the exposure surfaces of waste handlers during work was also recorded in the following proportions: mouth/nose (41.8%), hands (85.4%) and leg/feet (45.7%). The proportion of waste handlers with the highest exposure surfaces for mouth/nose (38.5%), hands (32.6%) and feet (35.9%) were those who performed three activities, i.e. swept, collected and disposed waste everyday (Table 4.2).

TABLE 4.2: TYPE OF PERSONAL PROTECTIVE GEAR AND EXPOSURE SURFACES OF WASTE HANDLERS PERFORMING DIFFERENT ACTIVITIES

n(%)	Waste handling activities							
Use of PPG/Exposure surfaces	S	D	C	T	SD	SC	CD	SCD
Type of personal protective working gear								
Wellington boot	16(9.3)	9(5.2)	9(5.2)	2(1.2)	2(1.2)	51(30.0)	27(15.6)	57(33.0)
Gloves	25(15.5)	9(6.0)	11(6.8)	0(0.0)	2(1.2)	39(24.2)	24(14.9)	51(32.0)
Mouth/nose cover	15(17.0)	5(6.0)	3(3.3)	3(3.3)	0(0.0)	23(26.0)	15(17.0)	26(17.0)
Overall apron	19(9.3)	10(4.9)	12(4.3)	3(1.5)	2(1.0)	62(30.4)	30(14.7)	66(32.4)
Exposure surfaces								
Mouth/nose	11(9.4)	8(6.8)	3(3.0)	2(1.7)	3(3.0)	32(27.4)	13(11.1)	45(38.5)
Hands	45(18.8)	14(6.0)	5(2.1)	5(2.1)	6(2.5)	57(24.0)	29(12.1)	78(32.6)
Leg/feet	23(18.0)	4(3.1)	6(5.0)	2(2.0)	3(2.3)	33(26.0)	11(9.0)	46(35.9)

Legend: S represent sweeping, D (disposal), C (collection), T (Transport), SD (Sweeping and disposal), SC represent sweeping and collection, CD (collection and disposal), SDC (sweeping, collection and disposal), n(%) represent frequency and row percentage, PPG (personal protective gear)

ASSOCIATION BETWEEN SOCIO-DEMOGRAPHIC CHARACTERISTICS, PERSONAL PROTECTIVE AR, EXPOSURE SURFACES AND TYPE OF WASTE HANDLING ACTIVITIES

shown in Table 4.3, the type of waste handling activities undertaken by waste handlers was ;ociated with socio-demographic characteristics including sex ($p < 0.0001$), number of years)rked with waste management organization ($p < 0.0001$) and monthly salary ($p < 0.0001$), based on : Likelihood ratio Chi-square test. Table 4.3 again shows that the type of waste handling activities rrelated with use and type of personal protective working gear such as Wellington boots (p).0001), gloves ($p = 0.004$) and overall apron ($p < 0.0001$). The type of waste handling activities ;ain correlated with surfaces of exposure such as direct exposure of hands ($p < 0.001$) as well as outh/nose ($p = 0.016$), based on the Likelihood ratio Chi-square test (Table 4.3).

ACTIVITIES AMONG STUDY PARTICIPANTS

n(%) Socio-demographic characteristics	Waste handling activities								LR	P-value
	S	D	C	T	SD	SC	CD	SCD		
Sex										
Male	3(4.4)	12(17.4)	8(12.0)	5(7.3)	2(2.9)	3(4.4)	29(42.0)	7(10.1)		
Female	48(23.0)	6(2.8)	4(1.9)	0(0.0)	4(1.9)	3(4.4)	29(42.0)	7(10.1)	140.0	<0.0001
Age in years										
<35	15(17.0)	6(7.0)	4(4.4)	1(1.1)	0(0.0)	26(29.0)	10(11.1)	28(31.1)		
35 and above	36(19.0)	12(6.3)	8(4.2)	4(2.1)	6(3.2)	43(22.6)	26(14.0)	55(29.0)	0.5	0.474
Highest Education Level										
None	25(22.0)	7(6.1)	3(2.6)	1(1.0)	3(2.6)	26(22.6)	14(12.2)	36(31.3)		
Primary	11(14.1)	4(5.1)	4(5.1)	0(0.0)	0(0.0)	28(35.9)	10(12.8)	21(26.9)		
JHS	7(23.3)	3(10.0)	1(3.3)	0(0.0)	1(3.3)	5(17.0)	4(13.3)	9(30.0)	27.3	0.501
MSLC	6(14.0)	3(6.8)	3(6.8)	3(6.8)	2(5.0)	8(18.2)	5(11.4)	14(31.8)		
Secondary	2(15.3)	1(8.0)	1(8.0)	1(8.0)	0(0.0)	2(15.4)	3(23.1)	3(23.1)		
No. of Years worked										
< 1 year	16(10.0)	7(4.3)	9(6.0)	1(0.6)	2(1.2)	54(33.3)	22(14.0)	51(31.5)		
1-2 years	17(53.1)	3(9.4)	0(0.0)	1(3.1)	0(0.0)	2(6.3)	1(3.1)	8(25.0)		
3-4 years	17(22.1)	7(9.1)	3(3.9)	2(2.6)	4(5.2)	11(14.3)	12(16.0)	21(27.3)	57.4	<0.0001
5 or more years	1(11.1)	1(11.1)	0(0.0)	1(11.1)	0(0.0)	2(22.2)	1(11.1)	3(33.3)		
Current Monthly Salary										
Less than ¢80.0	14(33.0)	7(16.3)	0(0.0)	1(2.3)	3(7.0)	5(11.6)	2(5.0)	11(26.0)		
¢80-c150	37(15.6)	11(4.6)	12(5.1)	4(2.0)	3(1.3)	64(27.0)	34(14.4)	72(30.4)	27.0	<0.0001
Type of personal protective working gear										
Wellington boot	16(9.3)	9(5.2)	9(5.2)	2(1.2)	2(1.2)	51(30.0)	27(15.6)	57(33.0)	33.3	<0.0001
Gloves	25(15.5)	9(6.0)	11(6.8)	0(0.0)	2(1.2)	39(24.2)	24(14.9)	51(32.0)	20.7	0.004
Mouth/nose cover	15(17.0)	5(6.0)	3(3.3)	3(3.3)	0(0.0)	23(26.0)	15(17.0)	26(17.0)	8.4	0.297
Overall apron	19(9.3)	10(4.9)	12(4.3)	3(1.5)	2(1.0)	62(30.4)	30(14.7)	66(32.4)	59.1	<0.0001
Exposure of body parts										
Mouth/nose	11(9.4)	8(6.8)	3(3.0)	2(1.7)	3(3.0)	32(27.4)	13(11.1)	45(38.5)	17.3	0.016
Hands	45(18.8)	14(6.0)	5(2.1)	5(2.1)	6(2.5)	57(24.0)	29(12.1)	78(32.6)	24.0	<0.001
Leg/feet	23(18.0)	4(3.1)	6(5.0)	2(2.0)	3(2.3)	33(26.0)	11(9.0)	46(35.9)	11.2	0.129

Legend: *S represent sweeping, D (disposal), C (collection), T (Transport), SD (Sweeping and disposal), SC represent sweeping and collection, CD (collection and disposal), SDC (sweeping, collection and disposal), n(%) represent frequency and row percentage*

4.5 Bivariate analysis of socio-demographic factors associated with self-reported health outcomes

Self-reported health problems were idenfied among waste handlers in the following proportions: fever (37.1%), diarrhoea (11.4%), headache (38.6%), skin disease (5.4%), cough (8.9%) and bodily pains (56.4%). Table 4.4 depicts a bivariate analysis to test for the association between socio-demographic characteristics of waste handlers and self-reported health outcomes. The likelihood ratio Chi-square test with the corresponding p-values indicate that the duration of work i.e. number of years worked and number of hours spent per day on waste handling activities were both associated with fever and bodily pain ($p < 0.05$), whilst current monthly salary was correlated with headache and bodily pains ($p < 0.0001$).

TABLE 4.4: SOCIO-DEMOGRAPHIC CHARACTERISTICS OF WASTE HANDLERS AND SPECIFIC SELF-REPORTED HEALTH OUTCOMES

Socio-demographic characteristics	Fever		Diarrhoea		Headache		Skin disease		Cough		Bodily pains	
	n(%)	p-value	n(%)	p-value	n(%)	p-value	n(%)	p-value	n(%)	p-value	n(%)	p-value
Sex												
Male	25(36.2)		7(10.1)		22(32.0)		4(5.8)		4(5.8)		44(64.0)	
Female	79(37.4)	0.857	25(12.0)	0.696	86(41.0)	0.185	11(5.2)	0.853	21(10.0)	0.273	114(54.0)	0.154
Age in years												
15-35	35(38.9)		13(14.4)		28(31.1)		7(8.0)		8(9.0)		45(50.0)	
35 and above	69(36.3)	0.678	19(10.0)	0.283	80(42.1)	0.075	8(4.2)	0.229	17(9.0)	0.987	113(59.5)	0.136
Highest Education Level												
None	41(35.7)		14(12.2)		49(42.6)		5(4.4)		9(7.8)		74(64.4)	
Primary	30(38.5)		12(15.4)		28(35.9)		4(5.1)		7(9.0)		41(53.0)	
JHS	11(36.7)		2(7.0)		9(30.0)		3(10.0)		3(10.0)		13(43.3)	
MSLC	20(45.5)		2(5.0)		17(38.6)		3(6.8)		4(9.1)		25(56.8)	
Secondary	2(15.4)	0.348	2(15.4)	0.317	5(38.5)	0.739	0(0.0)	0.577	2(15.4)	0.941	5(38.5)	0.125
Current Monthly Salary												
Less than ¢80.0	16(37.2)		5(11.6)		10(23.3)		2(5.0)		4(9.3)		18(42.0)	
¢80-¢150	88(37.1)	0.992	27(11.4)	0.964	98(41.4)	<0.0001	13(5.5)	0.820	21(9.0)	0.926	140(59.1)	<0.0001
No. of Years worked												
< 1 year	51(31.5)		21(13.0)		60(37.0)		7(4.32)		15(9.3)		104(64.2)	
1-2 years	19(59.4)		4(12.5)		14(44.0)		0(0.0)		3(9.4)		14(44.0)	
3-4 years	28(36.4)		6(8.0)		30(39.0)		6(8.0)		5(6.5)		36(47.0)	
5 or more years	6(67.0)	<0.001	1(11.1)	0.678	4(44.4)	0.884	2(22.2)	0.054	2(22.2)	0.555	4(44.4)	<0.0001
Number of hours worked												
<1	2(40.0)		1(20.0)		2(40.0)		0(0.0)			0(0.0)	5(100.0)	
1-2	20(62.5)	0.018	3(9.4)	0.813	14(43.4)	0.929	1(3.1)	0.746	0.470	2(6.3)	10(31.2)	<0.001
3-4	75(34.4)		24(11.0)		83(38.1)		12(5.5)			19(8.7)	131(60.1)	
>4	7(28.0)		4(16.0)		9(36.0)		2(8.0)			4(16.0)	12(48.0)	

P-value estimates from Likelihood Ratio Test

4.6 Association between waste handling activities and perceived causes of health problems

Approximately 91.0% of the waste handlers were of the view that wearing dirty personal protective working gear would not make them sick and more than half (54%) indicated that eating with contaminated hands has nothing to do with sickness. That notwithstanding, 61.7% indicated that physical contact with waste material and odour from waste materials could make them sick. Type of waste handling activities was associated with perceived cause of health problems such as smell/odour of waste material, contact of waste material with surfaces of exposure and eating with contaminated/dirty hands ($p < 0.05$), but not wearing of personal protective working gear ($p = 0.315$) as shown in Table 4.5.

TABLE 4.5: WASTE HANDLING ACTIVITIES AND PERCEIVED CAUSES OF HEALTH PROBLEMS

Waste Handling Activities	Perceived causes of health problems n(%)							
	Smell/odour	p-value	Contact with exposed body surfaces	p-value	Eating with contaminated/dirty hands after work	p-value	Wearing dirty PPG	p-value
Sweeping	22(43.1)	0.008	24(47.1)	0.001	35(68.6)	0.007	6(11.8)	0.315
Disposal	9(50.0)		12(66.7)		8(44.4)		3(16.7)	
Collection	6(50.0)		9(75.0)		5(41.7)		2(16.7)	
Transportation	5(100.0)		2(40.0)		4(80.0)		0(0.0)	
Sweeping and Disposal	5(83.3)		1(16.7)		2(33.3)		0(0.0)	
Sweeping and Collection	48(69.6)		50(72.5)		24(34.8)		4(5.8)	
Collection and Disposal	20(55.6)		26(72.2)		12(33.3)		5(13.9)	
Sweeping, Collection and Disposal	57(68.7)		65(78.3)		38(45.8)		4(4.8)	

P-value estimates from Likelihood Ratio Test

4.7 ASSOCIATION BETWEEN PERCEIVED CAUSES AND SELECTED SELF-REPORTED HEALTH OUTCOMES AMONG WASTE HANDLERS

The Likelihood Ratio test results as shown in Table 4.6 indicated that there was association between working with smelling/odorous waste material and reported fever ($p < 0.05$), contact with surfaces of exposure to waste was associated with reported cough and skin disease ($p < 0.05$), eating with contaminated hands after waste handling correlated with reported skin diseases and cough ($p < 0.05$) and wearing of dirty personal protective working gear was also associated with reported diarrhoea and cough ($p < 0.05$). There was however no correlation between eating with contaminated hands with diarrhoea or fever ($p > 0.05$).

TABLE 4.6: PERCEIVED CAUSES OF ILL HEALTH AND SELECTED SELF-REPORTED HEALTH OUTCOMES AMONG WASTE HANDLERS

Perceived causes of health problems	Self reported health outcomes n(%)							
	Fever	p-value	**Diarrhoea**	p-value	**Cough**	p-value	**Skin disease**	p-value
Smell/odour	72(41.9)	0.038	18(10.5)	0.525	19(11.1)	0.106	9(5.2)	0.907
Contact of exposed bodily surfaces	67(35.5)	0.399	24(12.7)	0.326	22(11.6)	0.013	14(7.4)	0.013
Eating with contaminated/dirty hands after work	54(42.2)	0.109	17(13.3)	0.372	5(3.9)	0.005	3(2.3)	0.032
Wearing dirty PPG	8(33.3)	0.684	0(0.0)	0.013	0(0.0)	0.030	0(0.0)	0.096

P-value estimates from Likelihood Ratio Test

4.8 Bivariate analysis of factors associated with self-reported health outcomes

As shown in Table 4.7, the type of waste handling activities, type of waste management organization, use of personal protective working gear, and exposure of hands to waste correlated with self-reported bodily pains ($p < 0.001$). Waste handling activities was somewhat associated with reported fever ($p = 0.05$). Exposure of the hands was associated with reported cough ($p < 0.05$) as well as bodily pains ($p = 0.002$). None of the socio-demographic factors correlated with diarrhoea and skin diseases ($p > 0.05$).

TABLE 4.7: FACTORS ASSOCIATED WITH SELF-REPORTED HEALTH OUTCOMES

	Specific self-reported health outcomes											
	Fever		Diarrhoea		Headache		Skin disease		Cough		Bodily pains	
	n(%)	p-value	n(%)	p-value	n(%)	p-value	n(%)	p-value	n(%)	p-value	n(%)	p-value
Waste Handling Activities												
Sweeping	21(41.2)		6(12.0)		24(47.1)		2(3.9)		3(6.0)		18(35.3)	
Disposal	4(22.2)		2(11.1)		6(33.3)		0(0.0)		1(6.0)		9(50.0)	
Collection	6(50.0)		1(8.3)		5(42.0)		0(0.0)		1(8.3)		7(58.3)	
Transportation	5(100.0)		0(0.0)		2(40.0)		1(20.0)		0(0.0)		2(40.0)	
Sweeping and Disposal	2(33.3)	0.054	0(0.0)	0.706	2(33.3)	0.938	0(0.0)	0.526	0(0.0)	0.271	3(50.0)	<0.001
Sweeping and Collection	24(35.0)		7(10.1)		26(38.0)		4(5.8)		11(15.9)		48(70.0)	
Collection and Disposal	11(31.0)		3(8.3)		12(33.3)		3(8.3)		1(3.0)		27(75.0)	
Sweeping, Collection and Disposal	31(37.4)		13(16.0)		31(37.4)		5(6.0)		8(9.6)		44(53.0)	
Waste handling Company												
Azontaba	50(32.3)		19(12.3)		59(38.1)		7(4.5)		15(10.0)		101(65.2)	
Area Council	5(25.0)		4(20.0)		6(30.0)		1(5.0)		2(10.0)		7(35.0)	
Zoomlion	3(33.3)		0(0.0)		3(33.3)		0(0.0)		1(11.1)		1(11.1)	
ZOIL	27(52.9)		6(12.0)		19(37.3)		4(7.8)		4(7.8)		21(41.2)	
Arise and Shine	19(42.2)	0.068	3(7.0)	0.322	21(47.0)		3(7.0)	0.752	3(7.0)	0.967	28(62.2)	<0.001
Type of protective working gear												
Wellington boot	63(36.4)	0.749	18(10.4)	0.496	73(42.2)	0.111	11(6.4)	0.333	18(10.4)	0.261	113(56.4)	<0.001
Gloves	55(34.2)	0.230	18(11.2)	0.879	69(43.0)	0.085	9(6.0)	0.840	17(11.0)	0.259	96(59.6)	0.209
Mouth/nose cover	33(37.0)	0.910	10(11.1)	0.908	42(47.0)	0.057	8(9.0)	0.081	10(11.1)	0.386	57(63.3)	0.107
Overall apron	72(35.3)	0.297	24(12.0)	0.770	84(41.2)	0.139	13(6.4)	0.186	20(9.8)	0.386	130(63.7)	<0.001
Exposure of body parts												
Mouth/nose	47(40.2)	0.375	10(8.6)	0.193	47(40.2)	0.642	5(4.3)	0.490	12(10.3)	0.511	68(58.1)	0.629
Hands	91(38.1)	0.431	30(12.6)	0.118	89(37.2)	0.273	11(4.6)	0.212	16(7.0)	0.005	126(52.7)	0.002
Leg/feet	53(41.4)	0.176	12(9.4)	0.319	59(46.1)	0.018	4(3.1)	0.119	11(8.6)	0.857	74(57.8)	0.668

P-value estimates from Likelihood Ratio Test

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ıtrolling for the confounding effect of type of waste handling activity, type of waste management anization, type of personal protective working gear, the odds of reporting bodily pains among ste handlers whose hands were exposed was 3.3 times (95%CI: AOR 1.4-10.0) higher than rkers whose hands were not exposed to waste materials. The use of personal protective working ır and exposure surfaces (leg/feet and mouth/nose) did not correlate with self-reported bodily ns. Workers whose hands were directly exposed to waste material were 4.2 times (95%CI: AOR -10.0) more probable to report cough symptoms than those whose hands were not exposed. The ds of reporting headache among waste workers whose leg/feet were exposed to waste materials s 1.8 times (95%CI: AOR 1.1-2.9) greater compared to those whose leg/feet were not exposed. e odds of reporting bodily pains among waste handlers who worked for 1-2 years was 1.2 times 5%CI: AOR 0.2-7.7) gretater than for those who worked for less than a year, whilst workers who ırked for more than 5 years were 50% less likely to report bodily pains (Table 4.8).

TABLE 4.8: THE EFFECT OF WASTE HANDLING ACTIVITIES, TYPE OF PPE AND EXPOSURE SURFACES ON SPECIFIC SELF-REPORTED HEALTH OUTCOMES

Socio-demographic/waste handling correlates	Specific self-reported health outcomes					
	Fever		Headache		Bodily pains	
	AOR(95%CI)	p-value	AOR(95%CI)	p-value	AOR(95%CI)	p-value
Current Monthly Salary						
Less than ¢80.0			1		1	
¢80-¢150			2.4(0.9-6.0)	0.037	0.5(0.2-1.5)	0.222
No. of Years worked						
< 1 year	1				1	
1-2 years	3.2(1.5-6.9)	0.096	#	#	1.2(0.2-7.7)	0.038
3-4 years	1.2(0.7-2.2)				0.3(0.0-1.8)	
5 or more years	4.4(1.0-18.1)				0.5(0.0-5.0)	
Waste Handling Activities						
Sweeping					1	
Disposal					1.6(0.5-5.1)	
Collection					1.0(0.4-7.6)	
Transportation					2.2(0.3- 18.0)	
Sweeping and Disposal	#	#	#	#	4.4(0.5-30.0)	0.063
Sweeping and Collection					3.0(1.1-7.0)	
Collection and Disposal					4.4(1.5-13.1)	
Sweeping, Collection and Disposal					1.7(1.0-4.0)	
Waste handling Company						
Azontaba					1	
Area Council					1.0(0.1-8.2)	
Zoomlion	#	#	#	#	0.3(0.0-8.0)	0.131
ZOIL					1.0(0.1-9.0)	
Arise and Shine					3.6(0.5-28.5)	
Type of protective working gear						
Wellington boot	#	#	#	#	2.0(1.0-4.0)	0.129
Overall apron	#	#	#	#	1.7(0.5-6.7)	0.300
Exposure surfaces						
Hands	#	#	1.0(0.3-1.3)	0.270	0.3(0.1-0.7)	0.004
Leg/feet	#	#	1.8(1.1-2.9)	0.018	1.1(0.7-1.8)	0.195

Legend: # represents variables that were not included in the multivariable model since they were not significantly associated with the outcome variable of interest in the univariable analysis stage and therefore no estimate for odds ratio and p-value in the multivariable analysis, AOR is adjusted odds ratio.

4.10 ASSOCIATIONS BETWEEN SOCIO-DEMOGRAPHIC CHARACTERITICS OF WASTE HANDLERS AND SELF-REPORTED MUSCULOSKELETAL PAIN

The Likelihood ratio Chi-square test showed significant association between the level of education with lower back pain ($p < 0.0001$). Monthly salary was correlated with both lower ($p < 0.0001$) and upper back pains ($p < 0.0001$). Duration of work i.e. number of years worked was associated with both lower ($p < 0.0001$) and upper back pains ($p < 0.0001$); whilst number of hours worked per day correlated with upper back pain ($p = 0.043$). There was however no association between the covariates, age and sex with the outcome variable, reported musculoskeletal pains ($p > 0.05$) as shown in Table 4.9.

