Wood-dust exposure and respiratory health among particleboard workers in Ethiopia

Akeza Awealom Asgedom

Thesis for the degree of Philosophiae Doctor (PhD)
University of Bergen, Norway
2019

UNIVERSITY OF BERGEN

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Date of defense: 22.11.2019

Year: 2019

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Print: Skipnes Kommunikasjon / University of Bergen

List of Abbreviations

CIH	Centre for International Health
NUFU	The Norwegian Programme for Development, Research and Education
KAP	Knowledge Attitude and Practice
PPE	Personal Protective Equipment
SD	Standard Deviation
CI	Confidence Interval
USA	United States of America
M/F	Male/Female
N/Y	No/Yes
IRB	Institutional Review Board
ACGIH	American Conference of Governmental Industrial Hygienists
OEL	Occupational Exposure Limit
TWA	Time Weighted Average
ILO	International Labour Organization
OSH	Occupational Safety and Health
WHO	World Health Organization
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
MoLSA	Ministry of Labour and Social Affairs
AM	Arithmetic Mean
GM	Geometric Mean
USA	United States of America
UK	United Kingdom
m^3	Cubic meters
kg	Kilograms
l	Litres
cm	Centimetres
mm	Millimetres
mg	Milligrams

ml	Millilitres
g	Grams
µg	Micrograms
min	Minutes
l/min	Litres per minute
h	Hours
ºC	Degrees Celsius
rpm	Revolutions per minute
v/v	Volume by volume
m	Metres
ppm	Parts per million
EU	Endotoxin unit
CIS	Conical inhalable sampler
SKC	Sidekick Casella
MCC	Machine control centre
MCC1	Machine control centre 1
MCC2	Machine control centre 2
Fig.	Figure
e.g.	For example
FVC	Forced vital capacity
FEV_1	Forced expiratory volume in one second
$FEF_{25-75\%}$	Forced expiratory flow rate at 25-75%
ATS	American Thoracic Society
NIOSH	National Institute of Occupational Safety and Health

Contents

Scientific Environment

The research study ‘Dust exposure and respiratory health problems among particleboard workers in Ethiopia’ was carried out with the involvement of the scientific community from the Research Group for Occupational and Environmental Medicine, the Centre for International Health (CIH), the Department of Global Public Health and Primary Care, the University of Bergen, Norway, Addis Ababa University, Ethiopia and Aarhus University, Denmark. The collaboration between the University of Bergen, Norway and Addis Ababa University, Ethiopia was under the umbrella NORHED project entitled ‘Reduction of the burden of injuries and diseases due to occupational exposures through capacity building in low income countries’. Aarhus University, Denmark was involved in the exposure study through laboratory analysis and interpretation of the research findings.

Acknowledgements

In the Name of the Father and of the Son and of the Holy Spirit One God Amen!
I would firstly like to thank my Almighty God and his merciful mother St Mary for giving me great strength throughout my PhD training.

I secondly wish to express my deepest gratitude to my supervisors Professor Bente Elisabeth Moen and Professor Magne Bråtveit. My success was entirely due to your unreserved continuous supervision and energetic moral support. When I meet you, you always say, 'You are doing great!' and that has given me positive energy for my next work. I lack the words to express how grateful I am for your supervision. You have paved the way for my future career, and I thank you for your priceless support.

I extend my appreciation to the Royal Norwegian Government, the Norwegian State Education Loan Fund (Lånekassen) and the Norwegian Programme for Development, Research and Education (NUFU) for funding both my studies and my stay in Norway. Your financial support made a clear difference. Thank you for this support. In addition, my thanks go to Norad, as the funding of the project 'Reduction of the burden of injuries and diseases due to occupational exposures through capacity building in low income countries' gave me access to the requisite instruments during my field work in Ethiopia, thereby facilitating my studies.

I acknowledge the administrative staff of the Centre for International Health (CIH) and the Department of Global Public Health and Primary Care (IGS) for their valuable administrative support during my studies. I wish to thank Gunhild Koldal, Daniel Gunderson, Hallgeir Kismul, Solfrid Vikøren, Elinor Bartle, Linda Karin Forshaw and others. All your kind support was superb and extremely helpful.

I owe a debt of sincere gratitude to Professor Vivi Schlünssen and Kirsten Østergaard for all their cooperation and scientific help during exposure data analysis and laboratory visits at Aarhus University, Denmark. Professor Vivi, your valuable scientific input for the exposure study was very supportive – thank you for your help.

Special thanks go to my colleagues in the Occupational and Environmental Medicine research group: Israel Paul Nyarubeli, Ole Jacob Møllerløkken, Gro Tjalvin, Bjørg-Eli Hollund, Jorunn Kirkeleit, Ingrid Gjesteland, Erlend Sunde, Kaja Irgens Hansen, Nadia, Samsom Wakuma Abaya, Yifokir Tefera, Abera Kumie, Meaza Gezu and others. I had a great scientific and social environment during my period of study. I thank you all, and I hope we will maintain the momentum in our future careers.

I am very indebted to the administrative and production workers at the Maichew and Hawassa wood factories, Mercy Spring Water and Raya Spring Water. I am very grateful for all your cooperation and what you facilitated during my stay at your factories. My studies would have been impossible without your willingness and kind cooperation.

I wish to extend my gratitude to my Ethiopian friends and colleagues: Abay Kassa, Kasahun Gebre, Meselech Assegid, Samuel Deleta, Mengistu Bekele, Feven Girma, Dawit Desalegn, Alemayehu Desalegn, Behailu Aschalew, Daniel Asaye, Mekdim Tibebu, Wondwosen Kumsa and others.
Finally, I would like to thank my family and friends in Ethiopia for their wholehearted support. My family educated me at the expense of their literacy. They provided the ladder by which I have reached this extraordinary destination from an ordinary 'The cowboy- ጓሳ ከፍቲ'. My family, I am realizing my dream thanks to your boundless familial love, moral support and advice. I am indebted to you for your valuable help. I love you very much.

Akeza Awealom Asgedom
Bergen, July 2019

Abstract

Background

Work in the wood industry is often associated with exposure to wood dust, endotoxins and formaldehyde, which may cause respiratory health problems. Particleboard is a type of wood product manufactured primarily from wood chips, glued with urea formaldehyde resin and bonded under heat and pressure. In Ethiopia the manufacturing sector, like the wood industry, is growing. However, there is a scarcity of Knowledge, Attitude and Practice (KAP) concerning chemical health hazards and personal protective equipment (PPE) among particleboard workers. On top of this, workers' exposure to inhalable wood dust, endotoxins and formaldehyde and their effect on respiratory health has been insufficiently studied.

Objectives

The aim of this thesis was to assess exposure to wood dust, endotoxins and formaldehyde, respiratory health and KAP regarding chemical hazards and use of PPE among Ethiopian particleboard workers.

Method and materials

The thesis consist of three papers conducted in three phases from 2016 to 2017 at the two largest particleboard factories in Ethiopia.

In Phase One a cross-sectional study design was used for collection of data on KAP concerning chemical health hazards and PPE in production and administrative workers (n=172), and the study used both closed-ended and open-ended questions. Both permanent and temporary employees were included in the study.

In Phase Two an exposure study was performed. A total of 152 dust and endotoxin samples were collected using a conductive plastic inhalable conical sampler (CIS) in the two largest particleboard factories. One field blank sample was taken per day (n=18). In addition, 45 stationary formaldehyde samples were taken using Dräger tubes. Inhalable dust was analysed using the gravimetric method in a room with controlled climatic conditions using an analytical balance with 0.1 μg readability, and

the concentration was estimated in mg/m^3. Endotoxins were analysed using the Kinetic Amoebocyte Lysate test, and the concentration was estimated in EU/m^3.
In Phase Three a cross-sectional study involving 74 workers from two particleboard factories and 73 controls from two water-bottling factories was performed. Respiratory symptoms were collected using the American Thoracic Society's (ATS) standard questionnaire. A lung-function test was performed using spirometry following ATS guidelines.
Data was analysed using descriptive statistics, content analysis, the Chi-square test or Fisher's exact test, the t-test, Pearson's correlation analysis, regression analysis and mixed-effects models.

Results

For Paper I the mean age of the respondents was 28, and the average years of service was 3.7. The permanent workers were older than the temporary workers (29 vs 26 years, $p= 0.001$), and a very high proportion of the permanent workers had completed vocational education (90%), compared with the temporary workers (11%). The permanent production workers had significantly more knowledge of topics related to chemical hazards than did temporary workers, as well as more positive responses than temporary workers to questions about attitudes related to reduction of chemical hazards and the general work environment. Educational status was significantly associated with a total knowledge score. PPE was provided for permanent workers, but few temporary workers reported PPE provision from the factory. Neither permanent nor temporary workers were using a full set of PPE. The frequency of medical check-up at the health institution was reported as being 25% for temporary and 37% for permanent workers. The administrative personnel are aware of the chemical hazards in their factory. However, the majority of them believe all PPE offers the same level of protection, and they purchase PPE without any safety and quality specification. There was no regular training on occupational safety and health in the factory.
In Paper II the overall geometric mean (GM) of 142 personal inhalable dust and endotoxin exposure were 4.66 mg/m^3 (range 0.47 to 184) and 62.2 EU/m^3 (range 0.9 to 9202) respectively. The highest exposure to inhalable dust was found among

workers performing sizing, forming, flaking and chipping. The highest endotoxin exposure was found in chipping and flaking workstation workers. Of the 142 samples, 93% exceeded 1 mg/m^3, the TLV set by ACGIH for inhalable dust, and 41% samples exceeded 90 EU/m^3, the occupational exposure limit for endotoxins set by the Netherlands. The correlation between dust and endotoxin level was relatively high ($r= 0.68$). Factories and downtime explained 27% of the total variability in inhalable dust level, while workstations explained 34% of the total variability in endotoxin level. The highest median concentration of formaldehyde was recorded at blending workstations (3.5 ppm). Formaldehyde was detected at all the selected workstations except the first and last, i.e. chipping and sizing. Of the 45 samples, 13% exceeded the Norwegian peak exposure limit of 1 ppm.

In Paper III particleboard workers were older than the controls (28 vs 25 years; $p= 0.006$). The exposed workers had also more years of service than the controls (4 vs 2 years; $p< 0.001$). The prevalence of all recorded respiratory symptoms, wheezing, cough, cough with sputum production, phlegm and shortness of breath was significantly higher in particleboard workers (range of prevalence: 24% to 45%) than in controls (2.7% to 15%). Lung-function status was not statistically different when comparing the exposed persons and the controls, and did not appear to be associated with inhalable dust, endotoxins or formaldehyde exposure.

Conclusions

The study revealed that permanent production workers had significantly more knowledge of topics related to chemical hazards, and more a positive response to attitudes related to reduction of chemical hazards and the general working environment than temporary workers. Practice in use of PPE depended on the access to PPE.

The geometric mean exposure levels to inhalable dust exposure in the particleboard factories were above the Threshold Limit Value (TLV) of 1 mg/m^3 set by the American Conference of Governmental Industrial Hygienists (ACGIH). The geometric mean endotoxin level was lower than the recommended Dutch occupational exposure limit (OEL) of 90 EU/m^3. However, the endotoxin levels exceeded this limit at chipping and flaking workstations. The highest median formaldehyde concentration was found in blending workstations (3.5 ppm) – a level above the peak exposure limit value of 1 ppm set by Norway.

There was a higher prevalence of respiratory symptom in particleboard workers than in water-bottling workers. However, lung function status was similar in both groups. The symptoms might be related to the high dust-exposure levels found in the factories, but the results must be interpreted with caution because of the cross-sectional study design.

የጥናቱ ዋና ማጠቃለያ

የጥናቱ ዳራ እና ዓላማ

በእንጨት ኢንዱስትሪ ውስጥ መስራት ለእንጨት ብናኝ፣ኢንዶቶክሲን እና ፎርማልድሃይድ አደጋዎች ያጋልጣል። ሰራተኞቹ ለእንጨት ብናኝ፣ኢንዶቶክሲን እና ፎርማልድሃይድ ሲጋለጡ በስርዓተ መተንፈሻቸው ላይ የጤና እክል ያስከትልባቸዋል። ፓርቲክል ቦርድ በደምብ ከደቀቀ እንጨት ላይ ዩሪያ ፎርማልድሃይድ በመደባለቅ ሙቀትና ግፊት ታክሎበት የሚመረት የእንጨት ምርት ነው።

በኢትዮጵያ የእንጨት ኢንዱስትሪን ጨምሮ ማኑፋክቸርንግ ዘርፍ በከፍተኛ ሁኔታ እያደገ ይገኛል። ነገር ግን ከፋብሪካው ለሚወጡ የተለያዩ የጤና ችግር አምጭ ነገሮች በሰራተኞች ላይ ያለው ተጋላጭነት መጠን እና የሚያስከትለው የስርዓተ መተንፈሻ ችግር አልተጠናም። ከዚህ በተጨማሪም የሰራተኞቹ እና የፋብሪካው ኃላፊዎች በኬሚካል አደጋዎች እና የደህንነት መጠበቂያ መሳርያዎች ያላቸው የእውቀት፣ዝንባሌ እና ክህሎት በደምብ አይታወቅም። በአገር ደረጃ በማኑፋክቸርንግ ዘርፍ የሚሰሩ ሰራተኞችን የጤናና ደህንነት መጠበቅ የሚገልፅ መረጃ በጣም ውስን ነው። ከላይ የተገለፁት የመረጃ ክፍተቶችን ለመሙላት ዓላማ በማድረግ በአገርቱ ከሚገኙ ሁለት ትላልቅ የፓርቲክል ቦርድ ማኑፋክቸርንግ ኢንዱስትሪዎች የእንጨት ብናኝ፣ኢንዶቶክሲንና ፎርማልድሃይድ መጠን እንዲሁም በመተንፈሻ አካል ላይ የሚያስከትሉት የጤና ችግር ጥናት ተደርጓል። ከዚህ በተጨማሪም የሰራተኞቹ እና የፋብሪካው ኃላፊዎች በኬሚካልና የደህንነት መከላከያ መሳርያዎች ያላቸው የእውቀት፣አመለካከት እና ትግበራ የዳሰሳ ጥናት ተካህዷል።

የጥናቱ ዘዴ እና ቁሳቁስ

የፋብሪካው ሰራተኞችና ኃላፊዎቹ በኬሚካልና የደህንነት መጠበቂያ መሳርያዎች ያላቸው የእውቀት፣አመለካከት እና ትግበራ ለመረዳት ያስችል ዘንድ በ172 ሰዎች መጠይቅ መሰረት ያደረገ ጥናት ተደርጓል። በሰራተኞቹ ያለው የመተንፈሻ አካላት የጤና ሁኔታ (የስርዓተ-መተንፈሻ ምልክቶች እና የሳንባን ጤንነት ለመገምገም) በ147 ሰራተኞች (74 ከፓርቲክል ቦርድ እና 73 ደግሞ ለንፅፅር ከ 2 የውኃ ማሸጊያ ፋብሪካ ሰራተኞች) በማካተት የAmerican Thoracic Society (ATS) መደበኛ መጠይቅ መሰረት በማድረግ በመተንፈሻ አካላት ያሉ ምልክቶች ለመለየት ጥናት ተካሂዷል። በተጨመሪም የሳንባን የጤንነት ሁኔታ ለመገምገም የሳንባ የጉልበት መጠን spirometry በተባለ መሳሪያ የATS መመሪያዎች መሰረት በማድረግ ተለኪቷል።

የእንጨት ብናኝ እና ኢንዶቶክሲን ተጋላጭነት ለመረዳት 152 የእንጨት ብናኝ ናሙናዎች ከተለያዩ የስራ ክፍል (workstation) ደረጃውን በጠበቀ Conical Inhalable Sampler በተባለ መሳሪያ ተወስዷል። የአጭር ግዜ የፎርማልድሃይድ ተጋላጭነትን ለማወቅ 45 ናሙናዎች ከተለያዩ የስራ ክፍሎች Dräger tube በተባለ ደረጃውን የጠበቀ መሳሪያ ተለኪቷል።

የጥናቱ አንኳር ውጤቶች እና መደምደሚያዎች

በተወሰደው ናሙና መሰረት የሰራተኞቹ አማካይ የዕድሜ መጠን 28 ዓመት ሲሆን በፋብሪካው ለ 4 ዓመት ያክል አገልግለዋል። ለንፅፅር የወሰድናቸው የውኃ ማሸጊያ ፋብሪካ ሰራተኞች ደግሞ በአማካይ 25 ዓመት የዕድሜ መጠን ያላቸው እና 2 ዓመት በፋብሪካው ውስጥ ያገለገሉ ናቸው። ጥናቱ ቋሚ ሰራተኞች የተሻለ እውቀትና፣ በፋብሪካው አከባቢ የሚከሰቱ አደጋዎችን ለመቀነስም የተሻለ አመለካከት እንዳላቸው ያሳያል። በተጨማሪም የደህንነት መጠበቂያ መሳሪያዎችን ትክክለኛ የጥራት ደረጃ ያሟላ ባይሆንም ያለው በአግባቡ መጠቀም በቋሚ ሰራተኞች

