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OCCUPATIONAL EXPOSURE TO INHALABLE COTTON DUST, ENDOTOXIN AND HEALTH PROBLEMS ASSOCIATED WITH WORKERS OF ETHIOPIAN INTEGRATED TEXTILE INDUSTRY

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Occupational exposure to inhalable cotton dust, endotoxin and health problems associated with workers of Ethiopian integrated textile industry

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Dedication

"Dedicated to the memory of workers who lost their lives at work and suffered from occupational accidents. They strive uplift humanity while alive, and their suffering is the source of evidence to protect others."

List of original papers

This thesis work has been written based on the following three original research papers published. In this thesis, the papers referred to as Paper-I, Paper-II and Paper-III.

Paper I: **YIFOKIRE, TEFERA Z**., SCHLÜNSSEN, V., KUMIE, A., DERESSA, W., MOEN, B. E. & BRÅTVEIT, M. 2020. Personal inhalable dust and endotoxin exposure among workers in an integrated textile factory. *Archives of Environmental & Occupational Health,* 75**,** 415-421.

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Paper III: **YIFOKIRE, TEFERA Z**., KUMIE, A., DERESSA, W., BRÅTVEIT, M. & MOEN, B. E. 2020. Registered Health Problems and Demographic Profile of Integrated Textile Factory Workers in Ethiopia: A cross-sectional study. *BMC Public Health (2021) 21:1526 https://doi.org/10.1186/s12889-021-11556-4*

Acronyms and abbreviations

ACGIH	American Conference of Government Industrial Hygienists
AM	Arithmetic Mean
ANOVA	Analysis of Variance
AGOA	African Growth and Opportunity Act
AOR	Adjusted Odds Ratio
ATS	American Thoracic Society
BMI	Body Mass Index
BMRC	British Medical Research Council
BOLSA	Bureau of Labor and Social Affairs
CS	Cross-sectional Study
CCS	Comparative Cross-sectional Study
CIS	Conical Inhalable Sampler
COMESA	Common Market for Eastern and Southern Africa
COR	Crude Odds Ratio
DECOS	Dutch Expert Committee on Occupational Safety
EAC	East African Community
EBA	Everything But Arms
EIC	Ethiopian Investment Commission
ETIDI	Ethiopian Textile Industry Development Institute
EU	Endotoxin Unit
FDI	Foreign Direct Investment
FEV1	Forced Expiratory Volume in the first second
FEF25-75%	The mean forced expiratory flow between 25% and 75% of the FVC

FVC	Forced Vital Capacity
∆FEV1	Change in Forced Expiratory Volume in the first second
∆FVC	Change in Forced Vital Capacity
GDP	Gross Domestic Product
GLI	Global Lung Initiatives
GM	Geometric Mean
GSD	Geometric Standard Deviation
GTP	Growth and Transformation Plan
HSE	Health and Safety Executives
ICD	International Classification of Diseases
ILO	International Labor Organization
IOM	Institute of Occupational Medicine
ITMF	International Textile Manufacturers Federation
IUATLD	International Union Against Tuberculosis and Lung Disease
LAL	Limulus Amebocyte Lysate
LMICs	Lower and Middle-Income Countries
LLN	Lower Limit of Normal
LOD	Limit of Detection
LS	Longitudinal Study
ml	milliliter
mg	milligram
MOLSA	Ministry of Labor and Social Affairs
MRC	Medical Research Council
MSDs	Musculoskeletal disorders

NORHED	The Norwegian Program for Capacity Development in Higher Education and Research for Development
OEL	Occupational Exposure Limit
OSHA	Occupational Safety and Health Administration
PPD	Personal Protective Devices
SADC	Southern African Development Community
SD	Standard Deviation
SEG	Similar Exposure Group
SNNPR	Southern Nations Nationalities People Region
UTI	Urinary Tract Infection
VE	Vertical Elutriator
WHO	World Health Organization
WTO	World Trade Organization

Glossary

Integrated textile factory: A textile factory having four distinguished production departments Spinning, Weaving/knitting, Finishing and Garment

Inhalable dust fraction: approximates fraction of airborne material that enters the nose and mouth during breathing and is therefore available for deposition anywhere in the respiratory tract.

Thoracic dust fraction: this is the fraction of inhaled airborne material penetrating beyond the larynx.

Respirable dust fraction: this is the inhaled airborne material that penetrates the lung's lower gas exchange region.

Endotoxin: is an insoluble structural component of the bacterial cell wall attached to airborne dust.

External exposure: hazards present in worker's external environment, includes physical, chemical, biological, psychosocial and ergonomics.

Internal exposure: absorbed or penetrated hazard or change in physiology following external exposure.

Effect: Diseases or adverse health conditions resulting from excessive external exposure and related internal exposures.

Occupational Exposure Limit: An eight-hour time-weighted average exposure concentration at work allowed to workers and regulated.

Cross-shift change in lung function: The change in lung function measurement parameters before and after a work shift in a working day using spirometer.

Occupational disease: a disease known to arise from occupational exposure to workplace hazards, the disease is usually considered both medically and legally.

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Abstract

Background: Exposure to workplace hazards is a significant risk to workers' health in the textile and garment. Objective measurement of personal inhalable dust and endotoxin level and the effects of exposure to workers' health in this sector was not adequately investigated in Ethiopia.

Objectives: This study aimed to measure personal inhalable cotton dust and endotoxin concentration, examine lung function capacity, and analyze registered diseases and injuries of workers in the integrated textile factories of Ethiopia.

Methods and materials: Three independent studies were conducted to achieve the stated objectives. Personal inhalable cotton dust and endotoxin level, cross-shift lung function status with chronic respiratory symptoms and registered diseases and injuries are outcomes of the three studies. The overall study objectives were crafted within the framework of the three levels of occupational exposure: external exposure consider (inhalable dust and endotoxin), internal exposure (cross-shift lung function) and effect (diseases and injuries). An institution-based cross-sectional and comparative cross-sectional design was employed. The study settings were at three industrial zones in two regions of the country: Amhara Regional State and Tigray Regional State. The study involved three integrated textile factories (Factory 1, Factory 2 and Factory 3) and two soft drinks and water bottling factories as comparison groups.

In the first study, ninety-six (96) repeated air samples were collected from sixty-four (64) workers' breathing zone to analyze the personal inhalable cotton dust and endotoxin exposure levels. The samples were collected from seven work sections or seven similar exposure groups (SEG) from an integrated textile at Factory 1. The seven work sections are Carding, Open-end, Ring frame, Preparatory, Fabric making, Batching and Sewing found in the four production departments (spinning, waving, finishing and garment). Dust samplings were performed for a shift using a conductive plastic inhalable conical sampler mounted with a 37mm glass-fibre filter. The pump operated at a flow rate of 3.5 l. min^{-1}. The Time Weighted Average cotton dust level was determined by gravimetrical analysis and reported in $mg.m^{-3}$. Endotoxin was extracted from the cotton dust samples and analyzed using a quantitative kinetic chromogenic Limulus Amebocytes Lysate test and reported as EU. m^{-3}.

In the second study, cross-shift lung function tests and chronic respiratory symptoms assessment were performed among 306 workers from an integrated textile Factory 1 and 156 non-cotton exposed workers. The lung function test was conducted before and after the work shift using a portable spirometer (SPIRARE 3 sensor model SPS 320) for the parameters: Forced Expiratory Volume in one second (FEV_1) and Forced Vital Capacity (FVC). Moreover, the prevalence of chronic respiratory symptoms was assessed through a face-to-face interview using a standardized questionnaire adopted from the American Thoracic Society.

In the third study, a one-year registration of diseases and injuries of 7,992 workers were collected from the three integrated textile factories (Factory 1, Factory 2 and Factory 3). Data were retrieved from both the registration of factory clinics and human resources. Each worker has a chart/card in the clinic, labelled with the name and unique worker's identification number, similar to the one used in the human resource department database. All clinical consultations of workers during March 2016 to February 2017 were extracted from the health archives of the factory's clinic.

Exposure measurement, lung function and registered diseases data were entered into a Micro Soft Office excel template, whereas the data of the respiratory symptoms were entered using epidemiological information package (Epi-Info) version 7.1. All types of data were exported to SPSS for analysis. Missing values, incomplete recording, outliers and inconsistent records were checked and managed accordingly. The exposure assessment was described by the arithmetic mean, standard deviation, geometric mean (GM), and geometric standard deviation (GSD). The cross-shift change in FEV_1 (ΔFEV_1) and FVC (ΔFVC) was calculated by subtracting the after-shift value from the before-shift value. The Global Lung Initiative Quanjer GLI-2012 multi-ethnic reference value for the African American ethnicity was used to estimate the predicted value and the proportion of subjects with FEV_1 and FVC below the Lower Limit Normal (LLN). Prevalence, percentage and proportion were used to describe the respiratory symptoms and the registered disease conditions as categorical variables. The independent *t-test* was performed to analyze exposure differences between work sections and to compare the cross-shift difference FEV_1 and FVC among the textile and non-cotton exposed workers. A paired-samples *t-test* was performed to compare the pre- and post-shift difference of lung function parameters. The correlation between inhalable dust and endotoxin concentrations was analyzed using Pearson's correlation test. Analysis of Variance (ANOVA) was also performed to compare the GM of personal inhalable

dust, endotoxin exposure level, and endotoxin ratio to dust between departments and work sections. The Pearson Chi-square test or Fisher's exact test, if the expected value was less than 5, was used to testing the difference between the groups regarding the categorical variables. Logistic regression analysis was used two times in the study by adjusting confounding variables: 1) to compare the chronic respiratory symptoms between the integrated textile workers and control and 2) to identify work and personal factors associated with the registered work-related diseases and injuries. Furthermore, the amount of reduced cross-shift lung function capacity among the integrated textile workers was estimated using multiple linear regressions.

Results: In the external exposure measurement, the overall Geometric Mean (Geometric Standard Deviation) of cotton dust and endotoxin level was 0.75 $mg \cdot m^{-3}$ (2.6) and 831 $EU \cdot m^{-3}$ (5.4), respectively. The highest dust and endotoxin concentrations were observed in the carding section found in spinning department (1.34 $mg \cdot m^{-3}$) and (6,381 $EU \cdot m^{-3}$), respectively; while the lowest cotton dust (0.46 $mg \cdot m^{-3}$) and endotoxin levels (76 $EU \cdot m^{-3}$) were found in the garment department. There was a moderate linear relationship between personal inhalable dust and endotoxin exposure ($r = 0.45$, $p < 0.001$). In the internal exposure assessment, the cross-shift lung function reduction among textile workers (123 mL for FEV_1 and 129 mL for FVC) was significantly higher than the control group (14 mL for FEV_1 and 12 mL for FVC) at $p < 0.001$. The prevalence of chronic respiratory symptoms was significantly higher among textile workers (54 %) than the controls (28 %). Breathlessness was the most prevalent chronic respiratory symptom with the highest adjusted odds ratio of 9.4 (95 %; CI: 4.4–20.3). The prevalence of respiratory diseases was highest (34 %), followed by musculoskeletal disorders (29 %), gastrointestinal infection (21 %), peptic ulcer (19 %) and injury (17 %); the injury was the leading cause of sick leave. About 69 %, 65 % and 60 % of textile, garment and support workers, respectively, were diagnosed with a disease in one year. In the effect measurement, 27,320 consultations for different disease diagnoses were made by 5,276 (66 %) workers; claimed 16,993 workdays lost due to sick leave annually. Work-related and personal factors were associated with diseases and injuries; textile department, females, older and workers with low educational status had a significantly higher risk for most diseases than the support, male, young and workers with higher educational level.

Conclusions: We found a high level of personal inhalable dust and endotoxin in external exposure from workplaces. Eleven percent of the dust samples were higher than the Workplace Exposure Limit set by the Health and Safety Executives (HSE) of the United Kingdom and 89 % higher than the Dutch experts' recommendation for endotoxin exposure. A lower level of inhalable dust exposure does not guarantee safe exposure to endotoxin in work sections. The textile workers had a higher level of cross-shift lung function reduction in the internal exposure, which could be related to external exposure. The prevalence of chronic respiratory symptoms was also higher among textile factory workers compared to control. Majorities of the workers were diagnosed with different types of diseases and injuries as an effect. The textile and garment production workers had a higher risk of acquiring diseases than the support process workers, indicating that some diseases might have resulted from the external exposure and development of internal exposure at the workplace. Thus, factory clinics seem to be an essential source of evidence to understand the burden of occupational diseases and injuries. Further, the study showed the link between exposure and effect.

Recommendations: A comprehensive workplace hazard exposure assessment and worker's health protection program in the integrated textile factories should be strengthened. The occupational health and safety programs should be prioritized and focused on addressing the specific gaps and needs of high-risk workers. Besides, factory management, occupational health and safety practitioners, policy and regulatory bodies should be part of the program. Further research is required to assess exposure measurement to other hazards, including cotton dust and endotoxin, by tracking workers' exposure profiles to estimate cumulative exposure and relationship to disease outcome. The occupational diseases and injuries study may be extended to compare the results with the general population using a standard and similar diagnosis tool, the International Classification of Diseases (ICD) code.

Key words: Integrated textile factory; cotton dust; endotoxin; cross-shift lung function; respiratory symptoms; diseases and injuries

Chapter One: Introduction

1.1. Background

The current development strategy of Ethiopia has given top priority to the textile and garment sector (1). Ethiopia is one of the oldest ancient civilizations with a long history of traditional weaving in clothes making (2). The first modern textile factory, the Diredewa textile factory, was established in 1939 in Ethiopia. The agroecology of Ethiopia has a capacity of 10 % of the global cotton cultivation, but the country used less than 3 % of its potential (3). Understanding cotton as an essential resource, the government has developed a 15-year National Cotton Development Strategy (2017 - 2032) with a motto from 'Farm to Fashion.' In 2019 Ethiopia produced 53,000 metric tons of raw cotton and the second cotton consumer in Africa next to Egypt due to the increased number of local textile and garment factories (3, 4).

The textile and garment factories are growing worldwide. In Ethiopia, it expands in the industrial parks as the government's top priority sector for national development. Over 130 active enterprises have been registered that cover the entire value chain (5). The annual production capacity of the sector in 2014 is estimated to include 102,000 tons of yarn, 207 million meters of woven fabric, 50 million kg of knitted fabric, 63 million pieces of knitted garments, and 28 million pieces of woven garments (6). The integrated textile factories that comprised the four production factories; spinning, weaving/knitting, finishing and garment having forward supply linkage are the most preferred in the textile sector development program. These factories can create more jobs and value addition throughout the value chain from cotton to clothing (7). Therefore, the integrated textile factories are planned to achieve the "Farm to Fashion" development vision of the country (5). The term 'integrated textile factory' is used interchangeably with the term 'textile and garment factory' equally in this study.

In the early 19th century, respiratory health problems, including byssinosis, were widely known and affected cotton textile workers in Europe and the US (8-10). Later, economic globalization moved the textile factories to developing countries, mainly to Asia and Africa (11). Although several technical advancements in the types of machinery and workplace improvements to the ventilation system had taken place in the textile and garment sectors, recent studies in the low and middle-income countries (LMICs) have revealed that workers are vulnerable to many workplaces

health and safety hazards (12). It seems that the work-related health problems were exported along with the factories but not the improved occupational health and safety standards (13). The textile and garment production process is known to generate cotton dust and endotoxin exposure to workers (14-16). Still, workers are exposed to various occupational hazards, including a high level of noise, different types of hazardous chemicals and dyes, sharp materials, ergonomic related hazards, work in stressful and unhygienic conditions (17, 18).

Several investigations conducted among workers at the different textile and garment sector departments indicated the relationship between respiratory health problems and exposure to cotton dust and endotoxin (16, 19, 20). In a cohort of textile workers, the prevalence of chronic respiratory problems decreased, and lung function reduction showed improvement after cotton dust exposure cessation (21). Furthermore, recent studies in the textile and garment sector have indicated that workers suffered from a wide range of occupational diseases such as musculoskeletal disorders (MSD), injuries, allergies, hearing impairment, work-related stress, dermatitis and several other infections (12, 22-25). However, ample evidence about the relationship between occupational exposure and progressive disease development by workers in the textile and garment factories in Ethiopia is limited. Therefore, this is a comprehensive study aimed to conduct exposure assessment to inhalable cotton dust and endotoxin concentration and health problems of workers in the integrated textile factories; it describes the workplace hazard exposure and effect relationship (external exposure, internal exposure and effect). The external exposure includes hazards present in worker's external environment; internal exposure refers to absorbed or penetrated hazard or change in physiology following external exposure, and effect refers to the development of diseases or adverse health conditions as a result of excessive external exposure and related internal exposures (26) (Figure 1).

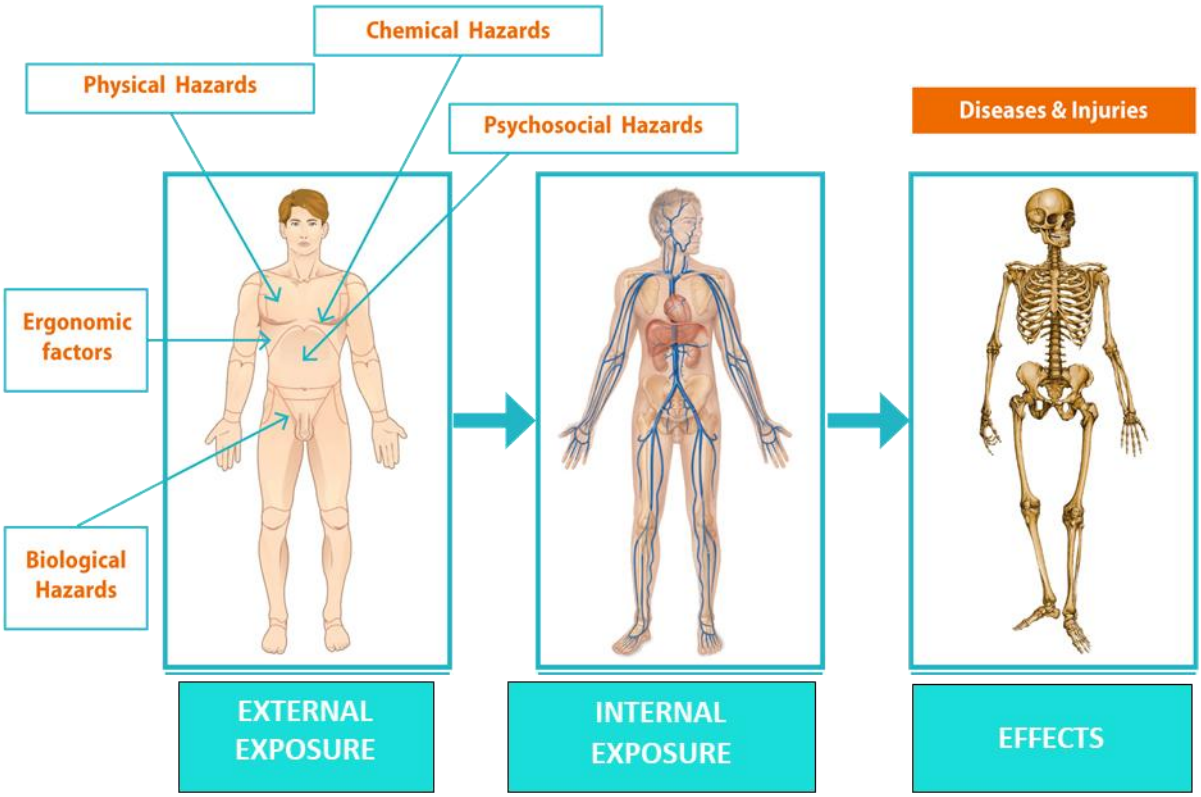

Figure 1: The relationship between exposure and effect; external exposure, internal exposure and effect (*Source*: Originally conceptualized by Bisessi (26) with modifications for this study.

1.2. Statement of the problem

Despite the growing concern for occupational diseases among the working population by the global disease burden report, the accurate estimate of diseases and injuries from the workplace is unknown (27). Besides, occupational health service access for workers is limited; only about 5 – 10 % of workers have occupational health services in LMICs (28). Occupational exposure to hazards in the integrated textile factories precipitates risks to different occupational diseases, including chronic respiratory diseases. However, evidence regarding personal level external exposure, physiological changes in the internal exposure and clinically confirmed health conditions of workers as an effect is limited.

Textile and garment factories are growing in most LMICs; the sector has seen an expansion in the Ethiopian industrial parks as a major strategy for industrialization and a significant employment

source (5, 29-31). The integrated textile factory is the type of manufacturing industry that processes raw cotton to produce clothes by integrating the separate standalone production process in one factory; spinning, weaving/knitting, finishing and garment production. The integrated textile factories that add value to the raw cotton into clothing are the top priority in the sector, under the Ethiopian government's "Farm to Fashion" policy initiative (5). They are the largest employers of workers from the textile and garment value chain in Ethiopia.

Cotton dust and endotoxins are external exposure factors responsible for several respiratory diseases, including lung function reduction, among textile and garment factories. Occupational exposure studies to inhalable cotton dust fraction and endotoxin in different LMICs (32, 33) showed workers are exposed to above the recommended Occupational Exposure Limits (OEL) 2.5 mg. m^{-3} set by the Health and Safety Executives (HSE) of the UK (34) for cotton dust and the Dutch Expert Committee of Occupational Safety (DECOS) 90 EU. m^{-3} (35) for endotoxin. Workers in this sector are also exposed to varieties of occupational hazards other than cotton dust that may increase workers' vulnerability to different diseases, such as MSDs, injury, allergy, hearing problems, etc. (12, 17).

Occupational exposure to cotton dust and endotoxin in the textile and garment factory workers was studied in different countries (32, 36-38). Although, the recommended OEL for inhalable cotton dust was 2.5 mg. m^{-3} (34) and for endotoxin 90 EU. m^{-3} (35), several studies measured exposure levels above these limits. A personal inhalable cotton dust exposure study from the Nepalese textile factory workers reported that 18 % of the samples exceeded the OEL value of the HSE (32). The average personal inhalable cotton dust exposure level reported from a full shift measurement by different studies from LMICs ranged from 0.81 – 12.1 mg. m^{-3} (14, 32, 33, 39, 40). Unlike the cotton dust, occupational exposure to endotoxin has not been adequately studied in LMIC textile factories. A comparatively higher concentration of endotoxin was measured from textile and garment workers in Nepal. The average endotoxin exposure level of the Nepalese study was 20-fold higher than the recommended value (32). In most studies that sampled inhalable cotton dust from personal exposure, the average endotoxin levels are above the recommended limit; they ranged from 191 – 2207 EU. m^{-3} (14, 32, 33, 39, 40).

External exposure to cotton dust and endotoxin can impact a physiological change in lung function internally. The relationship between occupational exposure of cotton dust and endotoxin to acute

airway problems has been studied by various researchers (41, 42). Acute airway response is defined as either a cross shift or a cross week fall in forced expiratory volume in one second (FEV_1) through a pulmonary function test (14). A significant cross-shift change in FEV_1 among cotton exposed workers resulted in a chronic lung function reduction (42). A prospective occupational cohort from Shanghai textile, cotton exposed workers showed a significant cross-shift reduction compared to the non-exposed workers (42). A cross-sectional study that measured the lung function of textile workers found high drops of cross shift FEV_1 (74 ml) and FVC (81 ml), but only the cross shift FEV_1 reduction was significant (41). Other cross-sectional studies from Iran (43) and China (44) have found an increased cross-shift lung function reduction among cotton exposed textile workers. The relationship between cotton dust exposure and lung function impairment has been an area of research interest in recent times. In some studies, the measured concentration of occupational exposure to cotton dust and endotoxin is associated with cross-shift lung function reduction (42, 45). In the Nepal study, exposure to inhalable dust was significantly associated with the cross shift FEV_1 reduction, but endotoxin exposure level did not show this relationship (41). Different studies also reported contradicting results that show null association between concentration of cotton dust and cross-shift reduction (14, 40, 44, 46).

Several textile and garment workers are diagnosed with respiratory diseases, which is an effect. The disease could be associated with external exposure to cotton dust and endotoxin at workplaces. Chronic respiratory symptoms, mainly chronic cough, phlegm, chest tightness, breathlessness and wheezing, have been previously reported among textile workers (15, 47). Different studies with a wide range of respiratory symptoms were also reported with an annual prevalence range of 20 – 85 % (19, 37, 41, 47-49). A recent self-reported respiratory symptoms assessment study from the integrated textile factory in Ethiopia reported annual prevalence for at least one respiratory symptom (48 %): cough (28 %), phlegm (20 %), chest tightness (30 %), breathlessness (27 %) (47). In a similar self-reported study from Pakistan, a prevalence of 15 % (cough), 20 % (phlegm), 12 % (chest tightness) and 20 % (wheezing) was recorded among spinning and weaving factory workers (15). Findings from comparative studies conducted between textile factory and non-cotton dust exposed workers (control) indicated a significant difference in the prevalence of respiratory symptoms. A higher prevalence of respiratory symptoms was observed in high cotton dust work sections (47, 50).

Different studies have also assessed and measured occupational hazards other than cotton dust and health risks to workers. Ergonomic hazard exposure assessment studies using ergonomic assessment tools such as Quick Exposure Check (QEC) in Bangladesh (22) and a Rapid Upper Limb Assessment (RULA) in Cambodia found that work tasks in the garment industry were high risk for work-related MSDs (51). Workers are frequently in contact with dangerous machines and manual handling activities; thus, a high prevalence of injury was also reported (18, 52). A recent systematic review of the health vulnerabilities of workers revealed that exposure to chemical hazards is one of the major health risks (12). There are also varieties of irritant chemicals and enzymes used for the sizing process, which could cause allergy (17). In Pakistan, an industrial hygiene assessment study revealed that most textile factories have dirt in the work environment, leakages, insufficient ventilation, and no washrooms (53). Several studies also reported work-related stress as a growing concern in the sector; the effects of stress-related health problems and work performance become visible (12, 18, 54-56). However, only a few studies tried to assess the overall disease burden among textile workers and reported: respiratory disease, MSDs, injury, allergy, gastrointestinal, hearing impairment and eye diseases (57-59).

Although integrated textile factories are the top priority from the overall clothing and apparel value chain, comprehensive occupational exposure measurement and disease burden assessment are not adequately studied. According to our literature review the following major research gaps were identified. Most previous exposure assessment studies were conducted either by observation or air sampling from by area sampling from few work sections of the textile factories. Besides, none of the studies measured endotoxin exposure from all work sections of the typically integrated textile factory in LMICs. Personal inhalable dust and endotoxin exposure assessment study has never been done in Ethiopia. Evidence was limited regarding the cross-shift lung function conditions of workers in the integrated textile factories compared to non-cotton exposed factory workers. Moreover, the type and magnitude of work-related diseases of workers in the sector were not adequately studied. Most of the occupational disease studies in the textile and garment sectors were conducted using a self-reported interview, which is prone to information bias; the recording and notification of occupational diseases and injuries system in Ethiopia are very weak. The lack of an occupational disease list in the country significantly affects the worker's compensation system and occupational health service access efforts.

Furthermore, knowledge regarding the measurement of exposure-outcome relationship; external exposure, internal exposure and effect in the integrated textile factories is limited. The external exposure includes specific hazards/agents from the worker or immediate contact (through personal measurement) and evaluation of the level in terms of concentration. Internal exposure refers to absorption or penetration of the hazard/agent into the worker's body following the external exposure with an indication of its presence or a physiological change. Effect is an outcome that includes the development of work-related diseases and injuries or adverse health conditions of workers due to excessive external exposure and related internal exposure in the occupational setting (26).

Therefore, this study aimed at measuring the three outcomes; first personal level inhalable cotton dust and endotoxin concentration; second cross-shift lung function status and chronic respiratory symptoms, and third registered work-related disease magnitude of workers from a factory clinic. Cotton dust and endotoxin are considered external exposure, lung function status as internal exposure, and registered work-related diseases and injuries as effect parameters in the outcome model.

1.3. Rationale and significance of the study

This study adds new knowledge to exposure assessment, particularly in the Ethiopian integrated textile sector. The personal level of inhalable dust fraction and the endotoxin concentration measurement could be baseline evidence for future studies and intervention programs to reduce external exposure. The study contributes to understanding the lung function status of apparently healthy workers as an internal exposure magnitude. The study also indicated the relationship between occupational exposure to cotton dust and endotoxin concentration levels and the risks of respiratory health problems of workers in the sector. Besides, the exposure assessment could help labour inspectors and occupational health professionals with personal level exposure measurement skills. Also, the study finding will be relevant to the Ministry of Labor and Social Affairs (MoLSA) to recognize the need to review the national occupational exposure limits for cotton dust, dust fraction and appropriate evaluation techniques.

Workers in the integrated textile factories were diagnosed with health problems in the factory clinics as an effect. Thus, workers' health records in the factories are a source of knowledge to

study work-related diseases and risk factors. This finding could help the national effort of preparing the list of occupational diseases, the recording and reporting of diseases and injury and the workers' compensation system. Also, the result indicates the possibility of retrieving occupational diseases and injuries information from the existing health care information system to have a better estimate of the occupational disease burden. Moreover, it adds new insight into occupational disease research to identify occupational risk factors for diseases and injuries. The study involved workers both in the production process and support services; hence, our findings show workers' overall exposure and health profile. Such comprehensive study helps to understand the possibility of worker's movement within the factory at a different job due to occupational disease development.

Generally, the study's comprehensive nature shows a broader extent of occupational exposure; assess the magnitude and relationship of external, internal, and effect in the integrated textile factories. Therefore, evidence from this study could inform policy, practice and research. Furthermore, the study indicates the possibility of factory management using the available worker's health data for planning and evaluating OSH intervention programs.

Chapter Two: Literature review

2.1. Overview of cotton production in Ethiopia

Cotton is the primary apparel fibre in the textile industry (60). It is a plant fibre and omnipresent commodity used for making textile products, the automotive industry and home furnishing (61). It is an important cash crop globally, with about 25 million tons worldwide (62). Cotton is farmed in many parts of the world. Ethiopia is one of the leading cotton producers (63, 64) with a potential of 3 million hectares of cotton cultivation which could account for 10 % of the world cotton production. However, the country currently used less than 3 % of this potential (3). In 2018/19, Ethiopia was the second cotton consumer in Africa next to Egypt due to increased local textile and garment factories (4). Currently, cotton production in Ethiopia contributes about 70 % of the raw cotton demand by the local textile industries (3). Understanding cotton as an essential resource in Ethiopia, the government has developed a 15 year National Cotton Development Strategy (2017 - 2032) and an implementation road map (3).

The quality of cotton depends mainly on the fibre length; the longer fibre, the better quality. The fibre length of cotton is classified as short fibre (< 25 mm), which is the lowest quality and used to make carpet, medium-length fibre (25-30 mm) and long fibre length (> 30 mm) usually used to make delicate fabrics and yarn (65). Contamination of cotton by foreign materials and high humidity content could affect the spinning process. Different things can contaminate cotton during the harvesting, collection, storage and ginning process. The International Textile Manufacturers Federation (ITMF) conducts a cotton quality assessment survey in the spinning mills with sixteen contamination parameters under five categories: fabrics, strings, organic matter, inorganic matters, and oily substances. According to a recent survey in 2016, the global cotton supply was 23 % contaminated. The level of contamination by organic matter was the highest, 47 % (66). Cotton contamination is a major constraint posing challenges for the textile industries in terms of textile products, health and safety of workers.

2.2.Textile and garment industry development

The term textile emanated from the Latin "*texere*" meaning to weave, which was applied in the weaving of fabrics from fibre (67). Processing cotton for clothing might be one of the oldest human

traditions and the first cottage industry in human history. Cotton is one of the oldest natural resources dating back to old civilization as a raw material for making clothes by handcraft in East Africa and South Asia before modern textile mills (68, 69). The emergence of cotton mills is traceable to the industrial revolution in the UK (70). The districts of Lancashire in the UK played a strategic role in the modern cotton mills during the industrial revolution.

The textile and apparel industry is one of the fastest-growing globally, with an estimated value of about one trillion USD and an annual growth rate of approximately 6.4 % (71). Africa engaged in cotton production and supply until the late 20th century to participate in textile manufacturing. In the last two decades, the textile industry has expanded in Africa with an estimated growth rate of 5 %. According to 2017, WTO data Africa exported about 13 billion USD from the textile and clothing market share. The implementation of the US African Growth and Opportunity Act (AGOA) in 2000, which granted tax-free access to African manufacturing products into the American market, boosted the textile industries across Africa (29).

2.3.The textile and garment industry in Ethiopia

Textile has a long history in Ethiopia, dating back to the traditional weaving practiced in the rural and semi-urban communities for making traditional clothes (2). Cotton has a central role in Ethiopians' rural and cultural life, where women grow or buy unrefined cotton and card by hand. Women twist the cotton by spinning “inzirt” to make a yarn. The “inzirt” is topped by “kesem” which acts as a bobbin to spool the thread. The weaver, traditionally male, uses handlooms commonly in a pit by interlacing the warp threads with weft threads and pressing pedals to make cloth (72) (Figure 2).

‘Inzirt’ (from carded cotton)

Handloom

Design and sewing

Dress

Figure 2: Processes of traditional Ethiopian cloth making from raw cotton to dress *(Photo Source, ETIDI (6))*

In the twentieth century, Ethiopia engaged in commercial cotton production and textile development. The first modern mill, Dire Dawa Textile Factory, was established in 1939 (6). In the 1960s, the number of privately-owned textile enterprises reached five, and the cotton production and textile brought an increased employment creation in manufacturing. The emerging textile factories stimulated the backward linkage of cotton production, which demands about a hundred thousand seasonal workers per year for cotton harvesting, but the forward linkage simulating the apparel industry was weak (30).

After the country returned to a market economy in 1991, the Government continued developing the textile and garment sector as a priority for poverty reduction and economic development. The textile and garment sectors showed sustainable growth after implementing the national Growth and Transformation Plan (GTP) (5, 30). The government continually developed investment enhancement strategies to encourage Foreign Direct Investment (FDI), improve infrastructure, cheap power supply, tax exemption benefit, and construction of industrial parks. Government incentives attracted key global buyers and investors to Ethiopia (6, 73). The Ethiopian Textile Industry Development Institute (ETIDI) was established to actualize the vision of "Farm to Fashion" by the Ethiopian government. The institute aims to empower Ethiopian cotton farmers, textile and garment producers with critical competencies in the global cotton market through a wide range of research and development support (6).

Currently, Ethiopia has become one of the largest textile and apparel exporters in Africa. The Ethiopia Growth and Transformation Plan (GTP II) has set a target for the textile and garment sectors to achieve one billion USD from export, a significant contribution to the GDP, and a hundred thousand new jobs by the end of the plan period (74). The relative proximity to Europe, preferential market access (AGOA, EBA, COMESA, EAC, SADC), the availability of quality raw material, significant state support and macroeconomic growth are enabling factors for the sector. Major export destinations for Ethiopia's textile products are Europe (40 %), Turkey (23 %), China (13 %), Italy (6 %), US (4 %) and others (14 %) (75). The sector produces a full range of products; annual production is estimated at 102,000 tons of yarn, 207 million meters of woven fabric, 50

million kg of knitted fabric, 63 million pieces of knitted garments, and 28 million pieces of woven garments (6).

The nature of the Ethiopian textile and garment sector is well known for its value addition throughout the value chain from cotton to clothing. In 2016, the sector registered over 130 active enterprises that cover the entire value chain, including ginning, spinning, weaving/knitting, dyeing and finishing, home textiles, and knitted/woven garment production. The sector's enterprises range from those with only a handful of employees to those employing over 6,000 workers (5).