TABLE 4.9: SOCIO-DEMOGRAPHIC CHARACTERISTICS OF WASTE HANDLERS AND SELF-REPORTED MUSCULOSKELETAL PAINS

Socio-demographic characteristics	Self-reported musculoskeletal pains							
	Neck pain		Lower back pain		Upper back pain		Wrist pain	
	n(%)	p-value	n(%)	p-value	n(%)	p-value	n(%)	p-value
Sex								
Male	11(15.9)		50(72.5)		52(75.4)		18(26.1)	
Female	38(18.0)	0.692	156(73.9)	0.811	160(75.7)	0.937	50(23.7)	0.689
Age in years								
13-35	16(18.0)		64(71.1)		72(80.0)		22(24.4)	
35 and above	33(17.4)	0.933	142(74.7)	0.523	140(74.0)	0.244	46(24.3)	0.966
Highest Education Level								
None	24(21.0)		94(81.7)		94(81.7)		29(25.2)	
Primary	14(18.0)		62(79.5)		61(78.2)		17(22.0)	
JHS	5(17.0)		19(63.3)		19(63.3)		5(17.0)	
MSLC	4(9.1)		25(56.8)		28(63.6)		14(31.8)	
Secondary	2(15.4)	0.485	6(46.2)	<0.0001	10(76.9)	0.086	3(23.1)	0.620
Current Monthly Salary								
Less than ¢80.0	7(16.3)		16(37.2)		23(53.5)		10(23.3)	
¢80-¢150	42(17.7)	0.817	190(80.2)	<0.0001	189(80.0)	<0.0001	58(24.5)	0.864
No. of Years worked								
< 1 year	33(20.4)		133(82.1)		135(83.3)		39(24.1)	
1-2 years	5(15.6)		21(65.6)		24(75.0)		7(22.0)	
3-4 years	10(13.0)		45(58.4)		46(59.7)		21(27.3)	
5 or more years	1(11.1)	0.489	7(78.0)	<0.0001	7(78.0)	<0.0001	1(11.1)	0.688
Number of hours worked								
<1	0(0.0)		5(100)		5(100.0)		1(20.0)	
1-2	4(12.5)		19(59.4)		20(62.5)		8(25.0)	
		0.434		0.047		0.043		0.966
3-4	40(8.4)		166(76.2)		171(78.4)		52(23.9)	
>4	5(20.0)		16(64.0)		16(64.0)		7(28.0)	

4.11 BIVARIATE ANALYSIS OF FACTORS ASSOCIATED WITH SELF-REPORTED MUSCULOSKELETAL PAINS

The use of personal protective working gear, type of waste handling activity, type of waste management organization and current monthly salary were associated with self-reported lower and upper back pains ($p < 0.05$). The Likelihood ratio Chi-square test showed a significant relationship between self-reported neck pain and exposure of leg to waste materials ($p = 0.037$), whilst the exposure of hands to waste materials correlated with self-reported wrist pain ($p = 0.008$) (Table 4.10). Exposure surfaces to waste material did not correlate to lower and upper back pains ($p > 0.05$).

TABLE 4.10: FACTORS ASSOCIATED WITH SELF-REPORTED MUSCULOSKELETAL PAINS

Waste handling correlates	Self-reported musculoskeletal pains							
	Neck pain		Lower back pain		Upper back pain		Wrist pain	
Waste Handling Activities	n(%)	p-value	n(%)	p-value	n(%)	p-value	n(%)	p-value
Sweeping	3(6.0)		33(64.7)		30(58.8)		7(13.7)	
Disposal	5(28.0)		11(61.1)		11(61.1)		2(11.1)	
Collection	1(8.3)		8(67.0)		9(75.0)		4(33.3)	
Transportation	1(20.0)		3(60.0)		4(80.0)		1(20.0)	
Sweeping and Disposal	0.(0.0)		1(17.0)		1(17.0)		1(17.0)	
Sweeping and Collection	16(23.2)		53(76.8)		53(76.8)		16(23.2)	
Collection and Disposal	5(14.0)		29(81.0)		31(86.1)		12(33.3)	
Sweeping, Collection and Disposal	18(22.0)	0.068	68(81.9)	<0.0001	73(88.0)	<0.0001	25(30.1)	0.234
Waste handling Company								
Azontaba	31(20.0)		128(83.0)		130(84.0)		37(24.0)	
Area Council	4(20.0)		9(45.0)		10(50.0)		3(15.0)	
Zoomlion	0(0.0)		3(33.3)		2(22.2)		0(0.0)	
ZOIL	8(16.0)		32(63.0)		37(73.0)		12(23.5)	
Arise and Shine	6(13.3)	0.298	34(76.0)	<0.0001	33(73.3)	<0.0001	16(36.0)	0.063
Type of protective working gear								
Wellington boot	29(17.0)	0.681	144(83.2)	<0.0001	139(80.4)	<0.0001	44(25.4)	0.568
Gloves	33(20.5)	0.121	132(82.0)	<0.0001	127(79.0)	0.152	46(29.0)	0.049
Mouth/nose cover	15(17.0)	0.800	72(80.0)	0.088	70(78.0)	0.577	23(26.0)	0.734
Overall apron	38(18.6)	0.409	168(82.4)	<0.0001	165(81.0)	<0.0001	51(25.0)	0.646
Exposure surfaces								
Mouth/nose	19(16.2)	0.637	87(74.4)	0.800	95(81.2)	0.067	35(29.9)	0.064
Hands	17(18.0)	0.594	175(73.2)	0.747	181(75.3)	0.987	51(21.3)	0.008
Leg/feet	29(22.7)	0.037	94(73.4)	0.963	103(80.5)	0.087	32(25.0)	0.798

2 MULTIVARIABLE ANALYSIS OF FACTORS ASSOCIATED WITH SELF-REPORTED SCULOSKELETAL PAINS

shown in Table 4.11, the higher the educational qualification attained by waste handlers (i.e. from nary to secondary), the less likely they reported lower back pain, compared with those with no ıcation ($p < 0.001$). For example, whilst the odds of reporting lower back pain among workers h only primary education was 20% less, this was 90% less for waste handlers with secondary ıcation, as compared with those with no formal education. Table 4.11 again depicts that ıtrolling for use and type of personal protective working gear, type of waste handling activity and ɔe of waste management organization, the odds of reporting lower back pain among waste handlers ıo earned between ¢80.0 to ¢150.0 a month was 8.4 times (95%CI AOR=2.0-35.3) greater than ɔrkers who earned below ¢80. Waste handlers who had worked for 1-2 years had 70% less risk of ɔorting upper back pains compared with those who had worked for less than a year, whilst those ıo worked for 5 years and above had 80% less risk of reporting upper back pains. Upper back pain d type of waste handling activities were dependent. Controlling for the effect of monthly salary, e and type of protective working gear and type of waste management organization, the odds of porting upper back pain among workers who performed single activities was 7 times greater for ınsporters (95%CI AOR:0.3-143.5), 2 times greater for collecters (95%CI AOR:0.4-11.0) and 1.4 nes greater for disposers (95%CI AOR:0.4-5.1) compared with sweepers. For workers who :rformed multiple activities, the odds of reporting upper back pains was 5.6 times greater (95%CI OR: 2.0-17.0) for those who performed three activities a day (sweeping, collection and disposal), l times greater (95%CI AOR:1.1-15.2) for those who performed two activities (collection and sposal) and 2 times greater (95%CI AOR:0.5-5.0) for those who swept and collected waste every ıy, compared with sweepers only (Table 4.11).

TABLE 4.11: THE EFFECT OF WASTE HANDLING ACTIVITIES ON SELF-REPORTED MUSCULOSKELETAL PAINS

Socio-demographic characteristics/waste handling correlates	Self-reported musculoskeletal pains			
	Lower back pain		Upper back pain	
	AOR(95%CI)	p-value	AOR(95%CI)	p-value
Highest Education Level				
None	1		#	#
Primary	0.8(0.3-2.1)		#	#
JHS	0.5(0.2-1.6)	<0.001	#	#
MSLC	0.3(0.1-0.7)		#	#
Secondary	0.1(0.0-0.4)		#	#
Current Monthly Salary				
Less than ¢80.0	1		1	
¢80-¢150	8.4(2.0-35.3)	0.023	3.7(0.9-15.2)	0.169
No. of Years worked				
1 year	1		1	
1-2 years	0.4(0.0-4.0)		0.3(0.0-3.5)	
3-4 years	0.1(0.0-0.7)	0.108	0.1(0.0-0.8)	0.002
5 or more years	0.9(0.0-20.0)		0.2(0.0- 4.2)	
Waste handling activities				
Sweeping	1		1	
Disposal	1.2(0.3-4.8)		1.4(0.4-5.1)	
Collection	1.0(0.1-3.0)		2.0(0.4-11.0)	
Transportation	1.1(0.1-17.0)		7.0(0.3-143.5)	
Sweeping and Disposal	0.1(0.0-1.8)		0.2(0.0- 3.0)	
Sweeping and Collection	1.2(0.4-4.0)	0.147	2.0(0.5-5.0)	<0.001
Collection and Disposal	1.6(0.5-6.1)		4.1(1.1-15.2)	
Sweeping, Collection and Disposal	2.2(0.7-6.4)		5.6(2.0-17.0)	
Waste handling Company				
Azontaba	1		1	
Area Council	21.3(1.3-342.3)		1.3(0.1-15.7)	
Zoomlion	9.1(0.3-298.0)	0.261	0.4(0.0-11.1)	0.023
ZOIL	33.0(1.7-635.5)		4.1(0.3-62.4)	
Arise and Shine	8.0(0.5-110.0)		5.7(0.5-71.2)	
Type of protective working gear				
Wellington boot	2.0(0.6-3.9)	0.607	1.0(0.2-1.6)	0.458
Gloves	1.4(1.0-3.5)	0.524	#	#
Overall apron	2.3(0.5-11.0)	0.836	0.3(0.1-2.0)	0.221

Legend: # represents variables that were not included in the multivariable model since they were not significantly associated with the outcome variable of interest and therefore no estimate for odds ratio and p-value in the multivariable analysis

4.13 PREVALENCE OF FAECAL INDICATOR *E. COLI* AND COLIFORMS AMONG WASTE HANDLERS BEFORE AND AFTER WORK

The overall prevalence of faecal contamination measured by the presence of indicator *E. coli* and Coliform after work among persons engaged in waste handling was estimated to be 23.2% (95%CI: 18.4-28.6) and 29.3% (95%CI: 24.0-35.0) respectively. The concentration of indicator *E. coli* and Coliforms among waste handlers before work were 133.9± 936.6CFU/ml and 375.5± 1804.7CFU/ml (mean± standard deviation), respectively. The concentration of indicator *E. coli* and Coliform after work were 3234.8±11402.9CFU/ml and 5300± 18178.8CFU/ml, respectively. The number of waste handlers that tested positive for both *E. coli* and Coliform was 16 (5.7%). The Wilcoxon rank sum test p-value indicated that there was no association between presence of *E. coli* and Coliforms (Fisher Exact $p = 0.437$).

4.14 UNIVARIABLE ANALYSIS OF FACTORS ASSOCIATED WITH CONCENTRATION OF *E. COLI* AMONG WASTE HANDLERS

The Wilcoxon matched-pairs signed test indicated a significant difference ($p < 0.0001$) in the level of *E. coli* before and after waste handling. The proportion of waste handlers that tested positive to faecal indicator *E. coli* was 23.2% (95%CI: 18.4-28.8). The mean log concentrations of indicator *E. coli* among waste handlers after work was 0.079 ± 1.6 CFU/50ml. The Kruskal Wallis test indicated a significant difference ($\chi^2 = 18.8$, $p = 0.0086$) in log concentration of indicator *E. coli* among the types of waste handling activities. Dunn's test indicated that there was a significant difference ($p = 0.0083$) in the concentration of *E. coli* among waste workers who only swept every day and those who performed two or more waste management activities everyday such as sweeping, collection and disposal. There was not enough statistical evidence to suggest that the level of *E. coli* among waste

handlers was dependent on the use of personal protective working gear ($\chi^2 = 0.91$, $p = 0.6354$). The Wilcoxon rank sum test p-values indicated that exposure surfaces to waste (hands, mouth/nose and feet) were independent of level of *E. coli* among workers ($p > 0.05$).

4.14 Univariable analysis of factors associated with concentration of Coliform among waste handlers

The Wilcoxon matched-pairs signed test showed a significant difference ($p < 0.0001$) in the level of Coliforms before and after waste handling. The mean log concentrations/level of Coliforms among waste handlers was 0.93 ± 1.7 CFU/ml and the proportion of waste handlers that tested positive to Coliform was 29.3% (95% CI: 23.9%-35.3%). The concentration of Coliform was not significantly different among the various type of waste management activities ($\chi^2 = 7.4$, $p = 0.381$) and waste management organization ($\chi^2 = 8.37$, $p = 0.0789$). The rank sum test p-value estimate showed a significant difference in the Coliform concentration among waste handlers whose legs were exposed ($p = 0.015$). The type and use of personal protective working gear as well as exposure of hand and mouth to waste were independent of level of Coliforms among waste handlers ($p > 0.05$).

4.16 Effect of socio-demographic characteristics and duration of work on the concentration of *E. coli*/Coliform among waste handlers

The results of the binary logistic regression analysis showed that level of education and number of hours spent per day on waste handling activities did not correlate with concentration of both *E. coli* and Coliforms on hands of waste handlers after work (Table 4.12). With respect to age, however, the results showed that waste handlers who were above 35 years were 4 times (95%CI: AOR:2.0-8.0) more likely to have faecal indicator *E. coli* on hands compared with those below 35 years. Female

waste handlers were 50% less likely to have faecal indicator *E. coli* on hands compared with male waste handlers. Waste handlers who earned between ¢80-¢150 were 2.4 times (95%CI: AOR:1.3-4.4) more likely to have faecal indicator Coliforms on hands compared with those who earned less than ¢80 per month. There was 1.2 times (95%CI: AOR:1.3-4.4) higher likelihood of contamination of hands with indicator Coliforms for waste handlers who have worked between 1-2 years compared with those who have worked for less than a year (Table 4.12).

MEASURED BY PRESENCE OF FAECAL INDICATOR *E. COLI* AND COLIFORM

Socio-demographic/duration characteristics	Faecal contamination measured by the presence of indicator *E. coli* and Coliform					
	E. coli			Coliform		
	n(%)	OR(95%CI)	P-value	n(%)	OR(95%CI)	P-value
Sex						
Male	24(35.0)	1		22(32.0)	1	
Female	41(19.4)	0.5(0.3-0.8)	0.010	60(28.4)	0.8(0.5-1.5)	0.585
Age in years						
<35	9(10.0)	1		24(27.0)	1	
35 and above	56(29.5)	4.0(2.0-8.0)	<0.001	58(30.5)	1.2(0.7-2.1)	0.508
Highest Education Level						
None	24(21.0)	1		39(33.9)	1	
Primary	16(20.5)	1.0(0.5-2.0)		20(25.6)	0.7(0.4-1.3)	
JHS	10(33.3)	1.9(0.8-4.6)	0.348	6(20.0)	0.5(0.2-1.3)	0.441
MSLC	13(30.0)	1.6(0.7-3.5)		13(30.0)	0.8(0.4-1.7)	
Secondary	2(15.4)	0.7(0.1-3.3)		4(31.0)	0.9(0.3-3.0)	
Current Monthly Salary						
Less than ¢80.0	11(26.0)	1		14(16.3)	1	
¢80-¢150	54(23.0)	0.9(0.4-1.8)	0.690	150(31.7)	2.4(1.3-4.4)	0.005
No. of Years worked						
< 1 year	41(25.3)	1		53(32.7)	1	
1-2 years	6(19.0)	0.7(0.3-1.8)		12(37.5)	1.2(0.6-2.7)	0.037
3-4 years	16(21.0)	0.8(0.4-1.5)	0.423	16(21.0)	0.5(0.3-1.0)	
5 or more years	2(22.2)	0.8(0.2-4.2)		1(11.1)	0.3(0.0-2.1)	
Number of hours worked						
<1	2(40.0)	1	0.363	4(80.0)	1	0.698
1-2	5(15.6)	0.3(0.02-3.7)		6(18.6)	0.1(0.01-0.3)	
3-4	50(22.9)	0.4(0.04-4.9)		65(29.8)	0.1(0.03-0.3)	
>4	8(32.0)	0.7(0.1-8.8)		7(28.0)	0.1(0.02-0.4)	

n(%) represent frequency and row percentage

4.17 DETERMINANTS OF FAECAL CONTAMINATION OF HANDS AS MEASURED BY PRESENCE OF INDICATOR *E. COLI* AND COLIFORM

The results from the zero inflated negative binomial regression model indicated that, type of waste management organization and type and use of personal protective gear were significantly associated with the concentration /level of *E. coli* and Coliforms ($p > 0.05$). The exposure surfaces of waste handlers (hands, mouth /nose and feet) were neither associated with concentration of *E. coli* nor Coliforms ($p > 0.05$) Waste handlers who worked for the Area Council were three times (95%CI: AOR:1.1-8.0) more likely to have faecal indicator *E. coli* on the hands compared with those who worked for Azontaba Construction Industries (ACI) (Table 4.13).

Risk factors	Faecal contamination measured by the presence of *E. coli* and Coliform					
	E. coli			Coliform		
	n(%)	OR(95%CI)	P-value	n(%)	OR(95%CI)	P-value
Waste Handling Activities						
Sweeping	8(16.0)	1		16(31.4)	1	
Disposal	3(17.0)	1.1(0.3-4.6)		6(33.3)	1.1(0.3-3.4)	
Collection	5(42.0)	3.8(1.0-15.2)		4(33.3)	1.1(0.3-4.2)	
Transportation	3(60.0)	8.1(1.2-56.2)	0.483	0(0.0)	****	
Sweeping and Disposal	2(33.3)	2.7(0.4-17.2)		0(0.0)	****	0.914
Sweeping and Collection	15(21.7)	1.5(0.6-3.8)		18(26.1)	0.8(0.3-1.7)	
Collection and Disposal	11(31.0)	2.4(0.8-6.7)		14(39.0)	1.4(0.6-3.4)	
Sweeping, Collection and Disposal	18(22.0)	1.5(0.6-3.7)		24(28.9)	0.9(0.4-1.9)	
Waste handling Company						
Azontaba	39(25.2)	1		52(34.0)	1	
Area Council	10(50.0)	3.0(1.1-8.0)		4(20.0)	0.5(0.2-1.6)	
Zoomlion	1(11.1)	0.4(0.1-3.1)	0.038	1(11.1)	0.2(0.03-2.0)	0.239
ZOIL	10(19.6)	0.7(0.3-2.0)		12(23.5)	0.6(0.3-1.3)	
Arise and Shine	5(11.1)	0.4(0.1-1.0)		13(29.0)	0.8(0.4-1.7)	
Type of protective working gear						
Wellington boot	38(22.0)	0.8(0.5-1.5)	0.529	58(33.5)	1.7(1.0-3.0)	0.049
Gloves	37(23.0)	1.0(0.6-1.7)	0.914	56(35.0)	1.9(1.1-3.3)	0.022
Mouth/nose cover	21(23.3)	1.0(0.6-1.8)	0.974	25(28.0)	0.9(0.5-1.6)	0.703
Overall apron	45(22.1)	0.8(0.4-1.5)	0.454	64(31.4)	1.5(0.8-2.7)	0.210
Exposure surfaces						
Mouth/nose	28(23.9)	1.1(0.6-1.9)	0.810	35(39.9)	1.1(0.6-1.8)	0.845
Hands	55(23.0)	0.9(0.4-2.0)	0.847	69(28.9)	0.9(0.4-1.8)	0.712
Leg/feet	32(25.0)	1.2(0.7-2.1)	0.516	36(28.1)	0.9(0.5-1.5)	0.695

*OR is unadjusted odds ratio, **** indicate the fact that parameter estimates were not possible since the number workers that had the outcome of interest was zero, n(%) represent frequency and row percentage*

4.18 MULTIVARIABLE ANALYSIS OF FACTORS ASSOCIATED WITH CONCENTRATION/LEVEL OF *E. COLI* AND COLIFORMS AMONG WASTE HANDLERS

Table 4.14 shows that controlling for type of waste management organization and sex, the odds of having faecal indicator *E. coli* on hands was 4.2 (95%CI: AOR:1.9-9.1) times higher among waste handlers aged 35 years and above compared with those less than 35 years. The odds of having *E. coli* on hands for waste handlers who work for Area Council was 3 times (95%CI: AOR: 1.0-8.4) higher than for workers who worked for Azontaba company controlling for age and sex. Controlling for the confounding effect of waste management organization, the use of Wellington boot and gloves, the odds of having Coliform on hands was 1.9 times (95%CI AOR:0.4-8.8) greater for waste handlers who have worked for 1-2 years compared with those who have worked for less than a year (Table 4.14).

	Faecal contamination			
	Presence of *E. coli*		Presence of Coliform	
	AOR(95%CI)	P-value	AOR(95%CI)	P-value
Socio-demographic characteristics				
Sex				
Male	1		****	****
Female	0.4(0.2-0.8)	0.009	****	****
Age in years				
<35	1		****	****
35 and above	4.2(1.9-9.1)	<0.0001	****	****
No. of Years worked				
< 1 year	****		1	
1-2 years	****	****	1.8(0.4-8.9)	0.027
3-4 years	****		0.3(0.0-2.5)	
5 or more years	****		0.2(0.0-1.3)	
Waste handling Company				
Azontaba	1		1	
Area Council	3.0(1.0-8.4)		1.6(0.4-6.7)	
Zoomlion	0.4(0.0-3.0)	0.009	1.8(0.1-24.0)	0.499
ZOIL	0.6(0.3-1.4)		4.1(0.8-20.5)	
Arise and Shine	0.3(0.1-1.0)		3.9(0.8-20.0)	
Type of protective working gear				
Wellington boot	****	****	1.2(0.7-2.4)	0.505
Gloves	****	****	1.8(0.9-3.3)	0.073

**** *Represent covariates that were not associated with faecal contamination at the Univariable analysis stage and therefore no parameter estimation at the multivariable stage, AOR is adjusted odds ratio estimate from a multivariable binary logistic regression analysis*

4.19 INCIDENCE RATE AND INTENSITY OF HELMINTHES INFECTIONS AMONG WASTE HANDLERS 3 AND 6 MONTHS POST-TREATMENT

The incidence rate of helminthes infections 6 months post-treatment among persons engaged in waste handling activities was 1.46% per month. No helminthes eggs were identified in stool specimen of waste handlers 3 months post-treatment with Albendazole. However, eggs of *Trichiuris trichiura* were identified among 12 waste handlers at 6 months post-treatment. There was no infection recorded for waste handlers who engaged in only sweeping, only disposal or who performed both activities in a day (Table 4.15). Among the five waste handlers who transported waste every day, two (representing 40%) had helminthes infections. Even though the intensity of helminthes infections 6 months post-treatment was light, (i.e. between 1- 999 egg per gram), waste handlers who only transported waste had the highest level of intensity (Mean = 33.6 ± 44.1 SD) (Table 4.15). Overall, the geometric mean intensity of helminthes infection was 2.8 ± 16.6 egg/gram at 6 months post-treatment. The proportion of light intensity helminthes infection rate among waste handlers was 4.3% at 6 months post-treatment. In relation to moderate and high intensity helminthes infection, the prevalence was 0.0% in both categories (i.e. 3 and 6 months post-treatment). Bivariate analysis of factors associated with the presence of helminthes among waste handlers, using the Likelihood ratio Chi square test statistic indicated a correlation between waste handling activity and helminthes infections (LR=15.3, p = 0.033).