የተሻለ ሁኖ አግኝተነዋል። ለልዩነቱ ምክንያት ግን ፋብሪካው የደህንነት መሳሪያዎችን ለቋሚ ሰራተኞች ብቻ ስለሚያቀርብ ነው። የፋብሪካው አሰሪዎች በፋብሪካቸው የተለያዩ የኬሚካል አደጋዎች እንዳሉ ግንዛበው አላቸው። አሰሪዎቹ ሁሉንም የድህንነት መሳሪያዎች እኩል የመከላከል ዓቅም እንዳለቸው እና የድህንነት መሳሪያዎቹ ሲገዙም ምንም ዓይነት የጥራት ልዩነት ታሳቢ እንደማያደርጉ የጥናቱ ውጤት ያሳያል። በተጨማሪም ፋብሪካው መደበኛ የሆነ የጤና ደህንነት ስልጠና አይሰጥም።

የእንጨት ብናኝ መጠን በAmerican Conference of Governmental Industrial Hygienists ከተፈቀደው 1 mg/m^3 መጠን በላይ ነው። ይሄ መጠን በተለያዩ የስራ ክፍሎች እንደ ስራው ዓይነት የተለያየ ነው። የኢንዶቶክሲን አማካይ ተጋላጭነት በኔዘርላንድ ሳይንቲስቶች ከተፈቀደው 90 EU/m^3 መጠን በታች ነው። ነገር ግን ሁለት የስራ ክፍሎች (Chipping እና Flaking) ከተፈቀደው መጠን በላይ ናቸው። ከ142 ናሙናዎች 93% ከ 1 mg/m^3 የሚበልጡ እንዲሁም 41% ደግሞ ከ 90 EU/m^3 የሚበልጡ ናቸው። የፎርማልድሃይድ መጠን በኬሚካል የስራ ክፍል (Blending) ከፍ ያለ መጠን (median value= 3.5 ppm)) መሆኑ ውጤቱ ያሳያል። ከ45 ናሙናዎች 13% በኖርወይ ከተፈቀደው የአጭር ግዜ የፎርማልድሃይድ መጠን (1 ppm) የሚበልጡ ናቸው። የፓርቲክል ቦርድ ሰራተኞች በስርዓተ መተንፈሻ አካላት ላይ የሚታዩ የህመም ምልክቶች ከውኃ ማሸጊያ ሰራተኞች ሲነፃፀር ከፍተኛ እንደሆነ ውጤቱ ያሳያል። በእንጨት ቤት ሰራተኞች ላይ የሚታየው የስርዓተ መተንፈሻ ላይ የሚታዩ የጤና እክል ምልክቶች ከእንጨት ብናኝ፣ ኢንዶቶክሲን እና ፎርማልድሃይድ ተጋላጭነት ጋር የተያያዘ ሊሆን ይችላል። የሳንባ ጉልበት መጠን በፓርቲክል ቦርድ ሰራተኞች እና ውኃ ማሸጊያ ሰራተኞች ትርጉም ያለው ልዩነት አላሳየም።

ጠቃሚ ምክሮች

ሰራተኞቹ ደረጃው የጠበቀ የድህንነት መጠበቂያ መሳሪያ ስለማይቀርብላቸው በቀላሉ ለተለያዩ የጤና ችግሮች ሊጋለጡ ይችላሉ። ይሄንን ለመቅረፍ ለሁሉንም ሰራተኞች ደረጃቸው የጠበቁ የደህንነት መጠበቂያ መሰሪያዎች ፋብሪካው ማቅረብ እንዳለበት ይመከራል። በተጨማሪም የተለያዩ የጤናና የደህንነት አጠባበቅ ላይ ያተኮሩ መደበኛ ስልጠናዎች መሰጠት አለባቸው። የእንጨት ብናኝ፣ኢንዶቶክሲን እና ፎርማልድሃይድ የተጋላጭነት መጠን መቀነስ አለበት። ከዚህ በተጨማሪም የተጋላጭነት መጠኑ ለመቀነስ ፋብሪካው የተለያዩ አስተዳደራዊ ስራዎች (በተለያዩ ክፍሎች እየተዘዋወሩ መስራት፣ በስራ መካከል ዕረፍት መስጠት፣በቂ ንፅሕና መጠበቂያ አገልግሎቶች ማቅረብ እና የተመቻቸ የስራ አከባቢ መፍጠር ወዘተ) ስራዎች መስራት ይጠበቅበታል። ከዚህ በተጨማሪም የፋብሪካው ሰራተኞች፣ አሰሪዎችና የሰራተኞችና ማህበራዊ ጉዳይ ቢሮ ከሌሎች ባለድርሻ አካላት በመተባበርና በመምከር የመፍትሄ አቅጣጫዎች በማስቀመጥ አብረው መስራት አለባቸው በቅንጅት አደጋ አምጭ ነገሮችንና ተግባራት መቀነስ አለባቸው። የስራ ቦታዎችም ለሁሉም ሰራተኞች አመቼ እንዲሆኑ በማድረግ የሰራተኛው ደህንነትና ጤንነት በመጠበቅ የተሻለ ምርትና ምርታማነት እንዲኖር ማድረግ ይገባል። በተጨማሪም አገርቱ ከፋብሪካ ለሚወጡ የእንጨት ብናኝ፣ ኢንዶቶክሲን እና ፎርማልድሃይድ ተጋላጭነት መጠን የሚያስከትለው የጤና እክል፣ ኢኮኖሚያዊ ዓቅም፣ ቴክንካዊ ነገሮችን ታሳቢ ያደረገ 'ተቀባይነት ያለው መጠን' በማበጀት ሁሉንም ፋብሪካዎች ለደንቡ ተገዢ እንዲሆኑ መሰራት አለበት።

List of articles

The study is based on the following articles

1. Asgedom AA, Bråtveit M, Moen BE. Knowledge, attitude and practice related to chemical hazards and personal protective equipment among particleboard workers in Ethiopia: a cross-sectional study. BMC Public Health. 2019;19(1):440. DOI: 10.1186/s12889-019-6807-0
2. Asgedom AA, Bråtveit M, Schlünssen V, Moen BE. Exposure to inhalable dust, endotoxin and formaldehyde in factories processing particleboards from eucalyptus trees in Ethiopia: *Submitted 2019*
3. Asgedom AA, Bråtveit M, Moen BE. High Prevalence of Respiratory Symptoms among Particleboard Workers in Ethiopia: A Cross-Sectional Study. International Journal of Environmental Research and Public Health. 2019;16(12):2158. DOI: 10.3390/ijerph16122158

1. Introduction

Production of particleboard for furniture-making and construction is increasing in many countries. The study was conducted at the two biggest particleboard factories in Ethiopia. Two water-bottling factories were included as controls for respiratory-symptom assessment and lung-function measurement. Particleboard is a type of wood product manufactured primarily from wood chips, glued with urea formaldehyde resin and bonded under heat and pressure. Work in the wood industry causes exposure to occupational hazards such as dust, endotoxins and formaldehyde, causing respiratory health problems (1-4). Respiratory diseases can cause suffering for workers and their families, and can be costly for the employer as a result of increased absenteeism, reducing productivity of the factory and associated medical costs for the sick workers. Occupational exposure is a potential cause of almost all respiratory diseases, but the majority of occupational related respiratory health problems are often under-reported, and recognition of occupation-related respiratory-health problems can be increased by expanding their epidemiology through comprehensive research (5).

According to the World Health Organization (WHO), 12.6 million people die as a result of living or working in an unhealthy environment, accounting for 23% of all deaths. There are 4.2 million deaths every year as a result of exposure to fine particulate matter, the occupational environment being a contributory factor (6). The economic cost of work-related injury and illness is 1.8 - 6% of Gross Domestic Product (GDP) in country estimates, with an average of 4% of GDP (7). These occupation-related health problems can be prevented by applying engineering solutions and administrative measures, and through use of personal protective equipment.

1.1. Industrial Development in Ethiopia

In Ethiopia, industry in the modern sense emerged as an economic entity only at the beginning of the 20th century (8). Since the 20th century Ethiopia has emerged as one of the top fast-growing economies in Africa, and there has been an expansion of the manufacturing sectors producing wood and furniture, chemicals, textiles and apparel, paper and printing, leather, foods and beverages, rubber and plastic, metal etc. The booming of the manufacturing sector plays an important role in terms of employment generation, exports, output and inter-sectoral linkages. The manufacturing sector comprises a range of industries that account for 6.9% of the national workforce in Ethiopia (9). The manufacturing sector grew much faster after 2005, with the annual rate of growth of industrial output doubling to nearly 20% by 2015–17. This may indicate that the industrial sector, particularly the manufacturing industry, is becoming the primary driver of the economy for the first time in Ethiopia (10). Ethiopia's manufacturing sector is also one of the key productive sectors of the country's economy identified under the Growth and Transformation Plan (GTP: 2010-2015). It can enhance economic growth and development, thanks to its high potential for wealth, employment generation and poverty reduction. The number of wood and wood-product establishments reached 83 (21 government and 62 private firms) in 2012/2013, and there were about 173 thousand employees (11). In the medium and large-scale manufacturing sector, wood and furniture represents an employment share of around 10% (8).

1.2. Occupational Health and Safety in Ethiopia

Ethiopia has been a member state of the International Labour Organization (ILO) since 1923, and has ratified 20 conventions. The Occupational Safety and Health Convention, 1981 (No. 155) is one of the conventions ratified for protection of workers in their work environment (12). The current government of Ethiopia included promotion of occupational health and safety as a priority issue in its health-policy statement released in 1993 (13). The government of Ethiopia has also issued a labour proclamation (Proclamation No. 377/2003), which addresses the occupational safety and health measures in Section 3, 'Obligations of an Employer' Article 12/4 (14). The issue of occupational safety and health is also included in the constitution of the country, with the right to a healthy and safe work environment being stated in Article 42/2 (15). However, there is no national occupational safety and health policy. The Ministry of Labour and Social Affairs (MoLSA) is in the process of formulating such a policy (12). Despite adoption of the ILO convention, the availability Ethiopian constitution and the labour proclamation, there are a lot of gaps in terms of occupational health and safety measures (16), as indicated by studies carried out in the wood, coffee, textile, cement, flower-farm and agricultural sectors (17-23).

The overall performance of the manufacturing sector is affected because it uses outdated technologies, and as a result of the poor state of the work environment, limited research and development, a poor institutional frame-work and inadequate managerial and technical skills (11). The International Labour Organization's (ILO) statement indicates that insufficient awareness and understanding of occupational hazards and risks, a lack of the requisite capacity for prevention, compliance and enforcement related to occupational safety and health (OSH), inadequate and inaccurate data on occupational fatalities, injuries and diseases, and inadequate legislation, regulations and policies on OSH remain significant challenges, particularly in developing countries, including Ethiopia (24).

1.3. Occupational Exposure Limits (OEL) in Ethiopia

In Ethiopia there are no established national occupational-exposure limit values for occupational exposure such as inhalable wood dust, endotoxins, formaldehyde and other physical, biological and chemical occupational hazards occuring in the various factories. Different countries and institutions have set different occupational-exposure limit values. The American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Value (TLV) for inhalable wood dust (8 h TLV = 1 mg/m^3) and the Dutch recommended health-based occupational-exposure limit of 90 EU/m^3 as a reference value for endotoxins (25, 26) are used as references for this study. In Norway the TWA and peak OEL for formaldehyde are 0.5 ppm and 1 ppm respectively (27).

1.4. The Particleboard Industry in Ethiopia and Occupational Health

The large scale wood-manufacturing found in Ethiopia are Maichew particleboard factory, Hawassa chipwood factory, Bamboo furniture factories, Finfinnee furniture factory, Salvatore de Vita & Family, and Wanza Furniture industry (28). Only Maichew and Hawassa are producing particleboard products.

Particleboard is a type of wood product that is increasingly being produced and used in Ethiopia. It is manufactured from lignocellulosic materials, primarily in the form of discrete particles, combined with urea formaldehyde resin and bonded together under heat and pressure. Particleboard is used as a raw furniture material for office tables and drawers, dressing tables, television stands, display shelves, kitchen cabinets, library shelves, file cabinets and computer desks. Particleboard products are also used in construction, for the interior wall panelling, building partitions, ceilings, doors and windows (29).

In parallel with an increase in furniture production using particleboards in Ethiopia (28), there is a lack of knowledge about occupational health and safety measures at these workplaces (16). As a result, there might be unsafe working environments, with a likelihood of exposure to various occupational hazards.

Research and new knowledge may help the policy-makers and other stakeholders to formulate occupational safety and health policy and set occupational-exposure limit values, by showing the magnitude of exposure to occupational hazards and related health problems. According to the Health and Safety Executive (HSE), the approved code of practice and guidance on 'Safe use of woodworking machinery' and the International Labour Organization's (ILO) 'Safety and Health at the wood workshop', the working environment in the wood industry needs to be safe and hygienic (30, 31). Thus, there should not be any exposure to hazards at work that may result in various occupational diseases. To achieve this, the factory owner is expected to create a safe working environment. Policy-makers need to establish standards and regulations that promote workers' safety and health, and to organise authorised workplace inspectors to confirm compliance with the gold standard for occupational safety and health.

Detailed description of the particleboard production process

The general steps involved in production of particleboard include raw-material procurement or generation, classification by size, drying, blending with resin and sometimes wax, forming the resinated material into a mat, hot pressing, finishing and occasionally lamination and impregnation. The details of the productions process are stated below.

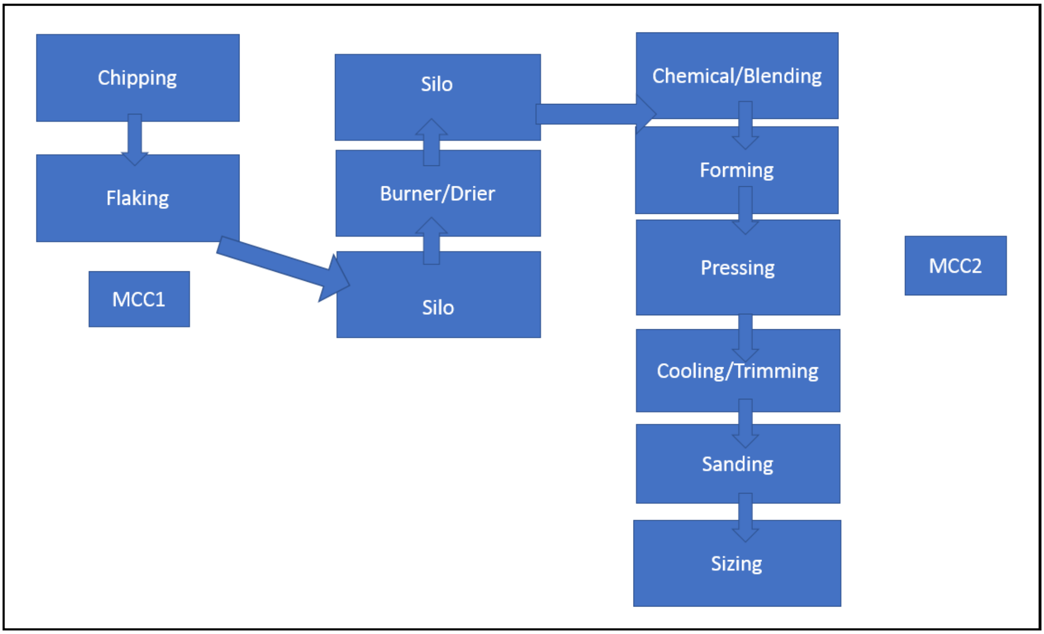

Fig. 1. Process-flow diagram of the particleboard production process. MCC1: Machine control centre 1; MCC2: Machine control centre 2

Fig. 2: Raw materials ready for chipping in particleboard manufacturing in Ethiopia (Photo: Akeza)

The production lines in the particleboard manufacturing process are similar in the two factories, having two separate sections. The first section is open-air with shades (Fig. 2), and includes chipping, flaking, silo, drier/boiler, Machine Control Centre 1 and silo. The raw material – a solid eucalyptus log – is chipped to a maximum chip length of 30 mm, and is further downsized using the flaker machine. Wood chips are temporarily stored in a silo. The drier removes moisture from the wood chips using hot gas, which is generated by a burner attached to a combustion chamber with an input of heavy fuel oil or a mixture of fuel and wood dust. The chipping and flaking process is controlled through MCC1.

Fig. 3. Partial view of the indoor work environment at particleboard factory in Ethiopia (Photo: Akeza)

The second section is a large closed hall located inside the factory, as partly shown in Fig. 3. Manufacturing activities here include blending/chemical, forming, pressing, trimming, sanding and sizing sections arranged consecutively. In the glue kitchen of the chemical section (Fig. 4) a urea/formaldehyde powder is mixed manually with water, to prepare the formaldehyde solution, and is further mixed/blended with wood chips. The mat is formed from the wood mix and is pressed at a high hydraulic pressure (250 bar) and temperature (175-190°C), to convert the formed material into solid board. The press machine was partly enclosed with iron sheets in Factory A, but not in Factory B. The solid board is cooled for some time before it is trimmed, sized and sent for sanding to attain a uniform board thickness and a smooth surface. It can be further resized in accordance with the customer's specification. The lower-grade particleboards (B or C) are also further resized when customers purchase at a low price relative to that for the higher-quality particleboard (Grade A). Workers are present throughout the entire section, and no personal protective equipment such as face masks is used.