2.4. Integrated textile factories in Ethiopia

The modern textile and clothing value chain has four main sectors; spinning, weaving/knitting, finishing and garment. Each of the value chain sectors can be established as an independent factory or in an integrated form. The integrated textile factory has the above four main sectors/departments within a factory having forward supply linkages. The integrated textile factories are interchangeably called textile and garment factories (7). In some cases, the textile and clothing value chain starts from ginning, which receives raw cotton from the farm and starts processing. The types of machinery and products of each department are different; the final product of each department can serve as a raw material input for the following department. The tasks and products of each department are presented in the following chapters.

Ginning

After harvesting cotton from the farm, the first in-house mechanical processing of cotton is ginning. The main task of ginning is to separate lint from the cottonseed. This process removes course-sized foreign materials from the cotton, which can significantly affect the quality of the lint. Besides, ginning the cotton comes with a minimum reduction in fibre spinning quality to satisfy the demand of spinners. The ginned cotton is then passed through heavy machinery, and the clean lint is compressed into bales with a packing density of 249 kg per bale (67). According to the International Cotton Advisory Committee, global cotton consumption reached 123 million bales yearly in 2019 (76). Ethiopia has 20 ginners with a production capacity of 330,000 cotton bales per year (5). The process of separating lint from the cotton seed releases a high level of inhalable cotton and organic dust, which increases the risk of respiratory health problems (47, 77).

Spinning

Spinning is the first sub-sector or department in the integrated textile factory. The purpose of spinning is to make yarn from lint cotton. Yarn manufacturing is a sequence of processes to convert raw cotton fibres to yarns for different purposes. There are different tasks in the spinning department for yarn production (67). According to the ITMF report, more than 250 million spinning spindles were installed globally in 2017 (78). Ethiopia has eight stand-alone spinning factories, 19 spinning factories in the semi-integrated and eight in the integrated textile factories. More than 300,000 spindles have been installed in the country. Annual production capacity reached 102,000 tons of cotton yarns (5). The different sections in the spinning department with distinct tasks are Blowing, Carding, Drawing, Roving, Open-end or Ring frame, Winding and Twisting.

Blowing or opening

Blowing/opening is the initial section in the spinning department. The cotton bales are opened and fed into the conveyor machine to convert the compacted layers of baled cotton into small, light, fluffy tufts to facilitate the removal of foreign matter (67). The processed cotton by the blowing machine directly feeds to the carding machine. The process of blowing during the removal of foreign matters from the cotton releases inhalable dust, increasing the risk of respiratory problems to workers in this section (47, 50).

Carding and combing

Carding is a central section of the yarn manufacturing process. The card machine performs another level of cleaning and removes foreign matters from the cotton. Fibres are collected into a rope-like form called “silver.” The process of combing helps the further removal of short fibres and trash, resulting in a clean, uniform and lustrous silver (67). The cleaning process in the carding and combing section releases dust into the environment. Besides, the carding machine produces a high level of noise (47, 50).

Drawing and roving

The silver from the carding process staked to the drawing frame makes the fibres straightened and parallel. Parallelization helps the fibre obtain the desired property, which is essential when twisting the fibre into yarn. The silver produced at this stage is passed through a roving process to reach a suitable size for the ring-spinning system to make yarn, and the product called “roving” is packaged on a bobbin (67). The rotating drawing and roving machines commonly leave cotton fluffs and leftover silver—the process of collecting and further recycling increase workers' exposure to inhalable dust.

Ring frame/Open-end

Ring spinning is a process that changes the roving into a desired yarn size or counts with the desired amount of twist. The spindle which holds the bobbin in the ring-spinning frame rotates at high speed, causing the yarn to balloon as the twist is imparted. Open-end is an alternative process of ring frame which converts the fibres to yarns and yarn package. It is a high-speed machine-operated process of separating the fibres in the silver to a single fibre and then twisting the fibre into a yarn structure to form a continuous strand of yarn. In this process, there is no need for a bobbin; instead, the yarn directly changes to a yarn package (67).

Preparatory step

This section is found between the end of the spinning task and before starting the weaving task. Once the yarn is produced in the spinning process based on the yarn's purpose, it passes through different steps in the preparatory process, including warping, winding, twisting, doubling and sizing. These processes improve yarn strength, increase smoothness, the elasticity of the warp and make the yarn suitable during weaving or knitting (67).

Weaving or knitting

Weaving/knitting means simply fabric making. In a weaving process, the warp and weft are combined to make a woven structure. The length of yarn is called the warp, and the width of yarn is called the weft. Knitted fabrics are mainly constructed by interlocking a series of loops made from one or more yarns, with each row of loops caught into the preceding row. Loops running lengthwise are called wales, running crosswise courses (67, 79). In the weaving and knitting

process, the machine works at high speed and creates a high noise and dust level. In the Ethiopian textile and garment value chain, 40 weaving and knitting segments are available, with an overall production capacity of 207 million meters of woven fabric and 50 million kg of knitted fabric (6).

Finishing

The fabric from weaving and knitting is a rough product which needs to pass through a range of mechanical and chemical process before transferred to the garment such as fabric quality inspection, scouring and bleaching, dyeing and printing. The process of souring and bleaching helps to remove dirt and colour-forming materials and facilitate the drying process. Through the application of heat in a heavy rolling machine dying and printing can be performed. Generally, a variety of finishing treatments could be applied to improve the strength, enhance appearance and lustre depending on the purpose of the cloth (67, 79).

Garment making

In the integrated textile factory, the garment is the final process segment. However, commonly modern garment factories are stand-alone. The three major activities in the garment segment are cutting, sewing and pressing. The cutting process involves sharp devices and chopping the fabrics to a designed size. Sewing is the primary activity in the garment section that can involve many workers performing the task. Pressing is a final process to change the garment's surface characteristics with heat, moisture, and pressure (79). Ethiopia produces 63 million pieces of knitted garment and 28 million pieces of woven garments annually from the available 78 garment factories (6). Most of the tasks in the garment factories were performed either in a long-standing or sitting position and awkward posture by repetition (22, 51).

The production workflow in the integrated textile factory starts from processing the raw cotton to final clothes (Figure 3).

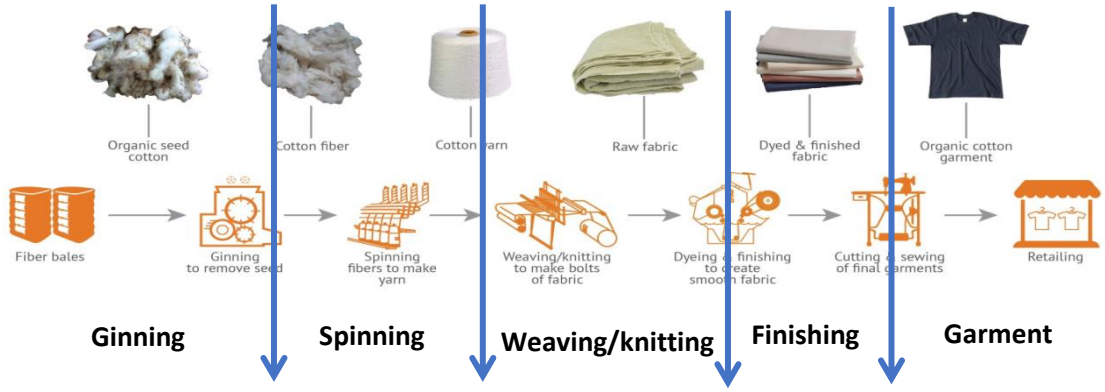

Figure 3: Production process from cotton to clothes in the integrated textile factory *(Photo source: Textile Exchange (80))*

2.5.Occupational exposures in the integrated textile factories

2.5.1. Occupational exposure to cotton dust and endotoxin

Cotton fibre is a single cell and the longest cell in plant outgrowths from the seed coat. The dry cotton fiber constitutes about 95 % crystalline cellulose, protein 1.3 %, pectic substances 1.2 %, ash/minerals 1.2 %, wax 0.6 %, total sugars 0.3 % and other constituents of 0.4 %. It is a short, fine and creamy white colour with a fibre length of 16-52 mm, and its width is about 1200-1500 times lower than the length (81, 82).

"Cotton dust means dust present in the air during the handling or processing of cotton, which may contain a mixture of many substances including ground-up plant matter, fibre, bacteria, fungi, soil particles, pesticides, non-cotton plant matter and other contaminants which may have accumulated in the cotton during the growing, harvesting and subsequent processing or storage periods (83)". The health-related conventional definition of dust particles which is accepted by the American Conference of Governmental Industrial Hygienists (ACGIH), the International Organization for Standardization (ISO), and the European Standards Organization (CEN), were classified into inhalable, thoracic and respirable fractions (84). The Inhalable particulate fraction is that fraction of a dust cloud that can be breathed into the nose or mouth. The thoracic particulate fraction is a

fraction that can penetrate and enter the airways. The respirable particulate fraction is that fraction of inhaled airborne particles that can penetrate beyond the terminal bronchioles into the gas-exchange region of the lungs (85). Cotton dust classified under the thoracic dust particle fraction can penetrate beyond the larynx. However, several cotton dust exposure studies have measured the inhalable and respirable particulate fractions only.

Few studies in the textile and garment industries have measured the concentration of endotoxin from inhalable cotton dust. Endotoxin is an insoluble structural component of the bacterial cell wall. The different gram-negative bacteria found in the environment, soil, and vegetation can contaminate cotton in harvesting and storage; then endotoxins become airborne (86, 87). The presence of a biological component in cotton dust has been first ascertained in the health departmental committee report (88). Later it has been suggested that endotoxins from the bacteria in the cotton could be of importance for the development of respiratory health problems (89, 90); further studies have found that a batch of dirty cotton, which caused symptoms of fever and acute respiratory symptoms during handling, was heavily contaminated with Gram-negative bacteria (91). Inhalation challenges with pure endotoxin and field studies confirm the relationship between these effects and exposure to dust-containing endotoxin (87).

Textile processing is known to cause cotton dust and endotoxin exposure to workers; evaluating these hazards from workers' breathing zone is considered an external exposure assessment (26). A high level of cotton dust exposure and associated respiratory diseases has been recorded in the textile sector since the early 1900s (16, 50, 92). Although several technical advancements in machinery, workplace improvements and ventilation system have been introduced in the textile sectors, recent exposure studies in LMIC textile factories have revealed a high level of exposure (14, 15). The presence of endotoxin within inhalable air is an indication of hygienic practices in the working environment. In recent exposure assessment studies, significantly higher endotoxin levels have been measured from the personal breathing zone of workers in the textile and garment industries (32). In some studies, measurement of endotoxin level moderately correlated with cotton dust in the workplace (32, 93).

A personal inhalable cotton dust and endotoxin exposure assessment study was conducted among Nepalese textile factory workers. A total of 114 air samples were collected from weaving, garment making, carpet-making, and recycling departments for the entire shift period using the institute of

occupational medicine (IOM) sampling head. Average inhalable dust of 0.81 mg. m^{-3} was recorded, ranging from 0.01 – 35.95 mg. m^{-3} exposure level at different tasks. The highest cotton dust exposure was measured in the recycling unit, whereas the lowest exposure level was measured from the garment and weaving departments. A comparatively higher level of average endotoxin (GM = 2160 EU.m^{-3}) was measured (32).

Another work area and personal level dust exposure study was performed from three textile factories in Shanghai to evaluate the variation of area and personal level measurements. A total of 82 personal cotton samples were collected from 41 workers using the IOM sampling head. The average cotton dust and endotoxin exposure level from the personal sampling was 1.74 mg. m^{-3} and 2207 EU. m^{-3}, respectively. Both the cotton dust and endotoxin exposure levels from the area sampling were lower than the personal measurements (33). The same authors (39) had performed an exposure assessment study in the three textile factories to compare sampler's performance. They performed sampling using the Chinese dust sampler (CDS) and the standard American vertical elutriator (VE); besides, inhalable dust samples were collected from personal and work area measurements using an IOM sampler. The personal inhalable cotton dust exposure concentration was higher (GM = 1.84 mg. m^{-3}) than the fixed point area measurements (GM = 0.68 mg. m^{-3}) using IOM sampling. The average endotoxin concentration measurement was 1871 EU. m^{-3} from the IOM sampling head, though this result was analyzed from area samples. Besides, the average dust measurements using the CDS filters were higher (0.79 mg. m^{-3}) than the VE (0.31 mg. m^{-3}).

Many personal air samples of 572 were collected from textile workers using the IOM sampling head in Turkey. The air samples were performed for a repeated time from workers for a standard complete work shift. The average cotton dust and endotoxin exposure level was 2.01 mg. m^{-3} and 191 EU. m^{-3}, respectively (14). Relative to other endotoxin exposure studies, lower endotoxin concentration was measured in this study; 66 % of the personal samples had an endotoxin level of < 260 EU. m^{-3} (14). Though the factories were old, the machines could release a relatively high level of dust. However, the quality of the raw cotton and the hygienic conditions of the factories may be reasons for the low level of endotoxin measurements (14).

Several exposure studies in LMICs have measured only cotton dust exposure concentration either from the area or personal level from textile workers. Endotoxin analysis needs an advanced

laboratory setting. A respiratory health and cotton dust exposure study was conducted among Iranian textile workers; although few personal inhalable cotton dust samples were measured, the average dust level, Arithmetic Mean (AM) was 12.1 mg. m^{-3} (40). A longitudinal exposure measurement study among Turkey textile workers from five workplaces using Vertical Elutriator (VE) found dust concentration levels ranged from 0.17 – 0.29 mg. m^{-3} (46). Another respiratory health study among Indian cotton ginning workers collected 188 personal dust samples of size PM 10. The average concentration of cotton dust from the ginning room and pressing room workers was 4.2 mg. m^{-3} and 3.2 mg. m^{-3}, respectively (94). A recent comparative cotton dust and endotoxin exposure assessment study was performed in Pakistan. This study collected a few dust samples with inhalable dust fractions from work areas. The measured cotton dust concentration was below the detection level, and the endotoxin concentration level was also low, ranging from 40 – 300 $EU.m^{-3}$ (95).

The particle size, the concentration and the composition of cotton dust varied alongside the textile process. Coarse dust particles, including visible fluffs, are generated in the first processing section. Several studies have also shown an exposure level gradient across the textile and garment production sections. The blowing and carding are the first sections in the spinning department where most of the studies have recorded high cotton dust. On the other hand, the lowest cotton dust exposure has been measured in the garment department (14, 32, 50). The dust composition in the first section has also contained non-cotton fibre, including other organic matters. The content of organic matter in the dust decreased in the later processing stages. The composition of the dust may contain some other chemicals, starch and dyes in the weaving, finishing and garment departments. Hence, different Occupational Exposure Limit (OEL) values have been set for the different tasks in the textile industry (34, 83). The cotton dust exposure level within the same department and the same operator at a different time can be varied. Exposure variation could be linked to many factors, including the nature of production activity and workplace conditions.

Like cotton dust, a higher level of endotoxin is measured in the first section of the textile process and lowest in the final stage of the process. The lower concentration in the last stage is mainly due to the washing, bleaching and warming of the yarn, and fabrics may remove the components. Researchers reported maximum level of endotoxin mainly in the recycling, opening and carding operation rooms (16, 32, 96). One of the personal inhalable dust exposure assessment studies

conducted in Nepal estimated 5110 $EU.m^{-3}$ in the recycling and 157 $EU.m^{-3}$ in the garment units (32). An industrial hygiene assessment study from 47 textile plants in Pakistan found the highest endotoxin concentration (1521 $EU.m^{-3}$) in the spinning sections, and the concentration significantly decreased in the weaving and finishing sections (21 $EU.m^{-3}$) (38).

Several exposure assessment studies in the textile factories have measured the highest concentration of cotton dust and endotoxin levels in the first sections of the production process but a varied level of correlation between the dust and endotoxin. In the Nepalese study, the inhalable cotton dust and endotoxin concentration showed a significant correlation ($r = 0.37$) in the garment and ($r = 0.82$) in the carpet departments (32). A similar study from Shanghai reported a strong correlation ($r = 0.58$) of cotton dust and endotoxin concentrations from an area using VE (39). Mehta and colleagues (33) conducted a detailed analysis using different sampling methods to find the best estimate of personal endotoxin exposure level; a weaker relationship of inhalable cotton dust and endotoxin concentration level was observed from the different sampling methods (VE and IOM), but the concentration of endotoxin had a strong correlation between the VE and IOM sampling methods. Another study from Pakistan reported that the endotoxin concentration was not correlated with cotton dust (53).

The following table presents a summary of exposure to cotton dust and endotoxin measurement studies published in the last two decades (Table 1).

Table 1: Summary of inhalable dust and endotoxin exposure studies

Study	Country	Study design	Air samples	Dust fraction and sampling approach	Dust level	Endotoxin
(95)	Pakistan	CCS	20	Inhalable area sample	Below Limit Of Detection (LOD)	Only in exposed 40 – 300 $EU.m^{-3}$
(53)	Pakistan	CS	About 5 hours	Inhalable area samples *	AM = 3.5 $mg.m^{-3}$*	AM = 350 $EU.m^{-3}$*
(32)	Nepal	CS	114	Personal inhalable dust	GM = 0.81 $mg.m^{-3}$	GM = 2160 $EU.m^{-3}$
(40)	Iran	CS	9	Area inhalable dust (IOM)	AM = 12.1 $mg.m^{-3}$	
(94)	India	CS	188	Personal PM_{10}	Ginning: AM = 4.2 $mg.m^{-3}$ Pressing: AM=3.2 $mg.m^{-3}$	
(46)	Turkey	LS	5	Area respirable dust (VE)	AM = (0.17 – 0.29 $mg.m^{-3}$)	
(33)	China	CS	82	Personal inhalable dust (IOM)	GM = 1.74 $mg.m^{-3}$	GM = 2207 $EU.m^{-3}$
(14)	Turkey	CS	572	Personal inhalable dust (IOM)	Median = 2.01 $mg.m^{-3}$	191 $EU.m^{-3}$
(39)	Shanghai	CS	346	Personal inhalable dust (IOM)	GM = 1.84 $mg.m^{-3}$	GM = 1871 $EU.m^{-3}$#

* Estimated weighted concentration calculated from real-time measurement of air samples; # endotoxin concentration from area sampling; AM = Arithmetic Mean, GM = Geometric Mean; VE = Vertical Elutriator; IOM = Institute of Occupational Medicine

Evaluation of cotton dust exposure assessment

Cotton dust exposure studies in the textile and garment industries were usually conducted either by aerial sampling or personal sampling. In the former method, the air sampling instrument is stationed around the operator's location or fixed point at the source to take a measurement. This method is widely used to estimate the workplace dust level to monitor and evaluate the dust control methods. In some studies, aerial measurements have been used to estimate the personal exposure level. In the latter technique, the sampling devices are attached to the body, and measurement is taken around the operator's breathing zone while performing the job during the shift (33). This method has been widely used to assess workplace standards and exposure-response relationship studies. Several studies have shown a higher level of cotton dust exposure in the personal air sampling method than the aerial method (33, 39).

There are varieties of dust sampling heads; the standard types that have been used in exposure assessment are the Institute of Occupational Medicine (IOM) and Conical Inhalable Sampler (CIS), Vertical Elutriator (VE) and total dust sampler. Respirable and an inhalable fraction have been widely used in many exposures assessment studies. Currently, air sampling of the inhalable dust fraction is used in many occupational exposure studies. However, using different sampling heads for sampling inhalable dust fractions has resulted in various exposure levels (33, 39). Although IOM sampling head is widely used for inhalable dust sampling study, laboratory and field studies have also reported that IOM sampler overestimate the exposure concentration compared to the Conical Inhalable Sampler, especially for larger particles (180).

Cotton dust is one of the well-recognized occupational hazards in the textile and garment sectors which OELs have regulated. The fraction of dust samples can determine the OEL values for cotton dust. The OSHA and ACGIH have set an OEL value of 0.2 $mg.m^{-3}$ and 0.1 $mg.m^{-3}$, respectively, for a respirable fraction of cotton dust using a vertical elutriator technique (83, 85). The HSE of the UK, on the other hand, used an OEL value of 2.5 $mg.m^{-3}$ of the inhalable cotton dust fraction (34). In Ethiopia, the OEL for cotton dust is set at 1 $mg.m^{-3}$ but the dust fraction is not clearly stated (97). Hence, comparing exposure assessment findings with the stated standard could be a challenge.

Evaluation of endotoxin exposure assessment

Endotoxins are lipopolysaccharides found in the outer membrane of the bacteria cell wall and released during cell lysis. It exists in suspension in the workplace atmosphere associated with other aerosol particles, which is the most common type in occupational settings (98). There are different techniques of endotoxin extraction from dust samples (99-101).

Chemical determination of endotoxin levels from cotton dust samples can be achieved using the Limulus Amebocyte Lysate assay (LAL) (102, 103). The LAL assay technique is commonly used in the occupational setting of personal endotoxin exposure assessment studies; gas chromatography-mass spectrometry and monoclonal antibody-based methods as alternative methods (99, 101, 104). Different endotoxin extraction protocols at different laboratories lead to a significant variation in concentration level (101). Besides, several studies have shown both personal endotoxin exposure levels over time and between individuals with huge variability (99, 103). A critical literature review about the method of workplace airborne endotoxin exposure measurement and analysis has revealed that the air sampling strategy, sampling filter, sampling head, sample handling, storage and analysis technique play a significant role in individual endotoxin exposure variability (98).

Though several studies have shown the relationship of workplace endotoxin exposure with respiratory diseases, threshold limit value or occupational exposure limit value for endotoxin is not yet set by international standards (34, 85). Of course, there is no international standard protocol for measurement and analysis to determine endotoxin exposure levels (98). However, the Dutch Expert Committee on Occupational Standards (DECOS) has recommended the occupational exposure limit of 90 $EU.m^{-3}$ endotoxins based on experimenting on sensitive healthy subjects with no effect for 6-hour exposure (35). This recommendation is widely used in exposure assessment studies; it served as a standard for workplace assessment in some places. Therefore, workplace-based research evidence about endotoxin exposure, particularly from the LMIC setting, is vital for developing OEL standards.

2.5.2. Occupational exposure to other hazards in the textile and garment industries

The textile and garment production process exposes workers to various workplace hazards other than dust; these hazards may include a high level of noise, different types of hazardous chemicals

and dyes, sharp materials, ergonomic related hazards, work in stressful and unhygienic conditions (18, 105). Some of the hazards have a global standard of OELs to measure the exposure level, but most of the hazards had no exposure limit for assessment. The presence of high noise level specifically in the weaving and spinning departments of the textile factories have been well documented. The Threshold Limit Value (TLV) (85) for noise exposure in the work environment is 85 dB(A) for eight hours, but exposure measurement studies in textile production have reported higher noise levels that exceeded the OEL values in many textile factories (105-108).

The effect of ergonomic hazards is widely recognized in different occupations; MSDs became the most commonly reported health problem from workers a decade ago (109). Several studies have shown ergonomic hazards in the textile and garment factories that could increase the risk of developing MSDs (110-112). Ergonomic hazard exposure assessment studies using the application of ergonomics assessment tools such as Quick Exposure Check (QEC) in Bangladesh (22) and a Rapid Upper Limb Assessment (RULA) in Cambodia (51) found that the tasks in the garment department were high risk for work-related MSDs (51). A questionnaire-based assessment study involved 600 participants from Bangladesh garment workers (113) and 628 textile factory workers from Ethiopia have also shown the effect of ergonomic hazards among textile workers (112).

Workers in the textile and garment industries are frequently in contact with dangerous machines and manual handling activities; the occurrence of injury due to the absence of safety standards is common (18, 52). A self-reported study in the Ethiopian textile factory assessed the injury status of 433 textile workers; the one-year prevalence of occupational injury was 31 %, and work-related hazards were significantly associated with injury occurrence (114). A case-control study by (115) and a self-reported cross-sectional study by (52) was conducted among Ethiopian textile and garment factory workers to identify the determinants of occupational injury. The result indicated that occupational and personal factors were significant predictors of work-related injuries.

The widely diversified textile and garment productions in the fashion industry increase the use of different dyes and chemicals during the production process, increasing workers' exposure to chemical hazards. A recent systematic review of health vulnerabilities of workers in the garment sectors has indicated exposure to chemical hazards as one of the major health risks (12). Organic solvents and alkaline are widely applied in textile and garment factories for machine cleaning and

bleaching purpose. There are also varieties of irritant chemicals and enzymes used for sizing, which could cause allergy (17). Many workers in a poorly organized work environment increased the contamination of workers with an infectious agent in the textile factories. An industrial hygiene assessment study in Pakistan using a checklist by experts revealed that most textile factories' working environment was dirty, have leakages, insufficient ventilation, and no washrooms (53). Several studies among textile and garment workers have reported a high prevalence of diarrhea and gastrointestinal diseases (116, 117).

In recent years work-related stress is the most widely known health problem of workers in all occupations. Few studies reporting work-related stress as a growing concern in the textile and garment sectors indicate the presence of stressful conditions at work and their effect on the health of exposed workers and performance (12, 54, 55). A recent study from 23 export-based textile factories in Pakistan reported a high level of perceived stress among workers; 70 % of the study participants had experienced stress, and 21 % had a severe level of exposure to hazards (55). Although work-related stress was developed due to the complex interactions at work, the most common overt conditions in the textile and garment industries are related to the production process, work demand, lack of control of the work and manager's relationship. Workers in the textile and garment industries are lowly educated, received low wages and are challenged for living conditions. Besides, production workers spend their time on monotonous tasks, work under pressure, and operate dangerous machines, and work in a dusty and noisy environment (12, 18, 23, 56).

2.6. Workers' health in the integrated textile factories

2.6.1. Lung function and occupational exposure to cotton dust and endotoxin

Lung function impairment is an acute or chronic pulmonary function reduction measured by FEV_1 (118). Naturally, lung functions decline with age; in a large study, the decline in FEV_1 was assessed longitudinally in 20-year-olds and was found to be 29 ml/year in men and 25 ml/year in women (119). Acute airway response is defined as either a cross shift or a cross week fall in forced expiratory volume in one second (FEV_1) through a pulmonary function test (118). The longitudinal change of lung function over a year could also be calculated (14). Cross shift change FEV_1 is considered as an acute and reversible airflow condition. However, in a longitudinal study, a

significant cross-shift change FEV_1 among cotton exposed workers results in a chronic lung function reduction. Chronic lung function impairment is commonly known as an irreversible pulmonary function that can be expressed by the percentage of the predicted value of an individual relative to the reference population. The FEV_1 is the most commonly reported lung function parameter used to measure the amount of annual decline. It is also a measure of airway obstruction. The inhalation of cotton dust and endotoxin from the work environment (external exposure) resulting in a change in lung function capacity indicates internal exposure (26).

Acute cross shift change in lung function

Longitudinal studies in an occupational setting have indicated that workers in the textile industry have shown a significant reduction in cross-shift lung function parameters, FEV_1 and FVC, compared to the non-cotton exposed workers. In one of the most known textile cohorts in Shanghai, cross-shift lung function has been monitored among the exposed (cotton workers) and control (silk workers). The lung function parameter FEV_1 was measured every five years. A significantly higher cross-shift FEV_1 reduction was observed among the cotton exposed group in the three surveys compared to the control (42). Cotton dust and lung function parameters were measured at different times; a significant reduction in cross shift FEV_1 (28 ml) was recorded at the 12 month measurement time (44). Another cross-shift lung function measurement that was performed among 157 textile workers in Turkey has also reported a reduced FEV_1 value across the work shift (14). However, a three-year longitudinal measurement study among 110 textile workers has shown an acute cross shift FEV_1 reduction greater than 5 %, but the reduction was not significant (120).

Several cross-sectional studies have also shown an increased cross-shift lung function reduction among textile workers. A comparative cross-sectional study was conducted to evaluate the respiratory health of textile dyeing workers. One hundred and one (101) textile dyeing workers and 90 administrative workers participated in the cross-shift spirometry studies. The cross-shift reduction of all the spirometer parameters (FEV_1, FVC, FEF25-75 % and FEF25 %) was higher among the exposed group than the control (43). A cross-sectional study was conducted among 89 Iranian, male and non-smoker cotton textile workers. The study measured cross-shift lung function parameters and personal inhalable dust. The mean cross-shift parameters of FEV_1, FVC, FEF25-75 % were significantly reduced after the work shift (40). Another cross-sectional study on

respiratory health and exposure to cotton dust and endotoxin was conducted among the Nepalese textile workers. The study recruited 938 participants from weaving, garment, carpet and recycling departments. The study did not include all the typical integrated textile departments, but it is well-design and comprehensive. The cross-shift lung function measurements showed a reduction after the work shift; FEV_1 (74 ml) and FVC (81 ml), but only the cross-shift FEV_1 reduction was significant (41).

A comparative study among blue-collar and white-collar textile workers in Turkey has also revealed that a reduction of the cross-shift in FEV_1 both among the blue-collar (102 ml) and the white-collar workers (60 ml), but the cross shift reduction was not significant (121). A cross-sectional across-shift study among 168 Indian cotton ginning workers showed all the parameters, FEV_1, FVC and FEF25-75 %, were not reduced across the work shift (122).

Studies indicated that cross-shift lung function reduction is related to permanent chronic lung function impairment. Longitudinal studies among textile workers have suggested that cross-shift lung function could result in chronic lung function reduction (45, 123). Several studies have indicated that exposure to cotton dust in the textile industry is associated with the change in pulmonary function impairment of the FEV_1 (94, 124-126). In the two surveys of the Shanghai cohort, the cross shift drop of $FEV_1 > 5$ % was a significant predictor for the annual FEV_1 change in lung function among the cotton group after adjusting the potential confounders; whereas, such an annual change in FEV_1 failed to show difference among the control groups (127).

In a 15 year survey of the Shanghai cohort, a cross-shift change in FEV_1 was associated with an annual loss of FEV_1 and FVC among cotton workers, irrespective of respiratory symptoms. The authors argued that across-shift drops in FEV_1 and chronic airway obstruction might not be in a causal relationship, and both may be a consequence of exposure to cotton dust (125). In the same study, after 20 years of follow-up, the cross-shift lung function reduction was associated with chronic lung function impairment among the cotton exposed group. The authors reported that cross-shift reduction could contribute 7-9 ml of the annual FEV_1 loss (42). Another prospective study measured cross-shift and cross-week lung function among 157 textile workers in Turkey; the report showed that only the cross-week FEV_1 predicts the annual FEV_1 decline (14). A five-year longitudinal study in the Turkey textile found an annual FEV_1 loss of 53.2 ml per year and a

ratio of FEV_1 loss of 1.4 %. This study recommended using the ratio of annual FEV_1 loss to baseline FEV_1 to get accurate pulmonary function deterioration than the annual FEV_1 loss (46).

The relationship between cotton dust exposure and lung function impairment has been an area of research interest. A longitudinal study among textile workers has indicated a significant relationship in reducing cross-shift FEV_1 with cotton dust exposure (45). Wang et al. (2008) suggested that cotton dust exposure could be the risk factor for cross shift drop in FEV_1 value. Evidence from the 20 years of Shanghai follow-up also showed that the dust exposure level was significantly higher among the cotton workers than the silk workers (control). The statistical analysis indicated that exposure to dust contributed to 10 ml annual lung capacity loss among cotton exposed groups but not in the silk workers. However, the cumulative dust exposure level and a dose-response relationship were not established in this study (42).

In the Nepalese study, exposure to inhalable dust was a significant predictor of the cross-shift FEV_1 reduction, but endotoxin exposure level did not show this relationship (41). In another, cross-sectional personal inhalable dust measurement and cross shift spirometry study in Iranian textile, all the lung function parameters (FEV_1, FVC and FEF 25-75 %) was significantly decreased across the work shift; however, the dust exposure concentration could not show a relationship with cross shift reduction (40).

In some studies, although a reduction in cross shift FEV_1 was observed but not associated with the measured dust exposure level. In the Shanghai textile cohort (127), a dust level of geometric mean range from 0.24-1.73 $mg.m^{-3}$ has been measured among the different cotton exposed mills, whereas in the control group, a geometric mean of 0.20 $mg.m^{-3}$ was reported. The study measured a higher decrement of cross-shift FEV_1 among the cotton exposed group than the control. Although it was an area dust measurement, the dose-response analysis among the cotton exposed group could not determine a relationship with the level of lung function reduction

A prospective study was conducted among a newly recruited cohort of female workers from three textile factories in China. Dust was measured at three different periods from the working environment; the weighted average dust level in the three measurement periods ranged from 0.48 – 0.68 $mg.m^{-3}$. A significant cross-shift lung function reduction in FEV_1 was recorded from the high dust exposure factories compared to the low dust factories. However, the measured dust level was not associated with the cross shift FEV_1 (44).

In a longitudinal study, personal dust exposure was measured from 157 newly hired textile workers in Turkey. Five hundred seventy-two personal dust samples were collected at the first, third, six and 12th months. The average personal cotton dust exposure level was 2.01 $mg.m^{-3}$. Although the cross shift FEV_1 reduction was observed, exposure to dust was not significantly associated with the cross shift FEV_1 drop in the one year (14)

A personal level of cotton dust exposure and lung function measurement was conducted among 188 cotton ginning and 59 socio-economically comparable controls in India. The mean dust concentration level ranged from 1.2 – 6.0 $mg.m^{-3}$. The lung function parameters, both FEV_1 and FVC, showed a significant reduction from the predicted value among the cotton exposed group compared to the control. The level of reduction in lung function was increased with cumulative dust exposure (94). However, cross-shift lung function change was not investigated in this study.

The five-year longitudinal study among the Turkey textile factory workers measured the dust level in two surveys with a mean concentration of 0.17 $mg.m^{-3}$ and 0.29 $mg.m^{-3}$ in 2006 and 2011. Although the annual FEV_1 and FVC showed significant decreases, the reduction was not associated with the measured dust level (46).

The 11 years Shanghai study (36) depicted a more significant loss of pulmonary function during the first five years (40 ml/year) compared with the second survey later on six years (18 ml/year). Besides, cotton dust strongly predicted the long-term pulmonary function loss but not cumulative endotoxin exposure level. On the other hand, a recent cross-sectional study measured lung function and endotoxin exposure among textile workers and control in Pakistan; a lower level of FEV_1 and FVC was significantly associated with endotoxin among the exposed group (95).

A group of 173 retired cotton textile workers from one cotton mill in Shanghai with 373 healthy age-matched individuals as a control group showed no significant difference in lung function parameters between cotton textile workers and a comparison group after retirement (128). Similarly, in the 25 years Shanghai follow-up study (129), textile workers have improved FEV_1 and fewer chronic respiratory symptoms after leaving work and that the changes are more pronounced for cotton than silk workers. Also, smokers had greater FEV_1 decline when actively exposed; and show faster improvement after work cessation than nonsmokers. The protective effect of stopping work reduced the magnitude of 5-year FEV_1 decline from 163.1 ml/5year when they were actively exposed to cotton dust to 115.3 ml/5 year after about ten years of work

cessation. The improvement appears to occur most rapidly during the first 10 to 15 years after work cessation

In the 20 years survey, 501 participated in blood samples, and a total of 499 subjects were genotyped successfully. Microsomal epoxide hydrolase polymorphism and endotoxin combined effect was investigated. Thus, the combined effect was associated with a faster and stronger lung function decline than endotoxin or genotype alone. The study further suggested the importance of investigating genetic and environmental factors endotoxin exposure and smoking in lung function decline and the development of Chronic Obstructive Pulmonary Diseases (COPD) (130). In a similar setting study of the 20 years follow up further analysis of the exposure-response relationship indicated that chronic loss of FEV_1 was more highly associated with the level of exposure to endotoxin than to dust itself, which support the hypothesis of endotoxin as the causative agent of the chronic obstructive airway (19).