TABLE 4.15: INTENSITY OF HELMINTHES INFECTIONS, 3 AND 6 MONTHS POST-TREATMENT, CATEGORIZED BY TYPE OF WASTE HANDLING ACTIVITY

Type of activity	Intensity of helminthes infection [Mean egg per gram (epg)]		*SD Egg per gram/6 months post-treatment
	3 months/post-treatment	6 months/post-treatment	
Sweeping	****	0.0	0.0
Disposal	****	0.0	0.0
Collection	****	1 (8.0)	20.8
Transportation	****	2 (33.6)	44.1
Sweeping and Disposal	****	0 (0.0)	0.0
Sweeping and Collection	****	5 (6.6)	28.0
Collection and Disposal	****	2 (1.3)	5.5
Sweeping, Collection and Disposal	****	2 (0.3)	2.6

SD - Standard deviation. ** Represents no helminthes infections at 3 months post-treatment.*

4.19.1 FACTORS ASSOCIATED WITH THE PRESENCE OF HELMINTHES AMONG WASTE HANDLERS

Table 4.16 shows that the sex of waste handlers and the use of gloves as a protective working gear were the only covariates associated with helminthes infections in the multivariable stage of the analysis. The analysis showed that the odds of helminthes infections among females was 80% less than the odds of helminthes infections among male waste handlers. Similarly, waste handlers who used gloves were 80% less likely to acquire helminthes infections compared to those who did not use gloves.

TABLE 4.16: SOCIO-DEMOGRAPHIC AND RISK FACTORS ASSOCIATED WITH HELMINTHES INFECTIONS

Socio-demographic/Risk factors	Helminthes infections 6 months post-treatment	
	AOR(95%CI)	P-value
Sex		
Male	1	
Female	0.2(0.0-0.8)	0.009
Age in years		
<35	1	
35 and above	1.0(0.9-1.1)	0.790
No. of Years worked		
< 1 year	1	
1-2 years	****	0.319
3-4 years	3.2(0.6-18.4)	
5 or more years	****	
Number of hours worked		
<1	1	
1-2	****	
3-4	****	0.691
>4	0.1(0.0-7.0)	
Waste handling activity		
Sweeping	1	
Disposal	****	
Collection	8.3(1.1-62.4)	0.963
Transportation	8.0(.08-87.0)	
Sweeping and Disposal	****	
Sweeping and Collection	8.1(1.5-43.3)	
Collection and Disposal	1.0(0.1-8.0)	
Sweeping, Collection and Disposal	****	
Type of protective working gear		
Wellington boot	****	****
Gloves	0.2(0.2-1.9)	0.033
Mouth/nose cover	4.6(2.0-16.6)	0.052
Overall apron	0.3(0.0-3.2)	0.296
Exposure surfaces		
Mouth/nose	2.5(0.6-9.7)	0.184
Hands	1.2(0.3-5.8)	0.780
Leg/feet	1.8(0.5-6.9)	0.397

**** *indicate the fact that parameter estimates were not possible since the number of workers that had the outcome of interest was zero; AOR is adjusted odds ratio estimate from a multivariable binary logistic regression analysis.*

4.19.2 COMPARATIVE ANALYSIS OF FACTORS ASSOCIATED WITH CONTAMINATION OF HANDS WITH E. COLI, COLIFORMS AND INTENSITY OF HELMINTHES INFECTION AMONG WASTE HANDLERS

The geometric mean concentrations of helminthes among waste handlers was 2.8 ± 16.6 egg/g and the incidence rate of helminthes infections among persons engaged in waste management activities was estimated to be 1.46% per month. The Kruskal Wallis test results showed a significant difference in the level of helminthes infection among the different types of waste handling activities ($\chi^2 = 27.4$, $p = 0.0003$) (Table 4.17). The Kruskal Wallis test indicated a significant difference ($\chi^2 = 18.8$, $p = 0.0086$) in log *E. coli* concentration/level among the type of waste handling activities. Dunn's test indicated that there was a significant difference ($p < 0.0083$) in the level of *E. coli* among waste workers who only do sweeping every day and those who perform two or more waste management activity everyday such sweeping, collection and disposal. There was no association between log Coliform concentration and type of waste handling activities (Table 4.17).

TABLE 4.17: COMPARATIVE ANALYSIS OF INTENSITY OF HELMINTHES INFECTION AND CONCENTRATION OF FAECAL INDICATORS ACROSS THE DIFFERENT TYPES OF WASTE HANDLING ACTIVITIES

		Waste handling activities	
Helminth infection and indicators of faecal contamination	χ^2 estimates with ties	p-value**	Posthoc test to examine difference based on Dunn's multiple comparison test ($p<0.05$)
Intensity of helminthes infection (egg/gram)	27.44	0.0003	C&S, T&S, SC&S, T&D, D&C, T&C, SCD&C, D&T, C&T, SD&T, SC&T, DC&T, SDC&T, D&SD, C&SD, D&SC, SDC&SC
Log *E. coli* concentration in CFU/ml	18.88	0.0086	T&S, DC&S, T&D, T&C, SD&T, SC&T, DC&T, SDC&T, D&SD, C&SD, D&SC,
Log Coliform concentration CFU/ml	7.47	0.385	

*Legend: S represent sweeping, D (disposal), C (collection), T (Transport), SD (Sweeping and disposal), SC represent sweeping and collection, CD (collection and disposal), SDC (sweeping, collection and disposal), n(%) represent frequency and row percentages, M is the median estimate, IQR is interquartile range, ** represent Kruskall Wallis p-value estimates*

4.20 DIAGNOSTIC PERFORMANCE OF THE TEST USED TO DISTINGUISH WASTE HANDLERS WITH AND WITHOUT FAECAL INDICATOR *E. COLI* AND COLIFORM

The Bland-Altman analysis indicated that there was 95% limits of agreement between *E. coli* and Coliforms indicators for evaluating levels of contamination of hands of waste handlers (i.e -2.1 to 1.8) as shown in Figure 4.3. The probability that the waste handlers were correctly classified by the test as having *E. coli* and Coliform was 94.1% and 50.0% respectively Thus, the *E. coli* and Coliforms provide similar measures for estimating the level of contamination of hands by faecal matter among the waste handlers. The Pitman's Test of difference in variance between the two indicators was not significant ($p = 0.978$).

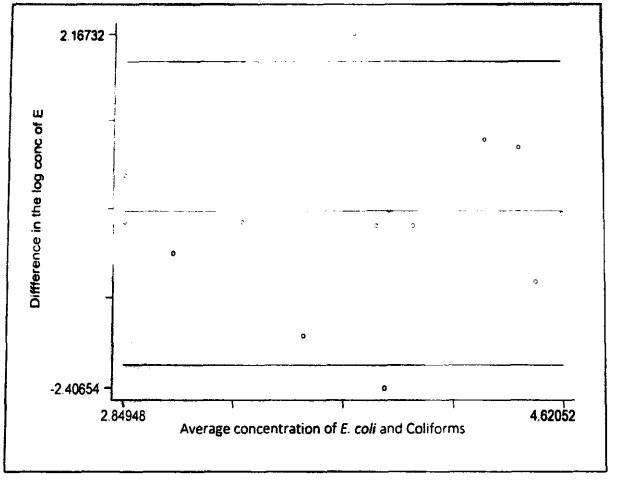

FIGURE 4.3: THE BLAND ALTMAN PLOT OF FAECAL INDICATOR *E. COLI* AND COLIFORM CONCENTRATION

RESULTS OF QUALITATIVE STUDY

ıe qualitative phase of this study, the responses of waste handlers were utilized to explore their eption about work conditions including use of Personal Protective Gears (PPGs), common health ɔlems and hygiene related issues. The purpose for using the qualitative study was to triangulate complement the quantitative phase of this study. Thematic content analysis was used to analyze qualitative data. Statements which were irrelevant to the research question were not included in report. The themes which emerged were the general impressions of the waste handlers which ;inated from the in-depth interviews a posteriori.

1.1 PERCEPTIONS ABOUT THE USE OF PERSONAL PROTECTIVE GEARS

depth interviews with the 22 waste handlers showed that two-thirds had knowledge about the ease protective purpose of wearing PPGs and the health implications they are likely to experience hey do not use PPGs. These are illustrated in the responses by waste handlers below:

e 32 year old female performing multiple tasks iterated that;

e use gloves to cover our hands, nose cover to cover our mouth and nose, Wellington boot and ɔes, to cover our feet. We use all these to protect ourselves from becoming ill when we are working th waste...

A 35 year old male waste collector also explained that;

f we do not use the hand gloves... we can contract some of the health problems, like diarrhoea".

nother waste handler said; *"This is why we have to be given something to cover our nose to*

mize the amount of dust that we inhale" (40 year old female waste handler who performed iple tasks).

field observations revealed that most waste handlers did not use PPGs consistently throughout a s work. In-depth interviews thus further sought to understand the main barriers to using PPGs the results are illustrated in the section below.

1.2 Barriers to using Personal Protective Gears

: reason mentioned by waste handlers was the inability to purchase PPG from personal funds. s was the concern for a group of waste handlers who were not officially employed by waste nagement companies and were made up of scavengers, night-soil-collectors, volunteer community ste handlers and private public toilet managers. These groups of waste handlers constituted roximately one fourth of all waste handlers and represented the poorest, since they only received ly wages based on the waste they scavenged and sold, how many households they visited to empty ines or how many customers used public toilet facilities. The community volunteer waste handlers not receive monthly salaries or allowances since they only performed waste handling activities asionally as part of communal initiatives.

e night soil collector explained his inability to purchase PPG to work with during manual lection and transport of night soil when he said;

I am transporting the human faeces, I don't have anything to cover my nose....sometimes, what I to protect myself gets spoilt and I don't have money to replace it".

ough the use of bare hands in night soil collection would represent a very high exposure to faecal ogens and the associated risk for oral transmission of disease among waste handlers involved, isk of disease was paradoxically mainly associated with the bad smell of faeces.

ther reason for not using PPG was simply not having it at all or inability of employers to replace n when they become worn out.

as not given anything to cover the nose. The entire bad air goes into me"..... This was narrated 55 year old male disposer. Another 27 year old male driver of waste carrying tricycle also said;

ve nothing to cover my mouth and nose. Sometimes I put on no protective gear". ..... (27 rs old male, who transported waste).

najority of waste handlers believe that PPGs must be provided by employers. Once employed by aste company, waste handlers were supposed to receive PPGs to perform their work. However, it s mentioned, during the in-depth interviews, by all waste handlers that once employed by waste npanies, PPGs were not supplied to all waste handlers. For waste handlers who were even vided with PPGs, these were not replaced by the employer after the protective gears became worn .. A 61 year old male sweeper narrated that;

hey (employers) must give us the nose covers and the gloves. We must get those items so that if we going to clean the toilet, we will wear them to prevent us from getting the stomach problems and se sicknesses".....

aste handlers had to manage with using torn or worn out PPGs that did not protect them equately. A 32-years old female collector described the problems:

en I use the nose cover today and fix it again for a period of time, sweat gets into it and then it gs out some bad smell and makes it uncomfortable to use".

ıs personal discomfort was a major barrier to wearing PPG. A waste collector expressed his ngs of panting for breath when wearing nose masks:

e nose cover causes us to pant for breath. There are some pores in the nose cover...Sometimes we in to pant for breath, so we take it off at a point and continue to work" (55-years old male waste ector).

blem with using gloves and boots were also commonly mentioned in interviews. The problems ed were mainly related to experiences of skin becoming hot, humid or wet inside gloves and ıts and developing into skin problems. One 55-years old male waste collector described the effects ısing Wellington boots:

or the boots sometimes, I contract foot rot when I use it for a long time".

·llington boots were also perceived as too heavy and unpractical to wear by everyone interviewed:

or the wellington boots, once the feet keep so long in the boot, my foot becomes hot. It's very ficult wearing them, because the boot is heavy and walking in the sun, it's not easy".... (A 37-ırs old male waste disposer).

34-years old female sweeper had similar experiences with using gloves:

he gloves...it's just that my fingers do not get enough air; they get wet. When I take my fingers ım the gloves it feels as though it's from the cold store".

ajor barrier mentioned to wearing PPG was discomfort. Discomfort with using mouth/nose mask commonly mentioned including feelings of panting for breath, having to use old masks which ıot protect from the inhalation of bad smell from human faeces and putrefying solid waste. This explained by a 55 years old male waste collector;

: nose cover causes us to pant for breath. There are some pores in the nose cover but if the pores ıme too big (or torn), we inhale the bad smell. Sometimes we begin to pant for breath, so we take ſ at a point and continue to work."

TABLE 4.18: CODING FRAME FOR THE USE OF PERSONAL PROTECTIVE GEAR

Content analysis by inductive reasoning			
inizing ne	Codes/meaning unit	Description and definition of code	Quote(s)
e of PPGs	1.1 Equipment and personal protective gear (PPG) used in waste handling by waste handlers in Prampram	Specific equipment and PPGs used in waste handling include: - Oro-nasal mask - Wellington boot - Shoes - Overall gown - Gloves - Long-stick brooms - Rake - Shovel - Helmet - Goggle - Wheel-barrow - Tricycles (manual and motor-powered) - Cutlass/Machete	*"We were given nose cover, safety boot, overall (that we put on). We use all these to protect ourselves. We wear them from the house. This is to ensure that the dirt and faecal matter does not have any physical contact with our body."..... **(32 year old female, who performs multiple task).***
	1.2 Rational for use of PPGs	Reason for wearing PPGs - To prevent physical contact with human faecal matter during waste handling Functions of equipment and specific PPGs used in waste handling - Glove – to avoid physical contact of the hand with human faecal matter - Overall gown (high visibility)– to avoid the direct impact of the sun, to be noticed by people and by on-coming vehicles - Nasal-oral mask – to	*"We use gloves to cover our hands, nose cover to cover our mouth and nose, Wellington boot and shoes, to cover our feet. We use all these to protect ourselves from becoming ill when we are working with 'waste'. We also use shovel and rake to collect the waste"... **(32 year old female, who sweeps and collects waste)*** *"We weed, when we see any where closer to the road which is bushy, we use machete to clear it all. Then we use the tricycle to collect and transport the grass together with other waste like human faeces".... **(35 year old male who sweeps, collects and disposes***

Content analysis by inductive reasoning			
izing	Codes/meaning unit	Description and definition of code	Quote(s)
		avoid inhalation of bad smell from human faecal matter, dust (from sweeping) and smoke (from burning 'waste') - Helmet – to avoid the direct impact of the sun, to be noticed by other people and by on-coming vehicles - Wheel-barrows and tricycles – to transport waste - Cutlass – to cut/clear weeds. Overall reason for using PPGs in waste handling: *Waste handlers use personal protective gears (PPGs) to protect themselves from the direct physical contact of waste materials during waste handling. If the PPGs are used appropriately, it will prevent direct contact of waste to the body and reduce the impact of health problems that can be experienced as a result of waste work. However, if the PPGs are not appropriately worn, then it will be easy to acquire health problems in waste handling.*	***waste)*** ***"The helmet, boot, nose cover, goggle, gloves, and the overall are the items we use to protect ourselves during waste work."... (35 year old female who sweeps waste)*** *"When I am going to work, I put on my working gear/clothe. I wear gloves so that the germs that may be in the faeces, does not get into my palm"..... **(55 year old male who performs multiple task)*** *"If I don't use the nose cover, the hand gloves or the wellington boot. If I do not use, any of these work gears I could easily contract diarrhoea, typhoid or give to my children at home. When I am bare footed, it is easy for me to contract health problems."..... **(27 year old male disposer of waste)*** *"The health problem comes through inhalation of the dust that rises when we are sweeping waste. The dust gets into our nose, and you notice that your throat is irritated. There will be the need for you to go to the drug store for you to explain to them (pharmacists or chemical sellers) the problem you have so they can give you the appropriate drug. This is why we have to be given something to cover our nose to minimize the amount of dust that we inhale."..... **(40 year old female sweeper)***

Content analysis by inductive reasoning			
izing	**Codes/meaning unit**	**Description and definition of code**	**Quote(s)**
		Waste handlers also belief that inhalation of dust and faecal odour can equally cause health problems".	*"This is because if we do not use, the nose cover or the hand gloves or the Wellington boot ... we can contract some of the health problems, like diarrhoea that you are talking about"..... **(35 year old male who sweeps, collects and disposes waste)*** *"The nose cover causes us to pant for breath. There are some pores in the nose cover but if the pores are too big (or torn), we inhale the bad odour. Sometimes we, begin to pant for breath, so we take it off at a point and continue to work."..... **(55 year old male who sweeps, collects and disposes waste)***
	1.3 Personal discomfort experienced by waste handlers in using PPGs	Specific PPGs and associated personal discomfort during waste handling Oral-nasal mask - Pant for breath - Sometimes they are torn and bad smell is still inhaled Gloves - fingers do not get enough air and they become wet	*"The gloves do not give much discomfort whiles working. Just that my fingers do not get enough air; they get wet. When I take the fingers from the gloves it feels as though it's from the cold store"..... **(34 year old female who sweeps and collects waste)*** *"For the wellington boots, once the feet keep so long in the boot, then my foot becomes hot." It's very difficult wearing them, because the boot is heavy and walking in the sun, its not easy but all the same, since that is what they have*

Content analysis by inductive reasoning			
izing e	Codes/meaning unit	Description and definition of code	Quote(s)
		Wellington boots - feet become hot - it is heavy - experience foot rot	*given us to use and that is what is going protect you, then we have to use it".....* ***(37 year old male who collects and disposes waste)***
	1.4 Personal experience and awareness by waste handlers about the impact of not using PPGs		*"We must get the nose covers and the gloves. We must get those items so that if we are going to clean the toilet, we will wear them to prevent us from getting the stomach problems and those sicknesses"..... **(61 year old male, who sweeps public toilet facility at Olowe.)*** *"I was not given anything to cover the nose. The entire bad air goes into me. Sometimes I put on no protective gear which I think gives me the health problems like diarrhoea"..... **(55 year old male disposer.*** *"If I am transporting the human faeces, I don't have anything to cover my nose. I know I can fall sick because of this". Sometimes, what I use to protect myself gets spoilt and I don't have money to replace it or it always delay before I get some, and I sometimes use my bare hands and the nose to do the work, so that is why I can get those sickness."..... **(38 year old male, who collects and disposes human faecal waste at night)***

21.3 WASTE HANDLING ACTIVITIES AND POOR HAND HYGIENE

bservations carried out at sites where waste handlings took place highlighted that access to water id soap for effective routine hand washing during work was limited; most waste handlers were part a mobile work force and did not have access to a site with running water and freely available soap r hand washing before eating or after defecation. Waste handlers elaborated on limited access to ater during work and the use of bare hands in waste handling as the main reasons for poor hand ygiene during a work day;

We don't get water when we come to sweep the town unless we go back home"..... (32 year old male sweeper). A 55 year old male waste handler stated that;

Sometimes I forget to wash my hands in a haste to eat when I am sweeping the gutter. May be I am ery hungry and just want to eat something. Instead of taking my time to wash my hands with water, I ay oh let me just finish this food quickly, this is nothing. But I have forgotten that whiles I was orking in the gutter, some of the waste water splashed on me.... Even if I wash my hands, I use only ater because there is no soap".

he health risks associated with poor hand hygiene, including the risk for helminthes and bacterial nfections, may be worse among waste handlers who used bare hands compared with those who used loved hands during work.

ABLE 4.19: CODING FRAME FOR WASTE HANDLING AND POOR HAND HYGIENE

Content analysis by inductive reasoning			
izing	Codes/meaning unit	Description and definition of code	Quote(s)
iene and ion	2.1 Use of hygiene and sanitation facilities	Adapting to sanitation issues during a day's waste handling activities - Practice open defecation in bush or at beach - Practice 'dig and bury' strategy - When waste handlings occur near a public toilet facility, that facility is used as place of convenience	*"There is no toilet around, so you can see that both we the workers and the community residents, we either go to the bush or the same sea shore to defecate because there is no toilet. In the morning whilst you are sweeping the beach, you will see neighbours defecating around....Yes that is the same place we go, that is the same place we also defecate, or the bush. This is because you can't leave the work area to go and defecate in another location.""..... **(55 year old male, who collects and disposes waste.)***
		Sources and use of water during waste handling: - Buy sachet water to drink, wash hands - From pipe borne water to drink, wash hands	*"When I am collecting the 'waste' in town around the lorry station, I buy sachet water which I drink and use to wash my hands after handling the 'waste'."..... **(32 year old female, who performs multiple task)***
		- From underground well to drink and wash hands - From dam, to wash hands, water coconut trees - From the sea, to bath	*"We don't get access to water when we come to sweep the town unless we go back home". At home I fetch from the pipe or if the pipe is not flowing, from the well. I use the water to drink or wash my hands after sweeping the town."..... **(32 year old female, who sweeper)***
	2.2 Adaptation to sanitation and hygiene practices	Adapting to hygiene life-style during a day's waste handling	*"As for water, I fetch from the dam (Dawenya dam), use some to wash my hands after weeding the grass*

Content analysis by inductive reasoning			
izing e	Codes/meaning unit	Description and definition of code	Quote(s)
	among waste handlers in peri-urban communities in Prampram	activities - Some waste handlers do not wash their hands at all before they eat or after visiting the toilet during a day's work. - Hands are washed only with water but not with soap	*and also use some to water the coconuts trees"..... **(34 year old female who collector waste)*** *"Normally I bath myself in the sea after sweeping the faeces at the beach. When I get back home, I use real water and soap to wash my hands"..... **(55 year old male who performs multiple task)*** *"Sometimes I forget to wash my hands in a haste to eat when I am sweeping the gutter. May be I am very hungry and just want to eat something. Instead of taking my time to wash my hands with water, I may say oh let me just finish this food quickly, this is nothing. But I have forgotten that whiles I was working in the gutter, some of the waste water splashed on me.... Even if I wash my hands, I use only water because there is no soap"..... **(55 year old male who sweeps, collects and disposes waste)***

21.4 WASTE HANDLING ACTIVITIES AND HEALTH RELATED PROBLEMS

ealth problems mentioned by waste handlers during in-depth interviews were listed and categorized : Non-specific (Eye problems, Fever, Cough, Bodily pains, Skin diseases), Central Nervous System)izziness, Headache, Migraine), Infectious (Diarrhoea, Typhoid, Itchy anus, Fever, Malaria), astrointestinal (Stomach pains, Nausea) and Psychosomatic (Stress, Tiredness, Sleep interruption, atigue). Clearly, waste handlers perceived that a relationship exists between waste handling ctivities and the reported health problems, as illustrated in the responses below.