Fig. 4. Chemical/blending working section (Photo: Akeza)

In addition, various other factory workers perform a range of activities. These workers include cleaners, who sweep the production-line floor, and quality-control workers, who monitor the moisture content of the wood chips and the bond strength of the produced particleboard. There are also maintenance workers, who repair machines and monitor the overall mechanical process. The production process in the indoor section is controlled by MCC2, which is to be found inside the big hall. Neither of the factories has mechanical ventilation systems or functioning dust-collection hoods.

The main production lines of the two factories have 4 and 6 gates respectively, as well as other openings for Factory A and Factory B. The size of the hall is 80 m x 30 m in Factory A and 65 m x 45 m in Factory B, and all the gates allow a truck to enter easily and forklift operators to drive inside the factory. Factory A produces triple-layered particleboard 8 mm to 40 mm thick, and has a maximum daily output of 170 m^3 and a maximum annual output of 40,000 m^3. The daily input for the factory was 200,000 kg of eucalyptus wood logs. The main input for Factory B was eucalyptus logs 10 cm to 40 cm in diameter, and the current consumption rate is 18,167 m^3 per annum. Every year it also produces 43,000 m^3 of boards 6 mm to 40 mm thick for local and export markets.

1.5. Wood-dust Exposure

Wood dust, an organic dust type, is one of the hazards arising from the processing of woods in the occupational environment (32). Wood-processing industries such as sawmills, furniture production and carpentry use both hard and soft woods, and is associated with a relatively high exposure to wood dust (1, 17, 33-38).

Wood dust is a complex substance generated from processing of the various wood types used for a wide range of applications. It contains approximately 40–50% cellulose, polyoses, lignin and a varying number of substances with a lower relative molecular mass that may significantly affect the properties of the wood. They include polar and non-polar organic extractives and water-soluble extractives (carbohydrates, alkaloids, proteins, and inorganic material). The biologically active compounds found in wood are sensitisers that may cause allergies (39). The tree species used in wood industries vary greatly depending on country and type of product. Both domestically grown and imported hardwoods and softwoods are used in the manufacturing process. Logging, sawmills and plywood and particleboard manufacture generally involve use of trees grown locally (40, 41).

1.6. Endotoxin Exposure

Endotoxins have been recognised as being an important biologically active component in organic dusts. Endotoxins, a component of the external membrane of most gram-negative bacteria, are naturally released when a bacteria replicate, and when the entire membrane content is released upon death and subsequent cell lysis (26). It is important to consider endotoxins in circumstances when the log has a high humidity and still has its bark/outer layer – a situation that is expected at the beginning of the production process. This can create an optimal environment for endotoxin-producing gram-negative bacteria. A high level of endotoxins was reported in the initial stage of the production process, probably indicating the impact of a high moisture content and the contribution of the protective outer layer of the log (42). Endotoxins become airborne during manufacture or handling of organic materials. Endotoxin exposure is therefore extremely relevant in wood-manufacturing industries, because protection of workers against exposure to endotoxins and their toxic effects in occupational settings is a prime concern. In the wood-processing industries such as fibreboard & chipboard sawmills, furniture production and carpentry, using both hard and soft woods, there is relatively high exposure to endotoxins (33, 35, 42, 43).

1.7. Formaldehyde exposure

The formaldehyde used in the wood industry is added to the urea resin and is thus present in the processes of glue mixing, mat forming, pressing, trimming, sanding and sizing. Workers in the wood-manufacturing industry are exposed to formaldehyde during the production process (41, 44-48). Formaldehyde is a colourless gas with a pungent odour that is produced worldwide on a large scale by catalytic vapour-phase oxidation of methanol. It is mainly used in the production of various types of resin. Urea and melamine resins are widely used as adhesives and binders in wood production (49). Formaldehyde is added, to be mixed and blended with the wood chips. As a result, occupational exposure to formaldehyde occurs in the wood industry, as in a wide variety of occupations (50, 51). According to American Conference of Governmental Industrial Hygienists (ACGIH), the Time Weighted Average (TWA) occupational exposure limit value of formaldehyde is 0.1 ppm (25). In Norway the TWA and peak exposure limit value for formaldehyde is 0.5 ppm and 1 ppm, respectively (27).

1.8. Exposure studies performed in the wood industry that are relevant to particleboard production

A few exposure studies in the wood industry have been carried out regarding plywood, fibreboard and chipboard. The geometric mean (GM) of dust exposure varies 0.7 mg/m^3 to 19 mg/m^3, the arthimetic mean of endotoxin exposure of the workstations vary <0.125 EU/m^3 to 1974 EU/m^3, and GM of formaldehyde varies 0.03 ppm to 0.06 ppm. However, most of them have involved in sawmills, furniture, joiners and pellets, as shown in Table 1. Only two relevant studies have been performed in Africa: one in Ethiopia regarding dust exposure in furniture industries and the other in Tanzania regarding dust and endotoxin exposure in wood workshops. The varying values are inconsistent, but both are exceed the TLV for dust (1 mg/m^3) (25) (range: 0.23 – 67 mg/m^3) and the OEL for endotoxins (90 EU/m^3) (26) (range: 9 – 4914.8 EU/m^3). Further studies regarding dust exposure have been carried out in Europe and Asia, and some in America and Australia. The GM of the results is low (range: 0.6 – 2.1 mg/m^3) in Europe, compared with the findings obtained in Africa (range: 3.3 – 6.82 mg/m^3) and Asia (range: 1.55 – 19 mg/m^3), and this could be because of the existing technological differences for hazard control. However, there are a few published studies on endotoxin and formaldehyde exposure. The overall findings show that there is a variation in occupational exposure from continent to continent, and country to country within a continent. The results also vary from study to study, and they have mostly been performed in sawmills and the furniture industry. This shows that there are huge discrepancies in occupational-exposure data, and further research into occupational exposure in the particleboard industries may be necesssary, to provide strong evidence of occupational exposure in this type of wood industry.

Table 1: Studies of dust exposure (mg/m^3), endotoxins (EU/ m^3) and formaldehyde (ppm) in wood industries by continent, country and year of publication

Continent/ country	Author (Year)	Scale and type of wood industry	Inhalable dust (mg/ m^3)		Endotoxins (EU/m^3)		Formaldehyde (ppm) GM(GSD)	Reference
			AM (SD)	GM (GSD)	AM (SD)	GM (GSD)		
Africa								
Ethiopia	Ayalew et al (2015)	Small-and medium-scale furniture		6.82 (1.82)				(17)
Tanzania	Rongo et al (2004)	Small-scale workshops	5.7**	3.3 (2.5)	288**	91(3.74)		(35)
Europe								
Norway	Straumfors et al (2018)	Large-and medium-scale sawmills		0.72 (2.6)		17 (4.3)		(52)
European Union	Kauppinen et al (2006)	Furniture and construction	16% > 5 mg/m^3					(53)
Denmark	Schlünssen et al (2008)	Furniture		0.95 (2.05) 0.60 (1.63)				(36)
Netherlands	Scheeper et al (1995)	Joinery and furniture	2.95**	2.10 (2.15)				(54)
Poland	Dutkiewicz et al (2001)	Fibreboard Chipboard			16.15-1974^{β} <0.125- 217.4^{β}			(42)
Poland	Dutkiewicz et al (2001)	Sawmills			0.24- 4 µg/ m^3			(43)
Sweden	Lofstedt et al (2017)	Pellet	3.5**	1.7***				(55)
Finland	Rosenberg et al (2002)	Sawmills			0.4 – 2.2*			(56)
Finland	Mäkinen et al (1999)	Plywood					0.03 – 0.31	(44)
Asia								
Iran	Neghab et al (2018)	Sawmills		2.44 (0.66)				(2)
Iran	Badirdast et al (2017)	Chipboard		19 (2.0)				(57)
Iran	Jafari et al (2015)						0.5-1.52*	(45)
Thailand	Thetkathuek et al (2016)	Furniture	7.67 (3.63)				2.62 (3.67) $^{£}$	(3)
Thailand	Sriproed et al (2013)	Furniture	2.42 (2.18)	1.55 (2.88)				(1)
Turkey	Vaizoglu et al (2005)	Furniture					0.6 (0.30) $^{£}$	(46)
America								

Hawaii (USA)	Malaka and Kodama (1990)					0.28-3.48*	(47)
USA	Harper et al (2006)	Joinery			11***		(58)
Alberta	Yamanaka et al (2009)	Sawmills	2.95**	2.04***			(59)
Australia							
New Zealand	Douwes et al (2006)	Sawmill		0.52 (2.66)			(60)
New Zealand	Fransman et al (2003)	Plywood		0.7 (1.9)	23(2.8)	0.06 (3.0)	(48)
New Zealand	Douwes et al (2000)	Sawmills		nearly 33.3% >1mg/m^3			(61)

* The range value is presented, **SD not stated, β The range of mean values for different working sections is presented, ***GSD not stated,

£AM(SD) is presented

1.9. Respiratory-health effects related to inhalable dust, endotoxins and formaldehyde exposure

Exposure to wood dust, endotoxins and formaldehyde may cause acute and chronic respiratory-health problems (47, 62, 63). Workers exposed to wood dust are found to have acute and chronic respiratory-health problems (1, 2, 38, 39, 55, 64-70) and reduced lung function (2, 55, 64, 71, 72), and wood dust is classified as being carcinogenic for humans (40). Endotoxin exposure induces an inflammatory response and dysfunction of the airways (70, 73, 74). Endotoxins have been reported as being associated with respiratory-health problems in studies in Canada, Italy, Tanzania, Sweden, the Netherlands and Thailand (33, 35, 37, 62, 75-77).

Formaldehyde exposure is associated with respiratory-health problems (3, 78) and decrements in lung function (47). Formaldehyde is classified as carcinogenic (Group 1) by International Agency for Research on Cancer (50).

In a Danish study in which 13% of the workers included were employed in particleboard and fibreboard industries, there was an accelerated decline in lung function among the female workers (79). A study at particleboard-manufacturing facilities in Canada indicated that rash, nasal and eye irritation, cough and annoying odours were the main complaints among workers (39).

According to the international literature on the prevalence of respiratory-health problems among wood workers in developing countries, this prevalence varies from 15.5% to 41% (2, 64). There are also decrements in lung-function status, as indicated by studies performed in Thailand, Pakistan, Iran and Sweden (2, 55, 64, 71, 72), whilst other studies carried out in Poland and Denmark do not show any decrements (80, 81). The international literature is not clear, and the situation varies from study to study. The findings regarding the respiratory health of wood workers are thus inconclusive. Appropriate exploration is needed by way of an investigation of the respiratory health of wood workers using the eucalyptus tree as a raw material in Ethiopia. The tree is an evergreen hardwood that is cheap, locally available, grows rapidly and is adaptable to a range of climates and soil types, making it a promising source of input. Respiratory health can be described and measured in many ways. In the present study respiratory health is evaluated by recording workers' subjective symptoms, and measurment of their lung function provides an objective result.

Table 2: Studies of prevalence of respiratory symptoms and lung function among wood industries by continent, country and year of publication

Continent/ Country	Author (Year)	Type of wood industry and scale	Study design	Prevalence of respiratory symptoms (Exposed vs Controls)	Lung function status Exposed vs Controls	Reference
Africa						
Tanzania	Rongo et al (2002)	Small-scale workshop	Not stated	Cough: (50.7% vs 39.5%) Wheezing: (9.4% vs 7.3%)		(38)
Nigeria	Bosan and Okpapi (2004)	Furniture	Cross-sectional	Cough (29%), breathlessness and wheezing (20%)		(82)
Europe						
Macedonia	Bislimovska et al (2015)	Parquet	Cross-sectional	Wheezing: (8.1% vs 5.4%) Cough: (29.7% vs 13.5%) Phlegm: (16.2% vs 5.4%)	FEV_1/FVC (%): 75(0.05) vs 78(0.03)	(68)
Sweden	Lofstedt et al (2017)	Pellet	Not stated	Dry cough: (41% vs 15%)	Mean % predicted of FEV%: 101.9 (8.9) vs 102.9 (8.1)	(55)
Denmark	Jacobsen et al (2008)	Furniture	Cross-sectional		FEV1% < 70% at baseline: 6.2% vs 3.9%	(79)
Poland	Baran et al (2009)	Furniture	Not stated		FVC (l) = 4.54 (0.82) FEV_1(l) = 3.69 (0.67) FEV_1/FVC (%) = 82 (8.1)	(80)
Asia						
Iran	Neghab et al (2018)	Sawmills	Cross-sectional	Wheezing: (37% vs 11%) Cough: (28% vs 3%) Phlegm: (24% vs 6%)	FEV_1/FVC (%): 83.82(10.76) vs 82.06 (8.39)	(2)
Iran	Badirdast et al (2017)	Chipboard	Cross-sectional		FVC (l): 3.90 (0.005) vs 4.85 (0.06) FEV_1(l): 3.52 (0.008) vs 4.01 (0.06) FEV_1/FVC (%): 90.51 (0.08) vs 80.62 (0.21)	(57)
Thailand	Thetkathuek et al (2016)	Furniture	Cross-sectional	Cough (28.5%), phlegm (11.6%)		(3)
Thailand	Sriproed et al (2013)	Furniture	Not stated	Wheezing (7.8%), cough (35.95%), shortness of breath (26.96%)		(1) $^{\pi}$
Thailand	Sripaiboonkij et al (2009)	Furniture	Cross-sectional	Cough: (17.5% vs 17.1%) Phlegm: (27.2% vs 31.6%) Wheezing: (15.5% vs 11.8%), Breathlessness:		(64)

				(18.4% vs 15.8%)		
Pakistan	Meo S.N. (2006)	Small-scale timber	Cross-sectional		FVC (l) = 3.37 (0.12) vs 4.12 (0.10) FEV_1(l) = 2.61 (0.12) vs 3.10 (0.09) FEV_1/FVC (%) = 77.34 (2.32) vs 75.54 (1.61)	(72)
America						
USA	Jayaprakash et al (2008)		Case-control	Increased risk of cancers of the nasal cavity, pharynx, lung and larynx		(83)
Australia						
New Zealand	Douwes et al (2006)	Sawmills	Cross-sectional		FVC = 4.61 (1.04) FEV1 = 3.59 (0.87)	(60)

FEV%: FEV_1/VC; $^{\pi}$: prevalence is computed by dividing the number of cases presented by the sample size (89)

1.10. Control of Workplace Hazards

Today's workplaces are complex, and the risks associated with various occupational hazards are on the increase (84). Exposure assessment is qualitative or quantitative estimation of the magnitude, frequency, duration and route of exposure for workplace hazards (85). Control of workplace hazards is primarily achieved through anticipation, recognition and evaluation of the hazards at the specific workplace. Exposure prevention or reduction is the principal aim of any control strategy with regard to workplace hazards. It is the process of conception, education, design and implementation of beneficial interventions and changes carried out to eliminate or minimise hazardous conditions. It might not be possible to completely prevent all exposures, owing to the nature of the hazard, practicability and economics. As a result, exposure reduction may be considered sufficient (86, 87). The hierarchy of occupational hazard-control mechanisms from the most effective to the least effective is: elimination, substitution, engineering control, administrative control and use of personal protective equipment (84, 88). As regards reduction of exposure to wood dust, endotoxins and formaldehyde, the most effective control measures may be lacking in most developing countries, or may not work sufficiently. As a result, in many workplaces personal protective equipment (PPE) is recommended as an immediate control measure, as the expense of providing PPE is relatively low, and provision by the employer is fairly easy compared with provision of the other most effective control measures. The cost of personal protective equipment is usually covered by the employer in most formal industrial sectors. It is recommended that workers in the wood industry wear appropriate face masks and eye protection in areas with high dust and formaldehyde exposure. Coveralls and industrial gloves are also needed, to protect the skin from exposure to the chemicals (89, 90).

1.11. Knowledge, Attitude and Practice

To reduce workplace hazards, it is not enough to inform workers about risks, hazards and their control mechanisms. Other actions are needed in order to change workers' behaviour, because changed behaviour can lead to good practice. For such actions, the involvement of workers in the planning of overall workplace control measures is vital.

It is important for workers to be informed about the health hazards and why control measures are necessary in a hazardous working environment. One has to know the types of hazard, the possible health problems and the existing barriers to the practice of proper safety measures. Information alone might not be enough to change occupational workers' attitude and practice (91). To better understand the situation in the wood industry and the challenges with regard to good safety practice in the work environment, we used a Knowledge, Attitude and Practice (KAP) model. The KAP model comprises three interactive factors (knowledge, attitude and practice) (92), and can help us understand why workers do not adhere to specific advice or rules by evaluating these factors (93). The KAP survey is defined as 'a quantitative method (predefined questions formatted in standardised questionnaires) that provides access to quantitative and qualitative information. KAP surveys reveal misconceptions or misunderstandings that may represent obstacles to the activities we would like to implement and potential barriers to behaviour change' (94).