Cross-shift lung function studies in the last two decades are summarized below (Table 2).

Table 2: Summary of cross-shift lung function measurement studies in the last two decades

Study	Country	Study design	Sample population	Cross shift lung function parameters			
				Δ FEV_1		ΔFVC	
				Exposed	Control	Exposed	Control
(41)	Nepal	CS	384 Textile workers	74 ml *		81 ml	
(43)	Iran	CS	101 Dyeing 90 Control (administrative)	103 ml *	18 ml	120 ml*	49 ml
(40)	Iran	CS	89 Textile workers	50 ml *		130 ml *	
(122)	India	CS	168 Ginning workers	Morning shift: 30 ml Afternoon shift: -130 ml			
(42)	Shanghai	LS	**Survey 1** 391 Exposed (Cotton workers) 376 Control (Silk workers)	58 ml*	6 ml		
			Survey 2 284 Exposed (Cotton workers) 307 Control (Silk workers)	48 ml*	26 ml		
			Survey 3 222 Exposed (Cotton workers) 225 Control (Silk workers)	54 ml*	20 ml		
(14)	Turkey	LS	157 Textile	Cross-shift FEV_1 > 5 % = 75 ml Cross-week FEV_1 > 5 % = 165 ml *			
(44)	China	LS	225 Female textile workers	28 ml *			
(121)	Turkey	CS	182 Exposed (Blue-collar worker) 41 Control (collar worker)	102 ml	60 ml *		
(120)	China	LS	60 Textile	5 % decrease			

* Significance level $P < 0.05$

2.6.2. Respiratory health problems of workers

Development of diseases following external and internal exposure at work is considered an effect (26). It was more than a century since the textile factory workers were identified for the risk of health problems due to cotton dust exposure (88, 131). In the mid-18th century, physicians described byssinosis as cotton spinner's phthisis, which differed from the common chronic bronchitis, a short dry harassing cough in the initial stages, and ceases after workers leave the mill. Byssinosis is a Greek word meaning linen or fine flax and has been described in cotton, flax, and hemp workers. It was believed that the symptoms gradually become more severe and eventually continues after employment cessation (92).

Earlier investigations have shown the relationship between the total concentration of contaminants in the air and the incidence of respiratory problems (89, 132). However, current studies argued that early cotton dust was the primary cause of respiratory health problems and lung function loss. An experimental study on carding room and animal studies showed no correlation between individual dust level exposure and lung function; instead, endotoxin was responsible for developing respiratory problems (16, 19, 20). More recent findings suggest that the magnitude of byssinosis could decrease, and lung function reduction showed improvement after cotton dust exposure cessation among a cohort of textile workers in China (21).

Chronic respiratory problems

Chronic obstructive pulmonary disease (COPD) is one of the leading causes of health problems globally, and almost 90 % of COPD deaths occur in LMICs (133). Occupational exposures contribute 15 % of the risk of COPD through occupational inhalant exposures, including cotton dust (134). Byssinosis is considered an obstructive lung disease characterized by chest tightness and shortness of breath (132). The development of respiratory diseases in the presence of an excessive concentration of cotton dust in the working environment indicates the effect (26).

Respiratory symptom assessments, such as chronic cough, chest tightness, chronic bronchitis and dyspnea, were commonly used among cotton dust-exposed workers (53, 129, 135-137). Other respiratory symptoms such as wheeze, rhinitis, chest pain, and nasal irritation were also reported (138, 139). Respiratory health effects of cotton dust exposure studies started in the UK. One of the oldest occupational cohorts in the Shanghai textile study confirmed the causal relationship of

cotton dust and endotoxin exposure to chronic respiratory diseases among textile workers (19). Several studies from Europe, the USA, Asia, and Africa revealed that textile workers have a higher prevalence of chronic respiratory symptoms (77, 123-125, 129, 140-142).

The proportion of respiratory disease prevalence decreases along the line of the textile production process, from the spinning department to the garment department (50, 143, 144). Several studies in the textile industry have found the highest prevalence of chronic respiratory diseases in the first working departments, i.e. spinning and weaving (15, 47, 48, 142). It followed a similar pattern to the cotton dust and endotoxin exposure level gradients across the working process (14, 32). However, some studies have also indicated that workers with health complaints moved from the high exposure section to the lowest exposure work section (135, 145).

The following table summarizes the respiratory symptoms studies among textile and garment factory workers conducted in the last two decades (Table 3).

Table 3: Summary of respiratory symptoms prevalence studies from recent literature

Study	Country	Study design	Sample population	Diagnosis method	Prevalence of symptoms In the textile (Exposed)	Prevalence of symptoms (Control)	Effect size OR (95 %CI)/P-value
(146)	Ethiopia	CCS	276 textile vs 137 administrative	BMRC	Cough=28.1 Phlegm=19.6 % Chest tightness=30 % Dyspnea=27.1 % All symptoms= 47.8 %	9.9 3.1 % 8.4 % 4.6 % 15.3 %	P<0.001 P<0.001 P<0.001 P<0.001 P<0.001
(15)	Pakistan	CS	303 male textile (spinning and weaving)	ATS	Cough=15 % Phlegm=20 % Wheezing=20 % Chest tightness=11.9 %		
(142)	Egypt	CS	100 textile and 15 non cotton exposed	ATS	All symptoms=59 %	0 %	
(37)	India	CS	100 male textile(spinning and weaving) 100 non textile	Questionnaire	Cough=65 % Chest tightness=30 % Breathlessness=85 %	10 % 0 % 5 %	P<0.001 P<0.001 P<0.001
(77)	Greek	CCS	256 textile and 148 office workers	ATS	Cough=9 % Phlegm=8.6 % Dyspnea=10.9 % Wheezing=5.9 %	7.4 % 5.4 % 3.4 % 0.7 %	P=0. P=0. P=0. P=0.
(48)	Ethiopia	CCS	51 Textile 51 Control (Administrative)	BMRC	Cough=65 % Phlegm=55 % Wheeze=39 % Breathlessness=41 % Chest tightness=43 %	25 % 14 % 8 % 6 % 0 %	2.23 (1.46- 3.4) 2.33 (1.61-3.37) 2.10 (1.51-2.91) 2.27 (1.67-3.13) 2.76 (2.06-3.69)

(147)	Thailand	CS	152 home-based garment	Questionnaire	Respiratory disorder=25 %		
(148)	Pakistan	CS	372 male textile	ATS	Chronic bronchitis=7.8 % COPD=6.7 %		
(149)	Iran	CCS	100 textile 100 non textile	ATS	Cough=47 % Dyspnea=15 % Phlegm=41 % Chest pain=12 % Chest tightness=26 % Wheezing=20 %	10 % 9 % 5 % 7 % 9 % 4 %	P<0.001 P=0.19 P<0.001 P=0.23 P=0.002 P<0.001
(150)	Benin	CCS	656 textile (spinning and weaving) 113 control	BMRC	Cough=16.8 % Bronchial secretion=5.6 % Chest constriction=7.2 % Dyspnea=9.9 % Asthma=1.5 % Chronic bronchitis=3.4 % Respiratory=21.1 %	2.19 % 0.9 % 2.7 % 16.8 % 0 % 0.9 % 21.2 %	P<0.001 P=0.003 P=0.003 P=0.05 P=0.088 P<0.001 P=0.9
(151)	Pakistan	CS	372 Textile	ATS	Chronic cough=8 % Chronic phlegm=13 % Chest tightness=19 % Chronic wheeze=22 % Shortness of breath=47 % Self-reported asthma=4 % Physician diagnosis=2 %		
(41)	Nepal	CS	938 Textile (garment, carpet, weaving and recycling)	IUATLD	Cough=8.5 % Phlegm=12.5 % Wheeze=3.2 % Breathlessness=6.5 % Chest tightness=12.3 %		
(38)	Pakistan	CS	800 Textile	Questionnaire	Fever=30 % Shortness of breath=31 % Chest tightness=31 %		

					Dry cough=26 % Mucous cough=5 %		
(152)	Thailand	CS	300 Garment	Questionnaire	Respiratory symptoms=22.3 %		
(43)	Iran	CCS	101 Textile dying 90 Control	Venables Questionnaire	Respiratory symptoms=34 % Asthma=12 %	19 % 6 %	P=0.01 P=0.13
(124)	Benin	CCS	109 Textile 107 Control	ICOH	Byssinosis=21.1 %	8.4 %	P=0.006
(139)	Pakistan	CS	372 Textile	ATS	Byssinosis =10.5 % Cough= 7.5 % Phlegm= 12.9 % Wheeze = 22.3 % Shortness of breath= 21 % Chest tightness =33.3 % Asthma=4 %		
(49)	Turkey	CCS	106 Textile (dyeing) 106 Control (administrative)	ATS	Cough=26 % Wheezing=27 % Dyspnea=14 % Phlegm=37 %	22 % 26 % 15 % 39 %	P>0.05 P>0.05 P>0.05 P>0.05
(138)	Nigeria	CCS	200 Textile (male) 200 Administrative	MRC	Chest tightness=22.5 % Cough=43 % Sputum=41 % Wheeze=24.5 %	6 % 14 % 12 % 12 %	4.55(2.23-9.43) 4.63 (2.77-7.78) 5.10 (2.97-8.79) 2.38 (1.35-4.21)
(153)	Ethiopia	CS	417 Textile	ATS	Byssinosis=38 % Bronchitis=32 % Cough=17 % Phlegm=18 % Chest tightness=12 % Dyspnea=38 %		
(154)	Greek	CS	443	ATS	Cough=38 % Phlegm=24 % Chest tightness=33 %		

					Dyspnea=22 % Asthma=32 %	
(155)	Pakistan	CS	83 Textile (spinning)	Questionnaire	Respiratory symptoms=35 % Cough=9 % Chest tightness=6 % Breathlessness=7.2 % Byssinosis=19 %	
(19)	Shanghai	LS	447 Textile 472 Control	ATS	Byssinosis=22 % Chest tightness=20.8 % Bronchitis=13.5 % Cough=16.1 % Dyspnea=23.9 %	0 % 8.1 % 13.2 % 11.5 % 23.3 %
(156)	Shanghai	LS	194 Textile	ATS	Three-month incidence: Cough with phlegm=4 % Dry cough=7 %	
(121)	Turkey	CS	223 Textile	WHO Questionnaire	Byssinosis=14 % Chest tightness=20 % Wheezing=12 %	
(157)	Bangladesh	CS	210 Textile	Questionnaire	Respiratory symptoms=53 % Cough=43 % Chest tightness=4 % Bronchitis or asthma=6 %	

2.6.3. Other health problems of workers in the integrated textile factories

Traditionally, the textile industry is known to cause respiratory diseases due to cotton dust and endotoxin exposure. Hence, the leading research regarding work and health in the textile and garment industries has been centred on respiratory diseases (48, 92, 138, 142). However, the presence of ranges of workplace hazards such as chemicals, dyes, heavy machines, mechanical contact, manual handling, repetitive work and working in awkward postures as well as increased work pressure can put textile workers at risk for work-related diseases (such as MSD, injuries, allergy, hearing impairment, work-related stress, dermatitis) (12, 22-25, 67, 115, 158-160).

Musculoskeletal disorders are a group of health problems that can affect the movement and quality of life-related to the muscles, tendons, joints, skeleton, ligaments and nerves. MSD is one of the growing health concerns in the textile and garment sectors; it became one of the most prominent occupational diseases recorded and the primary cause of compensation (161, 162). Several studies have reported a higher prevalence of MSD in different body regions of workers in the textile and garment industries. It is the leading occupational disease in garment factories (163-166). A study conducted on the Cambodian garment industry involving 714 workers reported an annual prevalence of 82 % (51). In another study, in a textile factory with 5100 workers in Ethiopia, 628 (53 %) workers reported MSD (112).

The textile and garment factories have also been well-known for high accident reports resulting in different levels of injury. The presence and contact with heavy machinery and sharp instruments during work activities can cause accidents (67). Besides, the textile production areas are commonly known for unclean workstations, dusty air, noisy work environments, and inadequate lighting, increasing the risk of work-related injuries. A cross-sectional study in an Ethiopian textile factory recruiting 455 workers found an annual injury prevalence of 37 %, while work environment factors, machinery and ergonomic factors were significantly associated with injury (52). Another injury prevalence study among textile workers has also reported a one-year work-related injury prevalence of 31 % (114). A case-control study in the integrated textile industry in Ethiopia indicated males, young age, stressed, and workers with sleep problems had a risk of work-related injury (115).

Recent studies have indicated that the textile and garment sectors made workers vulnerable to many other health conditions and diseases (12, 167). Cross-sectional studies among Cambodian, Indian and Bangladeshi garment workers found a high prevalence of anemia and nutritional deficiencies (58, 165, 168). A high prevalence of skin disease that was associated with exposure to textile dust and dyes was reported. The studies reported occupational allergic and irritant contact dermatitis due to exposure to textile dust (159, 169, 170). Other studies have also reported that textile workers suffer from occupational stress in their jobs. The level of stress in the work environment affects workers' health and performance (23, 54, 55). The presence of a high noise level above the OEL value among textile workers has resulted in hearing impairment. Several studies in LMICs have reported a higher level of noise-induced hearing impairment and reduced quality of life among textile workers (107, 108, 171-173). A recent audiometric study in the Chinese textile industry involving 534 Noise-Induced Hearing Loss (NIHL) patients and 534 controls found that workers exposed to the noise level above 85 dB had found a significantly higher risk of developing NIHL (174).

2.7. Conceptual framework

This conceptual framework was designed to guide the research, it mainly describes the three outcome variables of the three studies; personal level cotton dust and endotoxin, cross-shift change, and occupational diseases and injuries in relation with the personal and work-related factors based on the three levels of exposure assessment model. In this model personal cotton dust and endotoxin level is an external exposure, cross-shift lung function is an internal exposure and occupational diseases are effect (Figure 4). It also indicates how the independent factors (personal and work-related) affect the outcome variables in each study. Also, the framework helps to understand the scientific background and determine the scope of the literature review.

This conceptual framework was developed based on existing literature (21, 32, 42, 94, 124, 137, 139, 175, 176), a preliminary visit to the integrated textile factories, discussion with factories management and research advisers

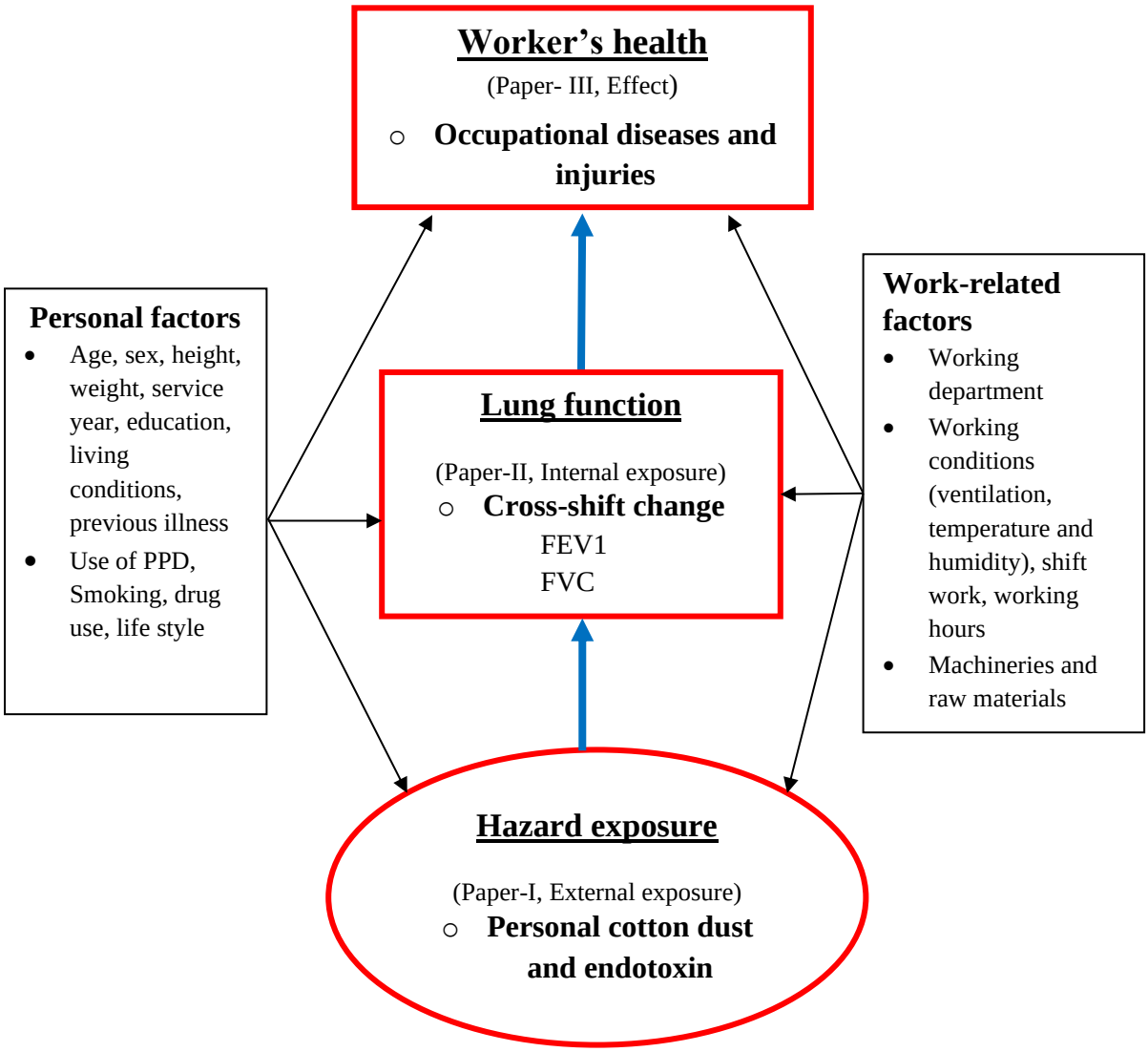

Figure 4: Conceptual framework of the exposure and effect relationships and the independent factors (personal and work-related). (*Source:* Author's design)

Chapter Three: Research objectives

3.1. General objective

This study aimed to measure personal inhalable cotton dust and endotoxin levels as external exposures, lung function status as an internal exposure and work-related diseases of workers as effects among workers of the integrated textile factories in Ethiopia, 2016-18.

3.2. Specific objectives

1. Measure the personal inhalable cotton dust and endotoxin exposure levels among workers in the integrated textile factories in Ethiopia
2. Examine cross-shift lung function reduction and chronic respiratory symptoms among workers in the integrated textile factories in Ethiopia
3. Explore recorded health problems of workers in the integrated textile factories in Ethiopia

Chapter Four: Research methods and materials

4.1. Study area

This study was conducted in three selected integrated textile factories (Factory 1, Factory 2 and Factory 3) situated at three different places in two regions; Amhara Regional State and Tigray Regional State (Figure 5). Factory 1 and Factory 2 were located in the Amhara Regional State, 550 km to the Northwest and 400 km to the Northeast of Addis Ababa, respectively. Factory 3 is located in the Tigray Regional State 1300 km to the North of Addis Ababa. The three factories were established in 1961, 1986 and 1992, respectively.

Figure 5**:** Map of location of the three integrated textile factories. Two in Amhara Regional State and one in Tigray Regional State. The green dots represent the spatial location of the factories sampled.

4.2. Study design and period

A cross-sectional study design was used to measure external exposure: the personal inhalable cotton dust and endotoxin concentration level among the integrated textile workers for the first study. The second study employed a comparative cross-sectional study design to compare the internal exposure level as cross-shift lung function, and chronic respiratory symptoms among the integrated textile factories and non-cotton exposed control groups. The third study employed a cross-sectional study design at the health facility using one-year clinic data to determine the effect of workers' diseases and injuries. The entire study was conducted between 2016 and 2018.

4.3. Source population

For the first and second study, all production workers in the integrated textile factories in Ethiopia that have four departments; spinning, weaving, finishing and garment for the exposed group. All workers in the water bottling and soft drink factories were source populations for the control group. For the third study, all workers (the production and support) in the integrated textile factories in Ethiopia were the source population.

4.4. Study population

The first and second study: Production workers in the four departments; spinning, weaving, finishing and garment found in the selected integrated factory one situated in Amhara Regional State. The three factories have similarity in production process, machine lay out and working condition, hence exposure assessment and cross-shift lung function test studies were conducted in one of the selected factory. And production workers from water bottling and soft drink factories found in the same region were the study population for the control group. The third study: All workers (production and support) found the three integrated textile factories situated in the two regional states.

4.5. Inclusion and exclusion criteria

The study included integrated textile factories that process mainly cotton and have factory clinics. Workers with age less than 18 years or who worked less than one year in the textile factory were

excluded. Semi-integrated textile factories without the four production departments were excluded in this study because the result may not represent the situation of most workers in the sectors. In the first and second studies, support department workers and apprentices were excluded because of the interest to measure the cotton dust and endotoxin exposure level of workers engaged in the production and comparing the respiratory effect against the non-exposed. Participants who had eye surgery, open chest or abdominal surgery, stroke, or heart attack specifically in the past three months were excluded from the spirometry test.

4.6. Selection of the study textile factories and control factories

There are 130 textile and apparel factories in Ethiopia, and 20 are considered integrated textile factories (6). This study focused on the integrated textile factories because they are a top priority in the national textile and apparel sector development program as they add value for major exports. Secondly, these companies encompass the spinning, weaving/knitting, finishing and garment, which can be found as standalone factories and are major employers in the sector.

Other factors include for the selection of the three integrated textile factories are operating in three shifts, a factory mainly processes cotton, a factory with an onsite health facility, and keeps workers' health records. A total of 7,992 workers were available in the selected three integrated factories during the study period, accounting for 17 % of the total workers recruited in the textile and apparel factories (6). The first and second studies were conducted in one of the three integrated textile factories. The third study includes all three integrated textile factories (Figure 6).

Also, two water bottling and soft drink factories were selected for control. Such factories are expected to have low dust exposure levels and have been used as controls in the comparative studies of respiratory health in other industries (177). The controls were used only for the second study; hence, selecting the two factories was from Amhara Regional State.

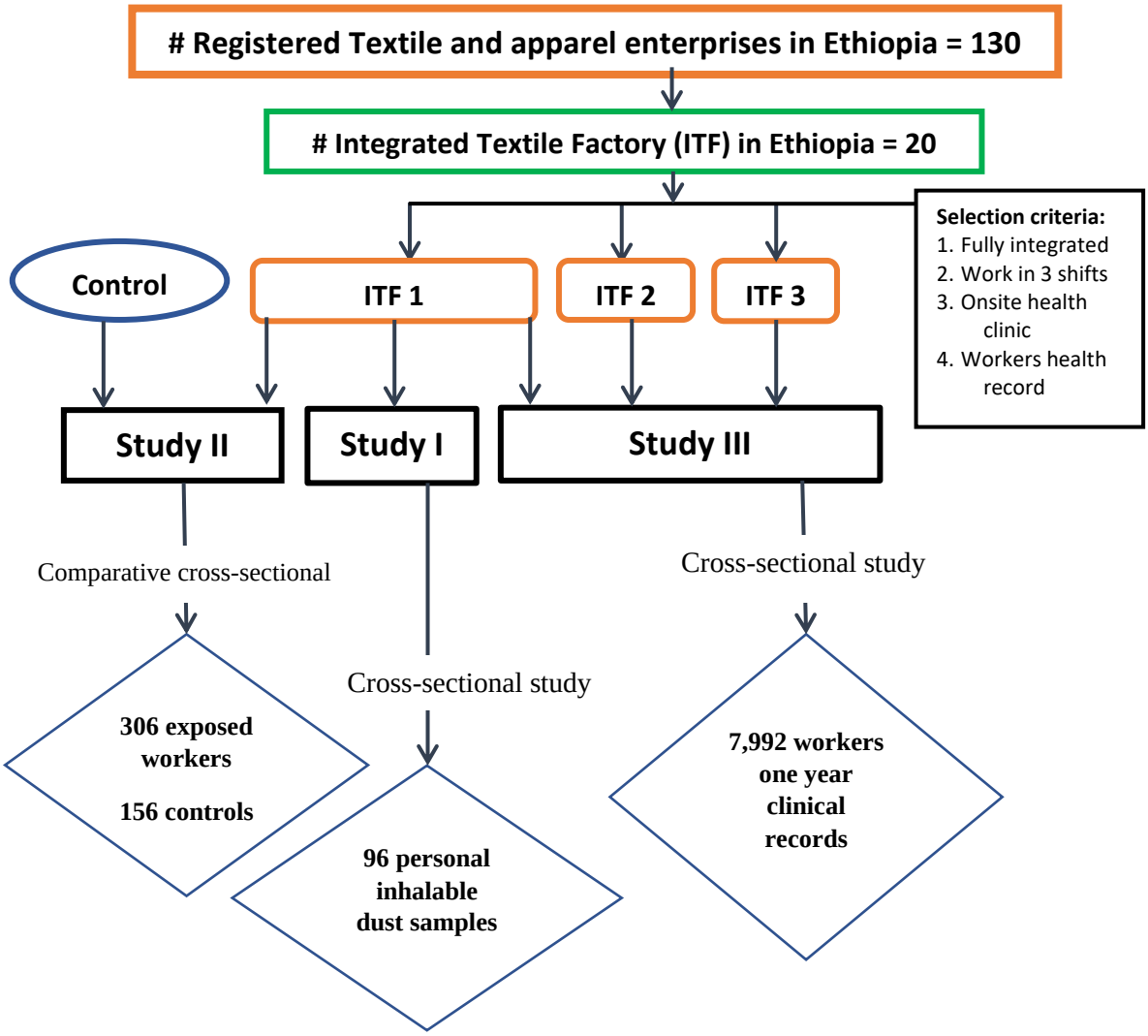

Figure 6: Schematic illustration of sampling methods for the three studies

4.7. Sample size determination and sampling techniques for

4.7.1. Cotton dust and endotoxin_ Study one

The four departments of the production process were classified into seven different similar exposure groups. Workers in each similar exposure group have shared the same work environment, machines, engage in common task and shared similar microclimate. Previous area measurements in the same factory showed the highest concentration and variability of cotton dust in the spinning department and the fabric-making section of the weaving department (50). Thus, four of the work

sections (carding, open-end, ring frame, and fabric making) were considered to be high-exposure groups with greater variability, whereas the other three work sections (preparatory, batching, and sewing) were considered to be low-exposure groups (Table 4). According to the recommendation for exposure assessment by Rappaport (178), 6-12 workers were selected from each similar exposure group for repeated personal air samples. Study participants were randomly selected from each homogenous group or work section using workers' records as a sampling frame. A total of 96 personal air samples were collected from 64 workers. Thus, repeated personal air samples were taken from 32 of these 64 workers (Table 4).

Table 4: Summary of task descriptions and product by section in the integrated textile factory

Department	Section	Description of tasks and activities	Products
Spinning	Carding	- Removing impurities and smoothing the raw cotton - Tasks include blowing, carding, and drawing	- "Silver" rope-like fibre
	Open-end	- Separating the silver rope into single fibres	- Yarn with high hairiness
	Ring frame	- Twisting the drafted strand with the required count and strength - Tasks also include roving and auto coning	- Higher-quality yarn with uniform structure and strength
Weaving	Preparatory	- Tasks include warping, winding, twisting, doubling, and sizing	- Strong, smooth, and elastic warp yarn
	Fabric making	- Combining warp and weft components to make a woven structure using a loom	- Fabric
Finishing	Batching	- Inspecting the quality of the fabrics, bleaching, and dying	- Good appearance of the fabrics
Garment	Sewing	- Pulling of sheets, cutting, and sewing	- Clothing

4.7.2. Lung function and respiratory symptoms – Study two

The sample size for the second study was calculated using double population formula considering the prevalence of respiratory symptoms and a cross-shift change in Forced Expiratory Volume for one second (FEV1). Using an OpenEpi software, the prevalence of respiratory symptoms among the exposed workers of 21 % and non-exposed workers 8.4 % (124), with a power of 90 %, 0.05 significance level, a ratio of 2:1 exposed vs non-exposed and 10 % non-respondents; 306 from cotton exposed and 156 from soft drink, a total of 462 subjects needed.

The sample size calculated for cross-shift lung function assessment was used by the Shanghai textile cohort study (42); the mean and standard deviation of cross shift FEV_1 among exposed and non-exposed of 58 (155) and 6 (131), respectively. A sample proportion of cotton exposed and control ratio of 2:1, with a power of 90 %, 0.05 significance level, and 10 % contingency for invalid spirometer measurements, 251 from cotton exposed and 128 from non-exposed; a total of 379 subjects needed (179). Therefore, the biggest sample size of 462 was taken for this study.

The total sample size for the cotton dust exposure was proportionally allocated to the four departments: spinning, weaving, finishing and garment. Then study subjects from each department were selected by simple random sampling technique using workers record as a sampling frame. Similarly, the control workers were selected from the production line of the water bottling and soft drink factory based on the list of workers from the human resource.

4.7.3. Registered diseases and injuries – Study three

One-year morbidity records of workers from the integrated textile factories were collected from clinics of the selected factories. All completed clinic visit records of workers from March 2016 to February 2017 were collected. A total of 7,992 workers' health records from the three textile factories were included (Figure 6).

4.8. Data collection

4.8.1. Personal inhalable cotton dust and endotoxin

Personal inhalable cotton dust was collected for an average duration of 4.3 hours (3.8–5.8 hours) from January to February 2017. Dust sampling was done using a conductive plastic inhalable conical sampler (CIS; JS Holdings, Stevenage, UK) mounted with a 37 mm glass-fibre (GFA) filter (Whatman International Ltd, Maidstone, UK) (180). The sampling head was attached to the worker's upper chest or lapel, not more than 30 cm away from the nose-mouth region (Figure 7). The pump operated at a flow rate of 3.5 l. min^{-1}. One blank per field site was collected every day as quality control (181). Pumps were paused during break time. Measurements were taken on randomly chosen days of the week, and the repeated sampling was conducted after a week.

A checklist was completed regarding tasks performed during sampling, characteristics of the working environment (air temperature, humidity, and type of ventilation system), and personal

protection used. The mean temperature in the working sections was 23.1–35.5 ºC, and the mean humidity was 40.6–47.1 %. The sampled filters were transported to Aarhus University, Denmark, for analysis.

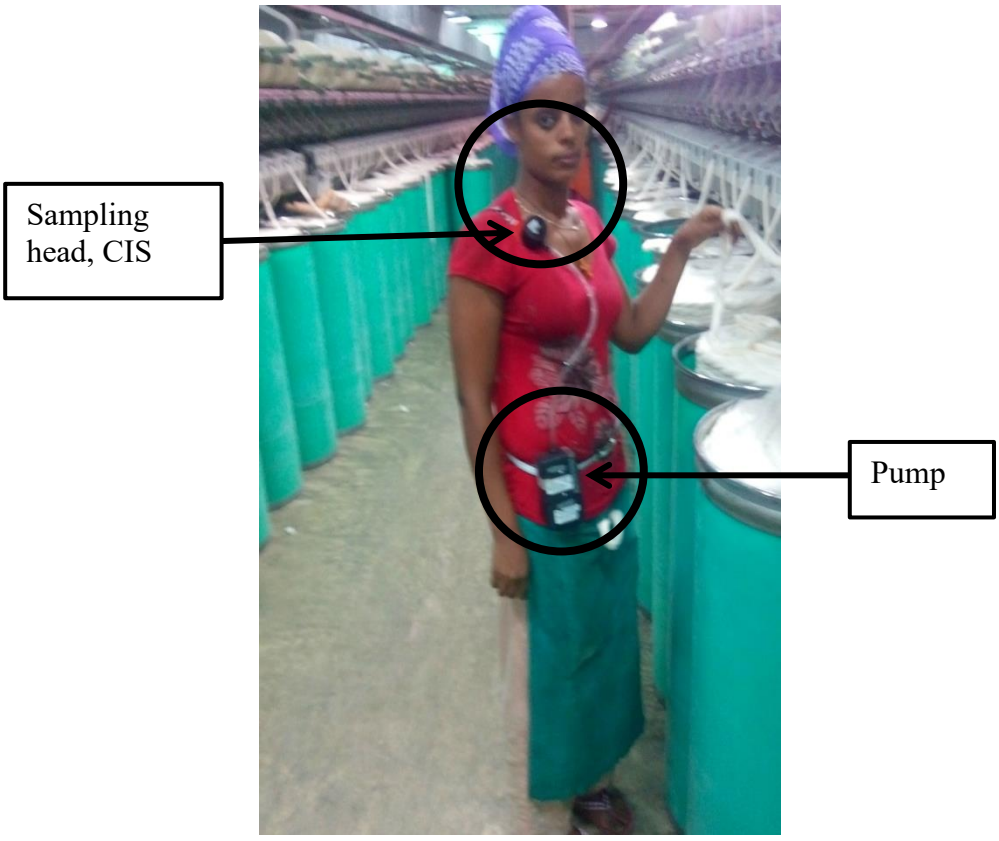

Figure 7: Personal dust sampling method from a worker's breathing zone (*Source*: Photo by Author)

4.8.2. Cross-shift lung function

Cross-shift lung function measurements performed using a computer-connected portable spirometer (SPIRARE 3 sensor model SPS 320) according to the ATS recommendations (182). The height and weight of participants were measured with an instrument approved by the Ethiopian national standard and accreditation agency. Three spirometer-trained operators (physician, nurse and the investigator) conducted the tests. A stepwise spirometer measurement protocol was prepared based on the ATS for field data collection. All spirometer tests were in a sitting posture. Three acceptable manoeuvres with consistent ("repeatable") results were retained, and the best values for Forced Vital Capacity (FVC) and Forced Expiratory Volume for one second (FEV1) were recorded (Figure 8).

The day and evening shift workers participated in the cross-shift lung function tests. Each worker examined before and after work. The day shift workers, before the shift and after shift spirometer measurements were done between 7:00 – 8:00 AM and 3:00 – 4:00 PM, respectively. Similarly, the evening shift workers, before the shift and after shift spirometer measurements were done at 3:00 – 4:00 PM and 10:00 – 11:00 PM, respectively.

Figure 8: Cross-shift lung function test using a computer connected spirometer (*Source*: Photo by Author)

4.8.3. Respiratory symptoms

Face-to-face interviews using the American Thoracic Society ATS-DLD-78-A standardized questionnaire used to assess respiratory symptoms (183). Four trained nurses conducted the interviews in a separate room in the factory clinics using a pre-tested questionnaire. The questionnaire included chronic cough symptoms, chest tightness, breathlessness and wheezing (yes/no), the previous history of respiratory health problems (pneumonia, tuberculosis, bronchitis, asthma, and chest injury).

Workers were asked about their socio-demographic and individual characteristics using a structured interview: age, sex, and educational level (primary, secondary, college and above), occupational history (total year of service in a similar sector, year of service in current department and year of service in other departments), working department and job, use of face mask (yes/no) and living conditions; cooking own food (yes/no); use of biomass fuel (yes/no) and living with

animals (yes/no). Participants' asked for smoking habits; have you ever smoked (yes/no), currently smoke (yes/no), number and year of smoking.

4.8.4. Registered work-related diseases and injuries

All workers from the three integrated textile factories were included in this study. Data were collected from both the department of human resources and clinics of the factories. The department of human resources provided the worker's profile in a Microsoft Excel spreadsheet. The spreadsheet contained records of workers with a unique identification number, date of birth, gender, date of employment, education, job type (recorded as operators of the different machines, electricians, mechanics, transporters, cleaners, supervisors, managers, engineers, firefighters, security guards, finance personnel, human resource personnel, drivers, chemists, secretaries, storekeepers and data coders), wages (recorded as Ethiopian Birr per month), and working departments (recorded as spinning, weaving/knitting, finishing, garment, maintenance/engineering and administrative).