, 27 years old male waste handler who disposed solid waste off a motor-powered waste tricycle arrated how he experienced itchy anus, a classical indication of helminthes infection;

It is the waste that I dispose around the lagoon area off the waste-carrying car. I have nothing to over the mouth and nose. Sometimes I put on no protective gear. For this reason it gives me the ealth problems...It is fever and sometimes I vomit... I experience nausea and itchy anus"

An 84 year old female, who sweeps and collects money at a public toilet facility, narrates how her leep is interrupted at night to attend to clients;

'I normally wake up at 4.00am to sweep and clean the toilet and prepare it for the day. I close at around 8.00pm. But sometimes I go to bed say 9.00pm or 10.00pm and then at 2.00am or 1.00am, someone knocks at your door that he wants to ease himself; I have to wake up and attend to the person. This disturbs my sleep".

Another 55 year old male who drives waste carrying tricycle describes how his eyes were deteriorating after joining a waste management company and working as a waste handler,

lfter I started this work as a waste tricycle driver in Prampram for Zoom Lion, I realize that my es are not able to see properly. Even if I work just for a little while I feel my eyes want to go ind".

35 year old male who sweeps gutters (open drains with mixed solid and liquid waste effluents) mplained about persistent non-specific health problems including tiredness, stress and fatigue since e first year he joined a waste management company and started working as a waste handler when e said;

As for me, I get tired, stressed and fatigued from the long period of engagement in sweeping the utter. I started experiencing these signs after about a year since I started working for Zoom Lion. I m now in my 6th year with the company".

high proportion (about 95%) of waste handlers interviewed (particularly those who performed ultiple tasks) complained of bodily pains after engaging in a day's waste handling activities. Bodily ains may be experienced among waste handlers due to continuous manual pushing and pulling of vaste material. A waste handler who experienced bodily pains explained the situation by saying;

"After collecting the waste, I push the waste in the wheel barrow several times in the morning, to the lump site to dispose. I feel waist pains (setso yemi) and pains in my whole body" (35-years old male vaste handler performing multiple waste handling tasks).

Another 32-years old female waste handler who sweeps solid waste from open spaces in the Prampram town also narrated her experience with bodily pains;

n sweeping the waste in the town, I have to bend each time I sweep because of the absence of the ng brush. This disturbs me a lot." I suffer a lot of pain in my body and my waist. Previously I do ıt experience these bodily pains but since I started this work then the pain also started".

deed personal observations on the field revealed that waste handlings were characterized by hard anual repetitive work. Apart from two motor-powered waste tricycles used to transport waste in rampram, all other waste handling equipments were manually operated with physical force. Waste andlers performed vigorous physical activities including dragging, pushing and pulling of waste ontainers and wheelbarrows. This hard physical work is likely to have resulted in the overwhelming roportions of reported bodily pains among waste handlers.

ABLE 4.20: CODING FRAME FOR WASTE HANDLING RELATED HEALTH PROBLEMS

Content analysis by inductive reasoning			
nizing ıe	**Codes/meaning unit**	**Description and definition of code**	**Quote(s)**
alth :ms g waste ers	3.1 Daily waste handling routines that predispose waste handlers to health problems	Major waste handling tasks performed in a day - Sweeping - Collection - Disposal - Transport High risk places where waste handlings occur - Gutter (open drain containing liquid, solid and human faecal waste) – sweeping and collecting mixed waste materials - Public toilet facility – collecting used papers and	*"It is the waste that I dispose around the lagoon area off the waste-carrying car. I have nothing to cover the mouth and nose. Sometimes I put on no protective gear. For this reason it gives me the health problems...It is fever and sometimes I vomit... I experience nausea and itchy anus"* ..... ***(27 years old male, who disposes waste off the waste tricycle.)*** *"When it comes to sweeping the gutter, we do it together with other waste handling organizations like the ACI. Then we collect the waste into the*

Content analysis by inductive reasoning			
izing	Codes/meaning unit	Description and definition of code	Quote(s)
		sweeping human excreta Gender-based waste handling activity levels - Women sweep - Men collect, transport, dispose	*tricycle which is used in waste collection and transport. Usually it is the women who sweep whilst the men collect, transport and dispose the waste into the waste containers."…… (35 year old male who performs multiple task).* *"I sell papers to people who come to use the toilet facility. Other times I sweep the toilet and collect the used tissue papers and I burn them" …… (40 year old female, who sweeps and collects money at a public toilet facility).*
	3.2 Bodily pains associated with waste handlings	Task-associated bodily pains Transporting waste: - waist (lower back) pain - fatigue Sweeping waste: - waist (lower back) pain - fatigue - discomfort in bending to clean/sweep Weeding: - lower back pain - upper back pain (trunk)	*"I push the waste in the wheelbarrow several times in the morning during our work to the dump site. Sometimes I feel pains in my waist and my whole body after pushing the refuse to the dump site"…… (35 year old male who performs multiple task).* *"In sweeping the waste in the town, I have to bend each time I sweep because of the absence of the long brush. This disturbs me a lot." I suffer a lot of pain in my body and my waist. Previously I do not experience these bodily pains but since I started this work then the pain also started"…… (32 year old female, who sweeps)* *"After the weeding, I feel pains at my waist and the sides of my chest. Because*

Content analysis by inductive reasoning			
ıizing e	**Codes/meaning unit**	**Description and definition of code**	**Quote(s)**
			*the work is too much for us."…… **(35 year old male who collects).***
	3.3 Duration of exposure to waste by waste handlers	Number of hours spent on waste handlings in a day - 4.00am-8pm (about 16hrs) - 5.30am-7pm (about 15hrs) - 5.30am-10.00am (about 5hrs)	*"I normally wake up at 4.00am to sweep and clean the toilet and prepare it for the day. I close at around 8.00pm. But sometimes I go to bed say 9.00pm or 10.00pm and then at 2.00am or 1.00am, someone knocks at your door that he wants to ease himself, I have to wake up and attend to the person. This disturbs my sleep"…… **(84 year old female, who sweeps and collects money at a public toilet facility).***
		Duration of exposure to waste and health effects - There is the need for training to acquaint waste handlers with appropriate use of PPGs - Possible contracting health problems with time - Recurring health problems	*"We normally start work in the community at 5.30am and by 10.00am we have closed"…… **(37 year old male who performs multiple task).***
			*"Sometimes it is good that they train us how to use the safety gears because unless we try to acquaint ourselves with its use, we can get the health problems in the near future."…… **(32 year old female, who performs multiple task).***
	3.4 Waste handling-associated health problems	Non-specific health problems experienced by waste handlers - Eye problems - Fever - Cough	*"If you don't use the safety gears properly, you may not contract those health problems now but with time as you inhale the bad odour and the waste touches your hand and body, you can become sick"…… **(32 year old female,***

Content analysis by inductive reasoning			
ıizing e	**Codes/meaning unit**	**Description and definition of code**	**Quote(s)**
		- Body pains – lower back - Skin disease Central nervous system health problems - Dizziness - Headache - Migraine Infectious health problems - Diarrhoea - Typhoid - Itchy anus - Fever - Malaria Gastrointestinal health problems - Stomach pains - Nausea Psychosomatic health problems - Stress - Tiredness - Sleep interruption - Fatigue	***who performs multiple task).*** *"After I started this work as a waste tricycle driver in Prampram for Zoom Lion, I realize that my eyes are not able to see properly. Even if I work just for a little while I feel my eyes want to go blind and I feel dizzy"…… **(55 year old male who drives waste carrying tricycle).*** *"Sometimes when the people (residents) throw waste and human excreta into the bush in the town, we (the Zoom Lion workers) go to weed the bush and collect the waste and sometimes our people (the waste handlers) complain of sicknesses like stomach pains, fever, cough or skin rashes. Or even because of the bending down to collect the waste, some complain about their waist, and I also experience these problems"…… **(35 year old male who collects waste).*** *"As for me, I get tired, stressed and fatigued from the long period of engagement in sweeping the gutter. I started experiencing these signs after about a year since I started working for Zoom Lion. I am now in my 6th year with the company"…… **(35 year old male who sweeps waste).*** *"If I stand by the waste container to*

Content analysis by inductive reasoning			
ıizing e	Codes/meaning unit	Description and definition of code	Quote(s)
			collect money, mosquitoes bite me and I get malaria and sometimes after standing in the sun then half of my head is aching very bad ***(migraine)****. I also experience like I want to vomit (nausea) and my anus itches me. I also sweep the place and burn the rubbish around the waste container"..... **(40 year old female who sweeps. She also collects money at the ACI** waste container).*

1.21.5 WASTE HANDLING ACTIVITIES AND PERCEIVED CAUSES OF SELF-REPORTED HEALTH PROBLEMS

A high proportion (67.5%; 189/280) of waste handlers reported direct exposure of uncovered parts of body to waste as the main cause of their health problems, whilst 61.4% (172/280) reported that inhaling bad smell of waste was a major cause of their health problems. Other factors reported to be associated with health problems included; eating with dirty/contaminated hands (45.7%; 128/280) and wearing dirty clothes for work (8.6%; 24/280). These factors in combination with working outdoors under harsh conditions were also commonly explained as causing disease:

"I sweep and collect money by the waste container, mosquitoes bite me and I get malaria (atlidii) and sometimes after standing in the sun then half of my head is aching very bad. I also experience like I want to vomit and my anus itches me (fitɔ mi plɛmi)" (40-years old female waste handler who swept and collected money near waste container).

21.6 'BAD AIR' AS A PERCEIVED CAUSE OF HEALTH PROBLEMS

ne 35-years old female waste handler who collected human faeces from the beach each morning xplained how inhalation of 'bad air' could lead to health problems when she narrated that;

The health problems come from the work we do...We handle human faeces and the bad scent gets uo our nose. We get increase in abdominal pain as a result. This morning for example, there were ots of human faeces at the beach...and as we sweep, the bad scent then gets into us and gives me ickness."

Whilst it may not be clinically proven that inhaling 'bad air' from waste can cause health problems, bservations at smelly dumpsites and public toilet facilities at the study sites suggested that 'bad air' nay indeed trigger nausea, vomiting and high levels of discomfort among waste workers during vork.

TABLE 4.21: CODING FRAME FOR 'BAD AIR AS CAUSING HEALTH PROBLEMS

Content analysis by inductive reasoning			
nizing ıe	**Codes/meaning unit**	**Description and definition of code**	**Quote(s)**
ıd smell'	4.1 Association between the offensive smell of waste materials and health of waste handlers	Inhalation of unpleasant smell that comes from different sources of waste aggravates health problems. The different sources of bad smell include: - Human faecal waste openly displayed at the beach, in parts of the communities and from public toilet	*"The health problems come from the work we do...We handle human faeces and sometimes the bad scent gets into our nose. You would get increase in abdominal pain as a result. This morning for example, there were lots of human faeces at the beach. The residents ease themselves there and as you sweep, the bad scent then gets into us and gives us sickness."..... **(35 year old female who sweeps waste).*** *"I don't have a nose cover and so the*

Content analysis by inductive reasoning			
izing e	Codes/meaning unit	**Description and definition of code**	**Quote(s)**
		facilities - Smoke from burning rubbish - Over-used oral-nasal mask - Unavailability of oral-nasal mask	*bad smell of human faeces on the toilet bowl always gets into my nose when I clean the toilet. When we set fire into the used toilet papers the bad smell of the smoke gets into our nose and makes us cough a lot."....* ***(59 year old female, who sweeps and collects money at public toilet facility).*** *"When I use the nose cover today and fix it again for a period of time, sweat gets into it and then it brings out some bad smell"..... **(32 year old female, who sweeps).***

'.21.7 STAKEHOLDER INTERVIEW

An interview with one district sanitation and environmental health officer about whether waste handlers were employed to excavate pit latrines, dislodge faecal sludge or empty cesspits in the peri-urban community showed that these were not their responsibility. The stakeholder said this during an interview:

'The Zoom Lion workers do not collect 'toilets' (i.e. human excrement), excavate pit latrines or empty cesspits. The District does not have a car for 'toilet' collection so we normally contract the services of private companies from neighbouring Ashiaman, Tema or Somanya to come once in a while to collect the 'toilets', depending on their charges."

5.0 CHAPTER FIVE – DISCUSSION

.1 WASTE MANAGEMENT PRACTICES AND SANITATION IN PRAMPRAM

he findings from transect walk and observation through Prampram to familiarize with waste ıanagement practices and state of sanitation which indicated inadequate sanitation facilities, ıdiscriminate dumping and pile-up of solid waste within the community and dumping sites as well s human feaces mixed up with solid waste, corroborates a previous report by the Ghana National :nvironmental Sanitation Strategy and Action Plan (NESSAP), (2010). The report stated that 25.9% f households in Ghana dump their waste in unapproved dumping sites (gutters, streams, drains, ıgoons) whilst more than 70% of Ghanaians practice indiscriminate waste disposal (NESSAP, '010).

he effect of indiscriminate dumping of waste has been reported to lead to accumulation of huge olumes of waste piled up in public open spaces, along streets, beaches, and in open drains both in ırban and peri-urban communities, in Ghana and in other African countries (Momoh and Oladebeye, 2000; Tsiboe and Marbell, 2004; Butu and Mshelia, 2014). As reported by Fobil *et al.*, in 2008, the apid increase in population and urbanization of peri-urban settings have contributed to increased Vaste generation and waste management problems in Ghana. In the peri-urban community of Prampram, particularly, where relatively larger numbers of people aggregate in smaller areas (unlike n rural settings) with inadequate waste management systems, the problem of indiscriminate dumping of waste in public open spaces becomes worse (Ahmed and Ali, 2004; Rathi, 2006). This finding ınderscores the necessity for interventions to improve sanitation systems and waste management ɔractices in peri-urban environments, particularly, in Prampram. One of such interventions is the ıeed to recruit waste handlers equipped with adequate understanding of the hazards and risks

ssociated with waste work to ensure health and safety. Waste handlers are challenged with the normous task of controlling huge accumulated waste pile-ups within communities. According to his study, there were a range of different waste handlers engaged in diverse waste handling activities n the peri-urban community of Prampram, similar to findings from other parts of Africa, (Getahun *et l.*, 2012), Asia (Zhang *et al.*, 2010) and Europe (Magrinho *et al.*, 2006), where a variety of waste orkers engage in different activities to control and reduce the volumes of accumulating waste in heir communities.

.2 Socio-demographic characteristics and reported health outcomes among waste ANDLERS

With respect to sex, the findings of this study showed significantly higher proportion of female waste andlers engaged in sweeping, compared with males (Table 4.1). This finding is corroborated by revious studies conducted by Agwu (2012) in Nigeria and Kadfak (2011) in Ghana, suggesting nore female participation in waste handling compared with males. There is a traditional perception n most African communities including Ghana that waste handling activities like cleaning and weeping, is the duty of females and not males. In fact it is believed among certain tribes in Ghana hat a male becomes impotent when touched by the broom, which is the tool for sweeping. Even hough this study did not specifically investigate hookworm infections among female waste handlers, revious research conducted in Ghana indicated that females were more likely to report anaemia rom occupation related hookworm infections compared with males (Glover-Amengor *et al.*, 2005; lumphries *et al.*, 2011). It is advisable for female waste handlers to take adequate protective recautions from exposures to contaminated work environments in order to avoid such infections.

ıe results of this study indicated that the age of waste handlers ranged from 13 to 87 years old. ıese waste handlers who were young (13 years) or old (87 years) worked out-doors at public toilet cilities in Prampram and were exposed to the hazards of smell, faecal contact and insect bites and ıuld be more susceptible to communicable diseases associated with waste handling, due to weak ımune status. It is known that Ghana, like many African countries, is endemic for many ɔmmunicable diseases. The exposure to agents of communicable diseases associated with waste ork could be responsible for non-specific health outcomes like fever and diarrhoea. It is therefore nportant for local government authorities in charge of waste management in Prampram to ensure ıat very young and old persons are excluded from waste handling activities at the community level, ıcluding the public toilet facilities.

ıs indicated in Table 4.1, the educational level and monthly income of waste handlers were low. Vaste handlers in Prampram adopt the use of rudimentary waste handling equipment and :chnology, which may not require high levels of education to operate. The use of such equipment, ıowever, may compromise efficiency of waste work and aggravate reported health problems among ıorkers (Zimmerman and Woolf, 2014). For example, waste handlers who attained primary and :condary level education were 20 and 90 per cent respectively, less likely to report lower back pain ·ompared with workers who had no formal education (Table 4.10). Previous research by Zimmerman ınd Woolf (2014) has also documented correlations between education and reported health ıutcomes, with evidence suggesting a link between higher education and determinants of health such ıs risky behaviours and health protective practices at work. Waste handlers who did not have any ·ormal education may be unaware of the proper safety techniques to adopt during work, thereby ncreasing their vulnerability to the hazards of work (Reddy and Yasobant, 2015).

he low levels of education may also be a determining factor to the low levels of monthly income rned by waste handlers. According to the Ghana Fair Wages and Salaries Commission-GFWSC 013), workers are remunerated according to the level of education attained. Thus, waste handlers in eveloping countries like Ghana, constitute one of the least paid occupations, regardless of the high vels of health risks encountered (Cointreau, 2006). The findings of this study indicated that the ighest income earned through waste handling was ¢150.0 a month, which was the main source of ncome for most waste handlers. This income was however far lower than the average monthly per apita income in Ghana, ¢225.0 (GSS, 2013).

his study showed that waste handlers who earned between ¢80.0 to ¢150.0 a month were about wice more likely to report headaches and eight times more likely to report lower back pain ompared with workers who earned below ¢80.0 a month (Tables 4.7 and 4.10 respectively). Waste andlers who earned between ¢80.0 to ¢150.0 a month were those who worked for waste nanagement organizations in Prampram whilst the others, who earned below ¢80.0, worked rimarily as community volunteers in waste handling. Waste handlers who worked for waste nanagement organizations had a more regular work schedule and spent more hours per day on waste andling activities compared with volunteer workers who engaged in occasional waste handling ctivities. The daily demands for spending more hours on regular work schedules may have ontributed to the higher likelihoods of reporting headaches and lower back pains among waste andlers who earned between ¢80.0 to ¢150.0 a month. Headaches frequently adversely affect the ives of workers, with some wide-ranging effects on work, such as reduced performance and bsenteeism (Leiper *et al.*, 2006).

3 WASTE HANDLING ACTIVITIES, DURATION OF EXPOSURE AND SELF-REPORTED HEALTH

TCOMES

ne type of waste handling activities undertaken by waste handlers was associated with waste anagement organization and number of years worked with these organizations. Waste handlers in rampram belonged to different groups of waste management organizations, including government, ivate/government partnership groups as well as community-led volunteer groups. The results of is study showed that a majority (over half) of waste handlers belonged to the private/government roup which had been in existence for less than a year. Similar to claims made by several authors in hana (Ahmed and Ali, 2002; Fobil *et al.*, 2008; Oduro-Kwateng and vanDijk, 2013) and in other arts of Africa (Cointreau-Levine and Coad, 2000; Massoud and El-Fadel, 2002; Post *et al.*, 2003), ne massive involvement of the private sector in waste management in Ghana has been a recent evelopment compared with the situation about two decades ago. Even though this recent evelopment may introduce more efficiency and effectiveness in the waste management system, here is need for all the different stakeholders to collaborate and work collectively to achieve the state f improved peri-urban environment and sanitation in Prampram.

he duration of exposure was described by number of years spent with waste management rganization and number of hours spent per day on waste handling activities. The findings from this tudy indicated that the number of years worked and number of hours spent per day on waste andling activities were both associated with fever and bodily pains (Table 4.4). Even though the trength of association was not significant, waste handlers who have worked with waste management rganizations for more than five years were about four times more likely to report fever compared vith those who have worked for less than a year (Table 4.7). Fever is a non-specific disease outcome

at may be associated with exposures to microbial agents. These agents survive in faecal ontaminated environments such as in solid wastes, as well as insect vectors like mosquitoes and are ansmitted respectively through ingestion and bites. The longer duration of exposure to faecal ontaminated environments, working outdoors and the transmission of fever causing agents may xplain the increased likelihood of reported fever among workers engaged in waste handling for ore than five years, rather than within a year (Asante and Oduro 2006).

eported bodily pains among waste handlers who worked for more than 5 years was 50% less likely, ompared with those have worked for less than a year (Table 4.7). Bodily pains are known to be an nherent health problem for solid waste handlers that may arise as a result of physical activities ncluding manual pushing, pulling, lifting, carrying or carting of heavy waste materials as previously eported by Poulsen *et al.*, (1995) and Yang *et al.*, (2001). A study by Landmark and colleagues 2013), showed that participants reported less pain when they engaged in vigorous physical activities or longer duration. Engaging in such vigorous activities for more than 5 years may have triggered he development and adaptation of muscles to withstand the associated bodily stresses, strains or prains accompanying waste handling, unlike working for less than a year, when the muscles of vaste handlers may now be getting used to the routines of work. Meanwhile pain conditions are najor reasons for work related disability and account for loss of productivity in a work force Stewart *et al.*, 2003; Gjesdal *et al.*, 2004).

The number of years engaged in waste handling was significantly correlated with both lower and upper back pains, whilst number of working hours per day correlated with upper back pain (Table 4.8). This finding was consistent with results from a study conducted in Iran by Mehrdad and

olleagues (2008) who reported that duration of employment of solid waste workers was gnificantly associated with upper back pains. Also, compared with waste handlers who have orked for less than a year, there was 70% and 80% less likelihood for reporting upper back pains nong those who have worked for 1-2 years as well as 5 years and above respectively (Table 4.10). pper back pain affects the thoracic spine and can be experienced by muscle strain, injury or poor orking postures assumed by waste handlers during work (Benyamin *et al.*, 2012).