There are studies showing different gaps in knowledge, attitude and practice in many occupations such as textile-factory worker, garment worker, dyeing and printing worker, agricultural worker, salt worker, and healthcare worker that involve chemical, biological and dust exposure. A study performed in the United States revealed that use of PPE was adversely affected by lack of comfort and poor fit, young age and lack of safety training (95). Studies have shown that use of PPE varies from 10% to 82% depending on accessibility, adequacy, affordability, fit for the user and discomfort (20, 91, 96, 97).

A study performed in Nigeria indicates that the low level of worker adherence to proper method of use of PPE is because of shortage, inconvenience and the perception of PPE as being unnecessary. Safety training played a significant role in increasing knowledge about PPE and health problems in the wood industry (98). KAP studies performed in farm workers in Ethiopia showed that 85% of the workers do not receive training regarding chemical pesticides, that only 10% of the workers were using full PPE and that their attitude and their handling chemical pesticides were poor (99). The participants' knowledge level regarding safety issues was affected by gender, safety training and work regulations (18). Furthermore, use of PPE was affected by safety training, education, work regulations and participants' knowledge of safety information (18, 100). In the textile industry in Ethiopia, employment status was a determinant for PPE use, since permanent workers apply safe practice to a greater extent than temporary workers (18).

Ethiopian wood-industry workers' knowledge regarding exposure to wood dust and formaldehyde and their health effects has not been studied. More knowledge of KAP is needed for implementation of control measures such as safety practices in this type of industry. Another aspect is that in the particleboard factory, as well as in other industries in Ethiopia, there are both permanent and temporary workers. The number of temporary workers is in general increasing, and several studies show that they are at greater risk of occupational injuries and diseases than permanent workers (101-105). This urgently requires investigation, so as to provide an understanding of the KAP of permanent and temporary particleboard workers in Ethiopia, and to facilitate application of evidence-based preventive measures. In the present study a KAP survey has been developed to describe and facilitate understanding of the existing chemical hazards, their health problems and the challenges regarding use of personal protective equipment as a last hazard barrier.

2. Study rationale

There is paucity of research findings in developing countries concerning wood dust, endotoxins and formaldehyde exposure and their associated respiratory-health effects on occupational workers. In Africa evidence of exposure studies in wood industries and the consequences for respiratory health are scant. In Ethiopia, for example, there are several gaps in occupational safety and health, e.g. lack of trained manpower, training and capacity gaps, weak implementation of policy and regulation and limited research, all of which reduce the possibility of anticipating, recognising, evaluating, and controlling hazards in various work environments. There is only one published study concerning medium-and small-scale wood-processing industries in Ethiopia, and it has reported high wood-dust exposure (17). This shows us that there is a long way to go to address occupational safety and health in Ethiopia (16).

According to the European Respiratory Society, occupational exposure is a potential cause of almost all respiratory diseases. However, the contribution of the work environment to respiratory-health problems is often underreported. As a result, there is a need to increase the recognition of respiratory-health problems in occupational settings through epidemiological studies (5). Studies performed in various wood industries have shown that workers are exposed to various hazards such as dust and formaldehyde, which cause serious health problems (1-4).

According to the International Labour Organization (ILO) report, every year 2.78 million workers die from work-related injury and disease and 313 million workers suffer from non-fatal work-related injury and illness (24). In 2012 the World Health Organization (WHO) estimated that 12.6 million people die as a result of living or working in an unhealthy environment, accounting for 23% of all deaths. Of those deaths linked to the environment, 4.2 million every year are caused by the occupational environment, resulting from exposure such as fine particulate matters (6). These serious health problems can be prevented if the sources of risks are removed. To prevent the risks comprehensive research is needed, and I wish to contribute in this regard by increasing the existing knowledge of occupational exposure and its epidemiology, as well as health and safety problems in the wood-working environment.

In the Ethiopian wood industry the eucalyptus – an evergreen exotic tree species – is used as the main raw material in the particleboard production process. The tree is cheap, locally available and able to adapt to a range of climates and soil types. It is also a promising renewable input at a time when native wood species are diminishing owing to deforestation and unwise use of natural resources.

There is a paucity of published studies on occupational safety and health in particleboard factories, and there are none in which the eucalyptus tree is used as a raw material. Furthermore, there is no well-designed and comprehensive published study on KAP concerning chemical hazards and PPE, inhalable wood dust, endotoxin and formaldehyde exposure and respiratory health effects in the large body of particleboard workers in Ethiopia, despite the great need for such studies for the development of national work and health policies.

3. Study objective

3.1. General Objective

The general objective of the study was to obtain more information about the work environment and respiratory health in particleboard factories in Ethiopia.

Specific Objectives

- To describe the KAP concerning chemical health hazards and personal protective equipment in particleboard workers, and to compare the KAP in temporary and permanent workers
- To assess to airborne exposure to wood dust, endotoxins and formaldehyde among particleboard workers in Ethiopia
- To assess the prevalence of respiratory symptoms and measure the lung function among particleboard workers in Ethiopia

4. Materials and methods

4.1. Study setting

This cross-sectional study was conducted in the two largest particleboard factories (A, B) using eucalyptus – an evergreen hardwood – as a raw material. Factory A, situated in Northern Ethiopia, was established in 2005 and has 663 workers. Factory B, located in southern Ethiopia, was established in 2002 and has 249 workers.

The control groups (Paper III) were workers employed in a water-bottling factory with a total of 339 workers selected from the northern site of the study.

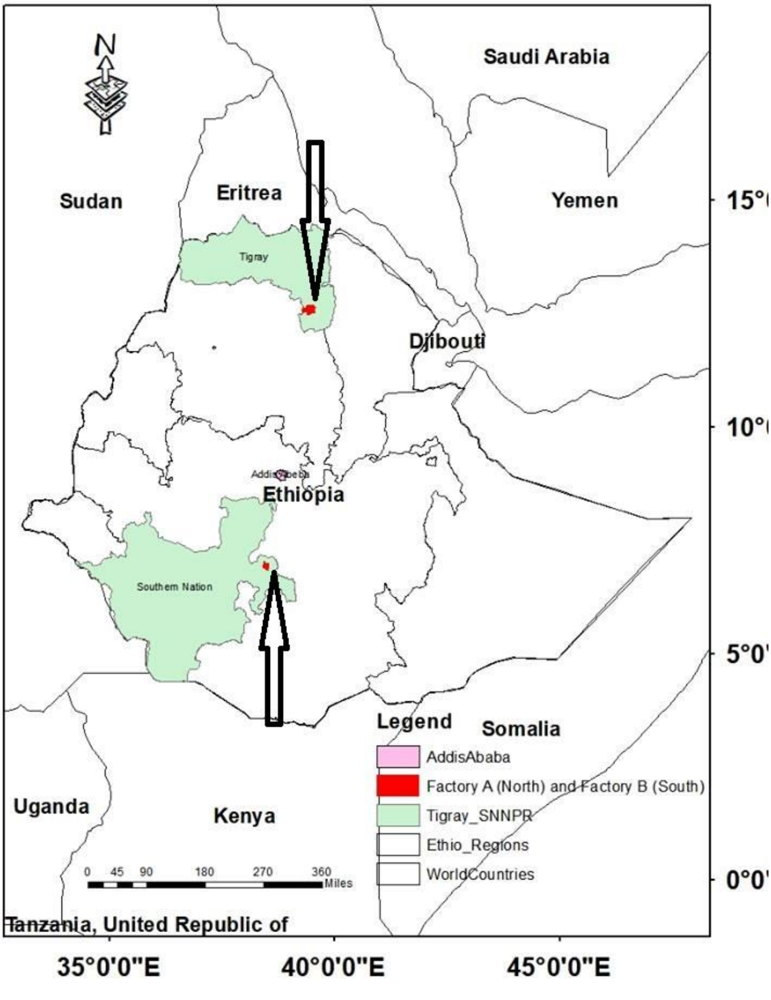

Fig. 5. Map of the study area (© Belay Manjur)

4.2. Study design, study populations and sample size

Paper I

Structured questionnaire-based data on Knowledge, Attitude and Practice was collected from the production workers at the particleboard factories. The requisite number of participants was calculated, with the purpose of describing the use of PPE by a means of a single-population proportion formula, by assuming 54% overall use of PPE as given to textile workers in Ethiopia (18). The formula, with a 95% confidence interval, 5% level of significance and finite population correction, produced a result of 167 workers. However, 159 workers consented to participate in the interview, resulting in a 95% response rate. In addition, qualitative information was obtained from 13 administrative staff with different positions (general manager, deputy manager, production manager, technical manager, quality control, safety coordinator, logistics & supply and health professional). The aim of the collection of qualitative data was to contribute to an understanding of their attitude and thinking regarding chemical hazards and PPE at the workplace.

Paper II

The exposure study for inhalable dust and endotoxins involved the production workers in the 10 working sections of the two particleboard factories. The total number of workers (n= 300) in each working section was: chipping (n= 83), flaking (n= 29), chemical/blending (n= 21), forming (n= 28), pressing and trimming (n= 21), sanding (n= 27), sizing (n= 12), cleaners (n= 27), quality control (n= 18) and maintenance (n= 34). Workers in each work section had similar tasks and exposure to dust, and were consequently considered to be similar exposure groups (SEG).

The sample size for measurement of inhalable dust, which is appropriate for aerosols such as wood dust that are usually deposited in the extra thoracic airways (106), was 10 to 20 measurements per SEG (i.e., 2 repeated measurements in 5 to 10 randomly selected persons) in each of the work sections (107). A total of 76 workers were selected for repeated sampling of inhalable dust (n= 152). In addition, one field blank sample was taken per day (n= 18). The persons were selected through consensus between the researcher and supervisors. Participation was also based on their willingness to participate and work convenience.

Work sections for formaldehyde exposure measurement were selected based on the researcher's assumed professional judgement, on the basis of existing activity and application of formaldehyde in the production process. The work sections were selected from and after the chemical section where the formaldehyde was mixed with wood chips. As an internal control, one workstation (chipping) where there is no addition of formaldehyde was selected. We applied a 'worst-case' sampling strategy immediately after addition of formaldehyde in the chemical section, and triplicate measurements were taken on different days from seven sections in Factory A (n= 21) and eight sections in Factory B (n= 24), resulting in a total of 45 samples measured using Dräger tubes (108).

Paper III

Structured questionnaire-based data on respiratory-symptom assessment and measurements of lung function was collected from production workers in the two particleboard factories (exposed) and in two water-bottling factories (control). The required number of participants for this study was calculated using OpenEpi software (http://www.openepi.com/SampleSize/SSMean.htm) sample mean difference, by taking into consideration forced expiratory volume in one second (FEV_1) as the main output of interest, because it resulted in the maximum sample size. The mean difference of FEV_1 for exposed persons (3.77 l/s, *SD*= 0.99) and for a control group (4.29 l/s, *SD*= 0.86) was taken from a previous unpublished study involving particleboard workers in Ethiopia (109). The output of the formula with 95% confidence interval, a 5% level of significance and finite population correction produced a result of 166 workers (83 from exposed and 83 from control groups). The same workers participated in both respiratory-symptom assessment and lung-function measurements. However, of the 157 workers who consented to participate in the interview (94.5% response rate), 147 (74 from particleboard and 73 from water bottling) were included in data analysis.

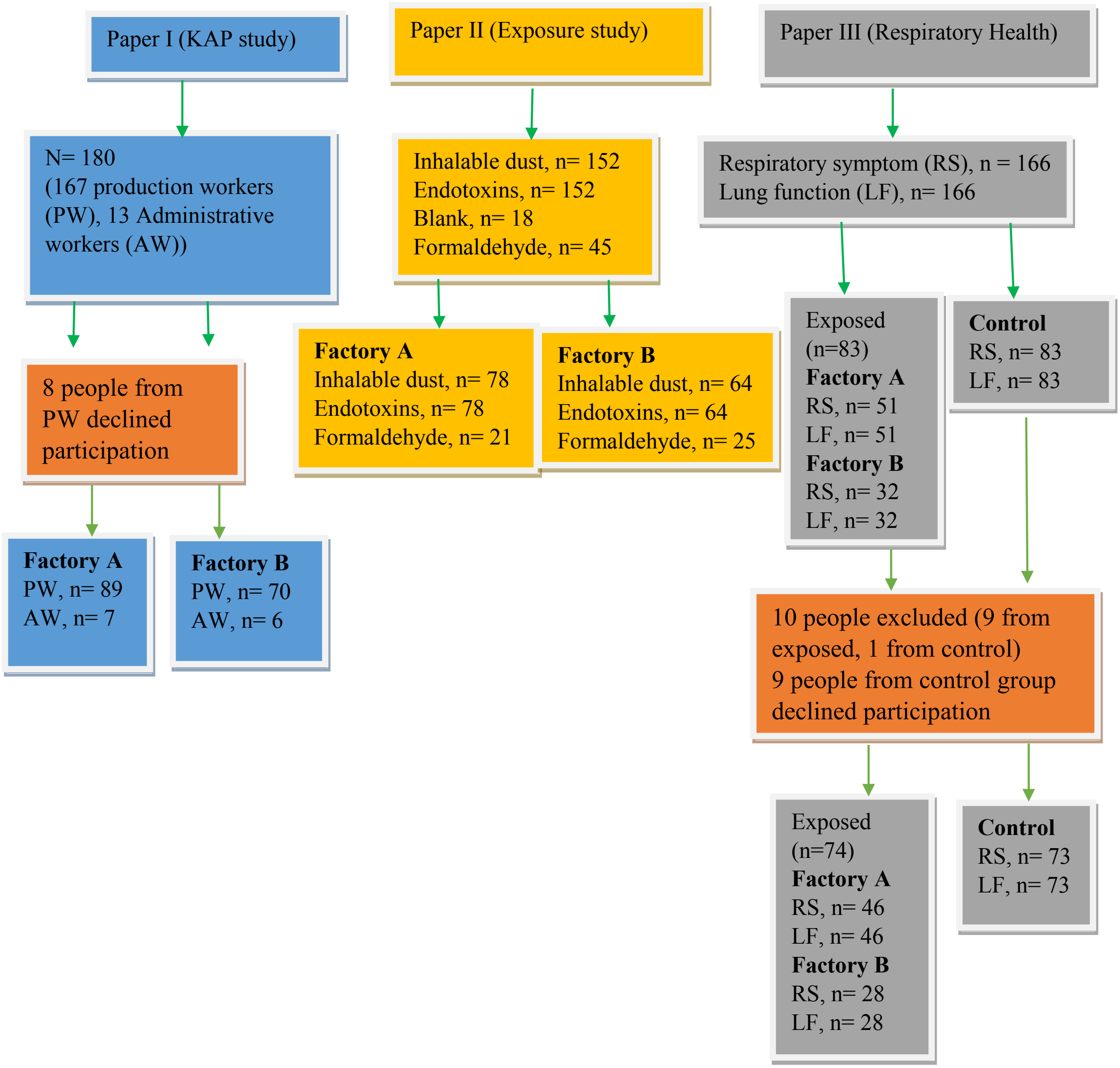

Fig. 6. Schematic diagram of sample size for the studies

4.3. Interviews

4.3.1. Assessment of Knowledge, attitude and practice

KAP questions from published articles regarding textile, petrochemical and other industries addressing workplace-related safety and health (18, 93, 110) were used for development of a questionnaire. The questionnaire was constructed so as to provide an understanding of workers' level of knowledge and practice, in order to address the hazards expected within the particleboard industries included in the study. The questionnaire comprised 31 closed-ended and 19 open-ended questions for production workers and 12 closed-ended and 12 open-ended questions for administrative personnel.

The structured questionnaire asked for sex (M/F), age (years), education (highest grade completed), profession, employment status (permanent/temporary), work section, number of years of service and total working hours per day. The main body of the questionnaire contained knowledge- (n= 20), attitude- (n= 10) and practice-related (n= 9) questions with No (N) or Yes (Y) response options and some open-ended questions. Completeness of the questionnaire, missing data and consistency were checked at the end of each day of data collection.

The questions were prepared in English and translated into Amharic by a translator, then translated back from Amharic to English by another translator, to check consistency. Pre-testing of the questionnaire was carried out in 5% of the sample population at one of the factories before the main study. The same translation procedure was applied for the respiratory symptoms (4.3.2)

4.3.2. Assessment of respiratory symptoms

Information on chronic respiratory symptoms in the particleboard production workers was collected using an adapted standard questionnaire from the American Thoracic Society (ATS) (111). The information collected was data on sex (M/F), age (years), education (highest grade completed), sources of energy at home, availability of separate kitchen (Y/N) and number of years of service. Questions about respiratory symptoms were asked as follows: whether the workers in the past 12 months have/had: cough (Y/N), a cough and sputum production (Y/N), phlegm (Y/N), an episode of coughing and phlegm production (Y/N), wheezing (Y/N), shortness of breath (Y/N), a history of respiratory illness (Y/N), occupational history in a dusty working environment and tobacco smoking (Y/N). Completeness of the questionnaire, missing data and consistency were checked at the end of each day of data collection.