Information about the health condition of the workers was obtained from the factory's clinic. Each worker has a patient card in the clinic labelled with the name and unique worker's identification number, similar to the records in the human resource department database. All diagnoses, the number of consultations and sick leave days were registered on the card. All clinical consultations of the workers during March 2016 to February 2017 were extracted from the health archives of the factories clinic and registered manually to a prepared logbook.

Clinic consultation for antenatal services, chronic disease follow-ups and visits to change the treatment regime were excluded from the study. A worker may visit the clinic for a new diagnosis or a previously known health problem requiring medical treatment. A worker may visit the clinic for consultations more than once for the same diagnosis category at a different time or for a different diagnosis.

4.9. Data management

In the first study, dust samples were analyzed gravimetrically (pre - and post - sampling weighing). An equilibration period of a minimum of 24 hours (22 ^{o}C, 45 % relative humidity) preceded filter weighing, which was performed using a Mettler UMT2 analytical scale (Mettler-Toledo Ltd,

Greifensee, Switzerland) with 0.001 mg precision. Based on sampling duration and air flow rate, personal level dust concentration was calculated in $mg.m^{-3}$. Sample extraction and endotoxin analysis were performed as described by Spann et al. (2008) in one of the duplicate dust samples randomly chosen (103). The extracts were analyzed for endotoxin in pyrogen-free water (1:200 dilution) using a quantitative kinetic chromogenic Limulus Amebocytes Lysate test (Kinetic-QCL 50- 650U kit, Lonza, Walkersville, Maryland, USA). Similarly, the personal level endotoxin concentration and amount of endotoxin per milligram of dust were calculated as $EU.m^{-3}$ and $EU.mg^{-1}$, respectively.

Questionnaire data were entered in an epidemiological information package (Epi-Info; version 7.1) (Centers for Disease Control and Prevention, Atlanta, GA, USA), developed by CDC of the USA, whereas lung function test data were entered into an Excel spreadsheet and then exported to IBM-SPSS version 22 (IBM, Armonk, NY, USA) for data cleaning and analysis. The lung function data was exported to SPSS and linked with the questionnaire data. The absolute values of the spirometer test measurements were used for the analysis of cross-shift change. The Global Lung Initiative Quanjer GLI-2012 multi-ethnic reference value for the African American ethnicity was used to estimate the predicted value and the proportion of subjects with FEV_1 and FVC below the Lower Limit Normality (LLN) (184). Missing values and outliers were checked using frequency tabulation and residual plotting and managed accordingly.

In the third study, the principal investigator checked the completeness of the data from the human resource database, which contained workers' profiles and the extracted diagnosis records from the factories clinic. The two data sources merged into one data set using workers ID. The merged data set was exported to IBM-SPSS (version 22, Chicago, IL, USA) for coding, cleaning and further analyses.

In this study, no specific diagnostic code system was used for the outcome variables. The clinic physicians used many diagnosis types; hence, the diagnoses were grouped into the following comprehensive categories: respiratory diseases, injuries, musculoskeletal disorders, allergy, ear diseases, eye diseases, gastrointestinal infections, mouth diseases, peptic ulcer diseases, reproductive health problems, skin diseases, neurologic and psychiatric diseases; rare and

unidentified diagnoses were grouped into another category—some disease-specific diagnoses used for diabetics, hypertension, anaemia, haemorrhoids, and urinary tract infection.

The two major independent factors were the work factor and the personal factor. Work factor is the primary exposure variable for comparison; it is classified into three groups; textile production department, garment production department and support process department. The textile department included spinning, weaving/knitting, finishing; the garment departments included workers in the garment production; whereas, the support process included maintenance and administrative workers. Each category represents and describes the peculiar nature of work-related circumstances found in each department, the machines, raw materials, work process, product, and the physical and psychosocial work environment. The textile and garment department workers are directly engaged in the production; they are more exposed to work environment hazards than the support department; hence the support department is a reference group during analysis. From the three integrated factories, the latest established, Factory 3, is also the reference category. Similarly, the personal factor, education is grouped into three categories: able to read and write, completed grade 1-10th, and those at the college level and above. Further, age is treated as a continuous variable, while male gender and higher educational status were reference groups during analysis.

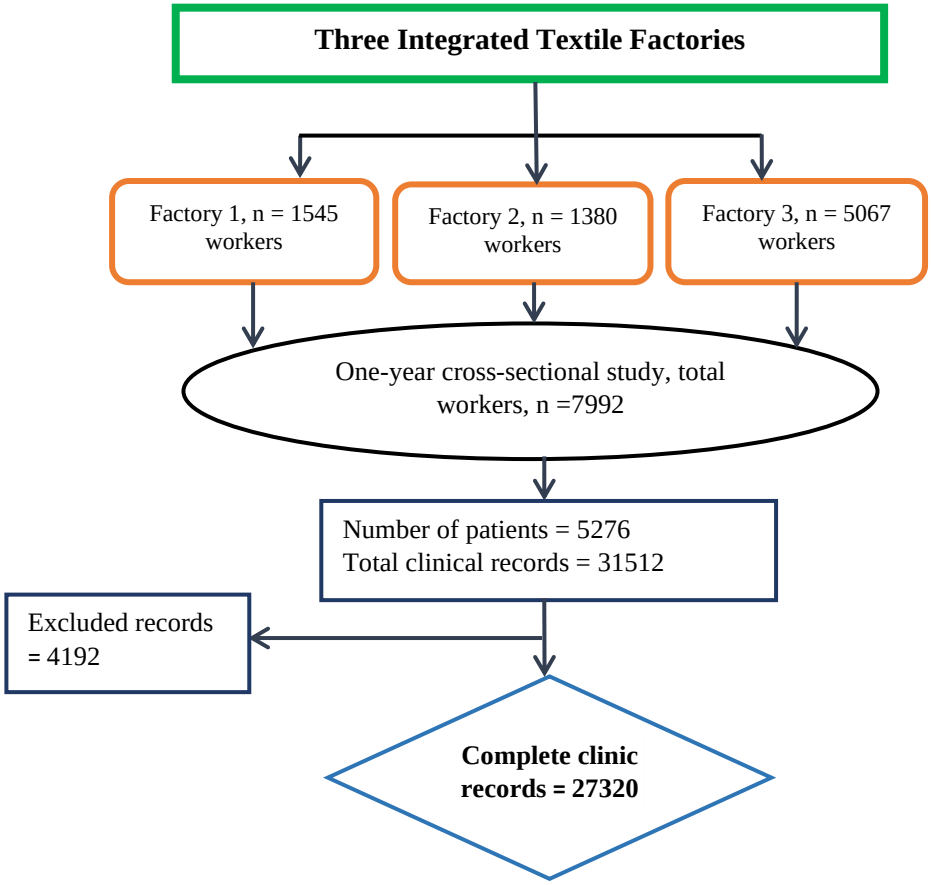

Figure 9: Schematic illustration of the data collection procedure for work-related diseases and injuries study

4.10. Data analysis

In the first study, the statistical analysis was performed using IBM-SPSS (version 22). Since the distribution of exposure data was skewed, then log-transformation was performed during statistical analysis. The average exposure level was presented by arithmetic mean (AM), geometric mean (GM) and geometric standard deviation (GSD). Independent *t*-tests were used to test the differences between two work sections within a department. Analysis of Variance (ANOVA) was performed to compare the GM of personal inhalable dust, endotoxin exposure levels, and endotoxin ratio to dust between departments and work sections. A post hoc test using Bonferroni was used to explore the difference between each work section. Pearson's correlation test analyzed the correlation between inhalable dust and endotoxin concentrations. Although the objective of the

first study was to estimate the personal cotton dust and endotoxin level, we have tried to further analyze mixed-effect model to determine the within and between person exposure variation. However, the model unable to converge due to some extreme measurement values.

In the second study, the independent t-test and the Chi-square tests were used to test the difference between groups for the continuous and categorical variables, respectively. In a separate analysis restricted to the textile group only, an ANOVA test was performed to assess the differences in continuous exposure variables between departments. Logistic regression analysis was used to compare the chronic respiratory symptoms between the textile workers and control adjusted for the variables age, gender, education, biomass fuel use, animals living in the house and working hours per week. A separate logistic regression analysis was also performed only among the textile group. Since the dust exposure varied among the textile departments, respiratory symptoms were analyzed by comparing each department with the garment department, as this had the lowest exposure levels. The result was reported as Adjusted Odds Ratio (AOR) with the corresponding 95 % confidence interval and the statistical significance level of a p-value. The absolute values of the spirometer test measurements were used for the analysis of cross-shift change. The cross-shift changes in FEV_1 (ΔFEV_1) and FVC (ΔFVC) were calculated accordingly:

$$\Delta\text{FEV1 (ml)} = \text{FEV1(pre} - \text{shift)} - \text{FEV1(post} - \text{shift)}$$

$$\Delta\text{FVC (ml)} = \text{FVC (pre} - \text{shift)} - \text{FVC(post} - \text{shift)}$$

The Global Lung Initiative Quanjer GLI-2012 multi-ethnic reference value for the African American ethnicity was used to estimate the predicted value and the proportion of subjects with FEV_1 and FVC below the LLN (184). A paired-samples t-test was performed to compare the pre and post-shift difference; an independent t-test was also performed to compare the cross-shift difference FVC and FEV_1 among the textile and control. Multiple linear regressions analysis was used to estimate the difference in cross-shift lung function parameters between textile workers and controls adjusting for age, sex, work shift, biomass fuel and animals living in the house. Due to the possible diurnal change in the lung function, the work shift was adjusted during analysis (185).

In the third study, descriptive statistics were used to present the different diseases observed and workers' characteristics. Also, the Pearson Chi-square test for categorical variables and

independent t-tests were performed on the continuous variables to compare disease prevalence among workers in the production and support process.

In the above study, logistic regression analyses were computed for crude and adjusted odds ratios (AORs) at 95 % CIs to identify factors associated with the diagnostic groups. The analysis was started by performing bivariate logistic regression for each disease group (outcome) with each independent variable. A disease diagnosis at least one time per worker counted for the outcome. A multicollinearity diagnosis test was performed among independent variables. The independent variables associated with the disease group at a significance level of $P < 0.2$ included in the multivariate logistic regression model.

4.11. Data quality assurance

In the first study, the air sampling procedure manual was prepared to guide the field data collection. Sample filters were labelled correctly by a unique ID, and details of each sample were recorded. During sampling, the pumps were checked every hour to ensure that the equipment is still working. For each sample filter, sample ID, flow rate, start and end time sampling was recorded. The calculated duration of the sampling period was checked against the recorded time on the reading from the pump. Field blanks were used to correct for any weight changes during sampling. The sampled filters were capped, packed, correctly labelled, put in a suitable glass box in hand luggage to prevent damage and transported to the Denmark Aarhus University laboratory for further analyses. The result of cotton dust was expressed in $mg.m^{-3}$ and the endotoxin concentration was given in $EU.m^{-3}$. Information regarding the worker, task-related characteristics and sampling result was entered in the Microsoft Excel sheet. The Microsoft Excel spreadsheet was exported to International Business Machine-Statistical Package for Social Sciences (IBM-SPSS) for further cleaning and analysis. The code and data were kept confidential and were accessed only by the research team.

In the second study, for chronic respiratory symptoms and lung function, standardized instruments adapted from ATS were used (183, 186). A manual was prepared to guide data collection to minimize the introduction of information bias. Before the actual data collection, a pre-test was conducted in a semi-integrated textile factory at Addis Ababa. Interview questions that were not easy for the participants to understand were rephrased to make them more easily understood. Well-

trained nurses conduct the interview. The principal investigator did close supervision during data collection, checked the collected data on-site for completeness and consistency of the interview questionnaire.

A stepwise lung function measurement procedure was adopted. The measurements were performed according to the ATS recommendation for spirometry (186). The height and weights of subjects were measured in a standing position using a standard instrument approved by the Ethiopian Standard Agency. Three trained spirometer operators (physician, nurse and the investigator) were involved in the test. Data collectors strictly followed the inclusion and exclusion criteria for participant enrolment to control selection bias during the data collection period. Participants were trained before the actual measurements using a short video of how to exhale. Three acceptable manoeuvres with consistent ("repeatable") results were retained, and the best of all of these was recorded. A difference between the largest and second-largest values for FVC and FEV_1 greater than 150 ml was rejected. Both the volume-time and flow-volume curves were evaluated for evidence of technical errors. If erroneous curves are detected, additional maneuvers were done.

In the third study, data extraction format and criteria were prepared. Four trained nurses at each clinic participated in the data extraction from patient cards. The principal investigator and supervisor in each factory monitored the data collection process and the data quality. Then clinic consultation for antenatal service, chronic disease follow-ups and visits for treatment regime changes were excluded from data extraction. From the 31,512 clinic consultations, 4,192 were excluded for the reasons mentioned above (Figure 9). Two data entry clerks participated to ensure quality.

4.12. Operational definitions

Cough: Participants were considered to have cough symptoms if they answered "yes" to at least one of the following four questions: Do you usually cough first thing in the morning, cough during the day or night, cough as much as four to six times a day in a week, or cough most days during three consecutive months during the year?

Chest tightness: Participants were considered to have chest tightness if they answered yes to the following questions: Do you usually experience chest tightness while at work or just after work?

Breathlessness: Participants were considered to have breathlessness if they answered yes to the question: Do you usually get troubled by shortness of breath when walking hurriedly on level ground or walking up a slight hill, or get shortness of breath when walking at your own pace on level ground?

Wheezing: Participants were considered to have wheezing if they answered yes to the question: Does your chest ever sound wheezy or emit a whistling sound?

Smokers: These were participants who currently smoke or had smoked more than 20 packs of cigarettes during their lifetime or more than one cigarette a day for one year.

Never smoker: participants who had never smoked.

Current smoker: participants who are currently smoking or stopped smoking less than one year ago.

FEV_1 is the maximal volume of air exhaled in the first second of a forced expiration from a position of full inspiration

FVC is the maximal volume of air exhaled with a maximally forced effort from a maximal inspiration

Cross-shift change in lung function: The difference in lung function measurement parameters before and after work shift in a working day using spirometer.

Integrated textile factory: A textile factory having four distinguished production departments Spinning, Weaving, Finishing and Garment

Control: Workers in the water bottling and soft drink factories.

4.13. Ethical considerations

Ethical approval was obtained from the Institutional Review Board of Addis Ababa University College of Health Sciences (Protocol number: 057/16/SPH). An official request letter was sent from Addis Ababa University School of Public Health to the factories and was discussed at

meetings between the research investigator and the factory managers. The factory management approved the study and allowed access to the factories. Written informed consent was obtained from all study participants, and participation in the study was voluntary. Confidentiality was ensured by not using the names of the workers and factories in any reports. Participants with lung function impairments were advised to consult the factory clinics.

4.14. Summary of dissertation work by objective and methods

The following table summarizes the details presented in the research methods and materials sections for each study: the objective, the study design, study subject, sample size, data collection techniques and analysis (Table 5).

Table 5: Summary of the research methods for each objective

Objective	Study design	Study subject	Sample size	Data collection	Analysis
Study I: Measure personal inhalable cotton dust and endotoxin exposure levels among workers in the integrated textile factories in Ethiopia	Cross-sectional	Production workers in an integrated textile factory	96 personal inhalable dust samples	- Personal dust samples from workers breathing zone using a conductive plastic inhalable conical sampler (CIS) mounted with a 37 mm glass-fibre (GFA) filter attached to Side Kick Casella pumps with a flow rate of 3.5 L/ min - Observational checklist	-Arithmetic mean (AM) -Geometric mean (GM) -Geometric standard deviation (GSD) - T-test - ANOVA
Study II: Examined cross-shift lung function reduction and chronic respiratory symptoms among workers in the integrated textile factories in Ethiopia	Comparative cross-sectional study	Production workers in an integrated textile factory and workers in water bottling and soft drink factories	- 306 workers from the integrated textile factory - 156 workers from water bottling and soft drink factories	-Chronic respiratory symptoms were assessed using the ATS questionnaire - Cross-shift lung function tests measured by a portable spirometer (SPIRARE 3 sensor model SPS 320)	- Descriptive statistics (AM, SD) - Independent t-tests - Paired t-test - Pearson Chi-square test - ANOVA - Fisher's exact test - Logistic regression analysis - Multiple linear regression - Quanjer GLI-2012
Study III: Explore registered health problems of workers in the integrated textile factories in Ethiopia	Cross-sectional study	All workers in the integrated textile factories	7,992 workers from three integrated textile factories	- One-year clinical diagnosis of all workers was collected from the factory clinic - Worker's profile was collected from the human resource	-Descriptive statistics (AM, SD) - Pearson chi-square test - Logistic regression analysis

Chapter Five: Results

5.1. Study I: Occupational exposure to dust and endotoxin

Sixty-four workers from seven working sections in the production departments of the integrated textile factories were sampled for the personal inhalable cotton dust air study; 89 % were operators and 11 % were transporters or cleaners with a repeated measurement with 96 exposure samples were collected and one sample discarded from the analysis due to sample overload. The overall personal inhalable dust exposure had a GM of 0.75 $mg \cdot m^{-3}$ and GSD of 2.6 (Table 6). The highest level of inhalable dust exposure was measured in the carding section (GM = 1.34 $mg \cdot m^{-3}$), while the lowest measurements were recorded in the ring frame, sewing, and preparatory sections (0.42 $mg \cdot m^{-3}$, 0.46 $mg \cdot m^{-3}$, and 0.47 $mg \cdot m^{-3}$, respectively). The inhalable dust exposure was significantly different between the sections within both the spinning and the weaving departments, and 11 % of the cotton dust measurements were above the workplace exposure limit (WEL) of the Health and Safety Executives (HSE) of the UK (34).

The overall personal endotoxins exposure had a GM of 831 $EU \cdot m^{-3}$ and GSD of 5.4 (Table 6). The highest personal endotoxins exposure was measured in the carding section GM of 6,381 $EU \cdot m^{-3}$, while the lowest exposure was found in the sewing section in the garment department GM of 76 $EU \cdot m^{-3}$. The mean endotoxins exposure level was significantly different across departments; there was also a significant difference observed among sections in the spinning department. About 89 % of the endotoxins measurements were above the occupational exposure limit value of 90 $EU \cdot m^{-3}$ recommended by the Dutch Expert Committee on Occupational Standards (35).

The ratio of endotoxins per mass of dust was higher in the first two departments of spinning and weaving (3,876 and 2,242 $EU \cdot mg^{-1}$, respectively) than in the last two departments of finishing and garment (340 and 358 $EU \cdot mg^{-1}$, respectively) along the production line. A significant difference was observed within the departments and work sections ($p < 0.001$ (Table 6).

Table 6: Variation in personal exposure to inhalable dust endotoxin, ratio of endotoxin per mg dust and correlation between dust and endotoxin across departments and sections in an integrated textile factory

Department and section	Inhalable dust ($mg \cdot m^{-3}$)			Endotoxin ($EU \cdot m^{-3}$)		Ratio of endotoxin to dust ($EU \cdot mg^{-1}$ dust)		Correlation b/n dust and endotoxin
	n	AM (Range)	GM (GSD)	AM (Range)	GM (GSD)	AM (Range)	GM (GSD)	r
Spinning	**48**	**1.3 (0.1–8.8)**	**0.71 (2.8)** * a	**4041 (80–30801)**	**1560 (5.0)** ** a	**3876 (106 -15432)**	**2271 (3)** ** a	**0.585** ** b
1. Carding	18	2.1 (0.5–8.8)	1.34 (2.4)	8665 (2344–30801)	6381 (2)	6526 (611 -15432)	5032 (2)	
2. Open-end	15	0.8 (0.2–3.6)	0.57 (2.1)	1824 (495–7077)	1315 (2)	2784 (407 -4811)	2323 (2)	
3. Ring frame	15	0.9 (0.1–7.6)	0.42 (3.1)	1017 (80–5877)	375 (4)	1966 (106 -8083)	902 (4)	
Weaving	**27**	**1.1 (0.1–6.7)**	**0.78 (2.3)** * a	**1944 (74–11492)**	**1086 (3.0)**	**2242 (350 -17938)**	**1394 (2)** * a	**0.650** ** b
1. Preparatory	12	0.7 (0.1–2.1)	0.47 (2.4)	2593 (74–11492)	992 (4)	3756 (350 -17938)	2097 (3)	
2. Fabric making	15	1.5 (0.7–6.7)	1.16 (1.8)	1424 (455–4818)	1167 (2)	1031 (584 -1332)	1005 (1)	
Finishing c	**11**	**2.2 (0.3–10.5)**	**1.25 (2.8)**	**465 (34–1667)**	**258 (3)**	**340 (32 -1406)**	**206 (3)**	**0.571**
Garment d	**9**	**0.5 (0.4–0.7)**	**0.46 (1.2)**	**393 (12–2476)**	**76 (6)**	**358 (25 -2464)**	**112 (4)**	**-0.052**
All	**95**	**1.3 (0.1–10.5)**	**0.75 (2.6)** ** e	**2647 (12–30801)**	**831 (5.4)** **e** * f	**2656 (3418)**	**119 (5)** ** e **f	**0.450** ** b

AM = Arithmetic mean; GM = Geometric mean; SD = Standard deviation; GSD = Geometric standard deviation; n = Number of samples; [a] Test for differences in means between sections within departments; [b] Test for correlation between inhalable dust and endotoxin; [c] Batching section in the finishing department; [d] Sewing section in the garment department; [e] Test for differences in means between sections in the factory; [f] Test for differences in means between departments in the factory; *p-value < 0.05; ** p-value < 0.001.

5.2. Workplace assessment

The observational checklist assessment in Factory 1 indicates, almost all workers were observed without wearing the proper respiratory protective devices. However, some workers in the spinning and weaving department cover their noses and mouth with pieces of clothes. A portable local exhaust ventilation system was installed in the ring frame and weaving machines at the spinning and weaving department to collect cotton fluffs from the workstations. Specifically, the spinning department has an extra underground structure that can collect cotton dust through the openings on the floor by negative pressure. Both the finishing and garment departments have no mechanical ventilation system for dust removal. The air conditioning system is a function only in the spinning and weaving department; for production purposes, the humidity and temperature are monitored in these departments. The air temperature and humidity levels were monitored for 24 hours at each work section during the data collection period using a temperature and humidity data logger; the average indoor air temperature and humidity range 26-28 ^{o}C and 45-46 %, respectively (Table 7). The factory does not have trained occupational health professionals; hence, exposure measurements from workers or the working environment were not practiced in the factory. The labour inspectors also conduct workplace hazard assessments without the use of measurement devices.

Table 7: Indoor air workstation measurement results of air temperature and humidity in the integrated textile factory

Department	Work sections	Average Temperature (^{o}C)	Average Humidity (%)
Spinning	Carding	26	46
	Open-end	27	45
	Ring frame	28	45
Weaving	Preparatory	28	45
	Fabrics making	25	46
Finishing	Finishing	27	45
Garment	Sewing	26	46

5.3. Study II: Lung function and respiratory symptoms

5.3.1. Socio-demographic characteristics of respondents

In the cross-shift lung function and respiratory symptoms study, a total of 303 production workers from the integrated textile factory and 155 controls from the water bottling and soft drink factories participated, making a response rate of 99 %. The average age of participants for this study from textile workers (exposed) and control is 34 years and 33 years, respectively, and the average height of workers was 166 cm and 165 cm, respectively. Only two workers from the textile industries were current smokers. There was no difference in age, sex and height between textile and control workers. However, there was a difference in educational level, biomass fuel for cooking, animals in the house and working hours per week. There was also no difference in the number of workers who participated in the day and evening work shifts (Table 8).

Table 8: Socio-demographic characteristics of study participants from integrated textile factories and controls for the cross-shift lung function and respiratory symptoms study, n=458

Variable	Textile workers N = 303	Controls N = 155	P-value
Age in years, AM (Range)	34 (22-63)	33 (19-62)	0.104[a]
Height in cm, AM (Range)	166 (144-186)	165 (149-185)	0.059[a]
Service in years, AM (Range)	10 (1-38)	9 (1-30)	0.138[a]
Body mass index, AM (Range)	22 (14-37)	22 (17-40)	0.238[a]
Sex:			
Female, n (%)	146 (48)	82 (53)	0.339[b]
Male, n (%)	157 (52)	73 (47)	
Education:			
Primary school, n (%)	59 (19)	24 (15)	
High school, n (%)	114 (38)	45 (29)	0.038[b]
College and above, n (%)	130 (43)	86 (55)	
Housing and living condition:			
Cook own food, n (%)	219 (72)	101 (65)	0.116[b]
Use biomass fuel, n (%)	198 (65)	123 (79)	0.002[b]
Ever-smokers, n (%)	5 (2)	2 (1)	1[c]
Animals living in the house, n (%)	57 (19)	15 (10)	0.011[b]
Previous respiratory illness, n (%)	13 (4)	2 (1)	0.088[b]
Working schedule:			
Working hours per week, AM (SD)	48 (1.4)	50 (6.4)	<0.001[a]
Day shift [d], n (%)	183 (60)	101 (65)	0.320 [b]
Evening shift [e], n (%)	120 (40)	54 (35)	

[a] Independent t-test; [b]Pearson Chi-square test; [c]Fisher's exact test; d = number of workers in day shift during lung function test; e = number of workers in evening shift during lung function test AM = Arithmetic mean; SD = Standard deviation; N = Number of workers in textile/control; n = Number of workers within the group

5.3.2. Cross-shift lung function reduction

In the exposed group, there was a significant reduction in both FEV_1 (123 ml) and FVC (129 ml) across the work shift ($p < 0.001$) (Table 9). In the control group, the across-work shift change in FEV_1 (14 ml) or FVC (12 ml) was not significant. Workers in all departments in the textile factory except the finishing department had a significant across-shift decrease in spirometry for both FEV_1 and FVC. The highest and the lowest across-shift change for FEV_1 and FVC were in the spinning and finishing departments, respectively. There was no difference in cross-shift change FVC comparing the textile factory's finishing department and the control. About 4.4% of the participants had FEV1/FVC < 70%; among exposed (5.4%) and among control (2.0%), however, the difference was not significant.

Table 9: Comparison of before and after shift and cross-shift lung function parameters between the integrated textile factory workers and controls, n=340

Variable	n	**FEV_1, ml** Before shift	**FVC, ml** Before shift	**Δ FEV_1, ml**		**ΔFVC, ml**	
		AM (SD) [a]	AM (SD) [a]	AM (SD)	p-value [b]	AM (SD)	p-value [b]
Control	101	2910 (637) ns	3567 (781) ns	14 (160)	*	12 (174)	*
Textile	239	2999 (715) **	3736 (865) **	123 (207)		129 (286)	
Spinning	63	2815 (635) **	3489 (757) **	142 (250)	**	165 (344)	**
Weaving	82	3310 (628) **	4132 (746) **	131(183)	**	137 (241)	**
Finishing	42	3053 (760) *	3810 (929) ns	81(229)	*	88 (309)	ns
Garment	52	2688 (711) **	3350 (858) *	121(162)	**	105 (256)	*

[a] Paired t- test for the before and after shift comparison; [b] Independent t- test for the cross-shift change (FEV1 and FVC) between textile and control, and between the respective departments and control; Significance level at p value, ns= $p \geq 0.05$; *= $P < 0.05$; **= $p < 0.001$

In the multiple linear regression analysis, the cross-shift change for both FEV_1 and FVC were significantly higher in the exposed compared to the control when adjusted for age, work shift, use of biomass fuel for cooking and animals living in the house (Table 10).

Table 10: Multiple linear regression of cross-shift change FEV_1 and FVC with exposure status among textile workers and controls, n=340

Variable	B	SE	Beta	p-value	95 % CI
Δ FEV_1, R^2adj = 0.105, n = 340					
Constant	-0.143	0.058		0.014*	-0.257 – -0.029
Controls (0), Exposed (1)	0.090	0.024	0.206	<0.001*	0.043 – 0.137
Day shift (0), Evening shift (1)	0.089	0.022	0.220	<0.001*	0.046 – 0.132
Animals in the house (0/1)	-0.045	0.030	-0.080	0.132	-0.103 – 0.013
Use biomass fuel (0/1)	0.014	0.023	0.0334	0.530	-0.031– 0.060
Female (0), Male (1)	-0.021	-0.021	-0.052	0.332	-0.063 – 0.021
Age, years	0.002	0.001	0.105	0.050	0.000 – 0.004
ΔFVC, R^2adj = 0.107, n = 340					
Constant	-0.119	0.076		0.009*	-0.349 – -0.050
Controls (0), Exposed (1)	0.097	0.031	0.169	0.002*	0.035 – 0.159
Day shift (0), Evening shift (1)	0.124	0.029	0.234	<0.001*	0.068 – 0.181
Animals in the house (0/1)	-0.083	0.039	-0.113	0.033*	-0.159– -0.007
Use biomass fuel (0/1)	0.040	0.030	0.071	0.184	-0.019– 0.099
Female (0), Male (1)	-0.051	0.028	-0.098	0.070	-0.107 – 0.004
Age, years	0.003	0.001	0.123	0.022*	0.000 – 0.006

* Significant P-value; SE, Standard Error; R^2adj, Adjusted R square; B, Coefficient; CI, Confidence interval

5.3.3. Respiratory symptoms

The prevalence of chronic respiratory symptoms was higher among the textile workers (range 20-37 %) than controls (range 5-17 %). Breathlessness was the most prevalent chronic respiratory

symptom (37 %) among textile workers and had an odds ratio relative to controls of (9.4) when adjusted for the variables: biomass fuel, education, animals living in the house and working hours per week (Table 11). Generally, 54 % of the textile workers and 28 % of the controls reported having at least one chronic respiratory health symptom.

Table 11: Prevalence of chronic respiratory symptoms among workers in the textile factories and controls

Variable	**Textile workers (N = 303)**	**Controls (N = 155)**	[a] **Adjusted Odds Ratio (95 %CI)**
Respiratory symptoms	n (%)	n (%)	
Cough	70 (23)	7 (5)	7.8 (3.1 – 17.9)**
Chest tightness	101 (33)	27 (17)	2.5 (1.5 – 4.2)**
Breathlessness	112 (37)	9 (6)	9.4 (4.4 – 20.1)**
Wheezing	60 (20)	20 (13)	1.6 (0.9 – 2.8) ns
Atleast one respiratory symptom	**163 (54)**	**43 (28)**	**3.1 (2.0 – 4.9)****

[a] Logistic regression analysis adjusted for biomass fuel, education, animals living in the house and working hours per week; ** = P < 0.001; ns = P > 0.05; N =number of workers in the groups; n = number of workers with symptom

Workers in the finishing department reported the highest prevalence of cough and breathlessness. These workers had a significantly higher prevalence of cough than the garment workers (OR = 8.1), breathlessness (OR = 3.0) and of at least one respiratory symptom (OR = 3.9) adjusted for gender, education, job, work in other dusty workplaces, cooking own food and animals living in the house. Workers in the spinning and weaving units had a significantly higher prevalence than garment workers of chest tightness (OR = 2.7) and cough (OR = 3.7), respectively. The finishing department workers were older and had served more years in the textile industry than workers in the spinning and weaving departments (Table 12). The majority (84.6 %) of the finishing department workers had previously worked in other departments of the textile factories.

Table 12: Workers age, service year and respiratory symptoms across the different departments of the textile factory, n=303

Departments	Age, Year	Service years in the textile			Respiratory Symptoms				
		In the current department	In other departments	Total	At least one symptom	Cough	Chest tightness	Breathlessness	Wheezing
	AM (SD)	AM (SD)	AM (SD)	AM (SD)	n (%)	n (%)	n (%)	n (%)	n (%)
Spinning, N = 81	33 (9)	6 (6)	2 (4)	8 (7)	42 (52) ^{ns}	12 (15) ^{ns}	34 (42) *	30 (37) ^{ns}	15 (18) ^{ns}
Weaving, N = 101	33 (10)	8 (8)	1 (3)	10 (9)	54 (53) ^{ns}	31 (31) *	30 (30) ^{ns}	31 (31) ^{ns}	21 (21) ^{ns}
Finishing, N = 52	37 (10)	7 (6)	7 (6)	13 (9)	37 (71) *	21 (40)*	20 (38) ^{ns}	27 (52) *	9 (17) ^{ns}
Garment, N = 69	35 (11)	5 (2)	6 (6)	11 (7)	30 (43) $^{+}$	6 (9) $^{+}$	17(25) $^{+}$	24 (35) $^{+}$	15 (22) $^{+}$
P value	0.040 ^{a}	0.007 ^{a}	<0.001 ^{a}	0.024 ^{a}	0.004 ^{b}	<0.001 ^{b}	0.001 ^{b}	0.001 ^{b}	0.413 ^{b}

a p-value of ANOVA test; AM = Arithmetic mean; (SD) = Standard deviation; N = number of workers in the department; n = number of workers have symptom; b p-value for Pearson chi-square difference among departments; * and *ns* are significance level at P-value * = $p < 0.05$ and *ns* = $p \geq 0.05$ for logistic regression adjusted for animals live in a house, cook own food, education, job, gender, age, work in other dusty workplaces; + Reference department because of low exposure level

5.4. Study III: Registered diseases and injuries

5.4.1. Socio-demographic characteristics of workers in the integrated textile factories

In the work-related diseases and injuries study, the clinical diagnoses of 7,992 workers from the integrated textile factories were recorded; females were 60 %, the average age of the workers was 40 years and the average years at work were 11 years. The majority of the workers were engaged in the garment department (44 %) whereas, the support department accounted for at least 16 % of the study sample (Table 13).

Table 13: Sociodemographic characteristics of participants from three integrated textile factories for the work-related diseases and injuries study, n=7,992

Variables	Category	Frequency	Percent (%)
Gender	Male	3,214	40
	Female	4,778	60
Education	Read and write	555	7
	Grade 1-10	4,188	52
	College diploma	2,827	35
	Degree	422	5
Working department	Textile	3,165	40
	Garment	3,515	44
	Support	1,312	16
Worker health status	Diagnosed	5276	66
	Not diagnosed	2716	34
Variables	**Measurement**	**Mean**	**Standard Deviation**
Age	Year	40	10
Service	Year	11	10
Salary	Ethiopian Birr	1,747	1,361

5.4.2. Registered work-related diseases and injuries

A total of 27,320 consultations for different diagnoses were made for the 5,276 (66 %) diagnosed workers, on average about five consultations per worker. The prevalence of respiratory diseases was the highest (34 %) followed by MSD (29 %), gastrointestinal infection (21 %), peptic ulcer (19 %) and injury (17 %). On the other hand, anemia, hypertension and diabetics were the lowest prevalent diseases (1 %) (Table 14). Other diseases category in Figure 10 includes cancer, cardiac,

kidney, goitre, chronic liver disease, chronic osteomyelitis, rectal prolapse, appendicitis, tumour, bone problem, insomnia and unknown health problem. The probability of a worker for repeated attack by the same disease in a year was highest for anemia (91 %) followed by hypertension (85 %), whereas the lowest probability of a repeated attack was for respiratory diseases (58 %).

A total of 16,993 workdays were lost due to sick leave in the registration period. The injury was the leading cause of sick leave (2,951 workdays) followed by respiratory diseases (2,327 workdays). Of all the different diagnoses, the highest average workdays lost per worker was injury (2.1 days/worker/injury), followed by hypertension (1.8 days/worker/hypertension). The number of workdays lost due to illness was 9,027; 6,415 and 1,481 among the textile, garment and support workers, respectively. The highest proportion of workday lost per the size of workers was observed in the textile department (Table 14).