.4 WASTE HANDLING ACTIVITIES AND SELF-REPORTED MUSCULOSKELETAL PAIN

he type of waste handling activity was associated with self-reported lower and upper back pains. omparing the odds of reporting upper back pains among waste handlers performing single activity, ransporters were found to have seven times higher odds of reporting upper back pains than weepers, whilst collectors and disposers were twice and 1.4 times more likely to report upper back ains respectively, compared with sweepers (Table 4.10). Waste transporters spend long hours lriving waste vehicles to disposal sites. The impact of prolonged seating, whole-body vibration, epetitive movements, forceful exertions, heavy physical and prolonged static posture are main haracteristics believed to be risk factors for transporters (Lis *et al.*, 2007; Mozafari *et al.*, 2015). These factors might have increased the likelihood for upper pains among transporters compared with ollectors, disposers and sweepers. Lis and colleagues (2007) reported a three times more likelihood or reported upper back and neck pain among drivers of waste vehicles compared with those erforming other activities.

or workers who performed two or more activities a day, the odds of reporting upper back pains was bout six times greater for those who performed three activities a day (sweeping, collection and

sposal) compared with sweepers only. Again, performing two activities a day increased the ‹elihood for reporting upper back pains to about four times greater for those who engaged in)llection and disposal, as well as twice greater for those who swept and collected waste every day,)mpared with sweepers only (Table 4.10). These observations indicate that engaging in multiple ·aste handling activities could aggravate a waste handler's musculoskeletal pain. Thus, the amount f physical exertion and bodily stresses like sprains, strains and contusions as well as strenuous hysical movements experienced by waste handlers carrying out multiple activities may be more ıan that required in carrying out just a single activity per day. Such waste handling associated ıusculoskeletal pains have also been reported by previous authors including Quansah (2005), Abou-:lWaf *et al.,* (2012), Thirarattanasunthon *et al.,* (2012), Norman *et al.,* (2013) and Kanchanomai *et l.,* (2015). The acquisition and use of simple but improved waste handling tools and the application ıf proper ergonomic postures during waste handling may help reduce musculoskeletal pains ssociated with waste handling.

5.5 WASTE HANDLING ACTIVITIES, EXPOSED BODY SURFACES AND SELF-REPORTED HEALTH OUTCOMES

Exposure to solid waste may take the form of direct physical bodily contact, penetrating skin njuries/infections, inhalation, or ingestion. Solid waste, mixed with human faecal matter, found within the peri-urban environment of Prampram provide favourable conditions for the survival and ransmission of biological agents, thereby posing health risks to those who are engaged in waste ıandling. The direct physical contact of exposure surfaces to solid waste may increase the likelihood ıf reported health outcomes across the different groups of waste handlers (Kretchy *et al.,* 2015). According to Table 4.2, the highest exposure surface of waste handlers was the hands (85.4%)

llowed by leg/feet (45.7%) then mouth/nose (41.8%). Table 4.3 indicates that the type of waste ındling activities correlated with exposure surfaces such as direct exposure of hands as well as .outh/nose. The group of waste handlers with the highest exposure surfaces were those who :rformed three activities, i.e. sweeping, collection and disposal everyday, in the proportion of hands 12.6%), leg/feet (35.9%) and mouth/nose (38.5%). The use of bare hands in sweeping, collection or isposal of waste are risk factors to acquiring gastrointestinal tract infections such as typhoid fever, olio virus infection, hepatitis E infection and cholera, which are often transmitted through hands ontaminated with human faeces (Boadi and Kuitunen, 2005). A research conducted by Aminuddin nd Rahman (2015), suggested that the use of bare hands among waste handlers in Malaysia was ssociated with gastrointestinal problems. Again, Dorevitch and Marder (2001), Rushton (2003) and \ckerson and Awuah (2012) reported association between the use of bare hands in waste handling vith gastrointestinal problems such as nausea, vomiting, diarrhoea and itchy anus.

The exposure of leg/feet may result in injuries from cuts, abrasions and punctured skin associated vith direct contact with sharp objects such as blades, needles and broken glass in solid waste (Abd El-Wahab *et al.*, 2014). Injuries from such objects may result in wounds contaminated with the spores of biological agents leading to accidental tetanus (Ferreira *et al.*, 2016). Furthermore, the lirect exposure of the leg/feet may predispose waste handlers to the risk of direct skin penetration by arvae of hookworms which could result in anaemia (Glover-Amengor *et al.*, 2005; Humphries *et al.*, 2011).

The findings of this study indicated that cough was associated with exposure of the hands during Waste handling. Workers whose hands were directly exposed to waste material were about four times

more probable to report cough symptoms than those whose hands were not exposed. Cough is a symptom of respiratory disease. Several studies have found association between contaminated hands and respiratory diseases such as cough (Curtis and Cairncross, 2003; Rabie and Curtis 2006). According to Aiello and colleagues (2008), the hands can serve as important infection transmission pathway for respiratory diseases. Therefore, public health interventions promoting hand hygiene does not only reduce gastrointestinal tract infections but also respiratory illnesses. However, cough may also be caused by inhalation of dust particles, bio-aerosols and volatile compounds in solid waste through exposure of the mouth/nose of waste handlers. Dust is generated in quite visible amounts during waste handling in Prampram. The activities of waste handlers such as outdoor sweeping, pouring of waste into collection bags and also during the transfer of waste into containers all generate dust. The inhalation of dust particles constitute a major hazard to waste handlers because of its possible contribution to bronchial asthma, cough, and other respiratory problems. Indeed, previous studies from developed and developing countries report occupational asthma, cough and other respiratory diseases as linked with inhalation of organic dusts, bio-aerosols and microorganisms during waste handling (Wouters *et al.*, 2002; Binion and Gutberlet 2012; Ross and Pons 2013).

Type of waste handling activities was associated with perceived cause of health problems such as smell/odour of waste material, direct contact of waste material with exposed bodily surfaces and eating with contaminated/dirty hands. Working with exposed bodily surfaces to faecal contaminated working environments coupled with eating with faecal contaminated hands due to inadequate access to hygiene facilities after waste handling may predispose workers to fever as a result of microbial infections. With reference to working with smelling/odorous waste material/sites, the findings of this study indicated an association with and reported fever (Table 4.6). Observations at smelly dumpsites

ıd public toilet facilities in Prampram strongly suggest that smell may indeed trigger nausea,)miting and high levels of discomfort to waste handlers. As reported by Rheinländer *et al.* (2013), e issue about bad smell of faecal waste has been associated with health hazards in African settings ıd the continuous inhalation by waste handlers may be a source of nuisance and discomfort)orevitch and Marder, 2001). A research by Watt *et al.*, (1997) also indicated that the smell of rganic waste was due to emission of gases such as hydrogen disulfide, methane, ammonia and arbon monoxide and workers who are exposed to such smell could develop sub-acute symptoms ke sore throat, cough, chest tightness, breathlessness, thirst, sweating, irritability and loss of libido.

he direct contact of exposed bodily surfaces to waste was associated with reported skin disease Table 4.6). Physical injuries to the skin of waste handlers such as skin cuts, pricks, abrasions and ıcerations from sharps, needles or thorns, as well as insect bites could be exacerbated among vorkers whose skin surfaces were exposed (Dorevitch and Marder, 2001; Tjoe Nij *et al.*, 2003). The noculation of microbial spores and infective stages of microbial agents into scratched or open skin ıf waste handlers during work may either initiate or aggravate skin diseases. The direct penetration ıf the larvae of hookworms (*Necator americanus*) through bare feet/sole of waste handlers whilst vorking in faecal polluted waste environments is a risk factor for hookworm infections. Bleck and Wettberg (2009), showed that waste workers are commonly affected by cuts and skin rashes caused)y razor blades or syringes disposed of in ordinary waste streams, which may be a source of severe ıealth risks to workers.

6 WASTE HANDLING ACTIVITIES AND USE/ TYPE OF PERSONAL PROTECTIVE EQUIPMENT

'aste handlers can be protected from the hazards of work by adopting safety procedures and ısuring the use of adequate personal protective equipment at the work environment (Dorevitch and larder, 2001). Personal protective equipment are specialized clothing or gadgets used by workers to ·event injuries, workplace hazards and diseases that are likely to arise from the working ıvironment (Konya *et al.*, 2013). As indicated in this study, the four main types of personal rotective working gears used by waste handlers in Prampram were, Wellington boot (61.8%), ıbber gloves (57.5%), nose/mouth cover (32.1%), as well as overall apron (72.9%). Thus, the most ommon personal protective gear used by waste handlers in Prampram was the overall apron. The roportion of waste handlers with the highest use of overall apron was those who engaged in weeping, collection and disposal of waste everyday (32.4%). The proportion of waste handlers with ıe highest use of nose/mouth cover were those who swept and collected waste everyday (26.0%) Table 4.2). As shown in Table 4.3, the type of waste handling activities correlated with use of Vellington boots, gloves and overall apron.

'he protective Wellington boots provide covering for the sole and feet of waste handlers and help ırevent infectious punctures through the skin as well as direct contact to human faeces. The rubber ;loves offer protection to the bare hands from exposures to infectious particles in waste material and ırevent exposure to human faeces and direct contact with sewage. It is important for employers to ·onsider the mechanical strength of gloves used for the manual activities by waste handlers to ırevent easy tearing. The mouth/nose cover are used by waste handlers to reduce exposures to ıirborne contaminants in solid waste, bio-aerosols and to protect the nose and mouth from splashes ıf human faeces. The use of protective overall apron can reduce the exposure to biological and

nemical agents in waste by providing covering to the surfaces of the skin of waste handlers and to eep human faeces from direct contact with personal clothing. The leak thickness and the resistance) permeation and penetration by biological and chemical substances have to be considered by mployers in the selection of protective overall aprons for waste handlers.

:ven though the use of personal protective gears are strongly recommended to reduce direct xposure to biological agents and physical damage in waste handling, a considerable number of vaste handlers did not use them regularly. Some reasoned that there was shortage in supply by waste ompanies and if the protective equipment was torn during work, they were not replaced. Others especially the community volunteer waste handlers) claimed they did not have the resources to self-urchase protective equipment. Non-compliance to the use of personal protective equipment by vaste handlers, in spite of having access to it was also linked to the discomfort in its use during a vorkday, considering the strenuous activities under hot and humid climatic conditions. The specific roblems of personal discomfort were mainly related to experiences of skin becoming hot, humid or vet inside gloves and boots and developing into skin problems as identified also in a study by Dall'Agnol and Fernandes (2007). For example, the waste transporters in Prampram preferred vorking without wearing the rubber gloves because these limit free movement of the hands during driving or cause skin irritation.

Even though the use of personal protective equipment does not remove the source of health hazards n waste handling, it can provide benefits that outweigh the harm and personal discomfort associated vith them and through proper use, can contribute to health and safety of workers (Alencar *et al.*, 2009). Therefore, persons involved in waste management should always wear recommended

rotective gear. This is partly the responsibility of employers but the workers must also be sensitized n the need to adhere to safety precautions. Waste companies operating in Prampram must actively nsure adequate supply of personal protective equipment, that the supplied protective equipment are ntact and working, and that these are properly used. Thus, waste handlers have to be provided and ained in the appropriate use of personal protective equipment to ensure health and safety at work. here is also the need to draw attention to local governments and commercial waste handling ompanies employing waste handlers that it is their responsibility to provide and instruct in correct se of protective equipment that workers can use to effectively protect their health.

5.7 CONTAMINATION OF HANDS BY DETECTION OF *ESCHERICHIA COLI* AND COLIFORM FAECAL INDICATORS

The significant difference in the level of contamination of hands with human faeces among waste handlers by the detection of higher levels of both indicator *E. coli* and Coliforms after engaging in waste handling activities suggests that waste handlers were exposed to human faecal matter in waste during work. A previous study conducted from Tanzanian among mothers whose hands were contaminated by human faeces showed that the levels of faecal indicator bacterial on hands of the mothers were higher after using the toilet and cleaning up a child's faeces (Pickering *et al.*, 2011). Widespread open defecation in the peri-urban community of Prampram, as reported by Asante and Oduro (2006), may be a major health risk factor to waste handlers, especially among those who worked directly with their bare hands in contact with waste. This may increase the likelihood of contracting sanitation related faecal oral health problems and perpetuate the transmission of same (Jegli *et al.*, 2004; Ray *et al.*, 2005).

ne results of the study on contamination of hands by faecal matter also indicated a significant fference in the concentration of faecal indicator *E. coli* among the different types of waste handling :tivities. Waste handlers performing multiple activities (including two or more of sweeping,)llection and disposal) a day had significantly higher concentration of *E. coli* compared with orkers who were only sweeping every day (Table 4.17). This suggests that performing two or more :tivities daily may increase the chances of exposure and contact of the hands to human faeces uring waste handling. Even though the results of this study did not show association between use of are hands in waste handling and contamination with faecal matter, the use of bare hands in waste andling is reported as a major health risk factor for fever and diarrhoea which are symptoms of astrointestinal tract infections acquired through the faecal oral route of transmission (Luby *et al.*,)07: Pickering *et al.*, 2010; Mattioli *et al.*, 2013).

As indicated in Table 4.14, waste handlers who were 35 years and above were about four times more ikely to have contaminated their hands with human faeces during work compared with those less han 35 years. This effect may be due to increasing reluctance for using protective measures among)lder waste handlers, presumably because of apathy or other differences in lifestyle and personal ehaviour not captured by this study (Dodrill *et al.*, 2011). Again, waste handlers who worked for the Area Council were thrice more likely to have contaminated their hands with faecal material in waste ompared with those who worked with the Azontaba Construction Industries (ACI). The explanation or this finding could be due to the duration of work (i.e. the number of years spent in waste andling), the predominant type of waste handled and the provision and use of personal protective quipment to workers by waste management organizations. Whilst waste handlers who worked for ACI had spent less than a year in waste handling, those who worked for Area Council had spent over

ve years, thereby increasing their risk of exposure to faecal material. Secondly, workers of the Area ouncil worked at public toilet facilities and as 'night soil' collectors and disposers within the peri- rban community and therefore may experience greater exposure to human faeces compared to the vorkers of ACI. Thirdly, the ACI, being a new private waste company in partnership with overnment, provided relatively new personal protective equipment to its workers and may have upervised their use compared with workers of the Area Council who were solely government ponsored. Workers of the Area Council did not constantly wear protective equipment and when hese were worn, the equipment (e.g. rubber gloves) were torn and therefore offered little protection. he findings of this study again indicated that waste handlers who have worked for 1-2 years in rampram were about twice more likely to have faecal indicator Coliform on their hands compared vith those who have worked for less than a year. This finding may further suggest that unlike the vorkers of ACI who have been working for less than a year in Prampram, the other waste handlers vorking for other waste management organizations like Zoom Lion, ZOIL and Area Council had een working for more than a year and may also be handling potentially more faecal polluted waste han the workers of ACI. The waste handlers with ACI might also be using newer and more effective ersonal protective equipment compared with the other workers of Zoom Lion, ZOIL and Area ouncil.

The mean concentration of faecal indicator Coliforms detected on hands of waste handlers was igher than that of *E. coli*. This finding was in agreement with a study conducted in Honduras on acterial contamination among household toys that found higher concentrations of faecal indicator oliform compared to *E. coli* (Stauber, *et al.*, 2013). Previous researchers have again reported that aecal indicator Coliforms were more commonly detected in higher concentrations as indicators of

ecal contamination than indicator *E. coli* in different settings (Hardina and Fujioka, 1991; Judah *et* ., 2010; Stauber, *et al.*, 2013). However the test for faecal indicator *E. coli* may comprise highly athogenic strains such as entero-haemorrhagic *E. coli* O111 or even *E. coli* O157:H7 that have the ability to present severe manifestation of gastrointestinal problems as well as systemic disease among waste handlers and their close contacts within the peri-urban environment unlike Coliforms. Public ealth advocacy must support the campaign for clean peri-urban community in Prampram and ncourage waste companies to provide adequate personal protective devices for use by waste andlers. The contamination of solid waste stream by human faecal material and the direct physical xposure to same among waste handlers is a major health risk not only to the waste handlers but also the entire community. There is need for improvement in environmental conditions in Prampram.

.8 INCIDENCE RATE AND INTENSITY OF HELMINTHES INFECTIONS

he use of Albendazole (400mg) to treat waste handlers at baseline was based on previous reports of ts successful anti-helminthic activity for the treatment of a wide range of helminthes infections since ts discovery in 1961 and approval for human use in 1982 (Pene *et al.*, 1981; Horton, 1990; Dayan, 003). Albendazole was used in the current study as a preferred choice over Mebendazole for the aseline treatment because of its broad spectrum of activity, low cost, high efficacy and the ease of dministration (Bennett and Guyatt, 2000; Farmer *et al.*, 2001). The waste handlers did not have roblem with compliance to the drug because they had been well sensitized and were familiar with he drug. The direct observation method also helped in monitoring the intake. There was no reported dverse events associated with the intake of the Albendazole among waste handlers.

he adoption of preventive treatment without testing for helminthes in the targeted waste handlers in rampram was consistent with the WHO and also used by other authors for the treatment of at risk opulations at baseline (Montresor *et al.*, 1998; Asante and Oduro, 2006; WHO, 2006). Furthermore, ıe limited access to water, sanitation and hygiene facilities among waste handlers during waste andling, posed a higher risk to helminthes infections compared with the general population. These actors have been found by previous researchers to contribute to the problem of persistence of elminthes infections among occupational risk groups including waste handlers (Mara *et al.*, 2010; *ay et al.*, 2006).

The zero incidence recorded for *Trichiuris trichiura* (*T. trichiura*) infections after 3 months post-reatment with Albendazole (400mg) was expected as the drug may have cleared all the eggs of the ıelminthes. Thus, recording zero incidence after three months of treatment with Albendazole may nean that new infections with *T. trichiura* had not been established at the time stool specimen was :ollected. Research conducted by Horton, (2000) and Narain *et al.*, (2004) have shown high rate of :learance of eggs of *T. trichiura* due to light intensity infections using Albendazole (400mg) :ompared with heavy intensity infections. Previous studies have also indicated that it takes ıpproximately three months for female *T. trichiura* to lay eggs after infecting the host (Jackson *et al.*, 1998; Cross, 1996). Thus, this study has demonstrated that at low intensities of infection with *T. richiura*, a single oral dose of Albendazole (400mg) is generally effective.

The low incidence rate of infection (1.5%) and the light intensity of infection (2.8 ± 16.6 egg/gram) with *T. trichiura* recorded among waste handlers after 6 months post treatment with Albendazole 400mg) may be due to the predominant adult population of waste handlers of average age of 42

ears. The most severe forms of infections with high incidence rates of *T. trichiura* have been :ported in children rather than in adults (Stephenson *et al.*, 2000; Lwanga *et al.*, 2012). However, omparing the current incidence rate (1.5%) recorded for *T. trichiura* among the waste handlers, with ıe national average recorded for an adult population (1.2%) and non-school going children (0.8%) in ndemic communities in Kintampo, Ghana, the incidence among waste handlers in Prampram was till relatively high (Tay *et al.*, 2010; Humphries *et al.*, 2011). This presumably shows that waste andlers in Prampram were at higher risk of infection with *T. trichiura* compared with the adult opulation of an endemic area in Ghana as a result of their occupational exposures. However a study onducted in endemic communities in India by Narain *et al.*, (2004) among a group of teenagers ound higher incidence of infection with *T. trichiura* (43.6%), six months post-treatment with \lbendazole (400mg).

The most common health complaint following infections with *T. trichiura* include mainly intestinal, such as diarrhoea and abdominal pain (Stepek *et al.*, 2006), whilst heavy infections in adults have ıeen associated with iron-deficiency anaemia (Gilgen *et al.*, 2001). Even though the light intensity nfections recorded among the waste handlers in Prampram may not be accompanied with severe ıealth complications like anaemia, those infected with the helminth may serve as important eservoirs for the continued transmission of the infective stages among waste handlers, their mmediate family members and the entire peri-urban community.

With reference to finding associations between demographic characteristics and helminthes nfections, this study indicated that the sex of waste handlers was correlated with helminthes nfections. Female waste handlers were 80% less likely to acquire helminthes infections compared

ith males (Table 4.16). Thus female waste handlers might have adopted better protective behaviour work in terms of use of protective working gear and personal hygiene practices. The type of waste andling activities also correlated with helminthes infections and that among the five waste handlers ho transported waste every day, two (40%) had helminthes infections.

ith reference to the use of personal protective working equipment, this study reported that waste andlers who used rubber gloves during work were 80% less likely to acquire helminthes infections ompared with those who did not. *Trichiuris trichiura* is a soil transmissible nematode acquired hrough faecal oral ingestion of the infective stages (eggs) from soil. Working in the faecal polluted eri-urban communities of Prampram without adequate protection of the hands was a risk factor. his result has consolidated the knowledge on the importance of hands in the transmission of soil ransmitted helminthes infections and the need to wear personal protective working gear to prevent he direct exposure of the bare hand to faecal contaminated working environments (Abd El-Wahab *et l.*, 2014). None of the waste handlers driving waste carrying tricycles wore rubber gloves during ork since it was not practicable to do so. It is therefore not surprising that two out of the five had nfections with *T. trichiura*. It was equally not surprising to find a correlation between contamination f hands by the detection of faecal indicator *E. coli* and helminthes infections because the risk factors ere the same for both, indicating exposure to human faeces. Nine out of the 12 waste handlers who ere positive for helminthes infections also tested positive for contamination of hands by human aecal indicator *E. coli*.

ublic health interventions such as periodic treatment of waste handlers with Albendazole (400mg) o eliminate eggs of *T. trichiura* at least once in every 6 months, wearing of rubber gloves to block ransmission of infective stages from faecal contaminated waste environments through bare hands nd use of hygiene facilities would help reduce or prevent the acquisition and spread of helminthes nfections among waste handlers in peri-urban Prampram, as reported in a similar study by Eassa *et al.*, (2016). Even though waste handlers were aware of the importance and timing of hand washing nd hygienic practices, access to convenient hand hygiene facilities was lacking (e.g. absence of water and soap for washing hands after work, defecation and before eating). Again, there was inadequate sanitation facilities for use of waste handlers during work (e.g. absence of toilet facilities at places where waste handling activities occur). These factors coupled with walking bare-footed during waste handling were also risk factors for acquisition of helminthes infections in waste handling (Vandemark *et al.*, 2010; Alemu *et al.*, 2011; Ziegelbauer *et al.*, 2012). Thus, using alternative preventive approaches, in addition to anti-helminthic drugs, need to be incorporated in the effort to reduce risk factors for helminthes infections among waste handlers in Prampram.

5.9 LIMITATIONS OF STUDY

Even though the current study was well conducted and the findings added valuable information on waste handling activities, exposure surfaces and use of personal protective equipment; Self-reported health outcome, risk of contamination of hands by human faeces as well as on the incidence rate and intensity of helminthes infections among waste handlers in the peri-urban community of Prampram, Ghana, there were few limitations. Firstly, the health outcomes were mainly self-reported and not clinically confirmed. Bias in recall may have resulted in over or under-estimation of health problems among waste handlers. The waste handlers in an attempt to portray good health and to avoid being

acked from work, may have under-reported or not reported health problems at all. The response on odily pain and musculoskeletal problems could have been exaggerated to portray evidence of hard ork. Another limitation is that the true source of faecal indicator *E. coli* and/or coliforms was not scertained. Finally, the cure rate of Albendazole (400mg) was not determined among waste handlers wo weeks post-treatment.