4.3.3. Lung-function measurements

Lung-function tests were performed in both the particleboard workers (exposed group) and the water-bottling workers (controls). The test was performed in a sitting position using spirometry (Minispir light with Winspiro software, Medical International Research (MIR), Rome, Italy) connected to a laptop to measure forced vital capacity (FVC), FEV_1, FEV_1/FVC and forced expiratory flow 25-75% ($FEF_{25-75\%}$) following the American Thoracic Society guidelines (112). Standing height (m) and weight (kg) were also measured. The spirometry measurements were taken throughout the working week, when the workers started their morning shift at 6 am, but before actually starting work. The measurements were taken by the trained researcher until the trial generated three acceptable manoeuvres. From these three records, the best trial was kept and used for the data analysis.

One of the particleboard workers was unable to properly perform the lung-function measurement, thus we discarded his trial results. There was also a low numbers of female participants (5.7%) in our study, corresponding to their representation in the factories. As a result, the female participants were excluded from further analysis.

4.4. Exposure sampling and laboratory analysis

4.4.1. Dust and endotoxin measurements

A total of 152 personal inhalable dust samples and 18 blanks were taken during the study. Inhalable dust samples were taken in the workers' breathing zone using a conductive plastic inhalable conical sampler (CIS; JS Holdings, Stevenage, UK) (113) mounted with a 37 mm glass-fibre (GFA) filter (Whatman International Ltd, Maidstone, UK) and connected to a Side Kick Casella (SKC) pump using an air flow of 3.5 l/min. During each sampling day we registered the production downtime and the volume of particleboard produced. We collected personal samples of inhalable dust for 2 to 4 hours per shift, and the air-flow rate was measured before, during and after each measurement. Collected samples were securely packed and transported to the laboratory at Aarhus University, Denmark, where the filters were weighed in a room with controlled climatic conditions (22ºC, 45% relative humidity; desiccation ≥24h) using an analytical balance with 0.1 μg readability (Mettler-Toledo Ltd,

Greifensee, Switzerland). The dust concentration was measured in mg/m^3. The gravimetric analysis followed an approved and standardised protocol, as stated elsewhere (114).
For analysis of endotoxins, the glass-fibre filters were extracted in 5ml pyrogen-free water with 0.05% (v/v) Tween-20 by means of orbital shaking (300 rpm) at room temperature for 60 minutes and centrifuging (1000g) for 15 minutes. The supernatant was stored at -80°C until used for the endotoxin assay. The supernatant was analysed for endotoxins using the Kinetic Amoebocyte Lysate test (Kinetic-QCL endotoxin kit, BioWhittaker, Walkersville, MA, USA) at Aarhus University, Denmark (114, 115), and the endotoxin measurements were expressed in EU/m^3.

4.4.2. Formaldehyde measurements

For formaldehyde-exposure measurement we applied a worst-case strategy, using Dräger tubes (formaldehyde 0.2/a 6733081 and formaldehyde 2/a 8101751) (108). During the morning shift, measurements were taken at seven workstations (chipping, glue kitchen, blending, forming, pressing, trimming, sanding) in Factory A and eight workstations (chipping, glue kitchen, blending, forming, pressing, trimming, sanding, sizing) in Factory B. One measurement was taken at each workstation at a height of approximately 1.5 m at an operator work site. The measurements were taken on three different days after urea-formaldehyde had been mixed with water in the glue kitchen for a total of 45 formaldehyde measurements. The glue kitchen and the blending section were assumed to have relatively high concentrations; consequently, for some of the measurements, we intially used the 2 to 40 ppm measuring range of the tubes, i.e. five strokes for 30 seconds (every 6 seconds) with the hand pump. The measuring range of 0.2 to 5 ppm, i.e. 10 strokes for 90 seconds (every 9 seconds), was used for the samples at the other workstations (108).

4.5. Statistical analysis

Data was analysed using the statistical package SPSS, Version 25 (International Business Machines Corporation (IBM), Armonk, NY, USA). In Paper I, the Chi-square test was used for comparing categorical variables. The t-test was used to compare means of continuous variables. Pearson’s correlation analysis was used to analyse the association between knowledge score, age and years of service. Multiple linear regression was used to analyse the association between employment status (permanent vs temporary) and total knowledge score, adjusting for significant variables ($p < 0.05$) associated with knowledge score in a univariate analysis. Qualitative data collected by interview and observations were analysed using content analysis.

In Paper II the exposure data was not normally distributed and was therefore ln-transformed before analysis. Data was presented using measures of central tendency (arithmetic and geometric mean) and variation (range and geometric standard deviation) across the workstations. Correlation between the volume of particleboard produced, downtime, inhalable wood dust and endotoxin level was calculated using the Pearson's correlation test.

Linear mixed models were used to explore for differences in mean inhalable dust and endotoxin exposure – between the factories (A, B) and among the workstations. Two separate mixed-effects models were subsequently used to identify significant determinants and variance components for dust and endotoxin levels respectively. Workers were entered in terms of random effect. Time with no production (downtime), volume of particleboard produced, factory (A or B) and workstations were entered as fixed effects. Press trimming was used as a reference workstation in the models. Determinants were retained in the models when significant ($p < 0.05$).

In Paper III lung-function parameters were normally distributed. Descriptive statistics (arithmetic mean, SD) was used to summarise data. Pearson's Chi-square test or Fisher's exact test (when the expected value was < 5) was used to check the difference between the groups of categorical variables. The independent t-test was used to compare means of continuous variables. Poisson regression analysis was used to determine the prevalence ratio of respiratory symptoms between particleboard workers and the controls when adjusted for educational status, previous work in a dusty environment, history of respiratory illness, age, use of biomass fuel for cooking and availability of a separate kitchen. The prevalence ratio (PR) was preferable to the prevalence odds ratio (POR), owing to the high level of symptom prevalence in this study (116). Multiple linear regression was applied to analysis of difference in lung function between the particleboard workers and controls, adjusting for age, height, previous respiratory illness, availability of a separate kitchen and use of biomass fuel as a source of energy.

Table 3. Summary of statistical methods used in the analyses by paper

Statistical Method	Paper		
	I	II	III
Arithmetic mean	√	√	√
Geometric mean		√	
Range		√	
Pearson's Correlation test	√	√	√
T-test	√		√
Pearson's Chi-square test or Fisher's exact test	√		√
Poisson regression			√
Multiple linear regression	√		√
Mixed model		√	
Content analysis	√		

4.6. Ethics

Ethical clearance for the study was obtained from the Regional Committee for Medical and Health Research Ethics, Western Norway on June 2, 2016 with the IRB Ref. IRB00006245, and from the Ethiopian Ministry of Science and Technology on October 7, 2016 with Ref. No. 3.10/148/2016. Study participants were informed about the purpose of the study, the confidentiality of their information, the duration of the interview, lung-function measurements and air sampling. They were also informed of the possibility of withdrawing from the study at any time. Written consent from each of the study participants and from factory management was ensured before data collection. We adviced the workers with high prevalence of respiratory symptoms to consult their health care workers in the clinic.

5. Summary of results

5.1. Paper I

The permanent production workers had significantly more knowledge of topics related to chemical hazards and a more positive response regarding attitudes related to reduction of chemical hazards and the general work environment than temporary workers. Educational status was significantly associated with total knowledge score. PPE was provided for permanent workers. However, few temporary workers reported that they got PPE from the factory. The permanent workers responded that provision of PPE varied from monthly to annually, but many workers did not know of any regular schedule for PPE distribution. Neither permanent nor temporary workers used a full set of PPE during work. Permanent workers used more PPE during work than temporary workers, owing to its accessibility (81% vs 18.4%). The PPE observed during the workplace visit did not have any specifications such as production date, intended use and protection level, making it impossible to evaluate its quality. There was also a common understanding among the workers that the face masks and other PPE available were not accompanied by any information on protection efficiency. Medical check-ups at health institutions were reported by 37% of the temporary workers and 25% of the permanent workers. Only 10% of the permanent and none of temporary workers reported attendance at training in occupational safety and health. Both permanent and temporary workers reported that there was no scheduled or regular training about occupational hazards in the factories.

The administrative personnel stated that dust and formaldehyde are the chemical hazards found in the factory, but none of the safety staff were able to monitor and ensure safe practice related to this in the factories. The administrative personnel in charge of supplying logistics and equipment to employees reported that they purchased safety material without considering the safety and quality specifications. The administrative staff stated that the availability of safety guidelines, good lighting, good ventilation and good communication between workers and the employer reduce exposure to chemical hazards. Most of the administrative personnel believed that all PPE provides the same level of protection. They also mentioned that the safety committee in the factory ensures the supply of PPE and creates awareness among workers. Although the majority of them stated that workers are given safety training, their response regarding the frequency of the training varied.

5.2. Paper II

The overall geometric mean (GM) for personal inhalable dust exposure (n=142) was 4.66 mg/m^3. Exposure to inhalable dust was statistically different in factory B (GM=8.67 mg/m^3) to exposure in Factory A (2.83 mg/m^3). The overall GM of endotoxin exposure (n=142) was 62.20 EU/m^3. There was no statistically significance difference in endotoxin exposure between Factory A (GM= 46.53 EU/m^3) and Factory B (GM= 88.23 EU/m^3). Of the 142 samples, 93% exceeded 1 mg/m^3 – the TLV set by ACGIH for inhalable dust – and 41% exceeded 90 EU/m^3 – the OEL for endotoxins set by the Netherlands. The endotoxin level was significantly correlated to inhalable dust level. Downtime during sampling correlated negatively with inhalable dust level. In the mixed-effects model, factory and downtime explained 27.0% of the total variability in inhalable dust level. The exposure model predicted that a one-hour increase in downtime will decrease exposure to inhalable dust by 15%. In the mixed-effects model for endotoxins, exposure was increased in chipping, flaking, forming, maintenance and cleaning, and explained 34.0% of the total variability. Formaldehyde was detected in all workstations along the production line, except the first and last station (chipping and sizing). The highest median concentration was found in blending (3.5 ppm), followed by glue kitchen (1.0 ppm), with decreasing concentration further down the production line. Of the 45 samples, 13% exceeded the Norwegian peak exposure limit of 1 ppm.

5.3. Paper III

Of the 166 workers invited, 157 (94.5%) (83 particleboard workers and 74 water-bottling workers) participated in the study. After exclusion of 9 females and one particleboard worker who did not manage to perform spirometry, only non-smoking males were included in the analysis. In total, 18 (24%) participants in the exposed group had previous diseases, and of this number 4 had more than one diagnosis: bronchitis (n=12), asthma (7), pneumonia (3) and tuberculosis (3). Such previous illnesses were not reported in the control group. The mean age of particleboard workers was 28 years with 4 years of service. The controls had a mean age of 25 years and 2 years of service.

The prevalence of all recorded respiratory symptoms – wheezing, cough, cough and sputum production, phlegm and shortness of breath – was significantly higher in those exposed (range of prevalence: 24 – 45%) than in the controls (2.7 – 15%). The prevalence ratio of cough in those exposed was 1.56 (95% CI; 0.61, 3.95), compared with the controls when adjusted for educational status, previous work in a dusty environment, history of respiratory illness, age, use of biomass fuel for cooking and availability of a separate kitchen. None of the workers used face masks to protect them from dust and other chemical exposures.

There was no significant mean difference in lung function among those exposed and the controls, when adjusting for age, height, previous respiratory illness, availability of a separate kitchen and use of biomass fuel as a source of energy. All had FEV_1/FVC values above 70%, indicating that none of the workers had an airflow limitation.

6. Discussion

6.1. Main Discussion

This study showed a personal level of exposure to dust above the recommended limit value in workers in the particleboard factories. The particleboard workers had a higher prevalence of respiratory symptoms than an unexposed control group, but their lung function was not different from the controls. Different interpretations of these findings are possible. One possibility is that we may see the start of a respiratory-health problem in these factories without any objective changes in lung function, since the workers had only been working for a mean of four years in these factories. However, there might be confounding factors in the study population, explaining the differences found. Infectious diseases might be present in the exposed group, as this study did not examine any infectious agents. For instance, tuberculosis is a common disease in Ethiopia (117), and we did not test for tuberculosis in this study. However, the factory work is physically strenuous, and it is most unlikely for there to be active tuberculosis infection within the workforce. This would have affected their ability to wok. Another possible confounding factor is the potential use of substances such as khat. Khat chewing is associated with respiratory-health problems (118). However, those exposed and the control groups come from similar social environment, and use of such substances should be the same in both groups. Cannabis use is also associated with respiratory symptoms (119), but it is not common in the study area. Tobacco smoking was not reported either exposed persons or controls. There are thus strong indications of a relationship between the reported respiratory symptoms and wood dust, endotoxin and formaldehyde exposure in the particleboard factories. However, the cross-sectional design of the study reduces the possibility of clear conclusions.

The particleboard workers had knowledge on most topics related to chemical hazards, as well as positive response to questions about attitudes related to reduction of chemical hazards and the general work environment. All workers were not using a full set of PPE.

6.1.1. Respiratory symptoms

The particleboard workers had a significantly higher prevalence of respiratory symptoms than water-bottling workers (controls). This finding is in line with studies involving wood workers in Tanzania, Macedonia, Iran and Sweden (2, 38, 55, 68).
In our study the prevalence of phlegm and wheezing was higher in particleboard workers than in the controls. This is consistent with the findings for parquet-manufacturing workers in Macedonia and sawmill workers in Iran (2, 68). Furniture-manufacturing workers in Thailand were at greater risk of wheezing and breathlessness than office workers (3, 64), which is also consistent with our finding. Other studies with similar reported respiratory symptoms have revealed a GM of wood-dust exposure of 1.7 mg/m^3 and 3.86 mg/m^3 (38, 55) and AM of dust exposure 2.44 mg/m^3 and 7.67 mg/m^3 (2, 3). All had dust levels above the TLV of 1 mg/m^3 set by ACGIH for wood dust (25), which probably contributes to the high prevalence of reported respiratory symptoms.
Not only the dust level in this work environment can cause respiratory symptoms. Formaldehyde exposure within the range 0.28 ppm – 3.48 ppm has been found to cause several respiratory symptoms (47). These levels are similar to the formaldehyde levels recorded here, though comparisons between these studies are difficult, as our levels are based on a 'worst-case' sampling strategy (range < 0.2 ppm – 5 ppm). A systematic review and meta-analysis of epidemiological studies of formaldehyde exposure also showed increased prevalence of various respiratory-health problems (78).
A high prevalence of past respiratory illness (24%) was reported for particleboard workers, but such illnesses were not reported in controls. However, the causes of these past respiratory illnesses were not investigated in detail in the present study, it being based on self-reports. Both these past respiratory illnesses and current respiratory symptoms may be caused by dust (2, 3, 38, 55), endotoxin (63) or formaldehyde exposure at the present work site, or for some of the particleboard workers also in previous jobs. Some (23%) of the particleboard workers reported having worked in other dusty environments.

Lung function

Particleboard and water-bottling workers had a similar lung-function status, and none of them had an airflow limitation. Our finding is in agreement with results from Iran and Pakistan (2, 72), which showed no difference in lung function between exposed wood workers and controls. According to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) recommendation, a ratio of FEV_1/FVC less than 70% indicates the presence of a persistent airflow limitation (120). In our study the FEV_1/FVC was higher than 70% for all workers, indicating the absence of a persistent airflow limitation. Reasons for the absence of reduced lung function could be that the relatively young workers only had a few years of work experience involving wood-dust exposure in particleboard factories (121), as well as a healthy worker effect.

Our finding is in agreement with the results from cross-sectional studies in wood industries in Iran, Macedonia, Poland and Pakistan, which all showed that the mean FEV_1/FVC was higher than 70% in the study participants (2, 57, 68, 72, 80). The two studies in Iran had different wood dust exposure levels, – one of them higher than in our study (GM= 19 mg/m^3), and the other lower (GM= 2.44) (2, 57). Although the FEV_1/FVC value was higher than 70%, there was a significant association between wood-dust exposure and change in pulmonary-function tests (2, 72). Exposure to wood dust in the Polish study was within the range 0.49 – 18.2 mg/m^3 (80) – a lower range of dust than our finding (range : 0.47 – 184 mg/m^3). The effect thus may not be detected in the present study, but a future change in lung function may occur.

The absence of an airflow limitation in our study may reflect the inconclusive nature of the cross-sectional study design concerning the cause/effect relationship between wood-dust exposure and lung function. However, a six-year longitudinal study involving furniture workers in Denmark with a low exposure (GM= 0.94 mg/m^3) at baseline and 0.60 mg/m^3 at follow-up showed that wood-dust exposure that may result a clinically important reduction in lung function (79). The exposure level in our study is higher (GM= 4.66 mg/m^3) than that reported in Danish furniture industries, but with fewer years of service. This may indicate the possibility of declining lung function in particleboard workers in our study over time. A systematic review of longitudinal studies with ≥ 1 year of follow-up also indicated an association between organic dust exposure and longitudinal lung-function change (122). A prospective study involving wood workers exposed to formaldehyde showed a dose/response relationship between exposure to formaldehyde and reduced lung function (123).

Low $FEF_{25-75\%}$ values may be associated with asthma-like symptoms in adult patients (124). Dust and endotoxins may cause asthmatic conditions (125, 126), so in the present study the $FEF_{25-75\%}$ values were examined. However, no statistically significant differences between the groups were found.