Table 14: Prevalence of diseases, frequency of consultations and workdays among workers in the textile factories from 2016-2017, n=7,992

Diagnosis	Number of clinical consultations [a]						Prevalence n [b](%)	Total consultations	Sick leave (workdays)
	One	Two	Three	Four	Five	Six and more			
Respiratory diseases	1593	616	283	127	54	38	2711 (34)	4691	2327
Musculoskeletal disorders	1365	549	237	94	45	22	2312 (29)	3916	1949
Gastrointestinal infection	1212	341	73	20	19	1	1666 (21)	2294	931
Peptic ulcer	1017	336	116	39	16	5	1529 (19)	2306	1323
Injury	1028	245	75	28	9	3	1388 (17)	1918	2951
Acute febrile illness	804	289	148	52	21	11	1325 (17)	2210	1822
Neurological and psychiatric	950	281	81	25	11	7	1335 (17)	1894	810
Urinary tract infection	695	195	50	21	4	3	968 (12)	1358	527
Skin diseases	678	150	34	10	4	0	876 (11)	1140	475
Mouth disease	726	141	31	7	0	0	905 (11)	1129	397
Eye diseases	675	116	31	6	5	0	833 (10)	1049	482
Allergy	516	97	21	7	1	0	642 (8)	806	416
Reproductive health problem	370	99	24	6	3	0	502 (6)	679	547
Ear problem	218	23	6	4	0	0	251 (3)	298	92
Hemorrhoids	102	24	3	2	1	0	132 (2)	172	77
Hypertension	97	9	4	1	0	0	111 (1)	131	200
Anemia	106	7	1	1	0	0	115 (1)	127	59
Diabetic	41	17	7	1	1	0	67 (1)	105	99
Others	579	160	41	13	2	3	798 (10)	1097	1509
Total								**27320**	**16993**

[a] Number of workers at different consultation frequency and [b] number of workers diagnosed with the disease at least one time

About 69 %, 65 % and 60 % of the textile, garment and support workers, respectively, developed a disease during the study period. The proportion of textile workers accounted for 40 % of the total workforce; however, the textile workers' overall proportion of disease burden was about 49 %. Most of the diseases were prevalent and above the overall average among textile department workers, but gastrointestinal infection, neurology and psychiatric, urinary tract infection, reproductive health, and anemia were prevalent among the garment department workers. Respiratory disease was the most prevalent in each of the three working departments; 37 %, 33 % and 31 % among textile, garment and support departments, respectively (Figure 10).

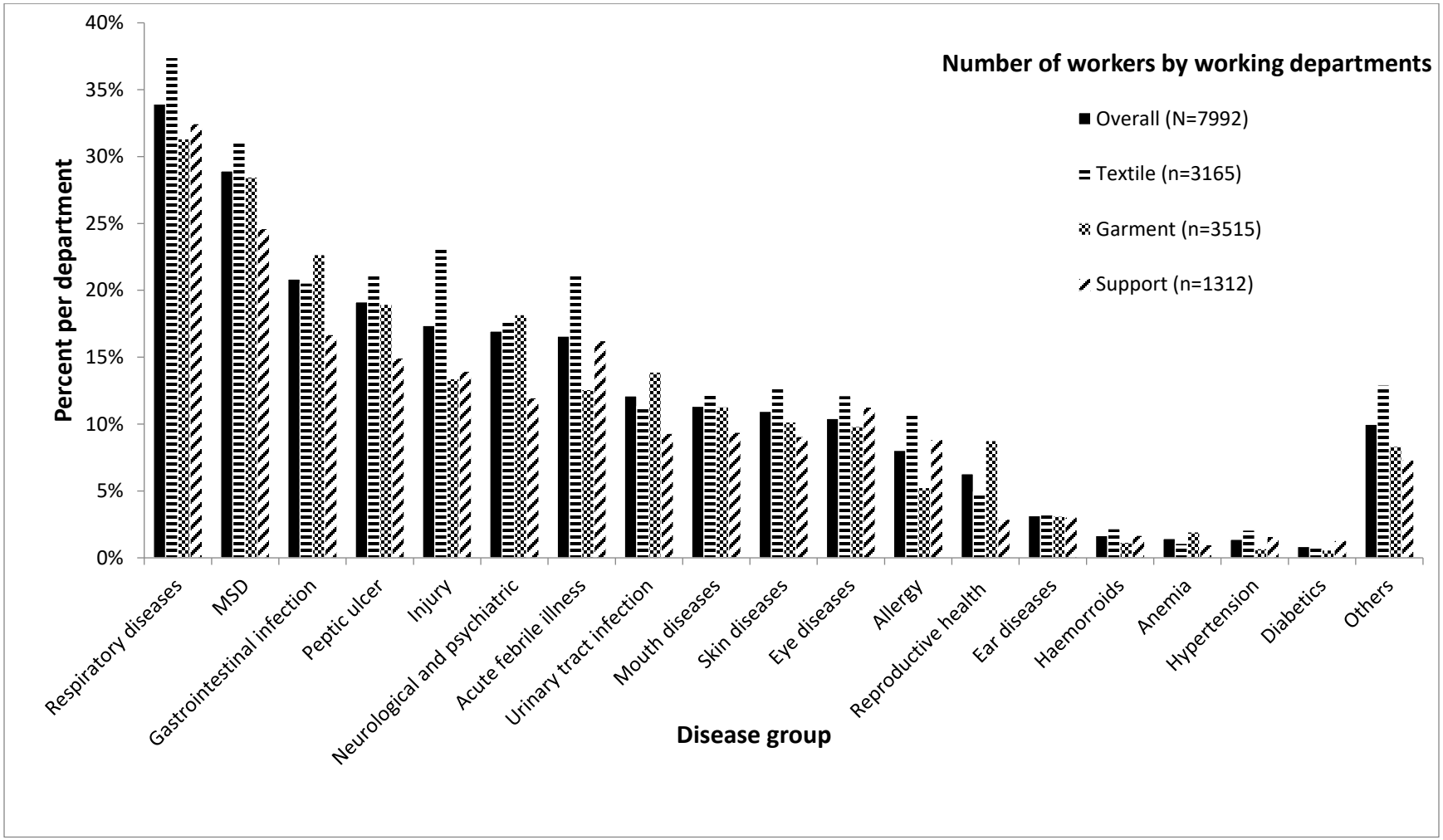

Figure 10: Prevalence of diseases by working departments in the integrated textile factories from 2016-2017

5.4.3. Factors associated with work-related diseases and injuries

Workers in the textile department, females and workers with lower educational status (only read and write) had a significantly higher odds ratio for most diseases that occurred in the integrated textile factories (Table 15). Textile department workers had significantly higher odd ratios for most diseases (AOR: 1.17-1.85) compared to other department workers (non-textile workers). Acute febrile illness, allergy, eye diseases, hemorrhoids, mouth diseases, skin diseases, peptic ulcers, hypertension, respiratory diseases, injury, MSD and rare diseases were the most predominant diseases. The garment department workers had significantly higher ORs than support department workers except for gastrointestinal infection (Table 15).

Female workers also had significantly higher ORs for most diseases (AOR: 1.27 – 14.89) compared to male workers who are prone to anemia, mouth diseases, reproductive health, peptic ulcer, urinary tract infection, hypertension, neurologic and psychiatric, MSD and rare diseases, but showed better protection from injury and eye diseases. Similarly, workers with lower educational status had a significantly higher risk (AOR: 1.31-1.74) of acute febrile illness, allergy, urinary tract infection, peptic ulcer, injury, MSD and rare diseases. This group had never shown protection from any diseases than other workers with a higher educational level.

Table 15: **Multivariate analysis results of disease group among workers in the integrated textile factories (n=7,992)**

Disease	Factor variables	Bivariate analysis COR (95 %CI)	Multivariate analysis[+] AOR (95 %CI)	P-value
	Textile	1.24 (1.08-1.42)	1.22 (1.06-1.41) *	0.007
	Garment	0.95 (0.83-1.09)	1.30 (1.11-1.52) *	0.001
	Female	0.91 (0.82-1.00)	1.13 (1.01-1.26) *	0.033
Respiratory diseases	Read and write	1.48 (1.25-1.77)	1.05 (0.87-1.27)	0.619
	Factory 1	2.32 (2.06-2.61)	2.72 (2.39-3.10) *	< 0.001
	Factory 2	2.92 (2.58-3.30)	2.29 (1.98-2.65) *	< 0.001
	Age	1.03 (1.02-1.03)	1.02 (1.02-1.03) *	< 0.001
	Textile	1.39 (1.20-1.61)	1.41 (1.21-1.65) *	< 0.001
	Garment	1.22 (1.05-1.41)	1.67 (1.41-1.98) *	< 0.001
	Female	1.11 (1.01-1.23)	1.37 (1.21-1.54) *	< 0.001
Musculoskeletal disorders	Read and write	2.14 (1.79-2.54)	1.52 (1.25-1.84) *	< 0.001
	Factory 1	2.12 (1.88-2.40)	2.88 (2.52-3.30) *	< 0.001
	Factory 2	2.89 (2.55-3.28)	2.08 (1.78-2.42) *	< 0.001
	Age	1.03 (1.03-1.04)	1.03 (1.03-1.04) *	< 0.001
	Textile	1.86 (1.56-2.22)	1.79 (1.49-2.16) *	< 0.001
	Garment	0.96 (0.80-1.15)	1.66 (1.35-2.05) *	< 0.001
	Female	0.63 (0.56-0.70)	0.82 (0.71-0.94) *	0.004
Injuries	Read and write	1.62 (1.32-1.98)	1.38 (1.10-1.73) *	0.005
	Factory 1	4.81 (4.18-5.54)	4.90 (4.20-5.70) *	< 0.001
	Factory 2	3.39 (2.92-3.95)	2.60 (2.17-3.11) *	< 0.001
	Age	1.01 (1.01-1.02)	1.01 (1.01-1.02) *	< 0.001
	Textile	1.29 (1.09-1.53)	1.29 (1.08-1.53) *	0.004
	Garment	1.47 (1.24-1.73)	1.67 (1.39-2.01) *	< 0.001
	Female	1.15 (1.03-1.29)	1.11 (0.98-1.26)	0.11
Gastrointestinal	Read and write	1.25 (1.02-1.53)	1.10 (0.89-1.36)	0.388
	Factory 1	1.31 (1.14-1.50)	1.57 (1.35-1.82) *	< 0.001
	Factory 2	1.48 (1.28-1.70)	1.39 (1.18-1.65) *	< 0.001
	Age	1.01 (1.01-1.02)	1.01 (1.01-1.02) *	< 0.001
	Textile	1.52 (1.28-1.81)	1.36 (1.14-1.64) *	0.001
	Garment	1.33 (1.12-1.59)	1.56 (1.28-1.90) *	< 0.001
	Female	1.39 (1.24-1.56)	1.79 (1.56-2.05) *	< 0.001
Peptic ulcer	Read and write	1.66 (1.37-2.02)	1.19 (0.96-1.48)	0.12
	Factory 1	2.55 (2.22-2.93)	3.45 (20.96-4.02) *	< 0.001
	Factory 2	3.12 (2.71-3.59)	2.84 (2.39-3.38) *	< 0.001
	Age	1.02 (1.02-1.03)	1.02 (1.01-1.03) *	< 0.001
	Textile	1.38 (1.17-1.64)	1.15 (0.95-1.38)	0.146
	Garment	0.74 (0.62-0.89)	1.19 (0.97-1.46)	0.1
	Female	0.81 (0.72-0.91)	1.29 (1.12-1.48) *	0
Acute Febrile Illness	Read and write	1.76 (1.44-2.15)	1.42 (1.13-1.78) *	0.003
	Factory 1	8.28 (7.12-9.62)	9.67 (8.19-11.40) *	< 0.001
	Factory 2	5.66 (4.83-6.64)	4.82 (3.99-5.83) *	< 0.001
	Age	1.02 (1.01-1.02)	1.01 (1.01-1.02) *	< 0.001
	Textile	1.25 (1.00-1.55)	1.16 (0.92-1.47)	0.206
	Garment	0.57(0.45-0.73)	1.09 (0.83-1.43)	0.527
	Female	0.61(0.52-0.72)	0.94 (0.78-1.12)	0.468
Allergies	Read and write	2.16(1.69-2.77)	1.07 (0.81-1.41)	0.621
	Factory 1	4.54(3.62-5.69)	4.76 (3.74-6.06) *	< 0.001
	Factory 2	10.20(8.28-12.55)	7.51 (5.88-9.59) *	< 0.001
	Age	1.05(1.05-1.06)	1.02 (1.01-1.03) *	< 0.001

Table 15: Cont'd

Disease	Factor variables	Bivariate analysis COR (95 %CI)	Multivariate analysis[+] AOR (95 %CI)	P-value
	Textile	1.34(1.08-1.66)	1.26 (1.01-1.57) *	0.041
	Garment	1.23(1.00-1.52)	1.19 (0.94-1.51)	0.15
	Female	1.35(1.16-1.56)	1.54 (1.30-1.81) *	< 0.001
Mouth diseases	Read and write	1.22(0.95-1.58)	1.02 (0.78-1.34)	0.877
	Factory 1	1.44(1.21-1.71)	1.65 (1.37-1.99) *	< 0.001
	Factory 2	1.67(1.40-1.98)	1.55 (1.25-1.91) *	< 0.001
	Age	1.01(1.01-1.02)	1.01 (1.00-1.02) *	0.005
	Textile	1.09(0.57-2.06)	0.99 (0.52-1.90)	0.976
	Garment	1.97(1.09-3.58)	1.17 (0.62-2.22)	0.631
	Female	3.23(1.99-5.25)	2.83 (1.67-4.79) *	< 0.001
Anemia	Read and write	1.43(0.76-2.67)	@	
	Factory 1	0.08(0.02-0.31)	0.10 (0.02-0.41) *	0.001
	Factory 2	1.21(0.79-1.87)	1.59 (0.99-2.55)	0.053
	Age	1.00(0.99-1.02)	@	
	Textile	1.31(0.80-2.15)	1.28 (0.77-2.14)	0.338
	Garment	0.42(0.23-0.76)	1.21 (0.65-2.24)	0.549
Hypertension	Female	1.11(0.75-1.63)	@	
	Read and write	3.41(2.12-5.48)	1.23 (0.74-2.05)	0.426
	Age	1.11(1.09-1.13)	1.07 (1.05-1.09) *	< 0.001
	Textile	1.45(1.17-1.80)	1.43 (1.15-1.78) *	0.001
	Garment	1.13(0.91-1.41)	1.26 (0.99-1.60)	0.061
	Female	0.86(0.74-0.99)	0.89 (0.76-1.05)	0.165
Skin disease	Read and write	1.00(0.76-1.32)	@	
	Factory 1	1.40(1.18-1.66)	1.31 (1.10-1.57) *	0.003
	Factory 2	1.09(0.90-1.32)	1.04 (0.85-1.26)	0.728
	Age	1.00(1.00-1.01)	@	
	Textile	1.25(1.00-1.55)	1.04 (0.82-1.31)	0.732
	Garment	1.57(1.28-1.94)	1.24 (0.98-1.57)	0.076
	Female	3.64(3.06-4.33)	5.09 (4.19-6.17) *	< 0.001
Urinary tract infection	Read and write	2.09(1.69-2.60)	1.36 (1.06-1.73) *	0.015
	Factory 1	1.30(1.09-1.55)	2.29 (1.88-2.79) *	< 0.001
	Factory 2	2.41(2.06-2.83)	1.94 (1.57-2.41) *	< 0.001
	Age	1.04(1.03-1.04)	1.05 (1.04-1.05) *	< 0.001
	Textile	1.06(0.73-1.54)	@	
	Garment	1.02(0.71-1.47)	@	
	Female	0.80(0.62-1.03)	1.02 (0.78-1.33)	0.872
Ear diseases	Read and write	0.67(0.37-1.20)	0.60 (0.33-1.10)	0.101
	Factory 1	2.62(1.98-3.47)	2.85 (2.13-3.81) *	< 0.001
	Factory 2	1.39(0.98-1.98)	1.05 (0.70-1.56)	0.817
	Age	1.01(1.00-1.03)	1.03 (1.01-1.04) *	< 0.001
	Textile	1.09(0.89-1.33)	1.24 (1.01-1.53) *	0.04
	Garment	0.74(0.60-0.91)	0.94 (0.74-1.19)	0.587
	Female	0.69(0.60-0.80)	0.80 (0.67-0.94) *	0.008
Eye diseases	Read and write	1.29(0.99-1.67)	1.21 (0.92-1.60)	0.169
	Factory 1	1.18(0.99-1.41)	1.12 (0.93-1.35)	0.246
	Factory 2	0.89(0.73-1.09)	0.58 (0.46-0.73) *	< 0.001
	Age	1.01(1.01-1.02)	1.02 (1.01-1.03) *	< 0.001

Table 15: Cont'd

Disease	Factor variables	Bivariate analysis COR (95 %CI)	Multivariate analysis[+] AOR (95 %CI)	P-value
Haemorroids	Textile	1.31(0.81-2.12)	1.42 (0.87-2.34)	0.163
	Garment	0.69(0.41-1.17)	1.07 (0.60-1.91)	0.823
	Female	0.59(0.42-0.83)	0.75 (0.51-1.11)	0.149
	Read and write	1.35(0.74-2.45)	[@]	
	Factory 1	1.82(1.19-2.77)	1.70 (1.09-2.66) [*]	0.02
	Factory 2	2.16(1.43-3.27)	1.38 (0.84-2.26)	0.198
	Age	1.03(1.01-1.04)	1.02 (1.01-1.04) [*]	0.012
Reproductive health problems	Textile	1.74(1.21-2.49)	1.33 (0.92-1.93)	0.127
	Garment	3.22(2.28-4.54)	1.27 (0.89-1.82)	0.194
	Female	14.76(9.77-22.30)	14.64 (9.58-22.39) [*]	< 0.001
	Read and write	1.00(0.70-1.43)	[@]	
	Factory 1	0.87(0.68-1.11)	[@]	
	Factory 2	1.02(0.80-1.30)	[@]	
	Age	0.99(0.98-1.00)	1.01 (1.00-1.02)	0.219
Neurologic and psychiatric diseases	Textile	0.97(0.65-1.45)	0.95 (0.64-1.43)	0.819
	Garment	1.37(0.94-2.00)	1.00 (0.66-1.51)	0.986
	Female	1.73(1.30-2.29)	1.60 (1.16-2.21) [*]	0.004
	Read and write	0.94(0.56-1.57)	[@]	
	Factory 1	0.53(0.36-0.79)	0.60 (0.40-0.90) [*]	0.015
	Factory 2	0.81(0.57-1.15)	0.90 (0.62-1.31)	0.59
	Age	1.00(0.99-1.01)	[@]	
Diabetics	Textile	0.70(0.39-1.29)	0.76 (0.41-1.43)	0.398
	Garment	0.46(0.24-0.87)	1.25 (0.61-2.57)	0.549
	Female	0.61(0.38-0.99)	1.22 (0.71-2.11)	0.466
	Read and write	1.32(0.57-3.07)	[@]	
	Factory 1	24.15(10.26-56.84)	33.49 (13.94-80.49) [*]	< 0.001
	Factory 2	11.15(4.42-28.14)	5.06 (1.89-13.55) [*]	0.001
	Age	1.07(1.04-1.09)	1.08 (1.05-1.10) [*]	< 0.001
Overall morbidity	Textile	1.64(1.43-1.87)	1.66 (1.44-1.92) [*]	< 0.001
	Garment	1.28(1.13-1.46)	1.65 (1.42-1.93) [*]	< 0.001
	Female	1.08(0.98-1.18)	1.33 (1.18-149) [*]	< 0.001
	Read and write	1.78(1.45-2.18)	1.42(1.14-1.76) [*]	0.002
	Factory 1	2.58(2.26-2.95)	3.32(2.87-3.84) [*]	< 0.001
	Factory 2	2.56(2.22-2.94)	1.86 (1.59-2.19) [*]	< 0.001
	Age	1.02(1.02-1.03)	1.03(1.02-1.04) [*]	< 0.001

COR = Crude odds ratio; AOR = Adjusted odds ratio; CI = Confidence interval; [+] Multivariate analysis; [@] Variables with P > 0.2 in bivariate not included in multivariate;* Significance level at P < 0.05; Production department, male, higher educational status and factory 3 are reference group; Nagelkerke R Square range from 0.1-0.23

5.4.4. Key findings from the three studies

Table 16: Summary of key findings from three studies

Study objective	Main findings
Study I**:** Measured the personal inhalable cotton dust and endotoxin exposure levels among workers in the integrated textile factories in Ethiopia	• The average cotton dust and endotoxin exposure levels were 0.75 $mg \cdot m^{-3}$ and 831 $EU \cdot m^{-3}$, respectively; the highest dust and endotoxin concentrations were observed in carding section; 1.34 $mg \cdot m^{-3}$ and 6,381 $EU \cdot m^{-3}$, respectively. • Eleven percent (11 %) of dust and 89 % of endotoxin samples exceeded workplace exposure limits. • A moderate correlation between personal inhalable dust and endotoxin exposure ($r = 0.45$, $p < 0.001$) was established.
Study II**:** Examined cross-shift lung function reduction and chronic respiratory symptoms among workers in the integrated textile factories in Ethiopia	• The prevalence of respiratory symptoms was significantly higher among textile workers (54 %) than in controls (28 %); Breathlessness was the most prevalent chronic respiratory symptom and significantly higher than non-exposed workers AOR= 9.4 (95 % CI 4.4–20.3). • The cross-shift lung function reduction among textile workers (123 mL for FEV_1 and 129 mL for FVC) was significantly higher than the non-exposed (14 mL for FEV_1 and 12 mL for FVC) at $p < 0.001$.
Study III**:** Registered health problems of workers in the integrated textile factories in Ethiopia	• 5,276 (66 %) workers made a total of 27,320 consultations for different disease diagnoses; they claimed 16,993 workdays lost due to sick leave. • The prevalence of respiratory diseases was highest (34 %) followed by MSD (29 %), gastrointestinal infection (21 %), peptic ulcer (19 %) and injury (17 %). • About 69 %, 65 % and 60 % of the textile, garment and support workers, respectively, were diagnosed with a disease • Textile department, female, workers with low educational status and older age had a significantly higher AOR to most diseases than the support, male workers with higher educational level and younger age.

Chapter Six: Discussion

6.1. Key Findings

In this study significant percent of air samples exceeded the workplace exposure limits. The highest dust and endotoxin concentration was measured from the carding section workers in the spinning department. This study also found a large reduction in cross-shift lung function among the textile production workers compared to the controls. Similarly, the cotton exposed workers had shown a significantly higher prevalence of chronic respiratory symptoms of cough, chest tightness and breathlessness than the control workers. Also, this study found that workers in the integrated textile factories were diagnosed with a wide range of diseases in one year. The diseases claimed 16,993 workdays lost due to sick leave. Respiratory disease was the leading cause of morbidity followed by MSD, whereas injuries caused workers to more days away from work. Workers in the textile department, females, older and low educated workers had a higher risk for most work-related diseases outcomes.

6.2. Exposure to inhalable cotton dust and endotoxin

The results of our dust sample were compared to the HSE WEL for personal inhalable cotton dust of 2.5 $mg \cdot m^{-3}$(34), the DECOS to endotoxin of 90 $EU \cdot m^{-3}$ (35) and with other exposure studies that measured personal inhalable cotton dust and endotoxin. The OEL values for cotton dust and other hazards are stated in the Ethiopian Occupational Health and Safety Directives (97). The OEL value for raw cotton dust in Ethiopia is 1 $mg \cdot m^{-3,}$ but the dust fraction, sampling procedure and technical guidelines are not clearly stated. Thus, it is difficult to use the national OEL value for comparison. Furthermore, Ethiopia has no occupational exposure limit values of its own for endotoxin.

In the current study, 11 % of the cotton dust samples and 89 % of the endotoxin samples were above the recommended standard by HSE (34) and DECOS (35). This could increase the risk of respiratory health problems among textile and garment workers. The concentration of personal inhalable dust exposure level of 0.75 $mg \cdot m^{-3}$ in this study was similar to the exposure levels found in studies conducted in Nepal textile factories (0.81 $mg \cdot m^{-3}$) (32) and in the UK's cotton mills study (1.09 $mg \cdot m^{-3}$) (187). Contrary, our study recorded a higher concentration than a study

performed in a Greek cotton textile mill (0.16 mg·m^{-3}) (154), and among cotton textile workers in Germany, where 71 % of the samples were below 0.21 mg·m^{-3} (188). The workplace hygiene improvements before the study in Germany, the efforts toward better work environments, and better workplace health programs in these countries might have contributed to the reduced dust concentrations. The results of the present study were, however, slightly lower than what was seen in Shanghai textile mills (GM = 1.74 mg·m^{-3}) (33), in Lancashire textile weavers (1.55 mg·m^{-3}) (189) and Turkish cotton mills (2.01 mg·m^{-3}) (14). The higher exposure levels in these studies could be associated with workroom factors (189), old machines (14), or sample measurements only being taken from the high-exposure sections in the cotton processing line (14, 33).

The average endotoxin exposure level of 831 EU·m^{-3} in this study is higher than studies from German textile factories (450 EU·m^{-3}) (188) and Turkish cotton mills (191 EU·m^{-3}) (14). The low endotoxin concentration may be associated with better quality raw cotton and hygienic housekeeping practices in Germany and Turkey (175). However, the average concentration of our study is lower than in the studies from Nepal (2,160 EU·m^{-3}) (32) and Shanghai textile (1,871 EU.m^{-3}) (39). The higher endotoxin exposures in those studies could be associated with high dust concentrations in the sampling locations in Shanghai (39). The fact that samples were also collected from the recycling section in the Nepalese study (32) could increase bacterial contamination. Studies indicated concentration of endotoxin at the workplaces could be varied by the endotoxin sampling and analysis technique (39, 103) and the quality of the raw cotton (118).

Personal level exposure concentrations and the ratio of endotoxin to dust were significantly varied across the textile production departments; it was higher in the first step in the production process than the last step, i.e. between the carding and the sewing sections of the spinning department. A Turkish study (14) measured higher dust exposure in the carding section (3.49 mg·m^{-3}) compared to the packing section in the garment (1.16 mg·m^{-3}), this showing a decline in exposure further along the production process. A similar decreasing endotoxin concentration from the spinning department to the garment department was observed in the Nepal study (32). One reason for this could be that in the first stage of the process, the raw cotton from the farms might contain bacterial contaminants from contact with soil particles, leaves, debris, and animal excretions that are gradually removed by industrial processing and cleaning activities at the different stages of the production process (32, 175). The considerably lower ratio of endotoxin to dust along the

production process from spinning to the garment in our present study supports this suggestion. It is also reflected in the moderate correlation between inhalable dust and endotoxin in the total dataset, while the correlation was relatively strong in the spinning and weaving departments. Several studies in the textile (32, 190) have also reported a correlation between cotton dust and endotoxin concentration.

6.3. Cross-shift lung function reduction

In the current study, a significantly higher mean (95 % CI) cross-shift change was recorded among workers in the integrated textile factories (ΔFEV_1, 123 ml (97 – 150) and ΔFVC, 129 ml (92 - 165)) compared to the non-exposed group (ΔFEV_1, 14 ml (-18 – 45) and ΔFVC, 12 ml (-23 – 46)). The cross-shift changes in both FEV_1 and FVC differed significantly between the two groups, with the exposed group having the largest decline in both parameters. The mean cross-shift reduction in the current study was a little higher than previous studies; the Nepalese textile (41), where the mean Δ FEV_1 and ΔFVC were 74 ml and 81 ml, respectively; the Iranian textile study (40), Δ FEV_1 50 ml and ΔFVC 130 ml; the study in textile dyeing (43), Δ FEV_1 and ΔFVC of 103 ml and 120 ml, respectively and the Shanghai cohort of all the four surveys (42), the ΔFEV_1 ranges 48 – 58 ml. However, our study result for the cross-shift change of FEV_1 was not significantly different from the studies mentioned above, as the confidence interval overlaps.

The observed mean increase in cross-shift reduction in the current study could be because measurements were taken among the morning and afternoon shift workers while the other studies (40, 41, 43) included only day shift workers. Previous studies have shown that reductions in FEV_1 and FVC are larger across periods corresponding to evening shifts than morning shifts (191-194). Besides, the difference in socio-demographic characteristics of the study population, exposure factors and measurement techniques may account for the differences.

In our study, a higher cross-shift reduction was measured among the spinning and weaving department workers than workers in the finishing and garment sections. Correspondingly, exposure to endotoxin was higher among workers in spinning (1560 EU· m^{-3}) and weaving (1086 EU· m^{-3}) than workers in a garment (258 EU·m^{-3}) and finishing (76 EU· m^{-3}) sections. However, the exposure concentration to inhalable dust was not significantly different between these departments; spinning (0.71 mg· m^{-3}), weaving (0.78 mg· m^{-3}), finishing (1.25 mg· m^{-3}) and

garment (0.46 mg· m^{-3}). The highest average inhalable dust exposure level was recorded among carding workers in the spinning department. Other studies (40, 41) also reported higher cross-shift reduction among workers from the spinning department. However, it is challenging to establish a direct relationship between personal exposure concentration and cross-shift reduction due to the lack of exposure measurement from all the lung function participants.

On the contrary, our study found a high prevalence of chronic respiratory symptoms from the finishing department with the lowest cross-shift reduction. This might emanate from the movement of workers with developing respiratory problems while working in dusty departments. The possibility of workers' movement has been indicated in studies to account for cotton dust exposure and respiratory diseases (135, 145). Furthermore, one of the longest longitudinal studies of a Shanghai textile cohort indicated a significant cross-shift measurement variation between surveys (42). Therefore, cross-shift lung function reduction may not be a direct indicator of chronic respiratory health symptoms.

6.4. Chronic respiratory symptoms

A significantly higher prevalence of chronic respiratory symptoms was observed in the integrated textile workers than in control. Recent studies indicate a decreased prevalence of byssinosis but a high prevalence of nonspecific chronic respiratory symptoms among cotton textile workers (13, 135). The overall prevalence of chronic respiratory symptoms in the textile cotton exposed group of this study (54 %) was comparable to previous research conducted in similar low- and middle-income settings such as another study in Ethiopia (48 %) (47), Egypt (59 %) (142), Nigeria (62 %) (138) and Bangladesh (53 %) (157). However, the prevalence was higher than in a study in an Iranian textile factory (26 %), where workers were relatively younger (40).

Breathlessness, chest tightness and cough were the most prevalent respiratory symptoms among the exposed workers in this study. These symptoms are known to occur among textile workers and correspond with the diagnosis of byssinosis (135). Several studies have also reported a high prevalence of these symptoms from textile workers (15, 37, 48, 77, 142, 195). Breathlessness was the highest reported respiratory symptoms (37 %) found in our study with an odds ratio (9.4, 95 %; CI: 4.4- 20.3) among the exposed groups, which were similar to earlier studies (37, 77, 176). However, cough was the highest reported symptom in other studies (48, 138, 142, 157).

Furthermore, wheezing was reported to be the least prevalent symptom, and no difference was observed between textile workers and control workers in our study, which is consistent with other studies (41, 48, 77, 138). The no observed difference of wheezing symptom among cotton dust exposed workers and control groups in this study may be ascribed to the fact that most people live around in the study area, the North West region of Ethiopia, commonly complaint about an asthma-like respiratory symptom.

Several previous studies have reported a higher prevalence of respiratory symptoms and a higher level of dust exposure in the first working section of textile manufacturing (50, 143, 144, 196). It necessitated many recent respiratory symptom studies in the textile industry to recruit study populations only from spinning and weaving departments (15, 47, 48, 142). A study conducted in Ethiopia that involved only spinning and weaving department workers found the highest prevalence of respiratory symptoms among the spinning workers (48). Sintayehu et al. (47) conducted a recent study in an integrated textile factory of Ethiopia but involved some departments (ginning, spinning and weaving), which has reported the highest prevalence of respiratory symptoms in the first work section (ginning department). Another study in Egypt textile recruit participants from the spinning and weaving departments reported the highest prevalence from spinning (142). However, in the current study, the highest prevalence of chronic respiratory symptoms was reported among workers in the finishing department (71 %). Different reasons could explain this, including the lack of involvement of all departments in the previous studies, workers' demography and workers move/change jobs across the departments in the factory, which is discussed in the next paragraph.

Studies conducted in textile factories have indicated that workers who have the longest period of service were associated with chronic exposure and have the highest risk of developing chronic respiratory health problems (15, 37, 41, 47). In the current study, the finishing department workers were the oldest and had the highest average year of service than the other department workers. It indicates older workers and workers with chronic pre-existing medical conditions may move to this department because of low workload and less hazardous jobs. Moving high-risk workers to a less hazardous job is one of the commonly recommended interventions in occupational settings (190, 197). The potential of exposure misclassification due to workers' movement was previously reported in respiratory studies in textile workers (42, 135). Hence, occupational disease studies to

understand the relationship of exposure to disease should not include only high exposure sections; this may lead to underestimating the disease burden. This result implies that research and intervention programs should be conducted in the textile and garment factories to involve all workers from the different sections of the integrated textile factories.

6.5. Registered diseases and injuries

6.5.1. The magnitude of the problem

The majority of workers, 5276 (66 %), had developed at least one disease or injury in the study period, but some workers had more diseases or injuries, making the total number of diagnoses 27,320. These figures are higher than reports from similar studies in other countries. For instance, a cross-sectional study that evaluated health conditions using clinical examinations of 514 male Indian textile workers found 754 disease diagnoses, making it 1.5 per worker (57). Again, a retrospective study from medical records of 1,906 workers from mobile clinics in Bangladesh textile and garment industries reported 25 % of workers diagnosed with at least one disease condition (58). A short survey that examined the occupational health conditions of 845 Indian textile workers found that 447 suffer from different diseases (59). Morbidity profile assessment studies in the Ethiopian textile industry (198), Lithuania textile (199), Indian textile mills (57, 59, 166), Sri Lanka garment (163) and Bangladesh garment industries (58, 116, 200) indicated a prevalence of several types of illness ranging from 25 % - 79 %.

The top causes of work-related diseases and injuries registered according to their prevalence were respiratory diseases (34 %), MSD (29 %), GI (21 %), peptic ulcer (19 %) and injury (17 %). Although workers were diagnosed with several types of disease groups to show the magnitude of work-related diseases, the discussion about prevalence estimation is limited to respiratory diseases, MSDs and injuries. These are commonly agreed on occupational diseases listed in the textile and garment sectors by ILO (201). A more comprehensive range of diseases among textile workers is also reported in a qualitative study in Bangladesh, where workers suffered from several types of diseases, including respiratory disease, MSD, headache, and eye diseases (167). Other studies in the textile and garment sectors reported respiratory disease was the leading cause of morbidity (198, 199). Most of the morbidity studies were self-reported in the garment or involved exclusively female workers (163, 164, 166). Hence, it is difficult to compare the prevalence estimate with these

studies due to methodological and risk differences among the study populations. Several studies (14, 32, 33, 59, 187) including our exposure assessment study have measured a high level of cotton dust in the textile factories that may account for the high prevalence of respiratory diseases.

MSD diagnoses were the second most prevalent disease (29 %) in this study and significantly associated with work-related and personal factors. Several studies in the textile and garment sectors reported a higher prevalence of MSDs than our result. Abrha et al. (112) conducted a study in an integrated textile factory of Ethiopia that found an annual MSDs prevalence of 53 %. Another study from Nepalese textile factory workers found 35 % lower back pain (111). In several other studies (163-166), MSD was the highest prevalence in standalone garment factories. The possible explanation for the higher prevalence of MSDs report in these studies could be primarily the disease assessment done by a self-reported questionnaire interview. The second is data collected from high-risk workers (garment department) excluded the low-risk group (support department workers). MSDs are a recurring health problem in individuals with several work-related and personal factors and have no prescribed medications; hence commonly, workers live complaining about their health condition. Thus, in a self-reported interview-based questionnaire, there is a high possibility for workers to report their MSDs condition. Therefore, clinic-based workers' morbidity data may underestimate the true magnitude of the MSDs complaint at work; this should be further investigated.