6.0 CHAPTER SIX – CONCLUSION, RECOMMENDATIONS AND POLICY PERSPECTIVES

.1 CONCLUSION

here is a growing number of waste handlers in the peri-urban community of Prampram engaged in ifferent types of waste handling activities, who also belong to different waste management rganizations. Waste handlers had different levels of exposures to waste and reported different health utcomes. The most common self-reported health problems were bodily pains, headache, fever and liarrhoea. Other health problems like eye problems, stomach pains 'itchy anus' and non-specific ymptoms such as stress and tiredness were also highlighted as commonly experienced.

The study indicated that direct contact of exposure surfaces of waste handlers to waste was ssociated with reported skin diseases. Waste handlers whose bare hands were directly exposed to waste were more likely to report cough symptoms than those whose hands were not exposed. Waste handlers who performed three activities a day (sweeping, collection and disposal) were more likely o report upper back pain than those who only swept every day. Waste handlers who swept every day ad less risk of developing upper back pain compared to those who performed two activities per day disposal and collection). Compared with those who swept solid waste everyday in Prampram, solid waste transporters were more likely to report upper back pains.

he prevalence and concentration of faecal indicator *E. coli* and Coliforms on hands of waste andlers were both estimated to be higher after work than that before work. Waste handlers erforming multiple activities (including two or more of sweeping, collection and disposal) a day had ignificantly higher concentration of *E. coli* compared with workers who were only sweeping every ay. A total number of 16 (5.7%) waste handlers tested positive for both *E. coli* and Coliform. Waste andlers who were above 35 years more likely to have faecal indicator *E. coli* on hands compared vith those below 35 years. Female waste handlers were less likely to have faecal indicator *E. coli* on ıands compared with male waste handlers. Waste handlers who earned between ¢80-¢150 were more ikely to have faecal indicator Coliforms on hands compared with those who earned less than ¢80 per nonth. Waste handlers who have worked between 1-2 years were more likely to have contamination ıf hands with indicator Coliforms compared with those who have worked for less than a year.

Light intensity helminthes infections was reported among few waste handlers after 6 months post-reatment. The incidence rate of helminthes infections among waste the waste handlers was however ıigher compared with results from an endemic community in Ghana. The likelihood of acquiring ıelminthes infections after 6 months post-treatment with Albendazole (400mg) single oral dosage vas less for female waste handlers as well as for waste handlers who used rubber gloves during work compared to males and those who did not use gloves respectively. The intensity of helminthes nfection in egg/gram, level of faecal indicator *E. coli* and Coliform measured in CFU/ml were ignificantly different with respect to the different types of waste handling activities.

This study concludes that waste handlers experience a burden of diseases which is likely to be consequences of their occupation. The study stresses that waste handlers in the peri-urban

ommunity of Prampram thus are in need of disease protection from suitable and affordable rotective gear. Waste companies and government institutions employing a growing number of waste andlers should address these issues. Using bare hands to perform waste handling activities increases ie likelihood of reporting health problems such as infection with *T. trichiura* among waste handlers n Prampram. Employers of waste handlers must thus ensure periodic treatment of waste handlers (at east every 6 months) and to provide adequate hygiene facilities (soap and water) and supervise their se during waste handling.

5.2 Recommendations and Policy Perspectives

There is need for further studies to determine actual health problems among waste handlers by conducting clinical examination in order to guide the design and implementation of specific health promotion measures to reduce health problems associated with waste handling activities in the peri-urban community of Prampram. For future research, it would be useful to include psychosocial health risk factors to waste handlers in Prampram. Using techniques in molecular biology to genetically identify possible pathogenic *E. coli* strains in circulation among waste handlers would be beneficial in the future. Conducting a baseline helminthes detection study and to determine cure rate of Albendazole (400mg) two weeks post-treatment among waste handlers is further recommended for future studies.

There is need for waste management organizations employing a growing number of waste handlers n Prampram as well as the Ningo-Prampram District /local government to collaborate to design and mplement the use of improved waste handling technology to deal with the issue of reported

nusculoskeletal pains by waste handlers. The employers of waste handlers in the peri-urban ownship need to also educate and train waste handlers to adopt correct ergonomic work postures articularly among those who sweep and collect solid waste in the Prampram community every day. The appropriate authorities and stakeholders in waste management (including employers of waste handlers and district/local government authorities) must provide waste handlers with appropriate and suitable personal protective working gears (PPGs) and replace old and worn out PPGs.

These stakeholders must not only provide PPGs, but also offer periodic education and training about the proper use of PPGs and how to maintain them. Waste management organizations in Prampram and the Ningo-Prampram District Sanitation and Environmental Health Directorate must design and implement sustainable hand hygiene promotion programmes, provide sufficient hygiene facilities (soap and water) for waste handlers in the community. Employers of waste handlers must ensure periodic medical screening/examination and provide the appropriate public health interventions to curtail health problems among waste handlers in Prampram.

6.3 Contribution to knowledge

This study has provided one of the first findings about self-reported health problems among waste handlers in Ghana. This is also the first time faecal indicator bacteria has been examined on hands of waste handlers in Ghana. Finally, this study has added knowledge about helminthes infections among occupational groups in Ghana, by reporting for the first time *T. trichiura* infections among waste handlers in Prampram.

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8.0 APPENDIX

8.1 CONSENT FORM

Title of study: Peri-urban Environment, Sanitation and Health – Associated Health Risks in Waste Handling in Prampram, Ghana.

Brief background of study: Sanitation and waste management is a problem in Prampram. Frequent open defecation within Prampram communities has high potential of faecal contamination of solid waste. The health of persons engaged in waste handling may therefore be compromised due to faecal contamination or due to other musculoskeletal pains and injuries resulting from waste handling activities. Different methods and tools including, observations qualitative, quantitative and laboratory tools will be used to collect data for this research and triangulated to assess health hazards associated with waste handling within peri-urban communities of Prampram.

Aim of Study: To Assess Health Risks to Waste Handlers in Prampram.

Investigator: James-Paul Kretchy

Participation Information: I would like you to be part of this study. However before you do so, I would like you to understand the following principles.

1. Participation is totally voluntary
2. You may choose to withdraw from the study at any time
3. You are free to ask any question/s to clear your understanding of the conduct of the study.

Administration of Albendanzole (400mg): You will be given one tablet of Albendanzole (400mg), a de-wormer by trained personnel. You will be directly observed by the person to ensure that you have truly taken your drug.

Biological samples: You will be requested to produce two stool specimens, in specimen containers which will be given to you, after taking the de-wormer. This will be used to determine presence or absence of worms in your stool as a result of waste handling practices.

Storage of biological material: The stool specimen will be stored in the laboratory at the Noguchi Memorial Institute for Medical Research (NMIMR) and used only for the above mentioned purposes.

Side effects of Albendanzole (400mg): You may experience upper gastrointestinal symptoms (e.g. epigastric or abdominal pain, nausea, vomiting) and diarrhoea may occur rarely. Headache and dizziness have also been rarely reported.

Contra-indication: Albendazole (400mg) is contraindicated in pregnancy and lactation. The drug would therefore not be administered to pregnant and lactating waste handlers.

Reporting side-effects: Please report any observed side-effect to a nurse, physician assistant or physician on-duty at the Prampram Health Centre.

Interviews and Questionnaires: I will like you to fill a questionnaire to be administered by myself or my field assistant. The information you provide will be analyzed to assess your knowledge about health risks in waste handling in Prampram. For interviews, I will request 45mins to 1 hour of your time for a chat with you which would be recorded with a digital device.

Duration of Participation: You will be interviewed once. You will also fill a questionnaire once. Your stool sample will be collected two times within six months period (at three months interval).

Assurance of Participant's Confidentiality: All records relating to your involvement in this study will remain confidential. No information revealing your identity will be used in any report from this study.

Benefits of the Study: You will receive free treatment with the de-wormer, Albendazole 400mg, at the start of the study. Additionally, information/results obtained from this study will be used to enhance our understanding on health risks in faecal waste management in Prampram. It would also help to recommend alternative and beneficial ways of handling waste as well as suggest interventions that would reduce the health risks of those engaged in waste management.

For additional information concerning your rights as a research participant, you may contact: Dr. Mawuli Dzodzomenyo (School of Public Health, University of Ghana); Mobile Phone Number: 0208-376845; OR Dr. Margerate Gyapong (Dodowa Health Research Centre): Mobile Phone Number: 0244-573138

In case you do not understand any portion of this consent explanation, do not hesitate to ask me (the investigator) before signing.

Participant's consent agreement: The background and aim of the study has been explained to me and I have been assured of strict confidentiality of my answers to questions in this study. I have had the opportunity to seek clarification on issues about this study I do not understand. I agree to voluntarily participate and give my full consent to publication of results from this study.

Taking pictures: I agree that you can take pictures of me during waste handling.

SPECIAL ID NUMBER OF PARTICIPANT.....

SIGNATURE/THUMBPRINT:.....DATE:.....

I verify that my participant has not been forced to giving consent to participate in this study. He/she willingly consented to participate in this study. The participant was given the opportunity to seek clarification on issues about this study he/she did not understand. I provided clarifications to him/her to the best of my knowledge.

NAME OF INVESTIGATOR/FIELD ASSISTANT: ..... DATE:.....

8.1.1 ETHICAL CLEARANCE (DHRC-IRB – STUDY NO.01/10/11)

In case of reply the number and date of this letter should be quoted.

Dodowa Health Research Centre
Ghana Health Service
P. O. Box DD1
Dodowa

Tel: +233-0302-925-837

My Ref. : DHRC/1RB/11/02/
Your Ref. No.

03 April 2019

Mr. Kretchy
Department of Biological, Environmental and
Occupational Health Sciences
School of Public Health

College of Health Sciences

University of Ghana

Legon

RE: **STUDY NO.01/10/11** **AT: DHRC-IRB EXPEDITED REVIEW**

Dear Sir,

PROTOCOL TITLE: MICOBIAL AND OCCUPATIONAL HEALTH RISKS OF WASTE MANAGEMENT WORKERS IN PRAMPRAM, DANGME WEST DISTRICT OF GREATER ACCRA REGION

This is to inform you that the DHRC IRB has approved the amendment to the above named protocol.

Yours sincerely,

IRB Administrator
DHRC, IRB

GHANA HEALTH SERVICE ETHICAL REVIEW COMMITTEE

In case of reply the number and date of this letter should be quoted.

My Ref: GHS-ERC 3
Your Ref No.

Research & Development Division
Ghana Health Service
P. O. Box MB 190
Accra
Tel: +233-302-681109
Fax: +233-302-685424
Email: nanatuesday@yahoo.com

1st August, 2013

James-Paul Kretchy
School of Public Health
University of Ghana, Legon
Accra

ETHICAL APPROVAL - ID NO: GHS-ERC: 09/07/12

The Ghana Health Service Ethics Review Committee has reviewed and given approval for the implementation of your Study Protocol titled:

"Peri-urban environment, sanitation and health - Associated health risks in waste handling in Prampram, Ghana"

This approval requires that you inform the Ethical Review Committee (ERC) when the study begins and provide Mid-term reports of the study to the Ethical Review Committee (ERC) for continuous review. The ERC may observe or cause to be observed procedures and records of the study during and after implementation.

Please note that any modification without ERC approval is rendered invalid.

You are also required to report all serious adverse events related to this study to the ERC within seven days verbally and fourteen days in writing.

You are requested to submit a final report on the study to assure the ERC that the project was implemented as per approved protocol. You are also to inform the ERC and your sponsor before any publication of the research findings.

Please always quote the protocol identification number in all future correspondence in relation to this approved protocol.

SIGNED.

PROFESSOR FRED BINKA
(GHS ERC CHAIRMAN)

Cc The Director, Research & Development Division, Ghana Health Service, Accra

8.2 STUDY PROTOCOLS

8.2.1 STAKEHOLDERS INTERVIEW GUIDE FOR INSTITUTIONS/ORGANIZATIONS EMPLOYING/SUPERVISING WASTE HANDLERS

This short interview guide is designed with the aim to classify, quantify and describe types of activities undertaken by waste workers in Prampram.

1. Date _____

2. Name of Institution/Organization _____

3. Location of Institution/Organization _____

4. Name of Person interviewed _____

5. Position of person interviewed _____

6. How does your institution/organization recruit waste management workers? **(PROBE)**

7. How many of these are in Prampram? _____

8. How does your institution/organization supervises/oversee waste management workers? **(PROBE)**

9. How many of these are in Prampram? _____

10. How many of these have you employed? _____

11. How many of these do you supervise/oversee? _____

12. What are the specific activities they perform? **(PROBE)**

13. How are the waste management workers paid?

8.2.2 *In-depth interview Guide*

This in-depth interview guide is designed to understand the experiences and perceptions about Health Hazards to Waste Handlers in the Prampram study area.

The purpose is to explore experience and perception of occupational health hazards in waste handling among selected waste handlers.

1. Which health problems do you experienced since you started work as a waste handler? Probe.
2. Why do you think you get these health problems? Probe.
3. What do you do to protect yourself in your work? Probe
4. Why do you do this? Probe.
5. Do you have any problems protecting yourself at work? Probe
6. What do you see as the biggest risk to your health as a waste handler? Probe. (Give examples).
7. How do you handle the risk?
8. How do you cope with going to toilet during work? Probe.
9. How do you access to water whilst at work? Probe.

8.2.3 QUESTIONNAIRE

This questionnaire is designed to gather information on use of PPGs, exposed bodily surfaces to waste and reported health problems among Waste Handlers in Prampram study area.

The purpose of this questionnaire is to identify types of activities undertaken by waste handlers, types of PPGs used, surfaces of exposure to waste and reported health problems among waste handlers in Prampram.

Question number	Question	Response/s
	Section A General background information	
1.	Participants special ID #	ACPR….. ZLPR…. ZOPR….ARPR…. ASPR….
2.	Participants name	
3.	Participants Telephone number	
4.	Date of administering questionnaire	☐☐ ☐☐ ☐☐☐☐ dd mm yyyy
5.	Consent has been read out to participant	Yes ☐ No ☐ If No, please read out.
6.	Participant has given his/her consent	Yes ☐ No ☐ If Yes, continue with study, If No, please discontinue.
	Section B Information for administering Albendazole (400mg) single oral dosage	
7.	What was your Date of Last Menstrual Period (LMP)?	If it is over a month do NOT administer drug
8.	Are you breastfeeding? (For female waste handlers only)	Yes ☐ No ☐ If Yes, do NOT administer drug, If No, administer drug.
9.	Do you have any known allergies/adverse reactions to de-wormers e.g. nausea, vomiting, abdominal pain?	Yes ☐ No ☐

Question number	Question	Response/s
		If Yes, do NOT administer drug, If No, administer drug.
10.	Have you taken any de-wormer within the past three months?	Yes ☐ No ☐ If Yes, do NOT administer drug, If No, administer drug.
	Section C Socio-demographic information	
11.	Sex (Indicate Male or Female as observed)	☐ Male ☐ Female
12.	Age/Date of birth	Years...../☐☐ ☐☐ ☐☐☐☐ dd mm yyyy
13.	Highest Level of Education	☐None ☐ Primary ☐ MSLC ☐ Secondary ☐ Tertiary
14.	Current Monthly Salary (State Current Salary Range in ¢GH)	☐ < ¢80 ☐ ¢80 - ¢100 ☐ Between ¢100 and ¢150
	Section D Information about work	
15.	What waste management organization (WMO) do you work for?	☐ Zoom Lion ☐ ZOIL ☐ ACI ☐ Area Council ☐ Community volunteer
16.	How long have you worked with this WMO?	☐ <1 year ☐ 1 – 2 years ☐ 3 – 4 years

Question number	Question	Response/s
		☐ 5 years and above
17.	What specific waste handling activity/ies do you perform? Tick all that apply to you.	☐ Collecting waste ☐ Disposing waste ☐ Sweeping waste ☐ Transporting waste
18.	On the average, how many hours do you work per day?	☐ < 1hr ☐ 1-2 hrs ☐ 2-3 hrs ☐ 4-5 hrs ☐ Any other/Please specify_____
	Section E Use of personal protective working gear and surfaces of exposure to waste material	
19.	What specific personal protective working gear/s do you use during waste handling? Please tick all that apply to you.	☐Nose mask/mouth cover ☐ Over-all coat/apron ☐Wellington boot ☐ Glove ☐ Any other/Please specify_____
20.	Which of your body surfaces has direct contact to waste material during waste handling? Please tick all that apply to you.	☐ Hands ☐ Leg/Feet ☐ Nose/Mouth
	Section F Waste handling and reported health problems	
21.	What health problems did you experience within the past two weeks of waste handling? Please tick all that apply to you.	☐ Fever ☐ Diarrhoea ☐ Headache ☐ Skin disease ☐ Cough

Question number	Question	Response/s
		☐ Bodily pains ☐ Any other/Please specify_____
	Section G Waste handling and perceived causes of health problems	
22.	What are the specific thing/s about waste handling that can give you health problems?	☐ The smell/odour ☐ Exposure of bodily surfaces in contact with waste material ☐ Eating with contaminated/dirty hands ☐ Wearing dirty personal protective working gear
	Section H Waste handling and reported musculoskeletal pains	
23.	Which part of your body did you feel the most pains within the past two weeks?	☐ Neck ☐ Wrist ☐ Lower back (waist) ☐ Upper back

8.2.4 *Sample Observational Checklist*

The purpose for this structured observational checklist is to find out the type of activity performed and associated health hazards in waste handling in the Prampram study area.

1. Date _____

cation	**Olowe, Upper Prampram**			
fic site	Dumping site			
of waste er	**Sweeper**	**Collector**	**Disposer**	Transporter
ity/ ption	Sweeping (using brooms to clear/clean and gather garbage within community)	Collection Using gloved/bare hands to remove waste into waste bins for transport	Disposing Throwing away or discarding waste into Zoom Lion waste receptacles, landfills, etc	Transportation Driving waste carrying tricycle for disposal
ion of ure	**…..hrs**	…..hrs	…..hrs	**…..hrs**
of tion	i. Head gear ii. Nose **mask/mouth** cover iii. Wellington boot, sandals, bare foot, slippers iv. Over – all/apron	i. Head gear ii. Nose **mask/mouth** cover iii. Wellington boot, sandals, bare foot, slippers iv. Over – all/apron	i. Head gear ii Nose mask/mouth cover iii. Wellington boot, sandals, bare foot, slippers iv. Over – all/apron	i. Head gear ii. Nose mask/mouth cover iii. Wellington boot, sandals, bare foot, slippers iv. Over – all/apron

	v. Gloves	v. Gloves	v. Gloves	v. Gloves
od 25	i.Head, ii. arms, iii. chest, iv.trunk, v. hands, vi. leg, vii. feet, viii. under feet ix. Nose/mouth	i.Head, ii. arms, iii. chest, iv.trunk, v. hands, vi. leg, vii. feet, viii. under feet ix. Nose/mouth	i.Head, ii. arms, iii. chest, iv.trunk, v. hands, vi. leg, vii. feet, viii. under feet ix. Nose/mouth	i.Head, ii. arms, iii. chest, iv.trunk, v. hands, vi. leg, vii. feet, viii. under feet ix. Nose/mouth

8.3 LABORATORY PROTOCOLS

8.3.1 CULTURE AND ENUMERATION OF INDICATOR E. COLI ON BRILLIANCE INDICATOR AND SELECTIVE AGAR

1. Collect two hand rinses from the same hand (the right hand) of waste handlers using clean water before and after a day's waste handling activity.
2. Gently rub each hand in 50ml clean water poured into a sterile stomacha polythene bag for about 60secs to dislodge faecal indicator bacteria into the clean water.
3. Gently pour the water containing dislodged faecal indicators back into 50ml falcon tubes and transport on ice to the Noguchi Memorial Institute for Medical Research.
4. Aliquot 1ml of the stock solution for serial dilution.
5. Use 1ml of the stock concentration to obtain stock, 10^{-1}, 10^{-2}, and 10^{-3} concentrations in a serial dilution.
6. Dispense 100µl of each concentration of hand rinse into labelled petri-dishes and pour about 20-25ml Brilliance *E. coli*/coliform selective indicator agar (Oxoid).
7. Swirl gently for even distribution/mixing of hand rinse with agar medium.

8. Allow the prepared plate to set and incubate at 44°C +/- 0.5°C for 24hrs.
9. Observe positive culture for faecal indicator *E. coli* as purple colonies, whilst other faecal coliforms appear pinkish after 24hr incubation.
10. Visually inspect the culture plates and count the number of *E. coli*/coliform colonies grown using the colony counter (gallokemp).
11. Record the number of colonies in a laboratory notebook.

8.3.2 KATO-KATZ TECHNIQUE

1. Collect early morning or first stool specimen from waste handlers three and six months after treatment with Albendazole (400mg)
2. Tease about 0.0417g of faecal specimen to fill the Kato-Katz template (according to manufacturer's instructions), to identify and enumerate infective stages (eggs, larvae) of helminthes.
3. Count the number of helminthes eggs/ova/larvae (infective stages) using low power objective lens magnification (X10/X40)
4. Multiply the number of eggs/infective stages in the 0.0417g of faecal specimen by a factor of 24 to obtain the intensity of infection expressed as eggs per gram (epg) of faecal specimen.
5. Classify the degree of intensity of helminthes infections according to the WHO categorization (light, moderate, and heavy) infections (WHO, 1994; WHO, 1998, WHO, 2002).

8.3.2.1 WHO classification of egg/gram (Intensity of infection) for *Trichiuris trichiura*

The following threshold epg values (intensity) proposed by the WHO were adopted for the classification of waste handlers infected with *T. trichiura* as having light, moderate or heavy intensity infections

	Light intensity infections	moderate intensity infections	Heavy intensity infections
Trichuris trichiura	1- 999 epg	1,000- 9,999 epg	≥ 10,000 epg

- *There were no heavy and moderate intensity infections with T. trichiura among waste handlers in peri-urban communities in Prampram 3 and 6 months post-treatment with Albendazole (400mg)*

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Full Length Research Paper

Title: Exposure, protection and self-reported health problems among solid waste handlers in a coastal peri-urban community in Ghana

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Abstract

Mixed method design was used to investigate exposure to waste, use of personal protective gear (PPG), and reported health problems among 280 solid waste handlers in a peri-urban township of southern Ghana. Most commonly reported health problems were bodily pains (56.4%), headache (38.6%) and fever (35.7%). In-depth interviews highlighted eye problems, stomach pains and non-specific symptoms. Waste handlers whose bare hands were exposed to waste had a higher likelihood to report fever [odds ratio (OR) = 1.89 (95% C.I 1.37 – 2.56), $p < 0.0001$] and diarrhoea [OR = 6.25 (95% C.I 4.17 – 10.00), $p < 0.0001$] compared with those who used rubber gloves. Similarly, waste handlers with uncovered mouth/nose had higher likelihood to report cough than those who used mouth/nose cover [OR = 7.69 (95% C.I 4.00 – 14.29), $p < 0.0001$]. Waste handlers who did not use PPGs consistently cited reasons including physical discomforts, impracticalities of wearing them in hot/humid conditions, inability of employers to supply or to self finance PPGs. Waste handlers need affordable and suitable protective gear against health problems coupled with provision of water and soap to promote personal hygiene at work. Employers must educate and train waste handlers on disease preventive purposes of using PPGs.