6.1.2. Exposure to inhalable dust

This study showed that particleboard workers in Ethiopia were exposed to a geometric mean (GM) of 4.66 mg/m^3 of inhalable wood dust, with 93% of the samples exceeding 1 mg/m^3 – the Threshold Limit Value (TLV) for inhalable dust set by ACGIH. A previous study involving 20 small- and medium-scale Ethiopian wood-processing enterprises revealed that workers were exposed to a geometric mean of 6.82 mg/m^3 of dust (range 0.24 – 23.3 mg/m^3) (17), which is comparable with our study in large-scale factories. However, there is huge range of dust levels in our study, ranging from 0.47 – 184 mg/m^3. To our knowledge there are no previous studies of exposure to inhalable dust in particleboard factories in Ethiopia, and this finding will add knowledge of occupational exposure to inhalable dust in large wood industries. A study involving Iranian chipwood workers indicated that the workers were exposed to a GM of 19 mg/m^3, which is considerably higher than our finding. The possible reasons for the higher level of recorded inhalable dust could be its primitive processing, inappropriate wood-storage conditions and a lack of engineering-control measures (57). However, a study concerning plywood in New Zealand indicated that workers were exposed to a GM of 0.7 mg/m^3 (48), which is lower than our finding. This could be explained by differences in the work process and technological advances in the control of wood-dust emitted during processing.

Regardung exposure to inhalable dust reported in small-scale wood industries in Tanzania, there was a GM of 3.3 mg/m^3 (35), which was lower than in our study. This difference in exposure could partly be due to the outdoor location of the Tanzanian wood industries, which provides better general ventilation than in our study, which was mostly performed in a closed area. In addition, differences in the size of the factories and the manufacturing process might also have contributed to a variation in dust exposures between the studies. The level of exposure to wood dust was also lower among sawmill workers in Iran (2.44 mg/m^3) (2) and furniture workers in Thailand (1.55 mg/m^3) (1). The type of work process and wood product may result in different levels of dust exposure in these wood factories.

A study performed in joinery and furniture factories in the Netherlands reported lower exposure to inhalable dust (2.1 mg/m^3) (54) than in our study. Other studies in large- and medium-sized industrial sawmills in Norway (52) and furniture industries in Denmark (36) also recorded lower dust levels (0.72 mg/m^3 and 0.6 mg/m^3 respectively), which is different from our finding. A study of the pellet industry in Sweden reported lower personal dust exposure (1.7 mg/m^3) (55). Sawmill workers in Alberta and New Zealand were exposed to 2.04 mg/m^3 (59) and 0.52 mg/m^3 (60) of wood dust respectively. These differences could be due to the technological advances to be found in Norway, the Netherlands, Denmark, Sweden, New Zealand and Canada regarding control of dust emissions through mechanical ventilation, compared with our study, which did not involve any such control measures.

The level of exposure to inhalable dust varied from workstation to workstation, the highest level being recorded in sizing, forming, flaking and chipping workstations. This highest exposure level is probably linked to the dust-emitting, woodcutting and chipping processes. For example, sizing involves wood-cutting activities that create a lot of dust. Forming is also an activity whereby mixed woodchips with formaldehyde from the blending section are formed into a mat under high hydraulic pressure, with a lot of dust emission. The chipping and flaking processes also contribute to a high level of dust exposure in these sections, but the lowest dust exposure was recorded in quality control. This may be because these workers mainly stay in the laboratory, where there is a lower probability of dust emission because of the nature of activities taking place there. All workstations, however had dust levels above the TLV of 1 mg/m^3 set by ACGIH for wood dust (25). The variation in dust exposure across workstations is in line with a study performed in Danish furniture factories, indicating that work tasks were significant determinants of wood-dust exposure (36).

In the mixed-model analysis, factory (A, B) and downtime explained 27% of total variability and 36% of the between-worker variability for inhalable dust. The explained between-worker variability is lower than in a study performed in the Danish wood industry, which explained 42% of the between-worker variability for inhalable dust (36). In our study, downtime explained a relatively small part of the within-worker variance (11.6%) for inhalable dust. Since none of the workers changed factory from day to day, factory could contribute towards explaining between-worker variability only.

6.1.3. Endotoxin exposure

The particleboard production workers were exposed to a GM of 62.2 EU/m^3 of endotoxins. The percentage of samples exceeding the Dutch OEL for endotoxins (90 EU/m^3) was 41%. The endotoxin exposure in our study is lower than the findings from small-scale wood industries in Tanzania (GM = 91 EU/m^3) (35). However, it is higher than the findings from large-and medium-scale sawmills in Norway (17 EU/m^3) (52). The arithmetic mean for endotoxin exposure of particleboard workers in different workstations in our study varies from 10.6 to 564.8 EU/m^3, which is different to the results of a study with a mean range of 16.15 to 1974.0 EU/m^3 in different working sections in the fibreboard industry, and from <0.125 to 217.4 EU/m^3 in chipboard factories in Poland (42). Studies involving USA joinery workers (58) and plywood workers in New Zealand (48) indicated lower exposure levels than our findings (GM = 11 EU/m^3 and 23 EU/m^3 respectively).

In the present study the endotoxin exposure level exceeds the OEL in the first two workstations of the production process, i.e. chipping and flaking. The high moisture content in the protective bark of the eucalyptus tree in chipping and flaking at the start of the production process may constitute an optimal environment for endotoxin-producing gram-negative bacteria. After removal of the bark by flaking, the endotoxins per mg of inhalable dust in further processes was reduced. Although the endotoxin content per mg dust decreased from the intial to the later stages of the production process, endotoxin exposure correlated significantly with the inhalable dust level, and was considerably stronger (r= 0.68) than in a Tanzanian study (r= 0.44)

(35). This may be due to a difference in study setting, i.e. type of industry, sampling season and storage conditions for the raw material wood. The highest level of endotoxins in the Polish study was also recorded at the intial stage of the production process, when sharply decreasing during the subsequent production stages (42). The high level of endotoxins at the intial of the production could be due to the use of waste wood, which results in airborne microorganisms.

Workstations, namely chipping, flaking, forming, maintenance and cleaning activities, explained 58.8% of between-worker variance for endotoxins. Chipping and flaking had the greatest impact on endotoxin exposure. This is presumably because of the high content of endotoxins per mg inhalable dust in the first two stages of the production process. It seems reasonable that workstations were unable to explain any within-worker variance, since none of the workers changed workstations from day to day. In the linear mixed-effect model, factory (A, B) and downtime were not significant predictors of endotoxin exposure.

6.1.4. Formaldehyde exposure

Formaldehyde was detected in all measured workstations along the production line except the first (outdoors) and last workstations (indoor). The highest median air concentration of formaldehyde was recorded in blending (3.5 ppm), where the prepared formaldehyde solution and woodchips are mixed together, followed by the glue kitchen (1.0 ppm), with further decreasing concentrations down the production line. However, the formaldehyde measurements in our study were considered to be 'worst-case' measurements taken within a short sampling time, and do not indicate full-shift levels of formaldehyde in the factory. The measurements were taken when formaldehyde was prepared in the glue kitchen, and then sent to blending in order to be mixed with wood-chips. As far as we know, there is no other published data on such worst-case measurements of formaldehyde in particleboard industries. On the other hand, full-shift and short time (15 minute) measurements of formaldehyde taken in wood-processing industries ranged from 0.5 to 1.52 ppm in Iran (45). A study performed in furniture industries in Turkey shows an exposure level ranging from 0.02 to 2.2 ppm (46). A study performed in Finland among plywood workers showed a mean area concentration of formaldehyde varying from 0.03 mg/m^3 to 0.31 mg/m^3 (127), and in a study in Hawaii, USA it varied from 0.28 to 3.48 ppm (47). The GM for formaldehyde recorded was 0.06 ppm from a study performed among plywood workers in New Zealand (48). The variation may be due to a difference in sampling (stationary vs personal), duration (worst-case/peak vs full-shift and short-time), measuring equipment (indicator tubes vs sorbent tubes) and other unforeseen factors.

6.1.5. Knowledge, Attitude and Practice

The fact that more knowledge of chemicals and other hazards is gained from permanent workers than from temporary workers may be because temporary workers start their jobs as helpers, i.e. assisting permanently hired workers, without prior training in occupational health and safety. Our results from the KAP questionnaire has several similarities with analogous studies in other industries in Nigeria (100, 128). A Nigerian study of textile workers showed that permanent employment was a determinant for knowledge about workplace hazards, and this supports our results (128). While our study indicated that 82% all total workers knew of some types of chemical hazard, the Nigerian study reported that 74% knew of workplace hazards (128). High educational status in our study was associated with a high knowledge score, and this is in line with another Nigerian study (100).

Permanent workers also reported more safety-conscious responses (74% and above) to the attitude-related questions about reducing chemical hazards in the factory. However, the temporary workers reported less safety-conscious responses (3% and above). This finding is in line with the study performed in Nigeria, showing that permanent employment was a determinant for workers' attitude to workplace hazards (128).

Other studies have shown that the risk of injury in temporary workers is higher than in permanent workers, supporting the link between employment status and health & safety at the workplace (101-105). The finding that there is a high risk of injury in temporary workers may indicate that these workers have less knowledge of the various occupational hazards, and that the employer has given them less attention.

In our study neither permanent nor temporary workers reported use of a full set of PPE during work. In addition to the lack of a supply of PPE, especially for temporary workers, there was a negative perception regarding the protective value of the PPE available, which probably has an adverse effect on the practice of using the available PPE. The workers in Nigeria have similar perceptions, namely that the existing PPE is useless in terms of hazard protection (98). A low level of practice with regard to PPE is shown to be due to a low level of access to PPE and its unsuitability in various work settings (20, 91, 97, 99). Permanent workers had better practice than temporary workers, and this is consistent with another study involving Ethiopian textile workers regarding knowledge and safety (18). The workers also reported that low attendance at safety training might affect PPE use (18, 95). On the other hand, better use of PPE was reported in Ethiopian textile factories and Indian salt workers, presumably because of a high level of awareness (20) and availability of PPE (20, 96).

The administrative personnel were aware of various hazards such as wood dust and formaldehyde in their factory. The factories had no assigned occupational health and safety personnel that could monitor and ensure safety practice. This will have a negative impact on the technical requirements to be considered when ordering and purchasing PPE. As a result, the administrative workers in charge of supplying logistics and equipment to employees purchase PPE without any specification of the requisite quality. On top of this, most of the administrative personnel believed that all PPE provides the same level of protection.

6.2. Methodological discussion

6.2.1. Study design and setting

The cross-sectional study design used in the present study simple method to determine such things as prevalence of symptoms in a population. However, cross-sectional studies offer weak evidence for causality between exposure and health outcomes, as one cannot know for sure that the exposure preceded the symptoms. Theoretically, the workers may have had their symptoms before they started work in the factories, and this makes it harder to draw a clear conclusion from the present study. In the KAP study, these limitations of the cross-sectional study design will apparently not affect the validity of the data collected, because the information has no health variable and does not concern a causal relationship between exposure and health.

For the respiratory-health study we selected a control group from a water-bottling factory with a non-dusty work environment. We did not select a control from the general population, as we wanted to reduce selection bias that can be attributed to baseline characteristics such as economic differences between the groups. However, the workers were different in educational status but, controlled during the statistical analysis.

The exposure study was performed at the two of the country's biggest particleboard factories, and included every working section of these factories. On top of this, the inclusion of particleboard factories in different settings and sampling from every workstation will increase the representativeness of the study.

6.2.2. Validity

The main objective of research works is to obtain a valid estimate of both the exposure variables, as well as the effect measures of interest (129). Validity is an expression of the degree to which a test is capable of measuring what it is intended to measure, and it refers to the conceptual and scientific soundness of a research study (130, 131). Validity can be either internal or external.

6.2.2.1. Internal Validity

Internal validity is the degree to which the finding from an observation is correct for the group being studied. It reflects the ability of a research design to provide implausible alternative explanations for the result that the independent variable is directly responsible for the effect on the dependent variable (130, 131). In this study, the threats to internal validity such as selection bias, information bias and confounding will be discussed.

Selection bias

Selection bias can occur when the study participants are not randomly selected from the source population during the study (132, 133). The inclusion of both large-scale particleboards in the country will reduce the variation related due to setting. The results will be therefore applicable to large-scale particleboard wood industries. We chose large-scale industries rather than small-scale industries because of the assumption that the large-scale industries employ several workers and use power-driven machineries, unlike small-scale industries. We consequently wish to know more in detail about exposure and the work situation in the large-scale particleboard industries. The participants were young, with an average age of 28 years. This age factor may have an impact on the results, because of possible healthy-workers effects, owing to healthy hiring or the fact that less healthy individual workers might leave the work place. During data collection, participants from each working section of the factories were proportionally selected for all objectives. The selection of participants from the KAP study and respiratory health was followed by proportional and random sampling from each workstation.

Exposure samples were taken from similar exposure groups (SEGs), assigned based on the similar tasks they perform in each workstation. The sampling was performed by the researcher in consultation with the supervisors of each work station. The selection of persons from each working section was not totally random, but it is unlikely that it has influenced the representativeness of the workers. This is because we took the recommended number of samples from the production workers from each workstation, depending on the convenience of the ongoing production activities in the factories.

Information bias

In questionnaire studies, information bias happens as a result of wrong recording of individual factors because of an interviewer or interviewee problem (132). This is because the study participants can either disclose or conceal the information. The interviewer may also introduce bias during the interview process, e.g. by reading the questions too quickly for some people. Data collection was performed using a standard questionnaire, to reduce any possible information bias, though there may still be information or recall bias. The workers in the particleboard factory may have reported more respiratory symptoms than was actually the case, owing to a wish for an improved work environment. Conversely, the recorded symptoms may also have been underreported, because they may be hard to remember (134). Although information bias is difficult to completely avoid, we have partially prevented it by using a standardised questionnaire.

Before the study began, all study participants were clearly informed about the aim of the study and the confidentiality of their information, to avoid any concerns in relation to their job security and the overall benefit of the research. The data for the KAP study and respiratory health was collected using a structured questionnaire. The questionnaire for the KAP study was developed by reviewing KAP articles (18, 93, 110), with a pre-test being performed before data collection. The quantitative and qualitative information collected from production workers and management personnel may improve KAP regarding chemical hazards and PPE, from both the worker and the management perspective.

Even though data collection for both studies was performed using structured questionnaires one by one in a place without others listening, there may be still a response and interviewer bias. To avoid interviewer bias, we used interviewers in this study who were well trained for the work, and had been instructed to perform the interview the same way every time.

In the exposure study, calibration of the pump air-flow sampling rates every hour, use of approved-quality measuring equipment, a large sample size, several days of sampling with repeated measurements as well as approved and standardised protocol for analyses of inhalable dust and endotoxins may increase the validity of this study. However, the sampling time varied from 2 to 4 hours, because of excessive loose dust in the filters. Since the production system did not change during the sampling day, we have considered the 2 to 4-hours sampling time to be representative of full-shift exposure for the workers. In addition, to overcome certain behavioural activities in the workers that may challenge the validity of the data collected, the researcher visited each study participant every hour to monitor any unusual activities. The individual participants were also clearly informed about the aim of the study, how to behave during the sampling time and its overall benefit. They were all positive and highly cooperative throughout the study. As a result, we do not expect workers' behaviour to have manipulated the work process or the sampling to any great extent.

Participation rate

Information collected using structured questionnaires had a high response rate (95% for KAP study and 94.5% for respiratory-health study). In respiratory health, the response rate was 89% in the exposed group and 88% in the control group. The workers were neither forced nor paid to participate in the study. The high response rate was presumably due to the clear objective of the research and the close communication and cooperation between the researcher, the study participants and the employer. This may have motivated the workers to participate in the study.

The high response rate (88% in control groups and 89% in exposed groups), inclusion of the two biggest particleboard-producing industries found in the country and an additional two water-bottling factories as a control should increase the internal validity of the study.

Confounding

Confounding is a form of bias that concerns how the effect measure may change in value, depending on whether variables other than the exposure variable are controlled in the analysis. It is a distortion of effect measure that arises when we fail to control another variable (129). In our study, variables such as age, educational status, height, employment status and other variables were obtained, and the results were adjusted to allow for these factors in the statistical analysis. However, unknown factors may have been present and not allowed for in the analysis.

Dust and endotoxin sampling and analysis

The samples taken for wood dust were based on health-related aerosol sampling criteria, which state that the inhalable fraction is appropriate for aerosols such as wood dust that are usually deposited in the extra thoracic airways. Dust was sampled in filters using pumps with a recommended flow rate of 3.5 l/m (135), to draw air through the filters (136), and was analysed gravimetrically using the standard procedure (114). Workplace monitoring of endotoxin level is usually performed by sampling airborne inhalable aerosol, using pumps to draw air through the filters with subsequent aqueous extraction and analysis using the Kinetic Amoebocyte Lysate test (137) following the standard procedure (114, 115). Our sampling and analysis strategy for dust and endotoxins thus followed the standard procedures, which should increase the validity of the results.