The work-related injury was also one of the most reported health problems and the major cause of sickness absence in this study. The prevalence of injury in this study (17 %) was lower than other self-reported studies from an integrated textile factory in Ethiopia; by Gebremicheal (114), 31 %, by Yesuf et al. (202), 37 %, and by Damtie and Siraj (203) 43 %. The higher prevalence of injury in these studies might be due to the self-reported interview assessment, sample population and differences in the outcome count (203). The possibility of minor injuries, first aid managed injuries and lifetime occurrence of injury could be included in a self-reported interview-based study. Also, there is a tendency to include injuries that happen out of the workplace in a self-reported interview, increasing the work-related injury prevalence. It has been confirmed that the prevalence of injured and hospitalized workers at least for one day is 16 % in one of the above studies (202).

6.5.2. Work-related factors

Categories of the working departments as the textile, garment and support sectors are considered work-related exposure units for the different diseases and injuries. The burden of diseases and injuries was prevalent among the textile workers compared to the garment and support department workers. Several studies had also reported a high prevalence of these health problems among textile workers. Workers in these departments have frequent exposure to different workplace hazards that have been reported as a cause for work-related diseases in several studies (17, 23, 41, 52, 67).

Textile workers had a higher risk for many diseases compared to other workers. Respiratory (37 %), MSD (31 %) and injury (23 %) were the top leading health problems in this department. Several other studies have also shown a high prevalence of respiratory problems among textile department workers (50, 59, 143, 144, 196). In our exposure assessment study, higher dust exposure level was also measured from the textile production workers than the garment department workers. The Time Weighted Average (TWA) of mean personal inhalable dust level in the textile department was 1.35 mg. m^{-3} and in the garment department 0.50 $mg.m^{-3}$. About 98 % of the dust samples exceeded the TLV (0.1 $mg.m^{-3}$) recommended by the ACGIH (85). This association might be due to the relationship between respiratory diagnoses and high dust levels in the integrated factories.

In the present study, MSD diagnoses are significantly associated with the work department; both textile and garment department workers have higher risks of MSDs than the support department workers. Other studies have shown the presence of ergonomic hazards in the textile and garment department that could increase the risk of MSDs (110-112). Also, ergonomic hazard exposure assessment studies in Bangladesh and Cambodia found that tasks in garment production increase risks of MSDs (22, 51). The development of MSDs may likely be linked to exposure to ergonomic hazards in the textile and garment departments.

Further, injuries are also significantly associated with work factors; both the textile and garment department workers have contact with dangerous machines and have a higher risk of injuries than workers in the support departments (18, 202). It implies that some of the injuries might be related to the working conditions in the textile and garment departments. Several studies identified

sleeping disorders, lack of PPE use, and OSH training as injury predictors (114, 115, 203). The textile and garment factories are commonly worked in 24 hours; hence production workers are supposed to rotate through day and night work shifts that can affect their sleeping pattern; this may decrease work concentration and non-compliance to safety rules.

6.5.3. Personal factors

Sex, educational status, age and more service years at work in the textile and garment factories are significantly associated with several work-related diseases. Female workers were diagnosed with more diseases compared to males in the current study. A qualitative in-depth interviewing and focus group discussion with 24 female workers from Bangladesh indicated that female workers suffered from several types of diseases in the garment factories (167). The morbidity assessment study by Singh and colleagues (59) also revealed that female workers in the textile had more severe anemia than males, which is similar to the present study's finding. It may partly be attributed to the monthly menstrual cycle among females.

Furthermore, a study in Bangladesh has reported a higher prevalence of different diseases among female workers than male workers but found a lower prevalence of injuries (58, 203). Similarly, our study shows a lower prevalence of injuries among females; this might be due to their difference in task roles where men often work with machines while many machines in the textile industry expose workers to a high risk for injuries (114, 203). Increased morbidity due to MSDs and respiratory diseases was reported among female textile workers in India (164, 166). The current study also found that females are at higher risk of MSDs than males, but there is no difference in respiratory diseases.

In general, previous studies indicate that high disease prevalence among female textile and garment workers could be linked to poor living conditions and an unhygienic work environment (58, 59, 168, 200, 204). These factors need further study to explore the contexts among the female working population.

This study shows that the low educational status of workers in the textile and garment factories is associated with several disease groups, including injuries, MSD, peptic ulcer, Urinary Tract Infection (UTI), Acute Febrile Illness (AFI) and hemorrhoids. Several studies (59, 113, 200, 205) have also revealed that textile and garment production workers with low educational status had an

increased risk of developing different diseases. Another study in India textile and garment indicates the overall morbidity was significantly associated with low educational status (59). A systematic review indicated that lower educational status could increase the health vulnerabilities of workers (12). This argument is supported by a large study from WHO (n = 30,146) that shows the low educational status of adults is significantly associated with MSD in the LMICs (206). The increased risk of diseases associated with low educational status could be because most workers with low education are engaged in blue-collar jobs and may not be aware of the presence of different workplace hazards and poor access to safety information at work.

Further again, worker's age is associated with diseases in this study; workers with an increased age have a significantly higher risk for several diseases, including respiratory, MSD, injury, ear diseases and gastrointestinal diseases, than younger workers. Similarly, a study of general health problems assessment among female garment workers in India showed that older age workers have a significantly higher risk for various diseases such as respiratory diseases, gastrointestinal diseases, MSD and eye diseases compared to the young workers (165). This may occur due to the exposure of older workers to workplace hazards for many years, increasing their risk of developing diseases from cumulative exposures. Moreover, workers with work services greater than five years had a significantly higher risk for 13 disease groups in the textile department than workers with service for less than five years.

6.5.4. Disease comparison among the general population

The ratio of total diagnosed cases from the number of all workers in the factories was 3.4, which is higher than the ratio of the total number of cases diagnosed from the general population, 0.50 in Ethiopia (207). The total number of cases diagnosed in the general population excluding children less than five years of age was 48.8 million, given that the general population's count of Ethiopia was 98.6 million (207). According to the Ministry of Health's annual morbidity statistics report (207), the annual outpatient visit per capita for a new and repeated health condition is 0.9, which is about four times less than our study. It indicates that workers from the integrated textile factories were diagnosed with more diseases than the general population; however, the high percentage might also be associated with better access to health services.

The magnitude and type of morbidities in the current study are higher and different from the general population in Ethiopia. The prevalence of top leading diseases in the general population of Ethiopia are pneumonia (2.6 %), acute upper respiratory infection (2.4 %), typhoid (1.7 %), dyspepsia (1.6 %) and functional intestinal disorder (1.4 %) (207). Unlike the general population, most of the diseases from the textile and garment department in this study are non-communicable diseases related to exposure to dust, ergonomic hazards, contact with chemicals and dangerous machines. However, workers in the integrated factories are different from the general population.

According to the "healthy workers effect" concept, a lower morbidity rate is expected among workers than the general population. However, the comparison of the morbidity statistics of the current study with the general population should be cautious. Generally, workers in the integrated factories were different from the general population in many ways; they have free access to health service and information, and the average age of workers is 40 years, whereas the average age in the population is 20 year and also 92 % of the study population attended formal education but only 67 % in the general population (42).

According to the ILO report (201), some of the diseases diagnosed among the textile and garment workers in the integrated factories could be work-related. The diseases are higher in magnitude and different from the diseases found in the general population, especially respiratory diseases, MSDs and injury. The occurrence of these diseases might be due to the presence of hazards known to cause these health problems. Therefore, the traditional view of dealing with only a few hazards and their associated diseases in the textile industry should be reviewed. Besides, the occupational health service should also address the demand of workers who suffer from other diseases due to hazards in the textile working environment. Moreover, future studies should consider exposure intensity and exposure interruption by tracing workers' exposure profiles.

6.6. Methodological discussion

6.6.1. Validity and generalizability

6.6.1.1. Internal validity

Different potential factors can affect the validity of an observational study, such as random error, bias and confounders. We consider several issues at the design and analysis stage to maintain the internal validity of this study.

Random error

The role of chance was considered and tried to address at the study proposal development stage and analysis of the result. In the exposure assessment study, the required number of personal cotton dust samples was collected according to the sampling recommendation for the occupational exposure assessment study by Rapport et al. (178). All integrated textile factories that fulfill the selection criteria in the country were included for the study of the work-related disease with a large number of workers participated, about 17 % of the workforce (6); registered diseases of the workers were also collected for one year period. Furthermore, the analysis report used the 95 % CI to compare the outcome variables of cross-shift lung function and chronic respiratory symptoms between integrated textile factory workers and controls; this helped assess the chance's effect.

Bias

Efforts were employed to minimize bias during the design and conducting of these studies. All integrated textile factories were involved in the study to avoid **selection bias** for the study of the work-related disease; none of the selection criteria were related to either the exposure or outcome of the study participants. All workers' health records for one year period were collected from the clinic. One textile factory was randomly selected for the exposure assessment, cross-shift lung function and respiratory symptoms studies. The factory is well organized, having a list of workers by the department so that participants were selected randomly from the prepared sampling frame in the departments. Though newly recruited workers passed through a general health assessment screening, workers' health status before joining the textile factory work was not documented; hence healthy workers' effect was not ruled out. Some workers may leave early from the textile job because of exposure-related diseases and conditions (190, 208). A control group of workers from a physically demanding task in the production department of water bottling factories was

included to minimize the effect of healthy workers. Furthermore, the participation rate in our studies was very high both from the textile and control groups; this could also help to minimize the bias related to the selection of participants.

Measurement related a systematic error was one of the potential bias identified in this study that was considered during data collection and analysis. The inhalable dust fraction was sampled from workers breathing zone for a repeated entire shift to determine the equivalent personal level exposure. Besides, calibrated instruments were used for air sampling, lung function test, height and weight. The cotton dust and endotoxin level was analyzed gravimetrically and LAL assay, respectively, in a certified laboratory at Aarhus University, Denmark. For the cross-shift lung function measurement, three acceptable maneuvers with consistent (repeatable) results were retained, and the best of these were recorded. In the chronic respiratory symptoms assessment study, the standard ATS assessment tool was used to apply for both the exposed and control groups.

Moreover, the overall one-year disease conditions of workers were assessed by clinical investigation. Furthermore, the date of birth of the workers was retrieved from the human resource record. These can avoid the personal desirability bias of workers, which could have been found in the interview-based questionnaire. However, we could not fully control measurement bias for age; it may not be sure that the actual date of birth was registered during the first recruitment time. Though this problem might be present only among a few workers, it is unlikely to create a significant problem.

Generally, the field data collection was guided by a prepared measurement manual and strictly followed the procedure. Data collectors were well trained with the data collection tools and instruments; the principal investigator did regular close supervision; advisers observed the field operation, and double data entry were performed to enhance measurement quality.

Confounders

The potential confounding variables were identified during the study design, and their effects were controlled during analysis. Workers were grouped into similar exposure groups (homogeneous) for the dust and endotoxin exposure assessment before the study; this restricts the potential confounders in each group. The most known confounders for the cross-shift lung function and respiratory symptoms study were measured. These variables were included in the regression

analysis. The working department of the subjects was retrieved from the human resource record; workers might have worked in other departments within the factory for some times; hence there might be a possibility of movement of workers from the registered department, which could result in exposure misclassification in the work-related study while comparing the health status of production workers against the support service workers. Furthermore, few variables were collected from the factory clinic data to find the relationship of personal and work-related factors with the registered work-related diseases; hence the unmeasured confounders were left uncontrolled during analysis.

6.6.1.2. External validity

External validity is the generalizability of a study result in another context. The findings of this study are potentially reproducible in a similar setting. The geographical distribution of the textile factories covered three industrial zones in different regional states of the country; the selected integrated textile factories encompass all the stand-alone processes present in the textile and garment value chain. Besides, these factories employed many workers in the sector; the type of machines installed, cotton processing and factory design were similar to other factories in LMICs. However, workers' demographic characteristics and workers exposure profile should be critical. Therefore, the result could represent other workers in the textile and garment factories that process cotton and found in LMICs.

6.6.2. Strengths and limitations of the study

6.6.2.1. Strengths of the study

The use of multiple data collection tools, cover different industrial zones, and one-year data collection for the diseases and injuries outcome are strengths. Combining field exposure measurement and clinical disease diagnosis in the same study helped to understand the overall occupational health situation in the sector. The personal endotoxin exposure level of workers in the textile and garment factories of Ethiopia and regional countries has never been known before. Besides, samples for the study were collected from all the work sections representing the textile and garment value chain. Also, the exposure assessment employed an established method for dust and endotoxin sampling and the samples were analyzed in a certified laboratory. Both the production and support process workers were involved in the work-related disease study because

workers could move from one department to another due to the development of the exposure-related disease. Furthermore, this study used a control group of workers (none-cotton exposed) to compare the effect of exposure on the prevalence of respiratory symptoms and cross-shift lung function. Generally, the comprehensive nature of the study helped to show the link between the three levels of occupational exposure: external exposure (i.e. personal level dust and endotoxin), internal exposure (i.e., cross-shift lung function) and effect (diseases and injuries). Most previous studies in the textile and garment sectors did not cover all work sections found in the value chain and commonly used questionnaire-based interviews for work-related diseases assessment. Therefore, the findings of this study provide objectively measured helpful information for key stakeholders in the sector; the labour and social affairs, ministry of health, employers, unions, social security, insurance companies and researchers in the field of occupational health.

6.6.2.2. Limitations of the study

This study has several limitations that need caution during the interpretation and use of the study findings. The personal inhalable cotton dust and endotoxin exposure assessment study was not repeated in different seasons. This would be of interest for future studies in addition to studies at different production volumes. Since, other than the textile processing seasonality of cotton production, cotton storage and level of productivity can affect personal exposure.

In the cross-shift lung function and respiratory symptoms study, the external exposure measurements were done among few textile and garment participants, and no measurements were performed in the control groups. The dust and endotoxin exposure assessment study and the cross-shift lung function measurement study were conducted at the same time due to lack of available logistics. Besides, the cross-shift was not repeatedly measured, and the production rate was not measured. The workers may have been a source of bias, as the textile workers may have wanted to change workplace status, leading to over-reporting of respiratory symptoms. On the other hand, some workers may have had some reservations about complaining about their factory during the questionnaire interview, although the purpose of the study was clearly informed to participants before data collection. As it was a cross-sectional study design, no causality between dust exposure and respiratory health can be concluded with certainty.

Although the work-related diseases study used the registered diagnoses data from the factory clinic, this study still has limitations. The factory clinics were not used the standard International Classification of Disease (ICD) code; hence we used large categories for the diagnoses. Regarding the prevalence of different work-related diseases, workers may visit other health institutions than the factory clinic. However, the factory clinic serves workers free of charge and has a referral system to hospitals for advanced diagnostic and treatment; hence, it is very likely that workers can consult the factory clinics to a large extent. Furthermore, we have limited information about the workers' exposure profile and cannot collect the potential confounder variables such as previous health conditions, current work exposure at the different departments, lifestyle and related behavioural information. Hence, it is difficult to know the causes of different health problems. Using a control group from another factory might have improved this study. However, comparing groups inside the factory have advantages to link the heath problem by work conditions as the workers in the group had the same organizational experiences and the same factory culture. Still, there could be self-selection of workers for the job and movement of workers within the departments due to health condition could be an inherent problem that may lead to exposure misclassification.

Chapter Seven: Conclusions and recommendations

7.1. Conclusions

This study found a high level of personal inhalable cotton dust and endotoxin in the external exposure; the dust samples (11 %) were higher than the HSE WEL, and 89 % of the endotoxin samples were higher than the DECOS recommendation. Both personal dust and endotoxin exposure level was higher at the beginning of the textile processing and was lower in the last work section of the process. A higher level of cross-shift lung function reduction was found from the textile and garment workers in the internal exposure, which could be attributed to external exposure hazards. The prevalence of chronic respiratory symptoms was also higher among textile factory workers compared to control.

The majority of the workers (66 %) in the integrated textile factories were diagnosed with different types of diseases and injuries in the effect measurement. Respiratory disease was the most prevalent diagnosis, followed by MSD and injury as the major causes of sick leave. The textile and garment department workers had a higher risk of acquiring these diseases than the support department workers, indicating the linkage between a higher level of measured hazards in the external exposure and the reduction of measured lung function in the internal exposure in these departments. Moreover, the type and magnitude of most prevalent diseases in this study differed from diseases reported by the general population. Factory clinics seem to be an essential source of evidence to understand the occupational disease and injury burdens. Further study needs to investigate the reason for repeated clinic consultation of some workers and the occurrence of rare chronic diseases such as cancer, heart diseases, renal diseases and diabetics about workers' exposure profile.

Generally, the use of respiratory protective devices, regular risk assessment practices, exposure and occupational disease and injuries monitoring programs in the factories are minimal. The following major capacity gaps were identified as an area of intervention for workers health improvement: low OSH awareness by management and workers, poor workers participation in PPE use and OSH activities, inability to conduct a risk assessment by safety committee or officers, lack of technical capacity and lack of support system in exposure assessment by the regulatory agency.

7.2. Recommendations

Implication for policy and regulation

- The Ministry of Labor and Social Affairs (MoLSA) should review the OELs for cotton dust and other hazards and develop exposure assessment guideline to enhance labour inspection services and exposure-response studies
- The Ministry of Health (MoH) and MoLSA may need to work together to adopt ICD-11 code at the workplace clinics to generate information to prepare the national occupational diseases list.
- Institutional capacity needs to be strengthened to provide occupational health services and exposure assessment of factory workers.

Implications for factory management

- Factories management should be committed to workplace conditions improvement; the ventilation system, avail PPE and monitor its proper use to prevent dust and endotoxin exposure
- Factories management may design and support an internal capacity building program to equip management at all levels and all workers to monitor and track occupational exposures

Implications for practice and future research

- Factory safety officers and OSH committee should plan and execute OSH activities on hazard identification and risk minimization
- Factory safety officers and OSH committee should conduct a regular risk assessment and communicate the result and organize workers OSH participation programs
- Health professionals of the factory clinics should standardize workers' disease registration system and generate disease prevalence report to inform management, safety/OSH committee and workers to design factory-specific intervention programs.
- Workers should comply with factory OSH rules and properly use personal protective devices while at work.
- Workers should be actively engaged in factory-based workers' health protection campaigns and programs.

- Further exposure measurement research is encouraged to be conducted on other hazards, including cotton dust and endotoxin during different seasons and tracking details of workers' exposure profile to estimate cumulative exposure and relationship of disease outcomes.
- A comparative occupational diseases and injuries research between integrated textile factory workers and the general population using a standard diagnosis ICD code is recommended.
- The establishment of an occupational cohort in the industrial parks is strongly recommended to determine the incidence of occupational diseases and injuries, risk factors and evaluate intervention programs.

Chapter Eight: Knowledge translation

The use of research evidence to inform decision-making and improve workers' health is very limited in developing countries. Knowledge translation (KT) is a dynamic and iterative process that includes the synthesis, dissemination, exchange and ethically sound application of knowledge to improve health and strengthen an effective health services system. Lack of knowledge management is a major challenge for KT; most researches focused on validity but not the applicability of evidence. Recently, the importance of interaction between researchers and knowledge users in predicting the uptake of the research findings has gained prominence in practice. Traditionally, KT is considered the publication and dissemination of the research findings in a peer-reviewed journal; in the case where potential knowledge users other than researchers, this type of knowledge translation may not be the most effective approach to encourage awareness and uptake of findings (209).

In our research, the two primary goals of KT were to implement OSH intervention activities at the factory level and influence change in policy and practice to improve workers' health conditions through research and capacity building. Accordingly, an integrated knowledge translation approach was employed to focus on three identified KT components (training, policy-related, and research and publication) to reach three major knowledge user groups (factories, regulatory bodies and scientific communities). Support for the KT activities was granted from the regional ILO and NORHED while in this research. The process and implementation of each KT component mentioned above during the course of our research period are discussed below.

8.1. Collaboration

At the beginning of the research, a cooperative environment was created with the major stakeholders; it was considered as key for our KT activities. Initially, a repeated face-to-face discussion was made with each factory's management; factories agreed to participate and cooperate in the study. The regional state bureaus of labour and social affairs were also informed about the purpose of the research before commencement. Senior advisers of the research had also discussed with management and visited one of the factories' whole production process. This helped build trust with factories and allowed access to the factory's human resource database, workers' health profile records, and exposure measurements from workers. These are the most common challenges

in researching an occupational setting. Finally, the regional ILO office was contacted for support; it allowed us to take part in factories OSH capacity building in a newly launched project titled "*Improving Industrial Relations for Decent Work and Sustainable Development of Textile and Garment Industry Ethiopia*" (210). As a sectoral capacity program, this project has several components other than occupational health and included other textile and garment factories that were not part of our research. The research evidence generated during the research is being used for the capacity-building programs in these factories. The implemented KT interventions were presented accordingly in the following sections.

8.2. Capacity building

The ILO project largely supported our KT OSH interventions; the project supports the detailed engagement in six export-oriented textile and garment factories. The capacity-building program was intended to address the three hierarchical bodies in the company; 1) factory top management, including the CEO, 2) supervisors and line managers, and 3) OSH committee members and labour unions. The programs were designed with onsite training for 3-5 days at each factory and continuously supported the trainees in developing an action plan and assisting in executing intervention on their own in a month by providing onsite visits and support.

Awareness of OSH is minimal among many Ethiopian textile and garment factory workers; hence a comprehensive training was delivered, including the basics of OSH. The training components covered; OSH and business, common occupational hazards in textile and garment industries, occupational accidents and diseases in textile and garment industries, department-based risk assessment practice, OSH management system tools, coaching and supervision, workers participation in OSH and how to monitor OSH activities with a pre and post-test assessment. The top management training mainly focused on OSH and business to ensure management commitment to support the OSH activities in the factory. OSH committee, safety officers and union members were the main targeted groups in training; they are responsible for planning, implementing and leading the OSH activities in the factories. After the training, each factory trainee developed a factory OSH policy, prepared a factory OSH management document, communicated risk assessment results, and implemented workers' participatory interventions such as posting accident-free days and OSH awareness creations. Furthermore, three days of training

for trainers were given for 33 federal and regional bureaus of labour inspectors to support OSH activities in the textile and garment factories. (See Annex 7).

More female workers with MSDs were the most reported health problems in the garment factories in our study. An extension to the previous ILO engagement, another support was granted to implement further activities in two large garment export factories. In collaboration with other colleagues, a five-minute entertaining audio clip production was prepared, which directs a physical exercise around the work station and implemented during the work break; standard graphical posters were prepared on hygiene, workplace hazards, accident prevention, and the right PPE use. (See Annex 7).

Finally, a factory-level dissemination workshop was organized in collaboration with the regional bureau of labour and social affairs. The workshop conducted at each factory participated in this study except the one found in Tigray due to security problems. About 20 – 22 representatives, including the general manager (CEO), corporate advisers, production department heads, human resources, safety committee, union members, and health workers, participated in each workshop. The workshop in Bahar Dar was prepared under the theme ***"Exposure to cotton dust and endotoxin, and related health problems of workers in textile and garment factories"*** and in Kombolcha under the theme ***"Registered diseases and injuries of workers in Kombolcha textile factory"***(Figure 12 & 13). The main research findings were prepared with a colourful brochure in local languages and distributed to workshop participants. (See Annex 9).

8.3. Policy intervention

The Federal Ministry of Labor and Social Affairs had prepared a National Occupational Health and Safety Directive in 2008, which contains OELs; however, the technical guidelines needed for the exposure measurement that helped the labour inspectors were not available. Furthermore, labour inspectors have limited theoretical and technical competency on exposure measurement. Therefore, to influence this policy-related limitation, we engaged in a cooperative agreement initiated between the university and regulatory bodies. Here, the KT component is mainly targeted at the regulatory bodies in labour and social affairs. I took the lead to communicate with the Federal Ministry of Labor and Social Affairs (MoLSA) and the Regional Bureau of Labor and Social Affairs (BoLSAs) for a larger cooperative agreement with AAU SPH. Initially, the cooperative

agreement was successful only with Oromia Regional BoLSA in 2018; later on Amhara Regional BoLSA and Addis Ababa City BoLSA, and Federal MoLSA joined. (See Annex 8). An implementation project prepared to support the capacity of regulatory bodies under the cooperative agreement by NORHED. A standard training module on exposure assessment which lasted for six days, was prepared; other NORHED funded research team members also participated in the training module preparation and delivery. A total of 25 labour inspectors participated from the Federal, Addis Ababa city administration and Oromia BoLSA on the exposure assessment hands-on training at Kanoria Africa Textile Factory. The ultimate goal of this project was for the labour inspectors to draft exposure assessment technical guidelines for each hazard (cotton dust, noise, thermal and light) that has OEL value stated in the National Occupational Health and Safety Directive. The training was delivered successfully. Besides, the partnership opens free scholarship opportunities to five labour inspectors to join the master's training on the Environmental and Occupational Health program. The establishment of a partnership between the School of Public Health and Oromia Regional BoLSA and the accomplishment of the capacity-building program encouraged other regional BoLSAs to be part of the cooperation. Currently, Addis Ababa City Administration BoLSA and Amhara Regional BoLSA in 2020 and Federal MoLSA in 2021 have signed the memorandum of understanding (MoU) with the SPH of AAU.

Finally, a national policy dialogue workshop was organized to influence the policy and practice of key stakeholders. The research team received support from the NORHED to the workshop. In collaboration with the Ministry of Labor and Social Affairs, the School of Public Health organized the workshop under the theme ***"Recording and notification of occupational injuries and diseases system in Ethiopia-Research dissemination: Registered diseases & injuries from textile and garment industries"*** in Addis Ababa, Elilly International Hotel. About 36 delegates from key stakeholder institutions participated in the workshop: Ministry of Health, Civil Service Commission, Regional Bureaus of Labor and Social Affairs, Federal Attorney General, Employers Federation, Confederations of Unions, ILO, Social Security Agencies, Insurances Association, Rehabilitation Centers, University and Medias participated in the workshop. A plenary discussion was also conducted and chaired by H.E. State Minister Ayelech and Yifokire Tefera. The workshop was concluded by establishing a national technical working group from key stakeholders who prepare the national list of occupational diseases and injuries (Figure 11). The workshop was broadcasted through six media channels (https://youtu.be/rb5SIP0saP4). (See Annex 9)

8.4. Research and publication

The KT components in this category were targeted at the academic and scientific community and a higher level of decision-making bodies. Three scientific publications were produced from the external exposure (cotton dust and endotoxin), internal exposure (lung function) and effect (work-related diseases). The first two scientific works were published in international peer-reviewed journals, and the third one is accepted for publication. Also, the two working postures, either standing or sitting, are dominantly practiced in the garment factories. I proposed research to evaluate the risk of standing and sitting posture to the development of MSD among the garment workers; hence one postgraduate student is undertaking research in this area under my supervision. The research evidence may help to support garment factories on the appropriate working posture. Currently, I am engaged to revise *The Patty's Industrial Hygiene and Toxicology 7th Edition* book chapter "Cotton and Other Textile Dusts" based on our research evidence.

Furthermore, an eight-page policy brief document was prepared. The material contains a summary of the main research findings and policy implications focused on recommendations. The document was distributed to the Federal Ministry of Labor and Social Affairs, Regional State Bureaus of Labor and Social Affairs, Ministry of Health and other stakeholders. Brochures were prepared in local languages, a summary of the research findings and factory-level recommendations.

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Appendices

Annex 1: Participant information sheet

Information sheet English version

Title: “Cotton dust and endotoxin exposure and respiratory health of workers in the integrated textile factories of Ethiopia”

Principal Investigator: Yifokire Tefera (PhD student)

Sponsoring Organization: AAU & NORHED

Introduction: Textile industries are known to cause cotton dust exposure to workers. The dust can be respirable. Cotton dust is present in the air during the handling and processing of cotton. This dust may contain a mixture of many substances including ground up plant matter, bacteria, fungi, soil, pesticides and other contaminants.

Purpose of the study: However, little has been known about the magnitude of health problems and workers exposure.

The aim of this study is to measure the personal cotton dust and endotoxin exposures level and associated respiratory health problems among production workers in the integrated textile factory.

What participation involves

If you agree to join the study you will be required to participate in an interview which will be on your personal back ground, respiratory symptoms and information on your previous job experiences. For some of the workers we will also take some measurements on lung function by a spirometer, a non-invasive machine with non reusable mouth pieces. You will be also asked to carry dust sampling pump which will wait not more than half a kilogram around your waist to sample from your breathing zone for the whole shift.

Confidentiality

All information obtained from you will be kept confidentially in a computer using the identification number. The information will only be used for the purpose of this research. Your employer will have neither access to any of the information you gave us nor the results of your lung function test.

Risk and /or discomfort

The study does not have any inhumane treatment of research participants and free from any physical harm, social discrimination, psychological trauma and economic loss. In general we do not expect that any harm will happen to you because of joining this study.

Inducement, incentive and compensation

This study process has no any harm form of inducement, coercion and the study does not bring any risks that incur compensation.

Result Dissemination

The researcher is responsible for dissemination of findings. Maximum effort will be done to publish the findings in scientific reputable journal.

Right to withdraw

Your participations in the interview and every aspect of this study are completely voluntary. You have the choice to participate or not to. Your employer will have no access to your decision to participate or not.

Benefits

If you are found to have respiratory problems you will be referred to the clinic. The study does not have a short term financial and capacity building benefit to the research participants as individual or as a group but in the long run it will help the concerned organization and policy makers to have a policy consideration and direction and formulation of strategy and will help to come up with recommendations on how to improve the work environment.

In case of injury

We do not anticipate that any harm will occur to you in the course of this study.

Person to Contact

The participant has the right to ask information that is not clear about the research context and content before and or during the research work. You can contact the principal investigator and his advisor. Moreover this research undergone ethical reviewed and approved by Addis Ababa University College of Health Sciences (IRB). The main task of this board is to make sure that the ethical principles is adhered or not and the research participants are protected from harm.

If you need any clarification on the study you can contact the following people

Addis Ababa University College of Health Sciences IRB secretary office Tel: 0115512876

Principal Investigator: Yifokire Tefera; Phone: 0913654082; E-mail:yifoomitu@yahoo.com

Primary Supervisor: Dr. Abera Kumie; School of Public, College of Health Science, Addis Ababa University. Mobile: 0911882912

Information sheet Amharic version

(የሰራተኞች የተሳታፊነት መረጃ ፎርም)

የጥናቱ ርዕስ፡ የጥጥ ብናኝና የኢንዶቶክሲን ተጋላጭነትና የመተንፈሻ ጤና በኢትዮጵያ የጨርቃ ጨርቅ ፋብሪካ ሰራተኞች ላይ

የጥናቱን ዋና ተመራማሪ፡ ይፎክር ተፈራ (የዶክትሬት ተማሪ)

ስፖንሰር ያደረገው ድርጅት፡ የአዲስ አበባ ዩኒቨርሲቲና የኖርዌይ መንግስት የልማት ድርጅት

መግቢያ፡ ከጨርቃጨርቅ ፋብሪካ የሚወጣ ብናኝ ከመጠን በላይ ከሆነ በሰራተኞች የመተንፈሻ ጤና ላይ ችግር ሊያመጣ ይችላል፡፡ በአሁኑ ጊዜ በኢትዮጵያ ዉስጥ በርካታ ሰራተኞች በጨርቃጨርቅ ፋብሪካ ዉስጥ ተቀጥረው ይሰራሉ፡፡ እነዚህ ሰራተኞች ለጥጥ ብናኝና ኢንዶቶክሲን ይጋለጣሉ፡፡ ሆኖም ግን ተጋላጭነቱ በምን ያህል እና ምን አይነት የጤና ችግር እና በምን ያህለ መጠን የሚለዉ በቅጡ አይታወቅም፡፡ ስለዚህ እርሶ የጥጥ ብናኝና የኢንዶቶክሲን ተጋላጭነትና የመተንፈሻ ጤና በጨርቃ ጨርቅ ፋብሪካ ሰራተኞች ላይ በሚያጠና ጥናት ላይ እንድትሳተፉ ተመርጠዋል፡፡

የጥናቱ አላማ ፡ ከጨርቃጨርቅ ፋብሪካ የሚወጣ የጥጥ ብናኝና ኢንዶቶክሲን የሰራተኞች የመተንፈሻ ጤና ችግርን ለማጥናትና የችግሩን መጠን ለመለካት ያለመ ነው ፡፡ ይህ ደግሞ የስራ ቦታዎችን ደህንነትን ጤና ለማሻሻል የሚረዱ መረጃዎችን ያስገኛል፡፡

ለተሳታፊዎች መመሪያ፡ በዚህ ጥናት ለመሳተፍ ፍቃደኛ ከሆኑ በቃለ መጠይቅ እንዲሳተፉ እጠይቃለሁ፡፡ ቃለ መጠይቁ አጠቃላይ ስለ ራስዎ የመተንፈሻ አካል የጤና ችግርና ከዚህ በፊት የስራ ሁኔታ የተመለከቱ ይሆናል፡፡ አንዳዶቻችሁን የሳንባ የመተንፈስ አቅም ለማወቅ በስፓይሮሜትር በጤና ላይ ምንም ዓይነት ጉዳት በማያመጣ መሳሪያ እንለካለን፡፡ በተጨማሪ የጥጥ ብናኝን ለመለካት በግምት ከግማሽ ኪሎ የማይበልጥ የአየር መሳቢያ ፓምፕ በወገብዎት አካበቢ እንዲይዙ ይደረጋሉ፡፡

ሚስጥርን መጠበቅ፡ ሁሉም መረጃ ከርሶ የሚገኘው በሚስጥር ኮድ አማካኝነት በሚስጥር በኮምፒዩተር ውስጥ ይቀመጣል ፡፡ የተገኘው መረጃ ለዚሁ ጥናት አገልግሎት ብቻ ይውላል ፡፡ አሰሪዎ ከርሶ የተገኘውን ማንኛውንም መረጃና የሳንባ ምርምራ ውጤት ማየት ወይንም ማግኘት አይችልም፡፡

በተሳታፊዎች የሚደርሱ ጉዳት ወይንም ምቾት ማጣት፡ ይህ ጥናት ምንም አይነት ሰብአዊነትን የሚነካ ነገር የለዉም አካልን አይጎዳም ከህብረተሰበ መገለልን አያመጣም የስነልቦና ችግር አያመጣም እንዲሁም ማንኛውም አይነት የኢኮኖሚ ኪሳራ አያስከትልም፡፡ በአጠቃላይ በዚህ ጥናት ምንም ዓይነት አደጋ ይከሰታል ብለን አንጠብቅም፡፡

በጥናቱ ያለመሳተፍ መብት፡ በዚህ ቃለ ምልልስ ወይንም በዚህ ጥናት ለመሳተፍ ወይንም አለመሳተፍ ሙሉ መብት አለዎት፡፡ አሰሪዎ በርሶ ውሳኔ ላይ ምንም ዓይነት ውሳኔ መስጠት አይችልም፡፡ በዚህ ጥናት ምንም አይነት ማበረታቻ ወይንም ካሰ ወይንም ገቦ አይሰጥም፡፡

ዉጤትን ማሰራጨት፡ የጥናቱ ተመራማሪ ሙሉ በሙሉ ሃላፊነቱን ወስዶ ውጤቱን ያሰራጫል፡፡ እንዲሁም ወጤቱን በታወቀ የሳይንስ ምርምር ጆርናል ላይ አቅም በፈቀደ መጠን ያሳትማል፡፡

የተሳታፊዎች ጥቅም፡ የመተናፈሻ ጤና ችግር ከተገኘብዎት ወደ ሆስፒታል እንድሄዱ ይመከራሉ፡፡ ይህ ጥናት የስራ ቦታ ደህንነት እንዲሻሻል የሚረዱ መረጃዎች ያስገኛል፡፡ ይህ ጥናት ምንም አይነት የአጭር ጊዜ ገቢ እና የአቅም ግንባታ ለግለሰቡ ወይንም ለተሳታፊዎች አያስገኝም፡ ፡ ሆኖም ግን የተሻለ የስራ ቦታ ደህንነትና ጤና እንዲፈጠር ለሚመለከተው ክፍል እና ለፖሊሲ አዉጪዎች አቅጣጫና ስትራቴጂ ለማዘጋጀት ይረዳል፡፡

በአደጋ ጊዜ፡ በዚህ ጥናት ጊዜ ምንም ዓይነት አደጋ ይከሰታል ብለን አንጠብቅም፡፡

የሚያነጋግሩት ሰዉ፡ ተሳታፊዎች ስለ ጥናቱም ሆነ ስለሌላ ነገር ግልጽ ያልሆነ ነገር ካለ ጥያቄ ለመጠየቅ ሙሉ መብት አላቸዉ፡፡ ጥያቄ ካለዎት ዋና ተመራማሪውን ወይንም ዋና የጥናቱ አማካሪን ማግኘት ይችላሉ፡፡ በተጨማሪ ይህ ጥናት በአዲስ አበባ ዩኒቨርሲቲ የጤና ሳይንስ ኮሌጅ የምርምር ስነ ምግባር ቦርድና የህብረተሰብ ጤና ሳይንስ ት/ቤት የምርምር ስነ ምግባር ኮሚቴ የታየና የፀደቀ ነዉ፡፡ የምርምር ስነ ምግባር ቦርዱ ዋና ተግባርም ጥናቱ ስነ ምግባር በተሞላበት ሁኔታ እንዲካሄድና ተሳታፊዎችን ጥናቱ ጋር በተያያዘ ከሚደርስ አደጋ ለመከላከል ነዉ፡፡

ተጨማሪ ማብራሪያ ወይም ጥያቄ ካለዎት በሚከተለው አድራሻ መጠየቅ ይችላሉ፡፡

ይፎክር ተፈራ፤ ስልክ 09-13 75 40 82 ፤ ኢ.ሜ.ል yifoomitu@ yahoo .com

ዋና አማካሪ፤ ዶ/ር አበራ ኩሜ፡ ስልክ 09-11-88-2912

የምርምር ስነ ምግባር ቦርዱ ጸሀፊ፡ ስልክ 01-18-96-13-9

Annex 2: Consent Form

Consent form English version

Title: “Cotton dust and endotoxin exposure and respiratory health of workers in the integrated textile factories of Ethiopia”

Name of the department _____

Name of the working section_____

Hello, I am_____. I am working in the research team of Addis Ababa University, College of Health Sciences, School of Public Health, and Department of Preventive Medicine. I would like you to participate in a research study related to cotton dust exposure and respiratory health problem. No harm will happen to you because of joining this study instead your participation will help to improve working environment in the textile factories. Your name will not be written in this form, and will never be used in connection with any information you tell us. All information given by you will be kept strictly confidential and will be anonymously used in this research and only accessed by principal investigator. Your participation is voluntary and you are not obliged to answer any question you do not want to answer. If you fill discomfort with the interview please fill free to drop it any time you want. This interview will take about 25 minutes.