Key words: Solid waste handlers, Mixed method, Exposure, Protection, Health problem, Peri-urban.

Introduction

Population densities in urban areas are increasing worldwide and so are the solid waste generated. In many less developed countries, e.g. Ghana, waste handlers are occupied with the removal of large volumes of different types of contaminated waste, often by hand as they have limited access to appropriate waste removal technology (McGregor et al 2011; Amoateng et al 2013). These waste handlers are therefore predisposed to several health hazards which occur throughout the waste management chain, from collection to final disposal. Solid waste handling is therefore generally considered to be an occupation representing substantial health risks (Kitsantas et al 2000).

The magnitude of work related health problems may be influenced by an individual's level of protection and hazard exposure (Mutha et al 1999). Common ways to reduce exposure to health problems in waste handling include the use of personal protective gear (PPG) (Tjoe Nij et al 2003). The use of proper PPG may prevent direct physical contact of waste handlers to solid waste, which often is faecally contaminated, and also prevent cuts and injuries during waste handling activities.

Previous studies have described health effects among solid waste handlers and found health problems including bodily pains (Norman et al 2013), eye, skin, and gastrointestinal problems that were associated with solid waste handling (Dorevitch & Marder 2001; Rushton 2003). However, type and magnitude of health problems are likely to be influenced by culture and behaviour within local contexts under which waste handlers work (Whitelaw et al 2001; Tate et al 2003; Gutberlet 2008). Even though there is available information on health problems faced by waste handlers in North America (Rendleman and Feldstein, 1997) and Brazil (Gutberlet *et al.*, 2013), there is limited published research on health problems to waste handlers in Ghana with none focusing on those in

peri-urban communities. Existing studies on solid waste management in Ghana report mainly nuisance aspects of solid waste pile-up due to poor management (Fobil et al 2008; Ampofo 2013) and not direct health hazards that solid waste handlers are exposed to and associated disease problems. Nonetheless, the information about health problems is important to gain insight and to recommend public health measures that would curb the impact of these health problems among solid waste handlers in rapidly developing urban communities, in less developed countries like Ghana. This study therefore aimed to describe different waste handling activities and self reported health problems among solid waste handlers, including physical exposures and protection in peri-urban communities, the case of southern Ghana.

Materials and methods

Waste handlers were defined as those who either worked for waste management companies and institutions or as volunteers directly handling waste materials along the waste management chain. The waste managed included solid waste; solid waste mixed with fresh and decomposed human faeces or effluents from domestic waste pipes and septic sludge from tanks emptied into open drains.

Study area and design

This cross-sectional study was conducted in a coastal and peri-urban community located in the Dangme West District, in the southern part of Ghana. A mixed method design (Ulin et al 2005; McBurney & White 2009) including observations, in-depth interviews and researcher-administered questionnaire were used to collect data on exposure to waste, personal protection and self reported health problems.

Observations

The types of protective gear worn, (e.g. over-all gowns, nose/mouth cover, gloves, Wellington boots etc.) and parts of body of waste handlers exposed to waste whilst working were observed. Waste sites observed included open drains by the road-sides, around ponds, dumping sites, beaches, around waste containers, public toilet facilities and other open spaces within the peri-urban communities where waste was disposed, collected and handled. The observations were systematically recorded using observational guides and into field notes.

Questionnaire administration

All the 280 waste handlers identified based on their activities, were interviewed using a close-ended questionnaire comprising twenty (20) questions. The questionnaire was adopted from Mbeng et al (2009) and Ifegbesan (2010) and modified within the context of the current waste handling practices at the study site. Information was collected to classify and describe types of activities undertaken and to determine the type and level of exposure to waste as well as self reported health problems among waste handlers. The waste handlers were identified and questioned on the site where they carried out waste work.

In-depth interviews

In total 22 waste handlers, representing a diversity of all the different types of waste workers, were interviewed with the purpose of understanding their work conditions, perceptions of common health problems, and the use of Personal Protective Gear (PPG). A face-to-face in-depth interview approach was adopted to allow an open communication which could expand on some of the observations made at the waste sites (Sturges & Hanrahan 2004). The in-depth interviews were conducted in a neutral

venue away from the work place of waste handlers to create a relaxed interview atmosphere. Interviews were recorded using a digital audio device with each in-depth interview lasting between 45 minutes to one hour using a semi-structured interview guide.

Ethics statement

Ethical clearance was obtained from the Institutional Review Board of the Dodowa Health Research Centre, Ghana Health Service with review number (DHRC-IRB – STUDY NO.01/10/11).

Data management and analysis

Survey interviews and in-depth interviews were all conducted by research assistants fluent in the local language of Dangme. In-depth interviews were transcribed in the Dangme language by the research assistants on the day of the interviews and translated into full-text English. The first author conducted a thematic content analysis with an inductive approach (Elo & Kyngas 2008); all transcripts were manually coded and summarized into emerging higher level themes. The main themes identified were; exposure of uncovered parts of body to waste and the resulting risks to health, difficulties with using personal protection during waste handling, and health problems among waste handlers.

After fieldwork, each questionnaire was checked for completeness before entering data into SPSS 17.0 for Windows 7 (SPSS, Inc., Chicago, IL.) to minimize errors and to validate the data. Double entry of data from questionnaire responses was done to ensure accuracy. Cross tabulations were used to compare the differences in responses among the different waste handlers by Chi-square statistic and P-values. A logistic regression model was used to analyze the association between exposure (use

of bare hands, uncovered mouth/nose); protection (use of gloves, mouth/nose cover, overall gown, Wellington boots) and reported health outcomes (including fever, diarrhea, cough, skin problems). The information obtained from the different data collection methods were triangulated to obtain an in-depth understanding of reported health problems.

Results

Socio-demographic characteristics of waste handlers

The majority (76.1%; 213/280) of waste handlers were females and waste handlers had an overall mean age of 42.7 years, with a few (2.9%; 8/280) children as well as old people (8.9%; 25/280) (above 60 years) also engaged in waste handling (age range 8-87 years). Waste handlers within the very young or old age groups worked at public toilet facilities as sweepers or collectors of human faecal matter but also as disposers of solid waste generated both within and outside the toilet facilities. Most (69%; 193/280) waste handlers only had up to basic level education. A majority (82.9%; 232/280) earned between 80 and 100 Ghana Cedis (GH₵) per month from waste handling (i.e. approximately USD 36-45), which was the main source of income for most waste handlers. This income was far lower than the average monthly per capita income in Ghana (GH₵ 225; about USD 117) (GSS, 2013).

Waste handling practices

The highest proportion (69.3%; 194/280) of waste handlers engaged in multiple tasks including sweeping, collection and disposal. Other waste handling activities with proportions of waste handlers performing them were sweeping only (18.2%; 51/280), collection only (4.3%; 12/280), disposing

only (6.4%; 18/280) and transport only (1.8%; 5/280). Table 1 describes the specific waste handling activities.

Table 1: Classification and description of waste handling activities identified.

Waste handling activity	Description
Sweeping	*Using brooms to manually clean and gather wastes from streets, lorry park, beaches, gutters, sanitary facilities (public toilet facilities and dumping sites), waste receptacles, tricycles, around dumping sites and open spaces within the peri-urban communities such as the market place.*
Collection	*Using either bare or gloved hands, shovels, brooms, or rakes to pick or remove solid waste from beaches, public amenities, sanitary facilities (public toilet facilities and dumping sites), gutters, fresh water ponds, abandoned grave yards within the peri-urban communities. The waste materials were collected into solid waste receptacles or wheelbarrows and transported to landfill sites, buried or dumped into nearby bushes.*
Transportation	*Waste handlers who transported waste were tricycle drivers who used motor-powered tricycles with attached open tray/caravan for rear loading of solid waste from the peri-urban communities).*
Disposal	*Throwing or dumping collected solid waste into waste receptacles, landfill sites or 'unofficial' dumping sites along the beach, around fresh water ponds or in the bush. Waste disposal also involved burning or digging the soil to bury waste materials. Waste materials were usually disposed of in bulk without prior sorting or treatment.*

Exposure of uncovered parts of body during waste handling

Observations conducted among waste handlers during work showed that most workers had bare parts of their bodies exposed to waste during most of their daily work time. This was in agreement with the results from the questionnaire survey that showed that in all groups of waste handlers, most (87.1%; 244/280) used bare hands to handle waste including all transporters (5/5), 91.8% (178/194)

of workers performing multiple tasks, 88.2% (45/51) of sweepers, 83.3% (15/18) of disposers and 16.7% (2/12) of collectors. The survey further showed that 41.8% (117/280) of all waste handlers performed their work with uncovered mouth/nose. Observations again showed that pregnant and breastfeeding mothers also engaged in waste handling with uncovered mouth/nose, hands or feet. Few breastfeeding waste handlers (5.6%; 12/280) who brought their children to work, with no form of physical protection, also performed waste work whilst carrying the children at their back. Though these vulnerable groups of female waste handlers with their children were few, the possibility of reporting anaemia from hook worm infections and inhalation of organic dust among the children could be high.

Association between use of uncovered parts of body and self-reported health outcomes

A logistic regression showed that waste handlers who used bare hands to perform multiple waste handling tasks in a day had significantly higher likelihood to report fever [odds ratio (OR) = 1.89 (95% C.I 1.37 – 2.56), $p < 0.0001$] and diarrhoea [OR = 6.25 (95% C.I 4.17 – 10.00), $p < 0.0001$] than those whose hands were covered with rubber gloves. Similarly, waste handlers who performed multiple waste handling tasks whose mouth and nose were uncovered during a day's activities had significantly higher likelihood to report cough than those whose mouth/nose were covered with nose/mouth cover [OR = 7.69 (95% C.I 4.00 – 14.29), $p < 0.0001$].

During in depth interviews, waste handlers elaborated on the use of bare hands in waste handling and the reasons for not washing hands during a work day. A 55 year old male waste handler stated that; *"Sometimes I forget to wash my hands in a haste to eat when I am sweeping the gutter. May be I am very hungry and just want to eat something. Instead of taking my time to wash my hands with water, I*

say oh let me just finish this food quickly, this is nothing. But I have forgotten that whiles I was working in the gutter, some of the waste water splashed on me.... Even if I wash my hands, I use only water because there is no soap". Observations also highlighted that access to water and soap for effective routine hand washing during work was limited; most waste handlers were part of a mobile work force and did not have access to a site with running water and freely available soap for hand washing before eating or after defecation.

Use of and knowledge about Personal Protective Gear

The questionnaire interview yielded information about the different types of Personal Protective Gear (PPG) which were used by waste handlers during work. Four types of PPGs were mentioned; namely overall gowns to cover the surface of the body (72.6%; 204/280), Wellington boots to cover the sole and feet (62.5%; 175/280), gloves to cover the fingers and palms up to the wrist (59.3%; 166/280) and mask to cover the mouth and nose (32.1%; 90/280). The use of gloves (91.6%; 11/12), overall apron (100%; 12/12) and Wellington boots (75.0%; 9/12) was significantly higher among collectors compared to sweepers, disposers, transporters and those who performed multiple waste handling tasks ($p < 0.0001$). Observations further showed that almost every waste handler who did not wear Wellington boots wore open slippers and sandals as footwear, or were barefooted.

In-depth interviews with the 22 waste handlers showed that two-thirds had only basic knowledge about the disease protective purpose of wearing PPGs. One 32-year old female sweeper said; *"Sometimes it is good that they train us how to use the safety gears because unless we try to acquaint ourselves with its use, we can get the health problems in the near future".* A waste collector also explained: *"If we do not use the hand gloves... we can contract some of the health problems, like*

diarrhoea" (35 year old male). Another waste handler iterated that: *"This is why we have to be given something to cover our nose to minimize the amount of dust that we inhale" (40 year old female waste handler who performed multiple tasks).*

Barriers to using Personal Protective Gears

Contradicting the survey results, observations revealed that most waste handlers did not use PPGs consistently throughout a day's work. Waste handlers such as community waste volunteers, scavengers and night soil collectors did not have functional PPGs available.

In-depth interviews further sought to understand the main barriers to using PPGs. One reason mentioned was the inability to purchase PPG from personal funds. This was a problem for the group of waste workers who were not employed in official waste management companies including waste scavengers, night-soil-collectors, volunteer community waste handlers and private public toilet managers. These groups of waste handlers constituted approximately one fourth of all waste workers who were the poorest since they only received daily wages based on the waste they scavenged and sold, how many households they visited to empty latrines or how many customers used public toilet facilities. The volunteer waste handlers did not receive any salaries or allowances since they only performed waste handling activities occasionally as part of communal initiatives.

One night soil collector explained his inability to purchase PPG to use when he manually collected night soil into simple buckets, that were then transported and disposed of by hand: *"If I am transporting the human faeces, I don't have anything to cover my nose....sometimes, what I use to protect myself gets spoilt and I don't have money to replace it".* Though the use of bare hands in

night soil collection would represent a very high exposure to faecal pathogens and the associated risk for oral transmission of disease among waste handlers involved, the risk of disease was paradoxically mainly associated with the bad smell of faeces.

Another reason for not using PPG was simply not having it. Once employed by a waste company, waste workers were supposed to receive PPG to perform their work. However, it was mentioned by all waste handlers, employed by waste companies, during in-depth interviews that PPGs were not supplied to all waste handlers. For waste handlers who were provided with PPGs, these were not replaced by the employer after protective gear became worn out. Waste handlers thus had to manage with torn PPGs that did not protect them well. A 32-years old female collector described the problems: *"When I use the nose cover today and fix it again for a period of time, sweat gets into it and then it brings out some bad smell and makes it uncomfortable to use"*. Thus discomfort in general was a major barrier to wearing PPG. A waste collector expressed his feelings of panting for breath when wearing nose masks: *"The nose cover causes us to pant for breath. There are some pores in the nose cover...Sometimes we begin to pant for breath, so we take it off at a point and continue to work"(55-years old male waste collector).*

Problem with using gloves and boots were also commonly mentioned in interviews. The problems stated were mainly related to experiences of skin becoming hot, humid or wet inside gloves and boots and developing into skin problems. A logic regression model to show association between the use of Wellington boots [OR = 2.0 (95% C.I 1.43 – 2.86), $p < 0.0001$] and overall gown [OR = 2.94 (95% C.I 1.89 – 4.55), $p < 0.0001$] among waste handlers showed significantly higher likelihood for those who performed multiple tasks to report physical discomfort than those who did not use them.

During an in-depth interview, one 55-years old male waste collector described the effects of using Wellington boots: *"For the boots sometimes, I contract foot rot when I use it for a long time"*. Wellington boots were also perceived as too heavy and unpractical to wear by everyone interviewed: *"For the wellington boots, once the feet keep so long in the boot, my foot becomes hot. It's very difficult wearing them, because the boot is heavy and walking in the sun, it's not easy"....* (A 37-years old male waste disposer). A 34-years old female sweeper had similar experiences with using gloves: *"The gloves...it's just that my fingers do not get enough air; they get wet. When I take my fingers from the gloves it feels as though it's from the cold store"*.

Types, frequency and causes of self reported health problems among waste handlers

Different proportions of waste handlers reported various health problems which they linked to their occupation as revealed in the different types of questionnaire interviews. Even though some waste handlers reported health conditions that could be due to viral, bacterial or parasitic infections (such as fevers, diarrhoea, cough and skin disorders), the most common health problem reported in the interviews was bodily pains (56.4%; 158/280). Other health problems reported during questionnaire survey were headache (38.6%; 108/280), fever (35.7%; 100/280), feeling of discomfort (28.2%; 78/280), diarrhoea (11.4%; 32/280), dizziness (6.8%; 19/280), cough (8.9%; 25/280), skin disorders (5.4%; 15/280) and asthma (1.8%; 5/280). In addition, in-depth interviews with the waste handlers revealed that eye problems, stomach pains and non-specific symptoms such as stress and tiredness were common health problems.

Pains

The highest proportion (63.4%; 123/194) of waste handlers who reported bodily pain was those workers who performed multiple waste handling activities. A waste handler explained: *"After collecting the waste, I push the waste in the wheel barrow several times in the morning, to the dump site to dispose. I feel waist pains (setso yemi) and pains in my whole body" (35-years old male waste handler performing multiple waste handling tasks).* A 32-years old female waste handler who performed multiple waste tasks in a day also narrated her experience with bodily pains: *"In this waste work. I sweep, collect and dispose of the waste.... This disturbs me a lot. I suffer a lot of pain in my body and my waist. Previously I did not experience these body pains but since I started this work then the pain also started".*

Field observations revealed that handling wastes was characterized by hard manual work. Apart from two motor-powered waste tricycles used to transport waste, waste handling equipments were all manually operated including physical dragging, pushing and pulling of waste containers, wheelbarrows etc. This hard physical work is likely to have resulted in reported bodily pains among waste handlers.

Other causes of health self reported problems

A high proportion (67.5%; 189/280) of waste handlers reported direct exposure of uncovered parts of body to waste as the main cause of their health problems, whilst 61.4% (172/280) reported that inhaling bad smell of waste was a major cause of their health problems. Other factors reported to be associated with health problems included; eating with dirty hands (45.7%; 128/280) and wearing dirty clothes for work (8.6%; 24/280). These things in combination with working outdoors under harsh conditions were also commonly explained as causing disease: *"I sweep and collect money by*

the waste container. mosquitoes bite me and I get malaria (atlidii) and sometimes after standing in the sun then half of my head is aching very bad. I also experience like I want to vomit and my anus itches me (fitɔ mi plemi)" (40-years old female waste handler who swept and collected money near waste container). One 35-years old female waste handler who collected human faeces from the beach each morning explained how this caused her health problems and discomfort: *"The health problems come from the work we do...We handle human faeces and the bad scent gets into our nose. We get increase in abdominal pain as a result. This morning for example, there were lots of human faeces at the beach...and as we sweep, the bad scent then gets into us and gives me sickness."*

Discussion

Similar to research conducted in other parts of Africa, (Getahun et al 2012), Asia (Zhang et al 2010) and Europe (Magrinho et al 2006), our study shows that there are a range of different people engaged in waste handling activities in peri-urban communities to control and reduce the volumes of accumulating solid waste. The high proportion of females engaged in waste handling in these rapidly urbanizing townships in southern Ghana is in agreement to the traditional perception of female dominance in waste handling in Ghana (Kadfak 2011).

Though this study did not specifically investigate hookworm infections among female waste handlers, research conducted in Ghana has shown that females were more likely to report anaemia from occupation-related hookworm infections compared with males (Glover-Amengor et al 2005; Humphries et al 2011). The exposure of pregnant and breastfeeding waste handlers to waste may increase the likelihood of acquiring occupation-related hookworm anaemia among female waste handlers compared with males (Glover-Amengor et al 2005; Humphries et al 2011). Similarly, children of waste handlers who are brought to work may have reported higher prevalence of cough

due to inhalation of organic dusts and associated pathogens, (Wouters et al 2002; Park et al 2011) compared with adult waste handlers. It is advisable for female waste handlers to take adequate protective precautions against hookworm anaemia, and to keep their children away from exposures to contaminated work environments in order to avoid cough and other airborne infections.

Waste handlers who are young (8 years) or old (87 years) may have been more susceptible to infections due to weak immune status. This may account for the observed significant positive association between age and self-reported fever in this study. It is known that Ghana, like many African countries, is endemic for many infectious diseases, which cause non-specific symptoms like fever. It is important for local government authorities in charge of waste management in rapidly urbanizing communities to ensure that very young and old persons are excluded from waste handling activities at the community level, including public toilet facilities.

Widespread open defecation in peri-urban communities in southern Ghana, as reported by Asante & Oduro (2006), is a major health hazard for waste handlers who perform multiple waste handling tasks with their bare hands increasing the likelihood of contracting sanitation- related orally transmitted infectious diseases. The high rate of waste handlers reporting fever and diarrhoea with a significant positive association between such diseases and their exposure of bare hands to the waste suggest a real health problem. Similar to studies conducted by Dorevitch & Marder (2001), Rushton (2003) and Ackerson & Awuah (2012), the exposure to waste and possible transmission of biological agents from bare hands was also reported by the waste handlers to cause other gastrointestinal problems such as nausea. vomiting and itchy anus. A similar cross sectional study conducted by Jegli et al (2004) reported specific microbial pathogens including *Helicobacter pylori*, Hepatitis E and

helminthes, transmitted by faecal contaminated hands as causing gastrointestinal diseases among waste handlers. Compared with matched controls these disease conditions were found to be significantly higher among waste handlers (Ray et al 2005). Thus, an epidemiological study with control groups would be necessary to suggest real health risks among waste handlers in the current study area.

Whilst it may not be medically factual that inhaling the bad smell of waste can cause health problems, observations at smelly dumpsites and public toilet facilities did confirm that smell may indeed trigger nausea, vomiting and high levels of discomfort to waste handlers. As reported by Rheinländer et al (2013), the issue about bad smell of faecal waste has been associated with health hazards in African settings and the continuous inhalation by waste handlers may be a source of nuisance and discomfort during waste handling (Dorevitch & Marder 2001).

Bodily pain was the most frequently reported health problem among waste handlers who perform multiple waste handling tasks. As in the present study, Yang et al (2001) showed that despite the rapid urbanization of many African societies and the related exploding amount of heavy and mixed waste generated, it is still common for waste handlers to manually push, pull, lift or cart waste materials. Waste handlers in these areas are therefore prone to develop bodily pains, such as neck, wrist, lower and upper back pains from engaging in strenuous physical activities, as also reported by Quansah (2005), Kanchanomai et al (2011), Abou-ElWaf et al (2012), Thirarattanasunthon et al (2012) and Norman et al (2013). Even though bodily pain is known to be an inherent health problem for solid waste handlers (Poulsen et al 1995), there is a need for use of improved waste handling equipment and correct ergonomic postures in carting heavy loads of waste. Employers of waste

handlers in peri-urban townships need to offer training in correct ergonomic work postures to waste handlers.

Asthma and cough are linked with inhalation of different types of dust through exposed mouth and nose during handling of particular organic wastes. In this study, the exposure of mouth/nose of waste handlers who performed multiple tasks in a day was significantly associated with reported cough problems. This is corroborated by many other studies from both developed and developing countries which report occupational asthma, cough and other respiratory diseases are linked with inhalation of organic dusts, bio-aerosols and microorganisms during handling of organic wastes (Wouters et al 2002; Binion & Gutberlet 2012; Ross & Pons 2013), especially among young and old waste handlers. Follow-up studies are needed to characterize the actual airborne hazard types and concentrations that waste handlers are exposed to, e.g. types of dust and the actual hazards including myco-toxins and volatile organic compounds from stored organic waste. Such studies may include use of personal filter devices to collect airborne particles as well as analysis of metabolites in blood or urine (biomarkers of exposure). The use of worn out mouth/nose cover among waste handlers in this study may indicate a real hazard for respiratory/airborne diseases.