Formaldehyde measurement

Formaldehyde was measured using a 'worst-case' strategy, and there was no full-shift measurement. Few samples were taken, but triplicate measurements were taken in different working sections on different days. This may have strengthened the validity of data recorded. The Dräger tubes are designed for spot measurement, providing quantitative results with a high degree of accuracy and repeatability. The Dräger tube contains a sensitive reagent system that produces accurate readings of the air contaminant (108, 138). The results of this instantaneous measurement may thus be considered as a pilot study, but not for full-shift exposure evaluation. The reason why full-shift formaldehyde sampling was not implemented was practicalities. Full-shift measurement of formaldehyde using the US National Institute of Occupational Safety and Health method (NIOSH Method 2016) could have been used. However, the sample will only have 34 days of stability in cold storage (5 °C) after sampling (139), and it was not practical to apply this approach in our setting, because the exposure sampling was planned to take a minimum of two months.

As we had no knowledge whatsoever about the presence of formaldehyde in this working air, we decided to carry out the sampling as a type of pilot study. As we detected high levels of formaldehyde in some places, a future study in these types of factory should be performed by another the sampling method and strategy to obtain full-shift exposure levels.

Lung-function measurement

Lung function was measured using calibrated and sensitive portable equipment in line with the American Thoracic Society's recommendation. There are no lung-function reference values for the general population in Ethiopia. We consequently only presented the absolute lung-function values, and compared the absolute mean values from the exposed workers with the control groups. We also compared the results with other research findings in our discussion.

6.2.2.2. External Validity

External validity is the extent to which the findings of the study are generalised for people not involved in the study (130). The study involved the two biggest particleboard manufacturing factories that use eucalyptus wood as a raw material in Ethiopia. The two particleboard factories have the same work processes, and are situated in different geographical locations (the north and south of the country), which may increase representativeness.

The finding with regard to KAP by employment status might be generalisable for wood-industry workers. The present study finding is consistent with that for other studies performed in industrial sectors other than the wood industry (18, 101). The respiratory-symptoms findings can also be generalised for wood-industry workers. The lung-function results cannot be conclusive, because of inconsistent findings from other researchers.

The types of tree used in other industries for which we have seen wood-industry publications were rubberwood, spruce, pine, oak and beech, white fir, meranti and iroko (35, 36, 52, 55, 71), which is not similar to the eucalyptus tree used in our study. A mixture of trees was also used in these factories, while only hardwood was used in our study. Furthermore, the production process was not the same as ours.

In our study, the information was only collected from large wood-manufacturing industries, and the situation in small-scale, medium-sized and less formal wood-manufacturing industries could be different. It was also limited to male particleboard workers, because of the paucity of female workers, although it would have been advantageous if female participants had been involved in the study, so as to provide gender-based results. The findings cannot be generalised for developed countries with different work situations, different levels of technology and exposure-control mechanism and a more skilled workforce. This study can thus be generalisable for wood industries in developing countries with similar settings and work processes.

7. Conclusions

- The study concluded that permanent workers gave a higher proportion of positive responses regarding knowledge of and attitude towards chemical health hazards than temporary workers.
- PPE use depended on access, and was mostly provided for permanent workers, not for temporary workers. The quality of PPE was questionable.
- The findings revealed that the geometric mean (GM) inhalable dust exposure levels were above the Threshold Limit Value (TLV) of 1 mg/m^3 set by the American Conference of Governmental Industrial Hygienists (ACGIH).
- The GM endotoxin level was lower than the level of 90 EU/m^3 recommended by Dutch scientists as the occupational exposure limit, but samples taken in chipping and flaking workstations were above 90 EU/m^3.
- Formaldehyde was detected in the factories, and the median formaldehyde concentration was highest in the blending workstation.
- Particleboard workers displayed a higher prevalence of respiratory symptoms than controls.
- The lung-function status of particleboard workers was similar to that of controls.

8. Recommendation and future perspectives

8.1. Recommendation

The factories are advised to:

- Reduce exposure to dust, endotoxins and formaldehyde in these workplaces through engineering controls (installation of local exhaust ventilation or dust collection hood) or administrative strategies (e.g. job rotation, facilities for meals and rest breaks, sanitation facilities), so as to prevent work-related health problems.
- Provide proper PPE (face mask, overall, gloves, goggles etc) that is in line with the quality standard for both permanent and temporary workers.
- Provide training for all factory workers and management personnel on why and how to use the PPE.

The workers should:

- Follow safety rules and regulations drawn up for them.
- Attend training sessions on the use of PPE.

The responsible government body in Ethiopia should:

- Formulate national occupational-safety and health policies.
- Develop or adopt occupational-exposure limit values for Ethiopia, taking into consideration the health effect and economic and technical considerations, and should carry out evaluation and monitoring for compliance with the standards.
- Start building capacity for all players in Ethiopia in occupational health and safety, through education, training and consultative workshops.

8.2. Future perspectives

The following studies are suggested for the future.

- Performance of an intervention study with improvement of the work environment in the particleboard factories and evaluation of the impact of the improvements. Suggested improvements/interventions are for instance provision of proper safety materials, supported by training. They may also include administrative measures such as job rotation and breaks, as well as introduction of new safety guidelines.

- Full-shift formaldehyde measurement is necessary, to provide knowledge of workers' level of exposure to this chemical.
- A systematic qualitative study is necessary for future work on an in-depth understanding of the particleboard workers' Knowledge, Attitude and Practice regarding chemical hazards and personal protective equipment.

References

1. Sriproed S, Osiri P, Sujirarat D, Chantanakul S, Harncharoen K, Ong-artborirak P, et al. Respiratory effects among rubberwood furniture factory workers in Thailand. Archives of Environmental & Occupational Health. 2013;68(2):87-94.
2. Neghab M, Jabari Z, Kargar Shouroki F. Functional disorders of the lung and symptoms of respiratory disease associated with occupational inhalation exposure to wood dust in Iran. Epidemiology and health. 2018;40(0):e2018031-0.
3. Thetkathuek A, Yingratanasuk T, Ekburanawat W. Respiratory symptoms due to occupational exposure to formaldehyde and MDF dust in a MDF furniture factory in eastern Thailand. Advances in Preventive Medicine. 2016;2016:11.
4. Mathur N, Rastogi S. Respiratory effects due to occupational exposure to formaldehyde: Systematic review with meta-analysis. Indian Journal of Occupational and Environmental Medicine. 2007;11(1):26-31.
5. European Respiratory Society. European Lung White Book. 2nd ed: European Respiratory Society.
6. World Health Organization. Global Health Observatory (GHO) data Geneva, Switzerland World Health Organization; [cited 2019 1 May]. Available from: https://www.who.int/gho/phe/en/.
7. Takala J, Hämäläinen P, Saarela KL, Yun LY, Manickam K, Jin TW, et al. Global estimates of the burden of injury and illness at work in 2012. J Occup Environ Hyg. 2014;11(5):326-37.
8. Gebreeyesus M. Industrial policy and development in Ethiopia: Evolution and present experimentation.
9. Central Statistical Agency. Key findings on the 2013 national labour force survey. Addis Ababa; 2013.
10. Oqubay A. The structure and performance of the Ethiopian manufacturing sector. Abidjan, Côte d'Ivoire; 2018.
11. Addis Ababa Chamber of Commerce and Sectoral Association. A Survey of Ethiopian Manufacturing Sector. Addis Ababa, Ethiopia; 2014.
12. Confederation of Ethiopian Trade Unions. Occupational safety and health and HIV/AIDS at work place. Addis Ababa, Ethiopia.2012. p. 5.
13. Transitional Goverment of Ethiopia. Health Policy of the Transitional Government of Ethiopia. Addis Ababa, Ethiopia.1993.
14. Federal Democratic Republic of Ethiopia. Labour Proclamation. Addis Ababa, Ethiopia: Federal Negarit Gazeta; 2004. p. 52.
15. Federal Democratic Republic of Ethiopia. Ethiopian Constitution. Addis Ababa, Ethiopia: Federal Negarit Gazeta; 1995. p. 38.
16. Kumie A, Amera T, Berhane K, Samet J, Hundal N, G/Michael F, et al. Occupational health and safety in Ethiopia: A review of situational analysis and needs assessment. The Ethiopian Journal of Health Development = Ya'Ityopya Tena Lemat Mashet. 2016;30(1 Spec Iss):17-27.
17. Ayalew E, Gebre Y, De Wael K. A survey of occupational exposure to inhalable wood dust among workers in small- and medium-scale wood-processing enterprises in Ethiopia. The annals of occupational hygiene. 2015;59(2):253-7.
18. Tetemke D. AK, Tefera Y., Sharma H.R., Worku W.,. Knowledge and practices regarding safety information among textile workers in Adwa town, Ethiopia. Science Postprint. 2014;1(1):5.

19. Mekonnen Y, Agonafir T. Pesticide sprayers' knowledge, attitude and practice of pesticide use on agricultural farms of Ethiopia. Occupational medicine (Oxford, England). 2002;52(6):311-5.
20. Tadesse S, Kelaye T, Assefa Y. Utilization of personal protective equipment and associated factors among textile factory workers at Hawassa town, southern Ethiopia. Journal of occupational medicine and toxicology (London, England). 2016;11:6.
21. Zeleke ZK, Moen BE, Bråtveit M. Lung function reduction and chronic respiratory symptoms among workers in the cement industry: a follow up study. BMC Pulm Med. 2011;11:50-.
22. Hanssen VM, Nigatu AW, Zeleke ZK, Moen BE, Bråtveit M. High prevalence of respiratory and dermal symptoms among Ethiopian flower farm workers. Arch Environ Occup Health. 2015;70(4):204-13.
23. Abaya SW, Bråtveit M, Deressa W, Kumie A, Moen BE. Personal dust exposure and its determinants among workers in primary coffee processing in Ethiopia. Annals of work exposures and health. 2018.
24. International Labour Organization. Introduction to the ILO's programme: Global Action for Prevention on Occupational Safety and Health Geneza, Switzerland.2017 [cited 2019 30 April]. Available from: https://www.ilo.org/global/about-the-ilo/how-the-ilo-works/WCMS_495278/lang--en/index.htm.
25. American Conference of Governmental Industrial Hygienists. Threshold Limit Values and Biological Exposure Indices. Ohio, USA: ACGIH; 2019.
26. Dutch expert Committee on Occupational Safety. Endotoxins: Health-based recommended occupational exposure limit. Health Council of the Netherlands. The Hague, Netherlands.2010. p. 100.
27. Ministry of Labor and Social Affairs. Regulations on measures and limit values. List of limit values for contaminants in the working atmosphere. Norway.2011. p. 77.
28. Forum for Environment. Ethiopian Environment Review. Addis Ababa, Ethiopia; 2010.
29. Environmental Protection Agency. Particleboard manufacturing 2002. In: Wood Products Industry, [Internet]. Washington, DC, USA: Environmental Protection Agency; [29]. Available from: https://www3.epa.gov/ttnchie1/ap42/ch10/final/c10s06-2.pdf.
30. International Labour Organization. Safety and health at the wood workshop. Geneva, Switzerland; 2015.
31. Health and Safety Executive. Safe use of woodworking machinery. United Kingdom: Health and Safety Executive; 2015.
32. The National Institute for Occupational Safety and Health. Wood dust [updated 28 September, 2011; cited 2019 19 June]. Available from: https://www.cdc.gov/niosh/pel88/wooddust.html.
33. Gioffre A, Marramao A, Ianno A. Airborne microorganisms, endotoxin, and dust concentration in wood factories in Italy. The annals of occupational hygiene. 2012;56(2):161-9.
34. Magagnotti N, Nannicini C, Sciarra G, Spinelli R, Volpi D. Determining the exposure of chipper operators to inhalable wood dust. The annals of occupational hygiene. 2013;57(6):784-92.
35. Rongo LM, Msamanga GI, Burstyn I, Barten F, Dolmans WM, Heederik D. Exposure to wood dust and endotoxin in small-scale wood industries in Tanzania. Journal of exposure analysis and environmental epidemiology. 2004;14(7):544-50.

36. Schlünssen V, Jacobsen G, Erlandsen M, Mikkelsen AB, Schaumburg I, Sigsgaard T. Determinants of wood dust exposure in the Danish furniture industry-results from two cross-sectional studies 6 years apart. The annals of occupational hygiene. 2008;52(4):227-38.
37. Scarselli A, Binazzi A, Ferrante P, Marinaccio A. Occupational exposure levels to wood dust in Italy, 1996-2006. Occupational and environmental medicine. 2008;65(8):567-74.
38. Rongo LM, Besselink A, Douwes J, Barten F, Msamanga GI, Dolmans WM, et al. Respiratory symptoms and dust exposure among male workers in small-scale wood industries in Tanzania. Journal of occupational and environmental medicine. 2002;44(12):1153-60.
39. Saary MJ, House RA, Holness DL. Dermatitis in a particleboard manufacturing facility. Contact dermatitis. 2001;44(6):325-30.
40. International Agency for Research on Cancer. Arsenic, Metals, Fibres, and Dusts: A review of human carcinogens. Lyon, France; 2012.
41. International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. France: World Health Organization 1995.
42. Dutkiewicz J, Olenchock S, Krysinska-Traczyk E, Skorska C, Sitkowska J, Prazmo Z. Exposure to airborne microorganisms in fiberboard and chipboard factories. Annals of agricultural and environmental medicine : AAEM. 2001;8(2):191-9.
43. Dutkiewicz J, Krysinska-Traczyk E, Prazmo Z, Skorska C, Sitkowska J. Exposure to airborne microorganisms in Polish sawmills. Annals of agricultural and environmental medicine : AAEM. 2001;8(1):71-80.
44. Mäkinen M, Kalliokoski P, Kangas J. Assessment of total exposure to phenol-formaldehyde resin glue in plywood manufacturing. International Archives of Occupational and Environmental Health. 1999;72(5):309-14.
45. Jafari MJ, Rahimi A, Omidi L, Behzadi MH, Rajabi MH. Occupational exposure and health impairments of formaldehyde on employees of a wood industry. Health Promotion Perspectives. 2015;5(4):296-303.
46. Vaizoglu SA, Aycan S, Akin L, Kocdor P, Pamukcu G, Muhsinoglu O, et al. Determination of formaldehyde levels in 100 furniture workshops in Ankara. The Tohoku journal of experimental medicine. 2005;207(2):157-63.
47. Malaka T, Kodama AM. Respiratory health of plywood workers occupationally exposed to formaldehyde. Archives of environmental health. 1990;45(5):288-94.
48. Fransman W, McLean D, Douwes J, Demers PA, Leung V, Pearce N. Respiratory symptoms and occupational exposures in New Zealand plywood mill workers. The annals of occupational hygiene. 2003;47(4):287-95.
49. International Agency for Research on Cancer. Formaldehyde, 2-butoxyethanol and 1-tertbutoxypropan- 2-ol. 2006;88.
50. International Agency for Research on Cancer. Chemical agents and related occupations: A review of human carcinogens. Lyon, France; 2012.
51. Kauppinen T, Toikkanen J, Pedersen D, Young R, Ahrens W, Boffetta P, et al. Occupational exposure to carcinogens in the European Union. Occupational and environmental medicine. 2000;57(1):10-8.
52. Straumfors A, Olsen R, Daae HL, Afanou A, McLean D, Corbin M, et al. Exposure to wood dust, microbial components, and terpenes in the Norwegian sawmill industry. Annals of work exposures and health. 2018;62(6):674-88.
53. Kauppinen A, Savolainen K, Husgafvel-Pursiainen K, Kauppinen T, Kromhout H, Mirabelli D, et al. Occupational exposure to inhalable wood dust in the member states of the European Union. The annals of occupational hygiene. 2006;50(6):549-61.