Do you agree?

Participant agrees----------participant does not agree_____

I have read the contents in this form or it has been read to me in the language I comprehend and understood the condition stated above. My questions have been answered. Therefore, I agree to participate in this study and confirm my participation by signing the consent.

Signature of a participant_____

Interviewer: Name_____ signature_____

Date of interview_____ Time started_____ Time completed_____

Result of interview: 1.Completed 2.Respondent not available 3.Refused 4. Partially completed

For any inconvenience and problem you can contact the following people
Addis Ababa University College of Health Sciences IRB secretary office Tel: 0115512876
Principal investigator: Yiokire Tefera: Phone -0913754082; E-mail- yifoomitu@yahoo.com
Primary Supervisor: Dr. Abera Kumie; Mobile: 0911882912

Consent form Amharic version

የተሳታፊዎች ፍቃድኝነት መጠየቅያ ቅጽ

የጥናቱ ርዕስ፡ የጥጥ ብናኝና የኢንዶቶክሲን ተጋላጭነትና የመተንፈሻ ጤና በኢትዮጵያ የጨርቃ ጨርቅ ፋብሪካ ሰራተኞች ላይ

የዲፓርትመንት ስም ---------- የስራ ክፍል ----------

ጤና ይስጥልኝ እኔ ---------- እባላለሁ፡፡ እኔ የመጣሁት ከአዲስ አበባ ዩኒቨርስቲ ጤና ሳይንስ ኮሌጅ የሕብረተሰብ ጤና ት/ቤት የፐሪቬንቲቭ ሜዲሲን ት/ክፍል ቡድን አባል ሆኜ ነው፡፡

ከዚህ በመቀጠል ከጨርቃ ጨርቅ ፋብሪካ የሚወጣ የጥጥ ብናኝና የኢንዶቶክሲን ተጋላጭነት በመተንፈሻ ጤና ላይ ስለሚያስከትለው ጉዳት ለማወቅ በሚደረግ ጥናት ላይ እንዲሳተፉ እንጠይቃለን፡፡ በዚህ ጥናት ጊዜ ምንም ዓይነት አደጋ ይከሰታል ብለን አንጠብቅም፡፡ ከእርሶ የሚገኘዉ መልስ የስራ አከባቢ ደህንነትና ጤና አገልግሎትን ለማሻሻል ከፍተኛ እገዛ ይኖረዋል፡፡ ከእርሶ የምናገኛቸዉን ማንኛዉንም መረጃ በምስጢር እንጠብቃለን፡፡ ከዚህ ጥናት ጋር በተያያዘ በማንኛዉም ቦታ እና ጊዜ ስምዎ እንደማይጻፍና እንደማይጠቀስ ልንገልጽልዎ እንወዳለን፡፡ መጠይቁ በግምት 25 ደቂቃ ገዳማ የሚወስድ ሲሆን በጥናቱ የሚሳተፉት የእርሶን ሙሉ ፍቃድኝነት ስናገኝ ብቻ ነዉ፡፡ በመጠይቁ ሂደት የማይፈልጉትን ጥያቄዎች በከፊልም ሆነ ሙሉ ለሙሉ ያለመመለስ መብትዎ የተጠበቀ ነዉ፡፡

በጥናቱ ለመሳተፍ ፍቃደኛ ነዎት?

1 አዎ---------- 2 የለም ----------

እኔ ሙሉ ፀሁፉን አንብቤ ተረድቻለሁ ወይንም በሚገባኝ ቋንቋ ተነቦልኛል፡፡ ስለዚህ ከላይ የተጠቀሱትን ሃሳቦች በደንብ ተረድቻለሁ፡፡ ጥያቄዎቼ በሙሉ ተመልሰዋል ስለዚህ በዚህ ጥናት ለመሳተፍ እስማማለሁ፡፡

የተሳታፊ ፊርማ ----------

የጠያቂው ስም ---------- ፊርማ ----------

የቃለ መጠይቁ ቀን ----------የተጀመረበት ሰዓት ----------ያለቀበት ሰዓት ----------

ውጤት

1. ተጠቃሏል 2. ተጠያቂው አልተገኘም 3. ተጠያቂው ተቃውመዋል 4.በከፊል ተጠናቋል

ለማንኛውም መረጃ የጥናቱን ዋና ተመራማሪ በሚቀጥለው አድራሻ ማግኘት ይችላሉ፡፡•
በአዲስ አበባ ዩኒቨርሲቲ የህክምና ሳይንስ ኮሌጅ የምርምር ስነ ምግባር ቦርዱ ጸሀፊ፡ ስልክ 01-18-96-13-9
ይፎክር ተፈራ፤ስልክ 09-13 7540 82፤ኢ.ሜ.ል yifoomitu@ yahoo.com
የጥናቱ ዋና አማካሪ፤ዶ/ር አበራ ኩሚ፡ስልክ 09-11-88-2912

Annex 3: Questionnaire

Questionnaire English version

Section A: Demographic data

No	Questions/ variable	Responses	Skips
1.	Date of birth (day/month/year) in EC	/_____/_____/_____/	
2.	Age in years		
3.	Sex	1. Male 2. Female	
4.	Education level	1. Read and write 2. 1-4 3. 5-8 4. 9-10 5. 11-12 6. College and above	
5.	Profession by training	1. None/untrained 2. Electrician 3. Mechanic 4. Operator 5. Textile engineering 6. Other (specify)	
6.	Marital status	1. Single 2. Married 3. Divorced 4. Widowed 5. Other specify	

Section B: Occupational history

No	Questions/ variable	Responses	Skips
7.	What is your employment type	1. Permanent 2. Per time 3. Temporary	
8.	What is your current shift	1. Morning 2. Evening 3. Night 4. Day	
9.	For how long have you been working in this factory (years)		
10.	How long have you been working in this department, in years		
11.	How long have you been working in textile factories, including all periods in other textile too? (years)		
12.	How many hours do work per day? (hours)		
13.	How many hours do you work per week? (hours)		
14.	Have you ever worked other than your current departments in the past?	1. Yes 2. No	**Q16**
15.	If yes, which department you have been working? and for how long? (in years) (Multiple answer is possible)	1. Spinning ____ 2. Weaving____ 3. Finishing____ 4. Garment____	
16.	Have you ever worked in dusty types of work other than textile?	1. Yes 2. No	**Q18**
17.	If yes, have you worked in any of the following types of work (in years), multiple answer possible	1. Foundry ____/___ 2. Stone quarry____/____ 3. Asbestos ____/___ 4. Flower industry ____/___ 5. Millet processing ____/___ 6. Mines____/____ 7. Livestock farming ____/___ 8. Others_____/___/__	
18.	Do you normally cook food at home?	1. Yes 2. No	**Q20**
19.	Do somebody cook at in your living house?	1. Yes 2. No	
20.	Either Q18 or Q19 is Yes, what type of energy do you use in your home for cooking?	1. Charcoal 2. Fire wood/biomass 3. Kerosene	

		4. Electricity	
21.	Do animals live at your home?	1. Yes 2. No	

Section C: Respiratory symptoms

No	**Questions/ variable**	**Responses**	**Skips**
Cough			
22.	Do you usually cough first thing in the morning	1. Yes 2. No	
23.	Do you usually cough during the day or at night?	1. Yes 2. No	
	If Yes to any of the above continue Q24, if no go to Q39		
24.	Do you usually cough as much as 4-6 times a day for 4 or more days in a week?	1. Yes 2. No	
25.	Do you cough like this on most of days for as much as 3 consecutive months or more in a year?	1. Yes 2. No	
26.	For how long you had this cough? (years)		
27.	Do you cough most on any particular day of the week	1. Yes 2. No	
28.	If Yes, which day(s)		
29.	Do you have any seasonality to your cough	1. Yes 2. No	**Q31**
30.	If you say Yes, when do you usually cough?	1. Winter (October-January) 2. Spring (February-May) 3. Summer (June-September)	
Phlegm/Cough with sputum production			
31.	Do you usually cough with sputum first thing in the morning?	1. Yes 2. No	
32.	Do you usually cough with sputum during the day or at night?	1. Yes 2. No	
33.	Do you usually cough with sputum as much as twice a day, or 4 or more days in a week?	1. Yes 2. No	
	If Yes to any of the above Q31, Q32, Q33 then continue If No go to Q39		

34.	Have you had periods or episodes of (increased) cough and sputum lasting for 3 weeks or more each year?	1. Yes 2. No	**Q36**
35.	If Yes, for how long have you had at least one such episodes per year? Number of years		
36.	Do you cough with sputum on most of days for as much as 3 consecutive months or more in a year?	1. Yes 2. No	
37.	Do you have any seasonality to your sputum?	1. Yes 2. No	**Q39**
38.	If you say Yes, when do you usually cough with sputum?	4. Winter (October-January) 5. Spring (February-May) 6. Summer (June-September)	
	Tightness in chest		
39.	Does your chest ever feel tight or your breathing become difficult?	1. Yes 2. No	**Q44**
40.	Is your chest tight or your breathing difficult on any particular days?	1. Yes 2. No	**Q42**
41.	If Yes, Specify	1. Most of the first days back at work only 2. Other days also 3. Only other days	
42.	Do you have any seasonality for your chest tightness?	1. Yes 2. No	**Q44**
43.	If you say Yes, when do you usually feel the chest tightness?	1. Winter (October-January) 2. Spring (February-May) 3. Summer (June-September)	
Breathlessness			
44.	Are you troubled by shortness of breath when hurrying on level ground or walking up slight hill? **Not due to disability**	1. Yes 2. No	**Q52**
45.	If Yes, do you have to walk slower than people of your age on level ground because of breathlessness?	1. Yes 2. No	**Q47**
46.	If Yes for Q45, do you ever have to stop for breath walking at your own pace on level ground?	1. Yes 2. No	
47.	Is your breathlessness worse on any particular day?	1. Yes 2. No	**Q49**
48.	If Yes, specify the day(s)		
49.	For how long your breathless happened, in years		

50.	Do you have any seasonality for your breathlessness?	1. Yes 2. No	**Q52**
51.	If you say Yes, when do you usually feel the breathlessnes?	1. Winter (October-January) 2. Spring (February-May) 3. Summer (June-September)	
Wheezing			
52.	Does your chest ever sound wheezy or whistling	1. When you have a cold 2. Occasionally apart from colds 3. Most days or nights 4. No	**Q57**
53.	If your answer for the above question is 1, 2 or 3, for how many years this been present? In years		
54.	Have you ever had an attack of wheezing in the last 12 months?	1. Yes 2. No	
55.	Do you have any seasonality for your wheezing?	1. Yes 2. No	**Q57**
56.	If you say Yes, when do you usually wheezing?	1. Winter (October-January) 2. Spring (February-May) 3. Summer (June-September)	
Chest Illness			
57.	If you get a cold does it usually got to your chest?	1. Yes 2. No	
58.	During the last 3 years, have you had any chest illness which has kept you off work, indoors at home or in bed as much as a week?	1. Yes 2. No	**Q61**
59.	If Yes, did you bring up more phlegm than usual in any of these chest illnesses?	1. Yes 2. No	
60.	Have you had more than one illness like this in the past three years?	1. Yes 2. No	
Chronic bronchitis			
61.	During the past 3 years have you had a period of increased cough with increased sputum production for as long as three weeks or more?	1. Yes 2. No	
Respiratory symptoms while at work			
62.	Do you have any of the following noticeable feeling differently at workplace. Multiple answer possible	1. Cough 2. Phlegm 3. Tightness 4. Wheezing	

		5. Breathlessness 6. Sneezing 7. No	
Other symptoms			
63.	Do you wake up at night with air hunger or breathlessness and stand up or run to the windows for air	1. Yes 2. No	
64.	Do you high lifted or use more pillows to alleviate the breathlessness	1. Yes 2. No	
65.	Do you have body swelling?	1. Yes 2. No	

Section D: Past illness

No	Questions/ variable	Responses	Skips
66.	Did you have any lung trouble before the age of 16?	1. Yes 2. No	**Q68**
67.	If your answer is Yes, what was illness	1. An injury /operation affecting your chest 2. Heart trouble 3. Bronchitis 4. Pneumonia 5. Pleurisy 6. Asthma 7. Pulmonary tuberculosis 8. High blood pressure 9. Emphyseamia 10. Other	

Section E: Tobacco Smoking

No	Questions/ variable	Responses	Skips
68.	Have you ever smoked cigarettes? (**No** means less than 20 packs of cigarettes in a life time or less than 1 cigarette a day for 1 year)	1. Yes 2. No	**Q72**
69.	If Yes, do you now smoke cigarettes? (as of 1 month ago)	1. Yes 2. No	
70.	How many cigarettes do you smoke per day now?		
71.	How many years do you smoke?		
72.	Is there a smoker living in your house?	1. Yes 2. No	

	Family History		
73.	Were either of your natural parents ever told by a doctor that they had a chronic lung conditions	1. Yes 2. No	**Q75**
74.	If your answer isYes for Q73, what was the illness?	1. Chronic bronchitis 2. Asthma 3. Lung cancer 4. Other	

Section F: Respiratory protective devices

No	**Questions/ variable**	**Responses**	**Skips**
75.	Do you usually wear respiratory protective devices while at work?	1. Yes 2. No	**Q77**
76.	If yes, which of the respiratory protective device do you use?	1. Half mask 2. Full face mask 3. Other specify	
77.	If the answer for Q75 is No, Select the most appropriate reasons for not using respiratory protective device?	1. Not available 2. Not comfortable to wear 3. Do not offer enough protection against dust 4. The dust is not harmful 5. Other (specify)	

Section G: Physical Measurement

No	**Questions/ variable**	**Responses**	**Skips**
78.	Weight (Kg)		
79.	Standing height (cm)		

Questionnaire Amharic version

መጠይቅ

ክፍል አንድ ስነ-ሕዝብ በተመለከተ

ተ.ቁ	ጥያቄ	መልስ	ማሳለፊያ
1.	የትውልድ ቀን (ቀን / ወር / ዓ.ም)	/_____/_____/_____/	
2.	ዕድሜ በዓመት		
3.	ፆታ	1. ወንድ 2. ሴት	
4.	የትምህርት ደረጃ	1. አልተማረም 2. 1-4 3. 5-8 4. 9-10 5. 11-12 6. ኮሌጅና ከዚያ በላይ	
5.	የሙያ አይነት	1. ያልሰለጠነ 2. ኤሌክትሪሺያን 3. መካኒክ 4. ኦፕሬተር 5. የጨርቃጨርቅ ኢንጅነር 6. ሌላ ካለ ይጠቀስ	
6.	የጋብቻ ሁኔታ	1. ያላገባ/ች 2. ያገባ/ች 3. የፈታ/ች 4. የሞተበት/ባት 5. ሌላ ካለ ይጠቀስ	

ክፍል ሁለት የስራ ሁኔታ

ተ.ቁ	ጥያቄ	መልስ	ማሳለፊያ
7.	የስራ ቅጠር ሁኔታ	1. ቋሚ 2. የትርፍ ሰአት ሰራተኛ 3. ጊዜያዊ	
8.	አሁን በየትኛው ሽፍት ነው የሚሰሩት	1. የጥዋት 2. የማታ 3. የለሊት 4. የቀን	
9.	ለምን ያህል ጊዜ ነው እዚህ ፋብሪካ የሰሩት? (በአመት)		
10.	ለምን ያህል ጊዜ በዚህ ዲፓርትመንት ሰሩ (በአመት)		
11.	ለምን ያህል ጊዜ ነው በጨርቃጨርቅ ፋብሪካ የሰሩት በሌሎች የጨርቃጨርቅ ፋብሪካ የሰሩትን ጨምሮ? (በዓመት)		
12.	በአማካይ ለምን ያህል ሰዓት በቀን ይሰራሉ? (በሰዓት)		

13.	በአማካይ ለምን ያህል ሰዓት በሳምንት? (በሰዓት)		
14.	ከዚህ በፊት በሌላ ክፍል ሰርተዋል ወይ?	1. አዎ 2. የለም	**ጥ16**
15.	መልሱ አዎን ከሆነ በየትኛው ክፍል ሰሩ እና ለምን የህል ጊዜ እንደሰሩ ጥቀሱ (ከአንድ በላይ መመለስ ይቻላል)	ı. ፊትል_____ 2. ሽመና _____ 3. ፊኒሺንግ _____ 4. ጋርመንት _____	
16.	ከዚህ በፊት ከጨርቃ ጨርቅ ፋብሪካ ውጪ አዋራማ በሆነ ቦታ ላይ ሰርተዋል	1. አዎ 2. የለም	**ጥ18**
17.	መልሱ አዎን ከሆነ ለምን ያህል ጊዜ ከዚህ በታች በተጠቀሱት ቦታ ሰርተዋል (በአመት)**(ከአንድ በላይ መልስ ይቻላል)**	ı. ብረታ ብረት ____ 2. ድንጋይ መፍጫ ____ 3. አስፒስቶስ _____ 4. በአበባበ ልማት ____ 5. ማሽላ ማቀነባበሪያ ____ 6. ማዕድን_____ 7. የከብት ማደለብ_____ 8. ሌላ ካለ ይጥቀሱ_____	
18.	እራስዎ ምግብ ያበስላሉ ወይ	1. አዎ 2. የለም	**ጥ20**
19.	ከመኖሪያ ቤትዎ ውስጥ ምግብ በሌላም ሰው ቢሆን ይበሰላል ወይ	1. አዎ 2. የለም	
20.	ለጥያቄ ቁጥር 18 ወይም 19 መልስዎ አዎ ከሆነ በአብዛኛው ምግብ ለማብሰል ምን ዓይነት ሀይል ይጠቀማሉ	1. ከሰል 2. እንጨት 3. ጋዝ 4. ኤሌክትሪክ	
21.	የመኖሪያ ቤትዎ ውስጥ እንስሳት አብረው ያድራሉ ወይ	1. አዎ 2. የለም	

<u>ክፍል ሶስት የመተንፈሻ ችግር ምልክቶች</u>

ተ.ቁ	ጥያቄ	መልስ	ማሳለፊያ
ሳል			
22.	ብዙ ጊዜ ጠዋት ላይ ሳል አለዎት ወይ	1. አዎ 2. ለም	
23.	በቀን ወይንም በማታ ሳል አለዎት ወይ	1. አዎ 2. ለም	
ከዚኅ በላይ ላሉት ጥያቄዎች ለአንዱ መልስዎ አዎን ከሆነ ወደ ጥያቄ ቁጥር 24 ይሂዱ፤ የለም ከሆነ ወደ ጥያቄ ቁጥር 39 ይሂዱ			
24.	ከ4-6 ጊዜ በአንድ ቀን ለአራት ቀን ወይንም ከዛ በላይ በሳምንት ውስጥ ሳል አለዎት ወይ	1. አዎ 2. ለም	
25.	በተከታታይ ለሶስት ወራት ወይንም ከዛ በላይ አብዛኛውን ቀን ሳል ነበረዎት ወይ	1. አዎ 2. ለም	

26.	ለምን ያህል ጊዜ ነው ሳሉ የቆየዉ (በአመት)		
27.	ከሳምንቱ ቀናት ውስጥ በተለይ ሳል የሚበዛብዎ ቀን ወይም ቀናት አሉ	1. አዎ 2. ለም	
28.	መልስዎ አዎ ከሆነ በየትኛው ቀን/ናት		
29.	ሳልዎ በተለይ የሚበረታበት ወቅት/ወራት አለ ወይ	1. አዎ 2. ለም	**ጥ31**
30.	መልስዎ አዎ ከሆነ በየትኛው ወቅት/ወራት **(ከአንድ በላይ መልስ ይቻላል)**	1. በበጋ (ጥቅምት-ጥር) 2. በበልግ (የካቲት-ግንቦት) 3. በክረምት (ሰኔ-መስከረም)	
ሳል ከሃኪታ ጋር			
31.	ብዙ ጊዜ ጠዋት ላይ ሳል ከሃኪታ ጋር ነበረዎት ወይ	1. አዎ 2. ለም	
32.	ብዙ ጊዜ በቀንና በማታ ሲያስሎት ሳሉ ሀኪታ አለው ወይ	1. አዎ 2. ለም	
33.	በቀን ውስጥ ከ4-6 ጊዜ ወይንም ለ4 ቀንና ከዛ በላይ በአንድ ሳምንት ሳል ከሃኪታ ጋር ነበረዎት ወይ	1. አዎ 2. ለም	
ለጥያቄ ቁጥር 31፤32፤33 ለአንዱ መልስዎ አዎን ከሆነ ወደ ጥያቄ ቁጥር 34 ይሂዱ፤ የለም ከሆነ ወደ ጥያቄ ቁጥር 39 ይሂዱ			
34.	በአመት ለ3 ሳምንትና ከዚያ በላይ በተከታታይ የሚቆይ ሀኪታ የተቀላቀለበት ሳል አጋጥሞዎት ያውቃል	1. አዎ 2. ለም	**ጥ36**
35.	መልስዎ አዎ ከሆነ ይህ አይነት ክስተት ለምን ያህል አመታት ገጥሞዎት ያውቃል (በአመት)		
36.	ለ3 ወራት ወይንም ከዛ በላይ የቆየ ሳል ከሃኪታ ጋር ነበረዎት ወይ	1. አዎ 2. ለም	
37.	ሳልና ሀኪታው በተለይ የሚበረታበት ወቅት/ወራት አሉ ወይ	1. አዎ 2. ለም	**ጥ39**
38.	መልስዎ አዎ ከሆነ በየትኛው ወቅት/ወራት **(ከአንድ በላይ መልስ ይቻላል)**	1. በበጋ (ጥቅምት-ጥር) 2. በበልግ (የካቲት-ግንቦት) 3. በክረምት (ሰኔ-መስከረም)	
ደረት ላይ ክብድ/እፍን/ደረት የመወጠር ስሜት			
39.	ደረትዎ ላይ ክብድ/እፍን/ውጥር የሚያደርግና መተንፈስ የማስቸገር ስሜት ገጥሞዎት ያውቃል	1. አዎ 2. ለም	**ጥ44**
40.	ደረትዎ ላይ ክብድ/እፍን/ውጥር የሚያደርግና መተንፈስ የማስቸገር ስሜት በሳምንቱ የተለዩ ቀን/ናት ያጋጥምዎታል	1. አዎ 2. ለም	**ጥ42**
41.	መልስዎ አዎ ከሆነ መቼ መቼ ነበር	1. አብዛኛውን ጊዜ ከእረፍት መልስ የመጀመሪያውን የስራ ቀን 2. በሌሎች ቀናትም ጭምር 3. በሌሎች ቀናት ብቻ	

42.	ደረትዎ ላይ ክብድ/እፍን/ውጥር የሚያደርግ ስሜት በተለይ የሚበረታብዎ ወቅት/ወራት አለ ወይ	1. አዎ 2. ለም	**ጥ44**
43.	መልስዎ አዎ ከሆነ በየትኛው ወቅት/ወራት **(ከአንድ በላይ መልስ ይቻላል)**	1. በበጋ (ጥቅምት-ጥር) 2. በበልግ (የካቲት-ግንቦት) 3. በክረምት (ሰኔ-መስከረም)	
ትንፋሽ ማጠር/ቃታዬን የመሳብ			
44.	ስትቸኩሎ ወይንም ትንሽ ዳገት ስትወጡ ትንፋሽ የማጠር ችግር አለበዎት ወይ (ከአካል ጉዳት ውጪ በሆነ ምክንያት)	1. አዎ 2. ለም	**ጥ52**
45.	መልስዎ አዎ ከሆነ ከእድሜ እኩያዎ ጋር ሲነጻጸር ለጥ ባለ መንገድ ላይ ሲሄዱ የትንፋሽ ማጠር ይገጥሞታል ወይ?	1. አዎ 2. ለም	**ጥ47**
46.	ለጥያቄ ቁጥር 45 መልስዎ አዎ ከሆነ ለጥ ባለ መንገድ ላይ ሲጓዙ አየር ለመውሰድ ይቆማሉ ወይ	1. አዎ 2. ለም	
47.	የትንፋሽ ማጠሩ ከሳምንቱ ቀናት በተለየ የሚብስብዎ ቀን/ቀናት አሉ ወይ	1. አዎ 2. ለም	**ጥ49**
48.	መልስዎ አዎ ከሆነ በየትኛው ቀን/ቀናት ነው		
49.	ለምን ያህል ጊዜ ነው የትንፋሽ ማጠር የቆየብዎ (በዓመት)		
50.	የትንፋሽ ማጠር ስሜት በተለይ የሚበረታብዎ ወቅት/ወራት አለ ወይ	1. አዎ 2. ለም	**ጥ52**
51.	መልስዎ አዎ ከሆነ በየትኛው ወቅት/ወራት **(ከአንድ በላይ መልስ ይቻላል)**	1. በበጋ (ጥቅምት-ጥር) 2. በበልግ (የካቲት-ግንቦት) 3. በክረምት (ሰኔ-መስከረም)	
ኩር ኩር/ሲር ሲር የሚል ድምፅ			
52.	ሲተነፍሱ ደረትዎ ላይ ኩርኩር ወይንም ሲር ሲር የሚል ድምፅ ይሰማዎታል	1. በጉንፋን በሽታ ስያዝ 2. አብዛኛውን ጊዜ ከጉንፋን በሽታ ውጪ 3. አብዛኛውን ጊዜ በቀንና በማታ 4. የለም	**ጥ57**
53.	ለጥያቄ ቁጥር 52 መልስዎ 1፤2፤3 ከሆነ ለምን ያህል ጊዜ ኩርኩር ወይንም ሲር ሲር የሚል ድምጽ ተሰምቶዎታል (በአመት)		
54.	ባለፈው አንድ አመት ውስጥ ኩርኩር ወይንም ሲጥ ሲጥ የሚል ድምፅ ተከስቶበዎት ያውቃል	1. አዎ 2. ለም	
55.	ኩርኩር ወይንም ሲጥ ሲጥ የሚል ድምፅ ስሜት በተለይ የሚበረታብዎ ወቅት/ወራት አለ ወይ	1. አዎ 2. ለም	**ጥ57**
56.	መልስዎ አዎ ከሆነ በየትኛው ወቅት/ወራት **(ከአንድ በላይ መልስ ይቻላል)**	1. በበጋ (ጥቅምት-ጥር) 2. በበልግ (የካቲት-ግንቦት) 3. በክረምት (ሰኔ-መስከረም)	

የደረት ህመም			
57.	ጉንፋን ሲይዝዎት አብዛኛውን ጊዜ ወደ ደረትዎ ህመም ይቀየራል	1. አዎ 2. ለም	
58.	ባለፉት 3 አመታት ውስጥ በደረትዎ ላይ በሚሰማዎት ህመም ምክንያት ከስራ መቅረት ወይም ወደ ውጪ ሳይወጡ ለአንድ ሳምንት የቆዩበት ጊዜ አለ	1. አዎ 2. ለም	**ጥ61**
59.	መልስዎ አዎ ከሆነ በዚህ ጊዜ ከወትሮው በተለየ ሁኔታ በርከት ያለ አክታ ወጥቶዎት ነበር	1. አዎ 2. ለም	
60.	የዚህ አይነት ህመም ባለፉት 3 አመታት ከአንድ ጊዜ በላይ ገጥሞዎት ያውቃል	1. አዎ 2. ለም	
የቆየ የአየር ቧንቧ መቆጣት			
61.	ባለፉት ሶስት ዓመታት ጊዜ ውስጥ ለ3 ሳምንታትና ከዛ በላይ የቆየ ሳልና ሃክታ ነበረዎት ወይ	1. አዎ 2. ለም	
የመተንፈሻ ህመም ስሜት በስራ ላይ			
62.	ከዚህ በታች ከተዘረዘሩት የመተንፈሻ ህመም ስሜቶች የትኞቹን በስራ ቦታ/በስራ ላይ እያሉ ይሰማዎታል **(ከአንድ በላይ መልስ ይቻላል)**	1. ሳል 2. ሰል ከአክታ ጋር 3. ደረት ላይ ክብድ/እፍን ማድረግ 4. ኪርኪር/ሲር ሲር 5. የትንፋሽ ማጠር 6. ማስነጠስ 7. የለም	
ሌሎች ምልክቶች			
63.	አንዳንድ ጊዜ በአየር ማጠር ምክንያት በለሊት ከእንቅልፍዎ በመንቃት ወደ መስኮት አየር ፍለጋ ይሄዳሉ	1. አዎ 2. ለም	
64.	የትንፋሽ ማጠርዎን ችግር ለማሻሻል አብዛኛውን ጊዜ ከራስዎ ከፍ የሚያደርግ ነገር ወይም ተጨማሪ ትራስ ይጠቀማሉ	1. አዎ 2. የለም	
65.	የሰዉነት እብጠት አለብዎት ወይ	1. አዎ 2. የለም	

<u>ክፍል አራት - የቀድሞ በሽታ</u>

ተ.ቁ	**ጥያቄ**	**መልስ**	**ማሳለፊያ**
66.	ከ16 አመት እድሜዎ በፊት የሳንባ ህመም ችግር ነበረብዎት	1. አዎ 2. ለም	**ጥ68**
67.	መልስዎ አዎ ከሆነ የትኛው አይነት የጤና ችግር ከዚህ በፊት ገጥሞዎት ነበረ **(ከአንድ በላይ መልስ ይቻላል)**	1. በደረት ላይ የደረሰ ጉዳት ወይንም ቀዶ ጥገና 2. የልብ ችግር	

		3. የአየር ቧንቧ መቆጣት 4. የሳንባ ምች 5. የሳንባ ማቀፊያ መቆጣት/የሳንባ ዉሀ መቐጠር 6. አስም 7. የሳንበ ነቀርሳ/ቲቢ 8. የደም ግፊት 9. ኢምፊዜሚያ 10. ሌላ ኣይነት የጠቀስ	

<u>ክፍል አምስት ሲጋራ ማጨስ</u>

ተ.ቁ	ጥያቄ	መልስ	ማሳለፊያ
68.	ሲጋራ አጭሰው ያዉቃሉ (የለም ማለት በቀን ከአንድ ሲጋራ በታች ለአመት ማጨስ ወይም እስካሁን ድረስ ከ20 ፓኮ በታች ማጨስ)	1. አዎ 2. ለም	**ጥ72**
69.	መልስዎ አዎ ከሆነ አሁን ሲጋራ ያጨሳሉ (ባለፈው አንድ ወር ውስጥ)	1. አዎ 2. ለም	
70.	ምን ያህል ሲጋራ በቀን በአማካይ ያጨሳሉ		
71.	ምን ያህል አመታት ሲጋራ አጨሱ (በአመት)		
72.	በቤትዎ ውስጥ ሲጋራ የሚያጨስ ሰው አለ ወይ	1. አዎ 2. ለም	
የቤተሰብ የጤና ሁኔታ			
73.	ወላጅ እናትዎ ወይም አባትዎ በሀኪም የተረጋገጠ የቆየ የሳንባ/የደረት ላይ ህመም ነበረባቸው	1. አዎ 2. ለም	**ጥ75**
74.	መልስዎ አዎን ከሆነ በየትኛው በሽታ ታመው ነበር **(ከአንድ በላይ መልስ ይቻላል)**	1. የቆየ አየር ቧንቧ መቆጣት 2. አስም 3. የሳንባ ካንሰር 4. ሌላ ይጠቀስ	

<u>ክፍል ስድስት</u> መከላኪያ መሳርያ በተመለከተ

ተ.ቁ	ጥያቄ	መልስ	ማሳለፊያ
75.	በአብዛኛው በስራ ወቅት የመተንፈሽ መከላኪያ መሳርያ ይጠቀማሉ?	1. አዎ 2. ለም	**ጥ87**
76.	መልስዎ አዎ ከሆነ የትኛዉን መከላከያ መሳርያ ነዉ የሚጠቀሙት	1. የአፍና አፍንጫ መከላኪያ ማስክ 2. የሙሉ ፊት መከለያ መተንፈሻ 3. ሌላ ከሆነ ይጠቀስ_____	

77.	ለጥያቄ ቁጥር 75 መልስዎ የለም ከሆነ ዋነኛው ምክንያቱ ምንድን ነው	1. ስለሌለ 2. ስለማይመቹ 3. ብናኝ ስለማይከላከል 4. ብናኝ አደጋ ስለማያመጣ 5. ሌላ ምክንያት ካለ ጥቀሱ	

<u>ክፍል ስ</u>ባት፡<u>ቁመት ና ክብደት</u>

ተ.ቁ	**ጥያቄ**	**መልስ**	**ማሳለፊያ**
78.	ክብደት (ኪግ)		
79.	ቁመት (ሳ.ሚ)		

Annex 4: Air sampling Worksheet

Sampling place/department:

Sampling round:

Date	Sample ID	Pump no	Employee ID	Job tasks	Start time	Stop time	Sampling Durtation (minute)	Flow start	Flow stop	Sampling Volume (m^3)	Analysed Dust (mg)	Dust conc. (mg/m^3)	Endotoxin conc. EU/m^3

Air sampling participant activity follow up description

Date:

Place of sampling:

Pump ID	Filter ID	Activity description

Process Description:_____

Engineering Controls: _____

Work practice Control: _____

Ventilation Measurements: _____

Personal Protective equipment's used: _____

Production performance: _____

Annex 5: Spirometry measurement tools

Anthropometry measurement procedure

Steps	Anthropometric Measurement procedure
1	Calibrate the weight scale with the standard weight every day before start measurement
2	Use standardized and calibrated height scale
3	Contact the randomly selected person and ask consent for measurement
4	Two data collectors involve in the measurement, one person conduct measurement the other person record
5	Check the weight scale in Kg first weight measurement then height
6	Inform the person to remove any objects held by hand and head covers then allow properly stand on the weight and height scale on bare foot
7	Conduct measurement and record
8	Allow the person off from the measurement scale carefully and thank
9	Contact the next person and start from procedure 3

Prepared by Yifokire Tefera, PhD student

Event calendar

Field Spirometer Data Collection Date of Birth Estimation Event Calendar, 2017

Year in Ethiopia	Event
1944	Eritrea Federates with Ethiopia
1953	Coup attempted to overthrow Emperor Haile Silassie by Mengistu Neway and Germame Neway
1954	Emperor Haile Silassie makes Eritrea as one of Ethiopia's province
1955	First conference of the Organization of African Unity held in Addis Ababa
1965-66	The deadly famine in Wello province
1966	Fall off Emperor Haile Silassie
1967	Emperor Haile Silassie died
1967	"Meret larashu" or public ownership of rural lands and government ownership of urban lands and extra houses
1969	Somalia invades Ethiopia's Ogaden region
1969-70	"Yekey Shiber Zemecha" or Red Terror
1977	Ethiopia nationwide drought and famine
1983	Fall of Derg regime
1985	Eritrea becomes independent country following referendum
1990	Start of Ethio– Eritrea War
1997	Ethiopia political parties election dispute
2000	Ethiopia millennium
	If you went to school, do you know when you finished your school?