Even though the use of PPGs, including overall gown and Wellington boots, are very important to reduce direct exposure and physical damage, e.g. skin cuts, during waste handling (Dorevitch & Marder 2001; Tjoe Nij et al 2003), which was also acknowledged by waste workers in this study as important for protecting their health, the waste handlers experience different types of bodily discomfort when using them. Our study indicates that the most vulnerable self-employed waste handlers are not able to purchase own PPG and that waste companies are not actively ensuring

adequate supply of PPG, that supplied PPG is intact and working, and that PPG is properly used. There is a need to draw attention by local governments and commercial waste handling companies employing waste handlers that it is their responsibility to provide and instruct in correct use of PPG that workers can use to effectively protect their health.

Limitations of study

Bias in recall could result in over or underestimation of reported health problems among waste handlers. Further, waste handlers, in an attempt to portray good health and to avoid being sacked from work, may have underreported or not reported health problems. Thirdly, response on pain could be exaggerated to portray evidence of hard work. It should also be stressed that the health problems as reported by waste handlers may not necessary be associated with their occupation as it could be caused by other factors, e.g. bodily pain is also commonly reported by farmers during long hours of work in agricultural fields. As we were not able to include a control group in the study design, follow-up epidemiological risk factor studies are needed to assess the magnitude of such health problems.

Conclusion

The study concludes that waste handlers experience a burden of disease which may be consequences of their occupation. Using bare hands to perform multiple waste handling tasks increased the likelihood of reporting fever and diarrhoea among waste handlers. We stress that waste handlers in rapidly urbanizing areas thus are in need of disease protection from affordable protective gear, but also water and soap to promote their personal hygiene at the work place. Waste companies and government institutions employing a growing number of waste handlers should address these issues.

There is need for further research to determine actual health problems among the growing numbers of waste handlers (e.g. contamination of hands by human faeces and helminthes infections) in order to guide the design and implementation of health promotion measures to protect the health and safety of waste handlers in peri-urban areas of low income countries like Ghana. The authors suggest measures to include psychosocial health risk outcomes among waste handlers in future studies.

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3.5 Validation of the hand-rinse method of recovery of faecal indicator *E. coli* and Coliforms from hands of waste handlers in Prampram

1.0 Introduction

Although hand hygiene has been described for many years as a primary means to prevent the spread of faecal organisms, literature describing the quantity and quality of faecal indicators on hands of waste handlers is scanty (Curtis *et al.*, 2003; Curtis *et al.*, 2000). Different microbiological techniques have been used to recover faecal indicator organisms from hands to identify and enumerate these organisms. Some of the commonly used methods described in literature include the hand-impression (i.e. direct finger imprints on agar plates), hand-swabs (i.e. using sterile swab in 1% peptone buffer), and the hand-rinse (i.e. sterile bag-technique). Bacteriological isolation methods of different levels of sophistication are then applied to grow and isolate the organisms of interest for further analysis. The methods that allow recovery of relatively more bacteria in Total Plate Count (TPC) on microbiological growth media from both human and inanimate surfaces are preferred and applied for microbiological research purposes (Lambrechts *et al.*, 2014; Sanders, 2012). The applied methods require varying degrees of microbiological expertise, budgets and logistics, and accompanied by inherent merits and demerits (Table 1.1). Considering all these advantages and disadvantages of the different methods reviewed, the sterile bag-technique (hand-rinse method) seemed to be the most appropriate option suitable for recovery and estimation of level of contamination of hands by feacal material among waste handlers (Lambrechts *et al.*, 2014; Mattioli *et al.*, 2014; Mattioli *et al.*, 2015). However, the hand-rinse method needed to be validated against other standard methods such as the hand-impression and hand-swab (in 1% peptone buffer) to confirm its suitability or otherwise for the current study in Prampram.

Table 1.1: Frequently used techniques for recovering *E. coli* and Coliforms on hands

echnique	Representative studies	Purpose	Advantages	Disadvantages
irect ger nprints nto agar ate (hand-npression)	Larson, 1985; Henry and Rahim, 1990; Hansen, and Knochel, 2003; Luby *et al.*, 2007; Devamani *et al.*, 2014.	Screening for gross levels of hand contamination, especially in community settings.	Least expensive, technically simple.	Not quantitative, very insensitive; colonies may be very close, difficult to count and identify; air-borne contamination of agar.
ed swab ne ffer)	Han *et al.*, 1986; De Alwis *et al.*, 2012; Naeem *et al.*, 2015.	Quantitative analysis of small areas of skin.	Permits quantitation and identification of surface organisms.	Permits sampling of only small areas at one time; cannot readily estimate bacterial population of a larger surface area, such as entire hand.
and-rinse serile bag)	Pickering *et al.*, 2010; Davis *et al.*, 2011; Lambrechts *et al.*, 2014; Mattioli *et al.*, 2013; Mattioli *et al.*, 2015.	Quantitation of microorganisms of total hand surface.	Permits sampling of larger surface area of hands at one time compared with direct impression of fingers onto agar plate and swabbing of palm. Risk of air-borne contamination of sampling fluid is reduced.	More complicated procedure; initial dilution in sampling fluid may reduce sensitivity.

1.1 Main objective

To validate the hand-rinse (sterile bag) method for recovery of faecal indicator *E. coli* and Coliforms on hands of waste handlers in Prampram.

1.2 Specific objectives

1. To determine the concentration of faecal indicator *E. coli* and Coliforms on hands of waste handlers before and after engaging in waste handling activities, using three methods.

2. To compare the differences in concentration of faecal indicator *E. coli* and Coliforms on hands of waste handlers as determined by three methods before and after engaging in waste handling activities.

2.0 Methods

Three methods (i.e. hand-impression, hand-swab in 1% peptone water and hand-rinse) were used to recover faecal indicator *E. coli* and Coliforms from hands of 23 waste handlers all of whom were working with Zoom-Lion Company Limited, before and after engaging in waste handling activities as described below. Zoom-Lion was the foremost waste management company operating in the peri-urban community of Prampram.

2.1 Hand-impression method

Each waste handler placed all four fingertips, excluding the thumb, in a nearly horizontal angle for 10 seconds onto a Brilliance Chromogenic agar plate placed on a steady surface. This was followed by placing the thumb onto the same side of the remaining space in the center of the plate. Each agar plate was then be transported from the field on gel ice packs (about 4^0C) in a Styrofoam cooler to the laboratory at Noguchi Memorial Institute for Medical Research within 1 hour for laboratory analysis. In the laboratory, the plates were placed in the incubator at 45^0C and observed after 24 hours for growth and Total Plate Count (TPC) of faecal indicator *E. coli* and Coliforms (Devamani *et al.*, 2014; Devamani *et al.*, 2011).

2.2 Hand-swab (1% peptone buffer) method

The palm and fingertips of each waste handler was swabbed with sterile cotton swab stick dipped into 20 ml of recovery diluent (1% peptone buffer) and immediately placed into the diluent in falcon tubes and capped. The hand swabs were transported on gel ice packs (about 4^0C) in a Styrofoam cooler to the laboratory at Noguchi Memorial Institute for Medical Research within 1 hour for immediate laboratory analysis. The hand swabs were vortexed for 10 seconds to release bacteria from the cotton swab into the 1% peptone buffer. A ten-fold serial dilution was prepared for each hand swab. A 100 µl of each concentration was dispensed into labelled petri dishes after which about 20-25 ml of molten Brilliance *E. coli*/Coliform selective indicator agar was added, gently swirled and incubated at 45°C for 24 hours for growth and enumeration of indicator *E. coli* and Coliforms (Lee *et al.*, 2017; Naeem *et al.*, 2015; Tan *et al.*, 2013).

2.3 Hand-rinse (sterile bag) method

The hand of each waste handler was placed in 50 ml sterile distilled water in a stomacher polythene bag (Seward, UK). The hands were gently rubbed by researcher for about 60 seconds to dislodge any faecal indicators that may be present. The hand rinse sample was then gently poured into falcon tubes and transported from the field on gel ice packs (about 4^0C) in a Styrofoam cooler to the laboratory at Noguchi Memorial Institute for Medical Research within 1 hour for immediate laboratory analysis. A ten-fold serial dilution was prepared for each hand-rinse sample. A 100 µl of each concentration was dispensed into labelled petri dishes after which about 20-25 ml of molten Brilliance *E. coli*/Coliform selective indicator agar was added, gently swirled and incubated at 45°C for 24 hours for growth and enumeration of indicator *E. coli* and Coliforms (Lee *et al.*, 2017; Lambrechts *et al.*, 2014; Tan *et al.*, 2013; Mattioli *et al.*, 2013; Pickering *et al.*, 2010).

2.4 Data analysis

Data from questionnaire was coded and entered into Microsoft Excel spreadsheet for Windows 10 and later imported into STATA MP Version 13 (STATA Corporation, College Station, USA) for statistical analysis. The Wilcoxon matched-pairs signed test was used to estimate differences between mean concentrations of faecal indicator *E. coli* and Coliforms before and after work. The choice of this statistical test is appropriate for studies with a small sample size and when the variables of interest do not show normal distribution. Logistic regression was used to test for the effects of demographic characteristics, waste handling activities and use of personal protective equipment on contamination of hands of waste handlers. Covariates were found to be significant at the 95% confidence level ($P < 0.05$).

2.5 Ethical considerations and clearance

Ethical clearance for the study was obtained from the Institutional Review Board of the Dodowa Health Research Centre (DHRC-IRB – STUDY NO.01/10/11) and Ghana Health Service Ethical Review Committee (GHS-ERC – 09/07/12) before commencement of data collection. Permission was sought from the National Directorate of Zoom-Lion Company Limited, the District Director of Sanitation and Environmental Health in Prampram as well as the Assembly member in charge of waste workers. Waste handlers were voluntarily recruited after the objectives of the study were clearly explained and written consent obtained from them with signature or thumbprint. The identity of waste handlers who consented to participate in the study was not disclosed whilst the information provided by them was kept confidential. The samples collected from hands of the waste handlers were used in the laboratory according to the objectives of the study.

3.0 Results

3.1 Waste management practices and participant characteristics

A total number of 23 waste handlers were recruited for this study from Zoom-Lion Company Limited, Prampram. The proportion of males and females was 26.1% and 73.9% respectively with a mean age of 48.9 (±10.2) years. The youngest person among the waste handlers was aged 27 years and the oldest was 70 years. The proportions of waste handlers performing different activities were as follows: sweeping only 13 (56.5%), disposal only 10 (43.5%), collection only 8 (34.8%), transport only 2 (8.7%) and the number of workers that performed two activities; sweeping and collection 6 (26.1%), sweeping and disposal 2 (8.7%) as well as collection and disposal 4 (17.4%). The overall

distribution of type of personal protective working gear used during waste handling was as follows: Wellington boot 2 (8.7%), gloves 2 (8.7%), nose/mouth cover (0%) and overall apron 19 (82.6%). The categories of waste handlers with the highest use of overall apron were those who swept and collected waste everyday (100%). Detailed distribution of demographic and occupational characteristics of the waste handlers is presented Table 3.1.

Table 3.1: Demographic characteristics of waste handlers, waste handling activities and type of personal protective working gear

Demographic characteristics	n(%)
Sex	
Male	6(26.1)
Female	17(73.9)
Age(mean ±SD) **48.7 ± 10.2**	
Waste handling activities	
Collection	8(34.8)
Disposing	10(43.5)
Sweeping	13(56.5)
Transport	2(8.7)
Sweeping and Collection	6(26.1)
Sweeping and Disposal	2(8.7)
Collection and Disposal	4(17.4)
Type of PPG	
Glove	2(8.7)
Overall gown	19(82.6)
Wellington boot	2(8.7)
Nose/mouth cover	****

**** *Parameter did not have any estimation. SD: Standard deviation. n: Frequency of distribution*

3.2 Prevalence of faecal indicator *E. coli* and Coliforms

The overall prevalence of faecal contamination measured by the presence of indicator *E. coli* and Coliform after work among persons engaged in waste handling using hand-impression method were estimated to be 9% (95%CI: 1.0%-28.0%) and 47.8% (95%CI: 26.8%-69.4%) respectively. Using the hand-swab (1% peptone buffer) method the overall prevalence of faecal contamination of hands of waste handlers with indicator *E. coli* and Coliform after work were estimated to be 34.8% (95%CI: 16.4%-57.3%) and 56.5% (95%CI: 34.5%-76.8%) respectively. Using the hand-rinse method, the overall prevalence of faecal contamination with indicator *E. coli* and Coliform after waste handling

were estimated to be 34.8% (95%CI: 16.4%-57.3%) and 73.9% (95%CI: 51.6%-89.8%) respectively. Only one person tested positive for both *E. coli* and Coliform using the hand-impression method. Using the hand-swab method, the number of waste handlers that tested positive for both *E. coli* and Coliform was 7 (30.43%). Using the hand-rinse method the number of waste handlers that tested positive for both *E. coli* and Coliform was 6 (26.09%).

3.3 Concentration of faecal indicator *E. coli* and Coliforms before work

Using the hand-impression method, the concentration of indicator *E. coli* and Coliforms among waste handlers before work were 0.09± 0.42CFU/cm^2 and 2.91± 10.80CFU/cm^2 (mean± standard deviation), respectively. Using the hand-swab (1% peptone buffer) method, the concentration of indicator *E. coli* and Coliforms before work were 1.61± 4.92CFU/ml and 4.26± 10.83CFU/ml (mean± standard deviation), respectively. Using the hand-rinse method, the concentration of indicator *E. coli* and Coliforms among waste handlers before work were 19.78± 94.66CFU/ml and 4.30± 16.18CFU/ml (mean± standard deviation), respectively.

3.4 Concentration of faecal indicator *E. coli* and Coliforms after work

Using the hand-impression method the concentration of indicator *E. coli* and Coliform after work were estimated to be 0.52±2.9CFU/cm^2 and 33.04± 84.90CFU/cm^2, respectively. Using the hand-swab (1% peptone buffer) method the concentration of indicator *E. coli* and Coliform after work were 8.91±25.59CFU/ml and 49.87± 95.29CFU/ml, respectively. With the hand-rinse method, the concentration of indicator *E. coli* and Coliform after work were estimated as 81.70±175.05CFU/ml and 68.83± 105.85CFU/ml, respectively.

3.5 Differences in concentration of faecal indicator *E. coli* and Coliforms

The differences in mean concentration of *E. coli* and Coliforms obtained by using hand-impression, hand-swab (1% peptone water) and hand-rinse methods are presented in Tables 3.2 and 3.3. The Wilcoxon matched-pairs signed test indicated that apart from using the hand-impression method for recovery of faecal indicator *E. coli*, a significant difference ($p < 0.05$) was observed in the level of both *E. coli* and Coliform before and after engaging in waste handling activities. The highest mean concentration of both *E. coli* and Coliforms indicators on hands of waste handlers was obtained using the hand-rinse method (Tables 3.2 and 3.3). Tables 3.4 and 3.5 depict the effect of demographic characteristics, waste handling activities as well as type and use of personal protective working gear on contamination of hands with faecal indicator Coliforms and *E. coli*, respectively, using the three methods of recovery. The findings showed that none of these factors was significantly associated with contamination of hands with feacal indicator organisms using the three methods of recovery ($p > 0.05$).

Table 3.2: Recovery of *E. coli* on hands of waste handlers before and after work

	Concentration of *E. Coli*											
	Hand impression				1% peptone water				Hand-rinse			
	Before	After	Diff	*p-value*	Before	After	Diff	*p-value*	Before	After	Diff	*p-value*
Mean	0.1	0.5	0.4	*0.564*	1.6	8.9	7.3	*0.027*	19.8	81.7	61.9	*0.005*
SD	0.4	2.3	2.4		4.9	25.6	21.4		94.7	175.1	138.0	

Diff: Difference in mean concentration (After - Before); SD: Standard deviation

Table 3.3: Recovery of Coliforms on hands of waste handlers before and after work

	Concentration of Coliforms											
	Hand impression				1% peptone water				Hand-rinse			
	Before	After	Diff	*p-value*	Before	After	Diff	*P-value*	Before	After	Diff	*p-value*
an	2.9	33.0	30.1	*0.004*	4.3	49.9	45.6	*0.001*	4.3	68.2	64.5	*0.001*
	10.8	84.9	84.1		10.8	95.3	90.1		16.2	105.9	108.8	

Diff: Difference in mean concentration (After - Before); SD: Standard deviation

Table 3.4: Factors associated with contamination of hands with faecal indicator Coliforms using three methods of recovery

Covariates of waste handlers	Hand-impression			Hand-swab (1% peptone buffer)			Hand-rinse		
	n(%)	AOR (95% CI)	P-value	n(%)	AOR (95% CI)	P-value	n(%)	AOR (95% CI)	P-value
Sex									
Male	3(50.0)	****	****	2(33.3)	****	****	4(66.7)	****	****
Female	8(47.1)	****	****	11(64.7)	****	****	13(76.5)	****	****
Age	23(100)	0.9(0.8,1.2)	0.99	23(100)	****	****	23(100)	1.08(0.8,1.4)	0.62
Waste handling activities									
Collection	6(75.00)	0.6(0.0,15.0)	0.80	7(87.5)	****	****	5(62.5)	1	
Disposing	5(50.00)	1	****	4(40.0)	****	****	8(80.0)	0.9(0.0,30.5)	0.96
Sweeping	8(61.54)	1	****	11(84.6)	****	****	10(76.9)	1	****
Transport	0	1	****	0	****	****	0	1	****
Sweeping & Collection	4(66.67)	1	****	5(83.3)	****	****	3(50.0)	1	****
Sweeping & Disposal	2(100)	1	****	2(100)	****	****	1(50.0)	1	****
Collection & Disposal	4(100)	1	****	4(100)	****	****	3(75.0)	1	****
Type of PPG									
Glove	1(50.00)	1	****	2(100)	****	****	2(100)	1	****
Overall gown	11(57.89)	1	****	13(68.4)	****	****	16(84.2)	1	****
Wellington boot	2(100)	1	****	2(100)	****	****	2(100)	1	****
Nose/mouth cover	0	1	****	0	****	****	0	1	****

n(%) represent frequency and row percentage: AOR-Adjusted odds ratio estimate from a binary logistic regression analysis.

***** Represent covariates that were neither associated with faecal contamination nor have any parameter estimation with the regression analysis.*

Table 3.5: Factors associated with contamination of hands with faecal indicator *E. coli* using three methods of recovery

Covariates of waste handlers	Hand-impression n(%)	Hand-impression AOR (95% CI)	Hand-impression P-value	Hand-swab (1% peptone buffer) n(%)	Hand-swab (1% peptone buffer) AOR (95% CI)	Hand-swab (1% peptone buffer) P-value	Hand-rinse n(%)	Hand-rinse AOR (95% CI)	Hand-rinse P-value
Sex									
Male	0	****	****	3(50.0)	****	****	2(33.3)	****	****
Female	2(11.8)	****	****	5(29.4)	****	****	6(35.3)	0.1(0.0,16.5)	0.43
Age	23	****	****	23(100)	1.4(0.9,1.9)	0.074	23(100)	1.1(0.9,1.4)	0.23
Waste handling activities									
Collection	1(12.5)	****	****	4(50.0)	0.1(0.0,4.6)	0.199	4(50.0)	0.5(0.0,19.0)	0.74
Disposing	0	****	****	4(40.0)	3.1(0.0,705.6)	0.676	6(60.0)	0.9(0.0,44.5)	0.99
Sweeping	2(15.4)	****	****	5(38.5)	1	****	4(30.8)	1	****
Transport	0	****	****	0	1	****	0	1	****
Sweeping & Collection	1(16.7)	****	****	2(33.3)	1	****	3(50.0)	1	****
Sweeping & Disposal	0	****	****	1(50.0)	1	****	2(100)	1	****
Collection & Disposal	0	****	****	3(75.0)	1	****	3(75.0)	1	****
Type of PPG									
Glove	0	****	****	2(100)	1	****	0	1	****
Overall gown	2(10.5)	****	****	8(42.1)	1	****	7(36.8)	1	0.76
Wellington boot	0	****	****	1(50.0)	1	****	0	1	****
Nose/mouth cover	0	****	****	0	1	****	0	****	****

n(%) represent frequency and row percentage: AOR-Adjusted odds ratio estimate from a binary logistic regression analysis.

**** *Represent covariates that were neither associated with faecal contamination nor have any parameter estimation with the regression analysis.*

4.0 Discussion and Conclusion

There were a variety of different waste handlers engaged in diverse waste handling activities in the peri-urban community of Prampram, to control and reduce the volumes of accumulating waste in the community (Getahun *et al.*, 2012). Sweeping was the most common waste handling activity performed predominantly by females in Prampram (Agwu, 2012; Kadfak, 2011).

The hand-rinse method indicated highest yield of recovery of faecal indicator *E. coli* and Coliforms from hands of waste handlers, compared with hand-impression and hand-swab methods (Tables 3.2 and 3.3). This finding confirms previous studies conducted in similar settings in South Africa and Tanzania by Lambrechts *et al.*, (2014), as well as Julian and Pickering (2015) respectively, who explained that the hand-rinse method for the recovery of feacal indicators permits sampling of larger surface area of hands at one time compared with direct impression of fingers onto agar plate or swabbing of the palm. Julian and Pickering (2015), further reasoned that the risk of air-borne contamination of the hand-rinse sample is reduced during collection on the field, compared with hand-impression and hand-swab methods.

Waste handlers can be protected from the hazards of work by adopting safety procedures and ensuring the use of adequate personal protective equipment at the work environment (Dorevitch and Marder, 2001). Personal protective equipment are specialized clothing or gadgets used by workers to prevent injuries, workplace hazards and diseases that are likely to arise from the working environment (Konya *et al.*, 2013). Waste handlers in Prampram used four types of personal protective working gears (i.e. gloves, Wellington boots, overall gowns, and mouth/nose cover) to try to protect themselves at work. Even though the majority (about 83%) used the overall gown as a

means of protection, neither the use of personal protective gear nor any of the risk factors correlated with contamination of hands by feacal indicators among the waste handlers (Tables 3.4 and 3.5).

In view of the findings in this validation study as well as considering the inherent limitations associated with the hand-impression and hand-swab (1% peptone water) methods, as described in Table 1.1, the hand-rinse method was adopted as suitable method for recovering faecal indicator *E. coli* and Coliforms from hands of waste handlers in Prampram.

5.0 References

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