Prepared by Yifokire Tefera, PhD student

Spirometer test procedure

1. **Prior to spirometer test**
    a. Invite 4-5 participants at a time for spirometer test and ask their consent
    b. Check participants free from the following conditions
        i. Pneumothorax
        ii. Unstable cardiovascular status, recent myocardial infarction or pulmonary embolism
        iii. Thoracic, abdominal or cerebral aneurysms
        iv. Recent eye surgery
        v. Acute disorders affecting test performance, such as nausea or vomiting
        vi. Recent thoracic or abdominal surgicalprocedures
    c. Confirm participants
        i. Not drinking alcohol within 4 h
        ii. Not attending a dinner party and have large meal with in 2 h
        iii. Not vigorous exercise with in 30 min
        iv. Not Smoking with in 1 h
        v. If anyone is in a medication it should be documented
    d. Fill participants profile (ID, Name, Sex, Height (in cm), Weight (kg), Sex, Date of birth)
    e. Inform, train and demonstrate about the right spirometer practice
        i. Inform the participant will do spirometer test two times before and after shift (the first test will be until 20 minutes the start of shift and 20 minutes before the end of the shift)
        ii. Inform participants to maximal inspiration and forcefully expire and extends for 6 seconds
        iii. Each cross-shift test will be conducted for a minimum of 3 times and maximum of 6 trials
        iv. A deep breath can be taken in then the mouth placed tightly around the mouthpiece before a full expiration
        v. Let know each person use its own mouth piece, no cross contamination, no sharing of mouth piece
2. **Conduct spirometer test**
    a. Allow participant to sit down on arm chair
    b. Confirm the person identification with the data filled
    c. Give the packed mouth pieces for each person and ask them to unpack
    d. Fit the mouth piece with the spirometer and ask the person to inhale and expire forcefully, motivate the person to perform the test properly
    e. Give feedback for the person based on the spirometer exercise
    f. Shift the spirometer for the other person to do it the test to get a minimum of 15 seconds between each test performance
3. **After spirometer test**
    a. Ask the person fully inhale and exhale freely for maintainace
    b. Thank the person and ask to come back after the end of the shift for the second-round test performance
    c. Repeat the second-round test and follow the procedure start from step 2 and thank

Note: If any emergency indication observed on a person during spirometer consult the medical doctor

Prepared by Yifokire Tefera

Data collection process

Data collectors training, demonstration, field supervision and spirometer test result

Pulmonary Function Test Results

Visit date 10/01/2018

Patient code	W-B-B00324	Age	27
Surname	ABRARAW	Gender	Male
Name	GASHU	Height, cm	167
Date of birth	23/06/1990	Weight, kg	59
Ethnic group	Not defined	BMI	21.16
Smoke		Pack-Year	
Patient group			

Interpretation

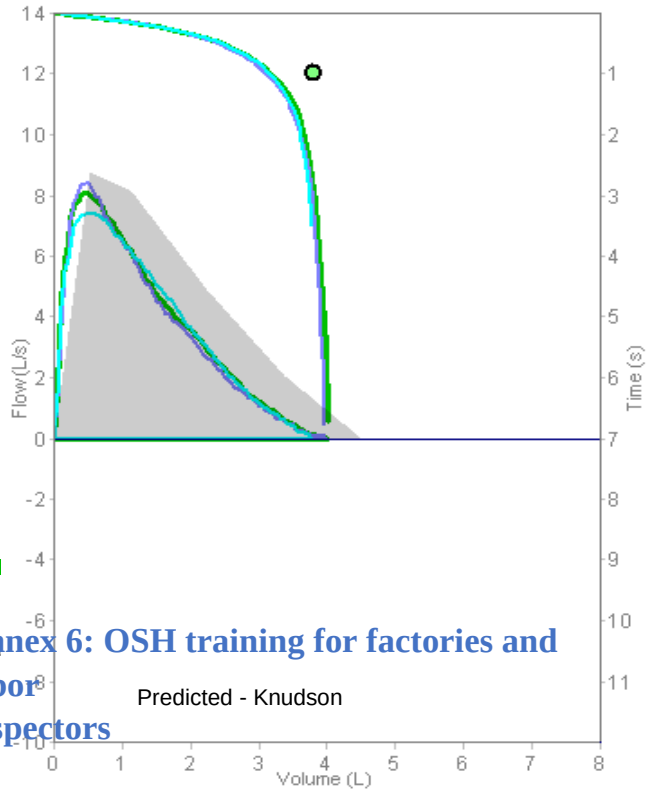
FVC	FEV1	FEV1%
PRE	PRE	PRE

Normal Spirometry

Best values from all loops

Parameters		Pred	PRE	%Pred	POST	%Chg
FVC	L	4.51	4.01	89		
FEV1	L	3.80	3.19	84		
FEV1%	%	85.4	79.60	93		
PEF	L/s	8.76	8.46	97		

Flow / Volume Loop and Volume / Time Curve **PRE**



PRE Trial date 17/01/2018 3:17:42 PM

Parameters		Pred	PRE # 1	%Pred	PRE # 2	PRE # 3	POST#1	%Pred	%Chg
FEV6	L	4.51	**3.95**	88	3.91	3.77			
FVC	L	4.51	**4.01**	89	3.97	3.77			
FEV1	L	3.80	**3.19**	84	3.12	3.15			
FEV1%	%	85.4	**79.6**	93	78.6	83.6			
PEF	L/s	8.76	**8.15**	93	8.46	7.48			
FEF2575	L/s	4.17	**2.89**	69	2.72	3.29			
FIVC	L	4.51							
ELA	Years	27	**48**	178	50	49			

BTPS 1.073 29 °C 84.2 °F

Conclusion / Medical report

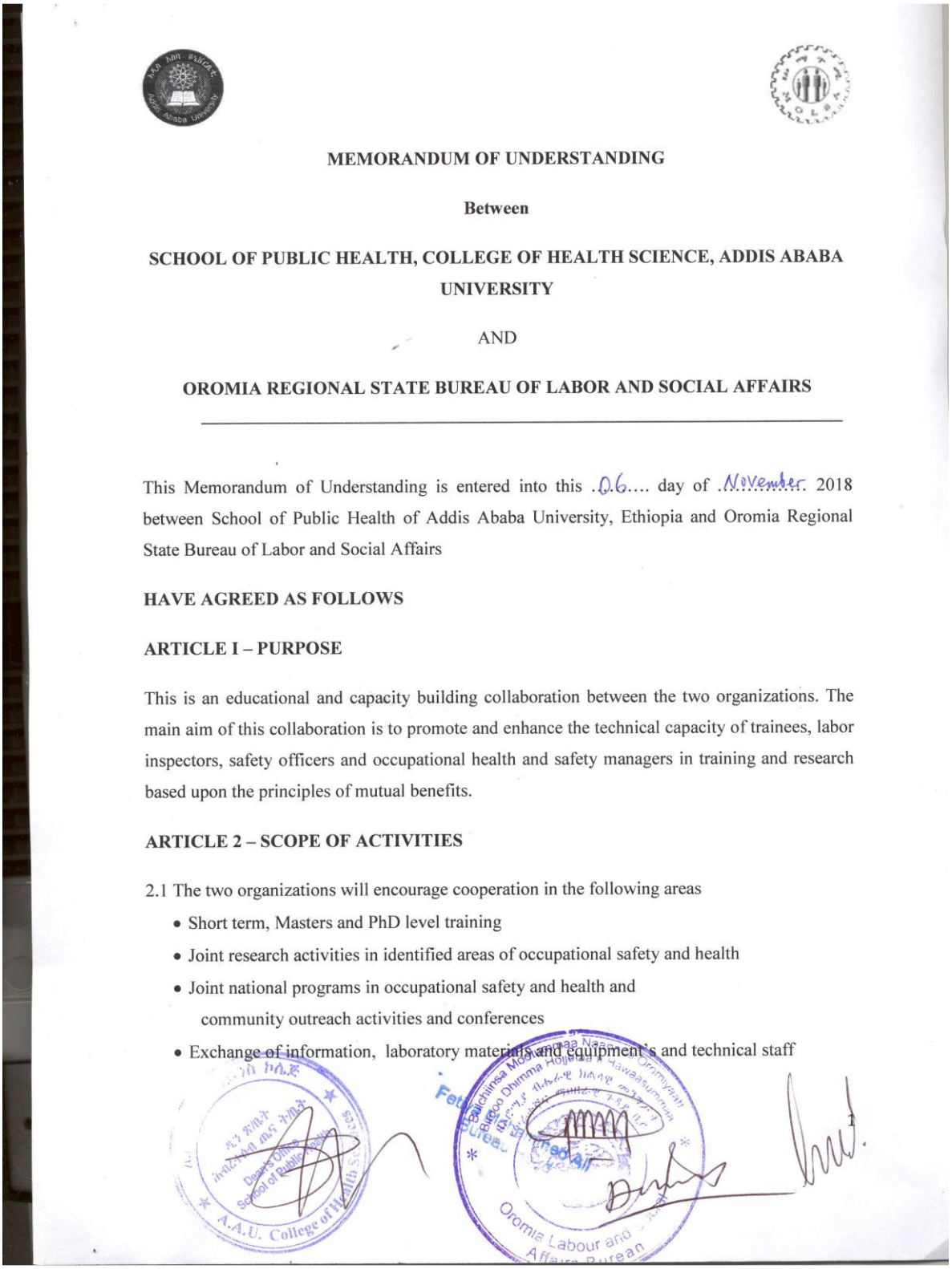
Signature

Instrument used
Minispir LT S/N K01899

Labor inspectors training under the cooperative agreement (MoU) to Oromia BoLSA, Amhara BoLSA, Addis Ababa BoLSA and SNNPR BoLSA

Labor inspectors during field training

Annex 7: Memorandum of Understanding sample



MEMORANDUM OF UNDERSTANDING

Between

SCHOOL OF PUBLIC HEALTH, COLLEGE OF HEALTH SCIENCE, ADDIS ABABA UNIVERSITY

AND

OROMIA REGIONAL STATE BUREAU OF LABOR AND SOCIAL AFFAIRS

This Memorandum of Understanding is entered into this .06.... day of .November. 2018 between School of Public Health of Addis Ababa University, Ethiopia and Oromia Regional State Bureau of Labor and Social Affairs

HAVE AGREED AS FOLLOWS

ARTICLE I – PURPOSE

This is an educational and capacity building collaboration between the two organizations. The main aim of this collaboration is to promote and enhance the technical capacity of trainees, labor inspectors, safety officers and occupational health and safety managers in training and research based upon the principles of mutual benefits.

ARTICLE 2 – SCOPE OF ACTIVITIES

2.1 The two organizations will encourage cooperation in the following areas

- Short term, Masters and PhD level training
- Joint research activities in identified areas of occupational safety and health
- Joint national programs in occupational safety and health and community outreach activities and conferences
- Exchange of information, laboratory materials and equipment's and technical staff

2.2 The terms of cooperation for each specific activity under this MOU will be discussed and detailed in writing by the institutions. Any such document will become a schedule to this MOU.

ARTICLE 3 - DEVELOPMENT OF SPECIFIC PROJECTS

- Each party shall Appropriate agreements for the implementation of these activities mentioned will be developed mutually for specific projects
- The agreement shall ensure that appropriate arrangements for jointly planning, organizing, implementing and monitoring the mentioned activities will be made

ARTILCE 4 -FINANCIAL ARRANGEMENTS

Both parties understand that financial arrangements will have to be negotiated and mutually agreed and will depend on the availability of funds. Both parties will seek financing of joint activities from sources available to them.

Article 5 - GENERAL COORDINATORS

Each party shall designate one coordinator to oversee and facilitate the implementation of any ag reements arising out of this Memorandum of Understanding. The department of Environmental and Occupational Health will be the functional or implementing department/unit from the side of School of Public Health Addis Ababa University.

These coordinators are from

The School of Public Health: **Yifokire Tefera**

Oromia Regional Bureau of Labor and Social Affairs: **Debela Hinsermu**

ARTICLE 6 - LEGAL RELATIONSHIP

This document is a Memorandum of Understanding and is not intended to create binding or legal obligations on either party and shall not be construed as creating any legal relationship between the parties. This Memorandum of Understanding shall be construed as a statement of intent to foster genuine and mutually beneficial collaboration.

Adiya Mohammed Ali
Bureau Head

ARTICLE 7 – Amendments, COMMENCEMENT, RENEWAL, TERMINATION

1. Any amendments to this MOU can be made only in writing signed by both parties and after consultation and mutual consent of the two parties.
2. This MoU shall come into force *from the date of signature* and may be terminated by giving six months notice in writing.
3. Without any notice of termination, the MoU will be terminated five years from the date of last signature. However, any exchange in place will be permitted to continue to completion date.
4. At the end of five years, the Agreement *could* be renewed by exchange of letters.

This MoU is written in English, in two originals, both of equal validity.

Signature

In witness whereof, both parties hereto have agreed on the most recent date below.

On behalf of School of Public Health Addis Ababa University, Ethiopia **Dr Mitike Molla (PhD)** Dean of School of Public Health , Addis Ababa University Signature: _____ Date: 06/11/18 Email: mitike.molla@aau.edu.et	**On Behalf of Oromia Regional State Bureau of Labor and Social Affairs, Ethiopia** **Fetiya Mohammed** Head of Oromia Regional State Bureau of Labor and Social Affairs Signature: _____ Date: 06/11/2018 Email: fetiyamuo@gmail.com
Yifokire Tefera The coordinator in the Department of Environmental and Occupational Health, School of Public Health, Addis Ababa University Date: _____ Email: yifoomitu@yahoo.com	**Debela Hinsermu** The coordinator from Oromia Regional State Bureaue of Labor and Social Affairs, Labor inspection team Date: _____ Email: hinsermudebela@yahoo.com

Annex 8: Dissemination Report

PhD Research dissemination, December 2020

Exposure to Cotton Dust and Endotoxin and Health Problems of Workers in the Integrated Textile Factories, Ethiopia

Prepared by: Yifokire Tefera

Research Team Members:

Yifokire Tefera

Dr. Abera Kumie

Prof. Wakgari Deressa

Prof. Bente E Moen

Prof. Magne Bratveit

National Level Policy dialogue participants

Introduction

These research disseminations are part of the ongoing knowledge translation component of my PhD study. The dissemination is organized after the two research articles published in the international peer-reviewed journals, one article under review and a monograph of the thesis finalized. The research dissemination has two purposes; the first is to aware and initiates the textile and garment factory management and workers representatives to implement occupational health and safety intervention programs to protect workers health; and the second is to indicate policy level gap about workers health protection and to call a collaborative partnership to reduce the occupational diseases and injuries through strategic direction based on research evidence. Thus, three dissemination workshops were organized. The dissemination workshop arranged at two levels; at factory level and policy makers' level. The contents of the research dissemination was prepared from the research findings and customized to the user. Summary of the thesis and factory level research findings are prepared on color full printed brochure and posters with local language and distributed in the workshop. The details of each dissemination workshop presented as; ***Policy dialogue at national level in Addis Ababa***, ***Bahir Dar textile factory dissemination*** and ***Kombolcha textile factory dissemination***. The contribution and the efforts of SPH-AAU/NORHED in terms of generating evidences for program and policy inputs were acknowledged both at the national policy dialogue forum and factory level dissemination workshops. For the dissemination workshop, three types of printed production are produced and distributed for participants. These materials are attached the end of this report: Policy dialogue brochure (at page 11-18), Bahar Dar dissemination (at page 19-20) and Kombolcha dissemination (at page 21-22).

I. National Policy Dialogue Workshop, December 24, 2020

The national level research dissemination workshop is conducted for one day with a discussion theme ***"Policy dialogue: Recording and Notification of Occupational Injuries and Diseases System in Ethiopia. RESEARCH DISSEMINATION: REGISTERED DISEASES & INJURIES FROM TEXTILE AND GARMENT"*** in Addis Ababa, Elilly International Hotel. The workshop is organized by SPH-AAU in collaboration with the Ministry of Labor and Social Affairs. About 36 delegates from different institutions participate in the workshop: Ministry of health, Civil Service Commission, Regional Bureaus of Labor and Social Affairs, Federal Attorney General, Employers Federation, Confederations of Unions, ILO, Social Security Agencies, Insurances Association, Rehabilitation Centers, University and Medias. The State Minister of the Federal Ministry of Labor and Social Affairs (HE Ayelech Eshete) and Dean of the School of Public Health (Prof. Damen Hailemariam) were key note speakers. Two presentations were delivered in the workshop: ***Recording and Notification of Occupational Accident and Disease system in Ethiopia: challenges and prospects*** – by MoLSA and ***Enterprise based Exposure Assessment and Registered Diseases and Injuries in Textile and Garment: Research evidences for policy in put –*** by Yifokire Tefera. A plenary discussion was also conducted chaired by HE. State Minister Ayelech and Yifokire. Participants raised several issues some mentioned, the lack of occupational diseases list, burden of occupational diseases not known, lack of professional on occupational medicine, workers not compensated for diseases, weak institutional capacity and cooperation, weak engagement of insurance companies on occupational disease prevention, etc. Finally, the workshop concluded by the establishment of national technical working group that represent key stakeholders to be chaired by MoLSA on Occupational diseases and injuries. The workshop was broadcasted through six media channels. https://youtu.be/rb5SIP0saP4

Opening remark by HE. State Minster

Key note address by Dean of SPH

Figure 11: National policy dialogue workshop organized in Elilly International Hotel Addis Ababa *(Source:* Photo by Author*)*

II. Bahar Dar Dissemination Workshop, December 28, 2020

The dissemination workshop is organized by the SPH-AAU, Amhara Regional BoLSA and Factory's Corporate Management on a theme ***"EXPOSURE TO COTTON DUST AND ENDOTOXIN, AND RELATED HEALTH PROBLEMS OF WORKERS IN THE TEXTILE AND GARMENT FACTORY"***. About 22 people representing different groups participate: corporate level management, production process directors, department heads, human resource, research unit, workers representative, safety officer, health worker, safety committee, labor inspectors, legal unit, etc. The factory's general manager (CEO) and the Amhara Regional Bureau of Labor and Social Affairs Employment and Peaceful Industrial Relation Directorate address key note speech. Main results to the external exposure (dust and endotoxin), internal exposure (cross-shift lung function) and effect (registered diseases and injuries) are presented. Focused intervention activities are also recommended. Summary of the research findings, key messages and recommendations is prepared on a colorful printed poster with local language to maximize the knowledge use. Active discussion was followed after the presentation about issues related to the finding, comparison of the factory workers disease prevalence with the general population, applicability of recommendation, weak workers participation in PPE use, the need of collaboration with universities, etc. Participants recognized the researchers' effort for organizing such type of workshop and share evidences with factory workers. The factory management acknowledges the presence of big occupational safety and health service gap in the factory and plans a safety campaign in the near future.

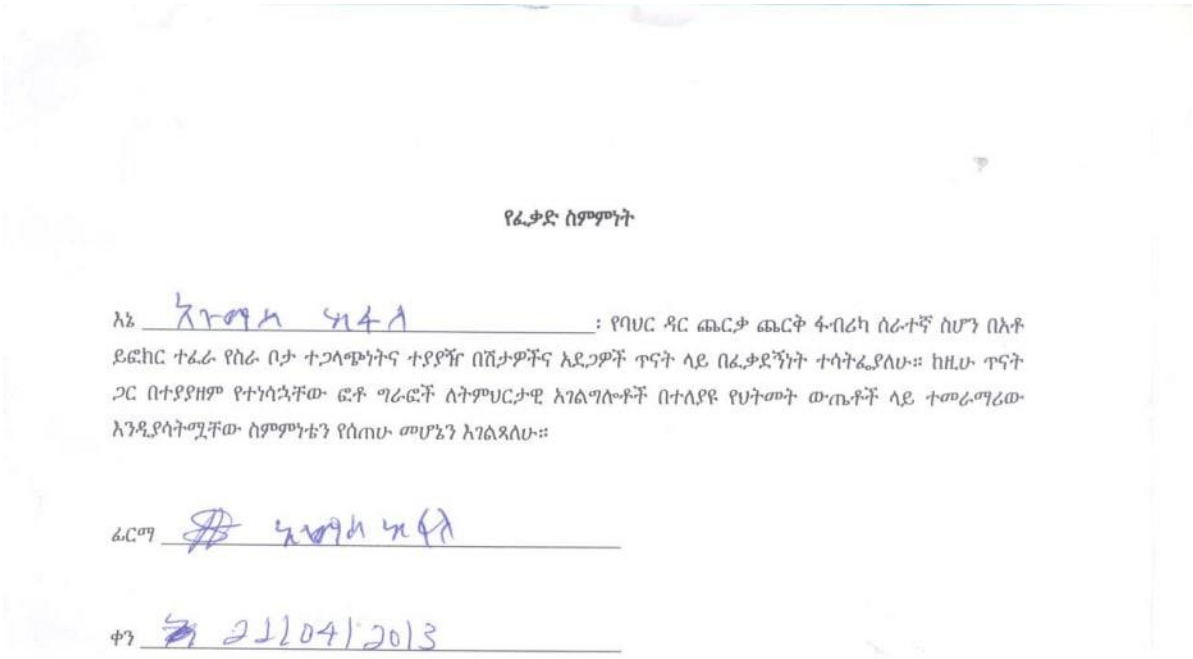
Figure 12: Bahar Dar textile General Manager opening remark, presentation and workshop participants, December 2020 (*Source*: Photo by Author)

III. Kombolcha Dissemination Workshop, December 30, 2020

The workshop was organized by the SPH-AAU and Zonal Bureau of Labor and Social Affairs and Kombolcha textile factory management with a theme ***"A RESEARCH DISSEMINATION WORKSHOP: REGISTERED DISEASES AND INJURIES OF WORKERS IN KOMBOLCHA TEXTILE FACTORY"***. Twenty people representing different groups of the factory participated in the workshop. In his key note address the factory's general manager mentioned that "Our factory is open to researches that will show our gap and give direction". The presentation focused on the recorded diseases and injuries, most affected groups and the possible intervention to reduce disease occurrence and sickness absence. Summary of the research findings, key messages and recommendations is prepared on a colorful printed poster with local language to maximize the knowledge use (Attached). Different questions raised in the discussion about why females more at risk, the high number of sickness absence, the limitation of the study, the recommendations, etc. Participants appreciate the research team and recognized the research findings. The factory human resource manager mentioned that it's a timing workshop. The finding can serve as baseline for OSH activity planning for the year 2021.

Figure 13: Kombolcha textile General Manager opening remark, presentation and workshop participants, December 2020 (*Source*: Photo by Author)

Photograph consent



የፈቃድ ስምምነት

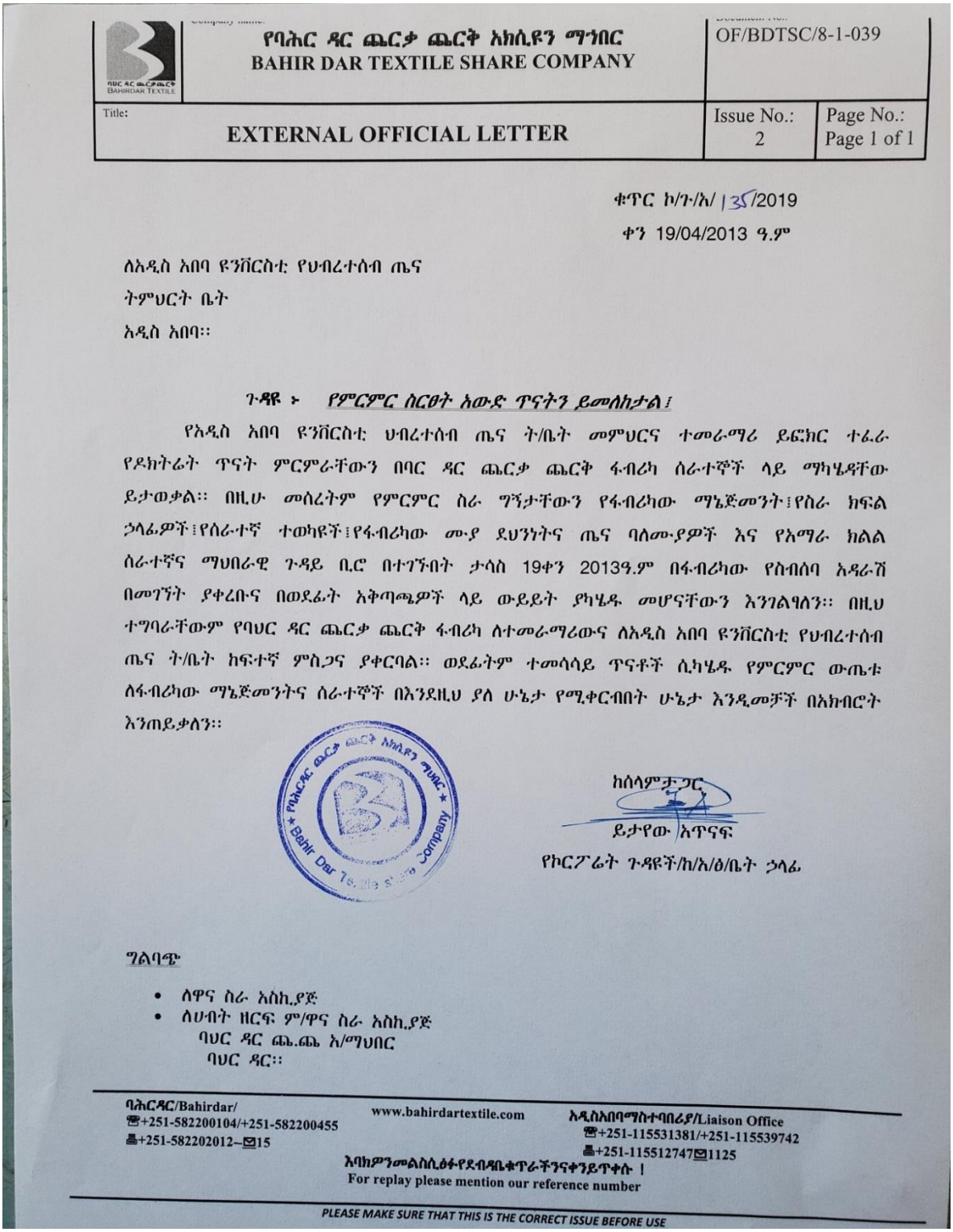
እኔ አገኘሁ ሃብቶ : የባህር ዳር ጨርቃ ጨርቅ ፋብሪካ ሰራተኛ ስሆን በአቶ ይፎክር ተፈራ የስራ ቦታ ተጋላጭነትና ተያያዥ በሽታዎችና አደጋዎች ጥናት ላይ በፈቃደኝነት ተሳትፈያለሁ። ከዚሁ ጥናት ጋር በተያያዘም የተነሳኋቸው ፎቶ ግራፎች ለትምህርታዊ አገልግሎቶች በተለያዩ የህትመት ውጤቶች ላይ ተመራማሪው እንዲያሳትሟቸው ስምምነቴን የሰጠሁ መሆኔን አገልጻለሁ።

ፊርማ አገኘሁ ሃብቶ

ቀን 22/04/2013

Annex 9: Letter from factories

1)Bahar Dar dissemination verification letter



የባሕር ዳር ጨርቃ ጨርቅ አክሲዮን ማኅበር
BAHIR DAR TEXTILE SHARE COMPANY

OF/BDTSC/8-1-039

Title: EXTERNAL OFFICIAL LETTER

Issue No.: 2

Page No.: Page 1 of 1

ቁጥር ኮ/ጉ/አ/ 135/2019

ቀን 19/04/2013 ዓ.ም

ለአዲስ አበባ ዩንቨርስቲ የህብረተሰብ ጤና
ትምህርት ቤት
አዲስ አበባ፡፡

ጉዳዩ ፦ *የምርምር ስርፀት አውድ ጥናትን ይመለከታል፤*

የአዲስ አበባ ዩንቨርስቲ ህብረተሰብ ጤና ት/ቤት መምህርና ተመራማሪ ይፎክር ተፈራ የዶክትሬት ጥናት ምርምራቸውን በባር ዳር ጨርቃ ጨርቅ ፋብሪካ ሰራተኞች ላይ ማካሄዳቸው ይታወቃል፡፡ በዚሁ መሰረትም የምርምር ስራ ግኝታቸውን የፋብሪካው ማኔጅመንት፤የስራ ክፍል ኃላፊዎች፤የሰራተኛ ተወካዮች፤የፋብሪካው ሙያ ደህንነትና ጤና ባለሙያዎች እና የአማራ ክልል ሰራተኛና ማህበራዊ ጉዳይ ቢሮ በተገኙበት ታሳስ 19ቀን 2013ዓ.ም በፋብሪካው የስብሰባ አዳራሽ በመገኘት ያቀረቡና በወደፊት አቅጣጫዎች ላይ ውይይት ያካሄዱ መሆናቸውን እንገልፃለን፡፡ በዚህ ተግባራቸውም የባህር ዳር ጨርቃ ጨርቅ ፋብሪካ ለተመራማሪውና ለአዲስ አበባ ዩንቨርስቲ የህብረተሰብ ጤና ት/ቤት ከፍተኛ ምስጋና ያቀርባል፡፡ ወደፊትም ተመሳሳይ ጥናቶች ሲካሄዱ የምርምር ውጤቱ ለፋብሪካው ማኔጅመንትና ሰራተኞች በእንደዚህ ያለ ሁኔታ የሚቀርብበት ሁኔታ እንዲመቻች በአክብሮት እንጠይቃለን፡፡

ከሰላምታ ጋር

ይታየው አጥናፍ

የኮርፖሬት ጉዳዮች/ኩ/አ/ፅ/ቤት ኃላፊ

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For replay please mention our reference number

PLEASE MAKE SURE THAT THIS IS THE CORRECT ISSUE BEFORE USE

2) Kombolcha dissemination verification letter

ኮምቦልቻ ጨርቃ ጨርቅ አክሲዮን ማኅበር
KOMBOLCHA TEXTILE SHARE COMPANY

ዋናው መስሪያ ቤት ኮምቦልቻ ወሎ
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Fax: 251-033 551 0266
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P.O.Box : 67

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Branch Office Addis Ababa
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P.O.Box 126

ቁጥር/Ref.No ኢአ.ኦኦ/140/158/13
ቀን/Date 21/04/2013

ለአዲስ አበባ ዩኒቨርሲቲ የህብረተሰብ ጤና ትምህርት ቤት
አዲስ አበባ፣

ጉዳዩ፦ የምርምር ስርፀት አውደ ጥናትን ይመለከታል

የአዲስ አበባ ዩኒቨርሲቲ ህብረተሰብ ጤና ት/ቤት መምህርና ተመራማሪ ይፎክር ተፈራ የዶክትሬት ጥናት ምርምራቸውን በኮምቦልቻ ጨርቃ ጨርቅ ፋብሪካ ሠራተኞች ላይ ማካሄዳቸው ይታወቃል። በዚሁ መሠረትም የምርምር ሥራ ግኝታቸውን የፋብሪካው ማኔጅመንት ፣የሥራ ክፍል ኃላፊዎች ፣የሠራተኛ ተወካዮች ፣የፋብሪካው መ/ያ ደህንነትና ጤና ባለሙያዎች እና የአማራ ክልል ሠራተኛና ማህበራዊ ጉዳይ ቢሮ በተገኙበት ታህሳስ 21 ቀን 2013 ዓ.ም በፋብሪካው የስብሰባ አዳራሽ በመገኘት ያቀረቡና ከወደፊት አቅጣጫዎች ላይ ውይይት ያካሄዱ መሆናቸውን እንገልፃለን። በዚህ ተግባራቸውም የኮምቦልቻ ጨርቃ ጨርቅ ፋብሪካ ለተመራማሪውና ለአዲስ አበባ ዩኒቨርሲቲ የህብረተሰብ ጤና ት/ቤት ከፍተኛ ምስጋና ያቀርባል። ወደፊትም ተመሳሳይ ጥናቶች ሲካሄዱ የምርምር ውጤቱ ለፋብሪካው ማኔጅመንትና ሠራተኞች በእንደዚህ ያለ ሁኔታ የሚቀርብበት አግባብ እንዲመቻች በአክብሮት እንጠይቃለን።

ከሰላምታ ጋር
ኮ/ር ሙስጠፋ ጀማል
ዋና ሥራ አስኪያጅ

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- ለሰ/ኃ/ል/አ/መሃመሪያ
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  ኮምቦልቻ
- ለአቶ ይፎክር ተፈራ
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Annex 10: Declaration

Letter for declaration

I, undersigned, declared that this is my original work, has never been presented in this or any other University, and that all the resources and materials used for the dissertation, have been fully acknowledged.

Name: _____

Signature: _____

Date: _____

Place: _____

Date of submission: _____

This dissertation has been submitted for examination with my approval as University Supervisor.

Name: _____

Signature: _____

Date: _____

Annex 11: Published articles