54. Scheeper B, Kromhout H, Boleij JSM. Wood-dust exposure during wood-working processes. The annals of occupational hygiene. 1995;39(2):141-54.
55. Lofstedt H, Hagstrom K, Bryngelsson IL, Holmstrom M, Rask-Andersen A. Respiratory symptoms and lung function in relation to wood dust and monoterpene exposure in the wood pellet industry. Upsala journal of medical sciences. 2017;122(2):78-84.
56. Rosenberg C, Liukkonen T, Kallas-Tarpila T, Ruonakangas A, Ranta R, Nurminen M, et al. Monoterpene and wood dust exposures: work-related symptoms among Finnish sawmill workers. American journal of industrial medicine. 2002;41(1):38-53.
57. Badirdast P, Rezazadeh Azari M, Salehpour S, Ghadjari A, Khodakarim S, Panahi D, et al. The effect of wood aerosols and bioaerosols on the respiratory systems of wood manufacturing industry workers in Golestan province. Tanaffos. 2017;16(1):53-9.
58. Harper M, Andrew ME. Airborne endotoxin in woodworking (joinery) shops. Journal of environmental monitoring : JEM. 2006;8(1):73-8.
59. Yamanaka MW, Guidotti TL, Koehncke N, Taylor FM, Taylor C, Harman L. Wood dust levels in Alberta sawmills. Arch Environ Occup Health. 2009;64(4):270-7.
60. Douwes J, McLean D, Slater T, Travier N, Cheng S, Pearce N. Pine dust, atopy and lung function: A cross-sectional study in sawmill workers. The European respiratory journal. 2006;28(4):791-8.
61. Douwes J, McLean D, van der Maarl E, Heederik D, Pearce N. Worker exposures to airborne dust, endotoxin and beta(1,3)-glucan in two New Zealand sawmills. American journal of industrial medicine. 2000;38(4):426-30.
62. Sriproed S, Osiri P, Sujirarat D, Chantanakul S, Harncharoen K, Ong-artborirak P, et al. Respiratory effects among rubberwood furniture factory workers in Thailand. Arch of Environ & Occup Health. 2013;68(2):87-94.
63. Liebers V, Bruning T, Raulf-Heimsoth M. Occupational endotoxin-exposure and possible health effects on humans. American journal of industrial medicine. 2006;49(6):474-91.
64. Sripaiboonkij P, Phanprasit W, Jaakkola MS. Respiratory and skin effects of exposure to wood dust from the rubber tree Hevea brasiliensis. Occupational and environmental medicine. 2009;66(7):442-7.
65. Shamssain MH. Pulmonary function and symptoms in workers exposed to wood dust. Thorax. 1992;47(2):84-7.
66. Schlünssen V, Schaumburg I, Taudorf E, Mikkelsen AB, Sigsgaard T. Respiratory symptoms and lung function among Danish woodworkers. Journal of occupational and environmental medicine. 2002;44(1):82-98.
67. Okwari OO, Antai AB, Owu DU, Peters EJ, Osim EE. Lung function status of workers exposed to wood dust in timber markets in Calabar, Nigeria. African journal of medicine and medical sciences. 2005;34(2):141-5.
68. Bislimovska D, Petrovska S, Minov J. Respiratory symptoms and lung function in never-smoking male workers exposed To hardwood dust. Open access Macedonian journal of medical sciences. 2015;3(3):500-5.
69. Bohadana AB, Massin N, Wild P, Toamain JP, Engel S, Goutet P. Symptoms, airway responsiveness, and exposure to dust in Beech and Oak wood workers. Occupational and environmental medicine. 2000;57(4):268-73.
70. Farokhi A, Heederik D, Smit LAM. Respiratory health effects of exposure to low levels of airborne endotoxin – a systematic review. Environmental Health. 2018;17(1):14.
71. Thetkathuek A, Yingratanasuk T, Demers PA, Thepaksorn P, Saowakhontha S, Keifer MC. Rubberwood dust and lung function among Thai furniture factory workers. International journal of occupational and environmental health. 2010;16(1):69-74.

72. Meo SA. Lung function in Pakistani wood workers. International journal of environmental health research. 2006;16(3):193-203.
73. Ljubicic Calusic A, Varnai VM, Cavlovic AO, Segvic Klaric M, Beljo R, Prester L, et al. Respiratory health and breath condensate acidity in sawmill workers. International archives of occupational and environmental health. 2013;86(7):815-25.
74. Liebers V, Raulf-Heimsoth M, Bruning T. Health effects due to endotoxin inhalation (review). Archives of toxicology. 2008;82(4):203-10.
75. Duchaine C, Mériaux A, Thorne PS, Cormier Y. Assessment of particulates and bioaerosols in eastern Canadian sawmills. AIHAJ - American Industrial Hygiene Association. 2000;61(5):727-32.
76. Rylander R, Michel O. Organic dust induced inflammation--role of atopy and TLR-4 and CD14 gene polymorphisms. American journal of industrial medicine. 2005;48(4):302-7.
77. Spee T, van de Rijdt-van Hoof E, van Hoof W, Noy D, Kromhout H. Exposure to wood dust among carpenters in the construction industry in the Netherlands. The annals of occupational hygiene. 2007;51(3):241-8.
78. Mathur N, Rastogi SK. Respiratory effects due to occupational exposure to formaldehyde: Systematic review with meta-analysis. Indian J Occup Environ Med. 2007;11(1):26-31.
79. Jacobsen G, Schlünssen V, Schaumburg I, Taudorf E, Sigsgaard T. Longitudinal lung function decline and wood dust exposure in the furniture industry. The European respiratory journal. 2008;31(2):334-42.
80. Baran S, Swietlik K, Teul I. Lung function: occupational exposure to wood dust. European journal of medical research. 2009;14 Suppl 4:14-7.
81. Jacobsen GH, Schlünssen V, Schaumburg I, Sigsgaard T. Cross-shift and longitudinal changes in FEV1 among wood dust exposed workers. Occupational and environmental medicine. 2013;70(1):22-8.
82. Bosan IB, Okpapi JU. Respiratory symptoms and ventilatory function impairment among wood workers in the Savannah belt of northern Nigeria. Annals of African Medicine. 2004;3(1):6.
83. Jayaprakash V, Natarajan KK, Moysich KB, Rigual NR, Ramnath N, Natarajan N, et al. Wood dust exposure and the risk of upper aero-digestive and respiratory cancers in males. Occupational and environmental medicine. 2008;65(10):647-54.
84. Steven D. Jahn, William H. Bullock, Joselito S. Ignacio. A Strategy for Assessing and Managing Occupational Exposures. USA: American Industrial Hygiene Association; 2015.
85. Daniel HA. The Occupational Environment: Its Evaluation, Control, and Management 3rd ed. USA: American Industrial Hygiene Association; 2011.
86. Brian D, John H. Control of Hazardous Substances. Australia: University of Wollongong; 2009.
87. Andrian H. Basic Principles in Occupational Hygiene. United Kingdom: IOHA; 2010.
88. United States Department of Labor; Occupational Health and Safety Administration. Hazard Prevention and Control [Available from: https://www.osha.gov/shpguidelines/hazard-prevention.html.
89. Health and Safety Executive. Wood dust. Selecting suitable respiratory protective equipment. United Kingdom: HSE; 2014.
90. Goverment of Western Australia Department of Commerce. 2015. Controlling wood dust hazards at work.
91. Parimalam P, Kamalamma N, Ganguli AK. Knowledge, attitude and practices related to occupational health problems among garment workers in Tamil Nadu, India. Journal of occupational health. 2007;49(6):528-34.

92. Ibrahim G. Badran. Knowledge, attitude and practice the three pillars of excellence and wisdom: a place in the medical profession. Eastern Mediterranean Health Journal. 1995;1(1):8.
93. Geer LA, Curbow BA, Anna DH, Lees PS, Buckley TJ. Development of a questionnaire to assess worker knowledge, attitudes and perceptions underlying dermal exposure. Scandinavian journal of work, environment & health. 2006;32(3):209-18.
94. Strengthening Partnerships Results and Innovations in Nutrition Globally (SPRING). The KAP Survey Model (Knowledge, Attitudes, and Practices): United States Agency for International Development (USAID) 2011 [cited 2019 29 May]. Available from: https://www.spring-nutrition.org/publications/tool-summaries/kap-survey-model-knowledge-attitudes-and-practices.
95. Lombardi DA, Verma SK, Brennan MJ, Perry MJ. Factors influencing worker use of personal protective eyewear. Accident; analysis and prevention. 2009;41(4):755-62.
96. Haldiya KR, Sachdev R, Mathur ML, Saiyed HN. Knowledge, attitude and practices related to occupational health problems among salt workers working in the desert of Rajasthan, India. Journal of occupational health. 2005;47(1):85-8.
97. Paramasivam P, Raghavan PM, Srinivasan PD, Kumar GA. Knowledge, Attitude, and Practice of Dyeing and Printing Workers. Indian Journal of Community Medicine : Official Publication of Indian Association of Preventive & Social Medicine. 2010;35(4):498-501.
98. Kalu O.O., Jimmy E.E., Hosea P. O. Utilization of personal protective equipments (PPEs) among wood factory workers in Calabar municipality, southern Nigeria. International Journal of Science and Research. 2013.
99. Negatu B, Kromhout H, Mekonnen Y, Vermeulen R. Use of chemical pesticides in Ethiopia: A cross-Sectional comparative study on knowledge, attitude and practice of farmers and farm workers in three farming systems. The annals of occupational hygiene. 2016;60(5):551-66.
100. Aluko OO, Adebayo AE, Adebisi TF, Ewegbemi MK, Abidoye AT, Popoola BF. Knowledge, attitudes and perceptions of occupational hazards and safety practices in Nigerian healthcare workers. BMC Research Notes. 2016;9:71.
101. Foley M. Factors underlying observed injury rate differences between temporary workers and permanent peers. American journal of industrial medicine. 2017;60(10):841-51.
102. Benavides FG, Benach J, Muntaner C, Delclos GL, Catot N, Amable M. Associations between temporary employment and occupational injury: what are the mechanisms? Occupational and environmental medicine. 2006;63(6):416-21.
103. Waenerlund AK, Virtanen P, Hammarstrom A. Is temporary employment related to health status? Analysis of the Northern Swedish Cohort. Scandinavian journal of public health. 2011;39(5):533-9.
104. Saha A, Ramnath T, Chaudhuri RN, Saiyed HN. An accident-risk assessment study of temporary piece rated workers. Industrial health. 2004;42(2):240-5.
105. Roquelaure Y, LeManach AP, Ha C, Poisnel C, Bodin J, Descatha A, et al. Working in temporary employment and exposure to musculoskeletal constraints. Occupational Medicine. 2012;62(7):514-8.
106. Gardiner K, Harrington JM. Occupational Hygiene. 3rd ed. Massachusetts, USA: Blackwell Publishing, Inc.,; 2005. 510 p.
107. Rappaport SM, Kupper L. Quantitative Exposure Assessment. California, USA: Stephen Rappaport El Cerrito; 2008. 168 p.
108. Dräger Safety AG & Co. KGaA. Dräger-Tubes & CMS-Handbook 16th edition 2011. Available from: https://www.draeger.com/Library/Content/tubeshandbook_br_9092086_en.pdf.

109. Nigsti A. Pulmonary Function Test and Pulseoximetry in Chip Wood Factory Workers of Maichew, Tigray Region: Addis Ababa University; 2014.
110. Langkulsen U, Vichit-Vadakan N, Taptagaporn S. Safety and health in the petrochemical industry in Map Ta Phut, Thailand. Journal of occupational health. 2011;53(5):384-92.
111. American Thoracic Society. Standards for epidemiologic surveys in chronic respiratory disease,. Recommended Respiratory Disease Questionnaires for Use with Adults and Children in Epidemiological Research.
112. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of spirometry. The European respiratory journal. 2005;26(2):319-38.
113. Tatum VL, Ray AE, Rovell-Rixx DC. The performance of personal inhalable dust samplers in wood-products industry facilities. Applied occupational and environmental hygiene. 2001;16(7):763-9.
114. Basinas I, Sigsgaard T, Heederik D, Takai H, Omland O, Andersen NT, et al. Exposure to inhalable dust and endotoxin among Danish livestock farmers: results from the SUS cohort study. Journal of environmental monitoring : JEM. 2012;14(2):604-14.
115. Thilsing T, Madsen AM, Basinas I, Schlünssen V, Tendal K, Baelum J. Dust, endotoxin, fungi, and bacteria exposure as determined by work task, season, and type of plant in a flower greenhouse. The annals of occupational hygiene. 2015;59(2):142-57.
116. Tamhane AR, Westfall AO, Burkholder GA, Cutter GR. Prevalence odds ratio versus prevalence ratio: Choice comes with consequences. Statistics in medicine. 2016;35(30):5730-5.
117. World Health Organization. Global Tuberclosis Report. 2018.
118. Woldeamanuel GG, Geta TG. Impact of chronic khat (catha edulis forsk) chewing on pulmonary function test and oxygen saturation in humans: A comparative study. SAGE Open Medicine. 2019;7:2050312118824616.
119. Gates P, Jaffe A, Copeland J. Cannabis smoking and respiratory health: Consideration of the literature. Respirology. 2014;19(5):655-62.
120. Global Initiative for Chronic Obstructive Lung Disease. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease(2018 Report). 2018.
121. Sharma G, Goodwin J. Effect of aging on respiratory system physiology and immunology. Clinical interventions in aging. 2006;1(3):253-60.
122. Bolund AC, Miller MR, Sigsgaard T, Schlünssen V. The effect of organic dust exposure on change in lung function – A systematic review. European Respiratory Journal. 2016;48(suppl 60):PA1169.
123. Alexandersson R, Hedenstierna G. Pulmonary function in wood workers exposed to formaldehyde: A prospective study. Archives of Environmental Health: An International Journal. 1989;44(1):5-11.
124. Raji H, Haddadzadeh Shoushtari M, Idani E, Tavakol H, Afrakhteh S, Dastoorpoor M, et al. Forced expiratory flow at 25-75% as a marker for airway hyper responsiveness in adult patients with asthma-like symptoms. Tanaffos. 2018;17(2):90-5.
125. Perez-Rios M, Ruano-Ravina A, Etminan M, Takkouche B. A meta-analysis on wood dust exposure and risk of asthma. Allergy. 2010;65(4):467-73.
126. Thorne PS, Kulhankova K, Yin M, Cohn R, Arbes SJ, Jr., Zeldin DC. Endotoxin exposure is a risk factor for asthma: the national survey of endotoxin in United States housing. American journal of respiratory and critical care medicine. 2005;172(11):1371-7.

127. Makinen M, Kalliokoski P, Kangas J. Assessment of total exposure to phenol-formaldehyde resin glue in plywood manufacturing. Int Arch Occup Environ Health. 1999;72(5):309-14.
128. Okafoagu NC, Oche M, Awosan KJ, Abdulmulmuni HB, Gana GJ, Ango JT, et al. Determinants of knowledge and safety practices of occupational hazards of textile dye workers in Sokoto, Nigeria: A descriptive analytic study. Journal of Public Health in Africa. 2017;8(1):664.
129. David G. Kleinbaum, Kevin M. Sullivan, Nancy D. Barker. A Pocket Guide to Epidemiology. USA: Springer; 2007.
130. Bonta R, Beaglehole R, Kjellström T. Basic Epidemiology. 2nd ed: World Health Organization; 2006.
131. Geoffrey Marczyk, David DeMatteo, David Festinger. Essentials of Research Design and Methodology. New Jersey: John Wiley & Sons; 2005. 305 p.
132. Hammer GP, du Prel JB, Blettner M. Avoiding bias in observational studies: part 8 in a series of articles on evaluation of scientific publications. Deutsches Arzteblatt international. 2009;106(41):664-8.
133. Pannucci CJ, Wilkins EG. Identifying and avoiding bias in research. Plastic and reconstructive surgery. 2010;126(2):619-25.
134. Fadnes L., Taube A., Tylleskär T. How to identify information bias due to self-reporting in epidemiological research. The Internet Journal of Epidemiology. 2008;7(2).
135. Health and Safety Executive. General methods for sampling and gravimetric analysis of respirable, thoracic and inhalable aerosols. UK: HSE; 2014. p. 13.
136. Gardiner K, Harrington JM. Occupational Hygiene. 3rd ed. USA: Blackwell Publishing, Inc.; 2005. 510 p.
137. The Nordic expert group for criteria documentation of health risks from chemicals and the Dutch expert committee on occupational safety. Endotoxin. University of Gothenburg; 2011.
138. ShopCross Industrial & MRO Supply. Formaldehyde 0.2/a 6733081 Draeger Tube [Available from: https://www.shopcross.com/product/formaldehyde-02a-6733081-draeger-tube.
139. National Institute of Occupational Safety and Health. NIOSH Manual of Analytical Methods. Method 2016: Formaldehyde. Washington, DC.2003. p. 7.

Annexes

Annex I. Original Articles

Annex II. Ethical clearance letters

Annex III. Questionnaire for Assessment of Knowledge, attitude and practice related to chemical hazards and personal protective equipment among particleboard workers and administrative personnel in Ethiopia

Annex IV. Questionnaire for Assessment of respiratory symptoms among particleboard workers (exposed) and water bottling workers (controls) in Ethiopia

Asgedom et al. BMC Public Health (2019) 19:440
https://doi.org/10.1186/s12889-019-6807-0

BMC Public Health

RESEARCH ARTICLE Open Access

Knowledge, attitude and practice related to chemical hazards and personal protective equipment among particleboard workers in Ethiopia: a cross-sectional study

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Abstract

Background: Work in the wood industry is often associated with exposure to wood dust and formaldehyde. The aims of this study were to describe the Knowledge, Attitude and Practice (KAP) concerning chemical health hazards among particleboard workers and to compare the KAP among temporary and permanent workers.

Methods: A cross-sectional study design was used to collect data by structured questionnaires in two particleboard factories in Ethiopia. A total of 159 workers and 13 management personnel participated in this study. Both closed-ended and open-ended questions were included in the interviews. Chi-square tests, *T* tests and correlation analyses were used for categorical and continuous data. Total knowledge score (range 0–8) was calculated as the sum score of 8 items weighing one point each. Multiple linear regression was applied to estimate the impact of employment status on total knowledge score adjusted for level of education. Content analysis was applied to analyse collected data from open-ended questions.

Results: The mean age of the respondents was 28 ($SD = 6$) years and on average they had 3.7 [3] years of service. The permanent workers were older than the temporary workers (29 vs 26 years, $p = 0.001$), and a considerably high fraction of the permanent workers had vocational education (90%) compared to the temporary workers (11%). Permanent workers had higher proportion of response on knowledge of 10 of 12 topics regarding chemical hazards and attitudes on 6 of 11 of these topics than temporary workers. Permanent workers had higher knowledge scores (3.7) compared to temporary workers (1.3) ($p < 0.001$), also after adjusting for education ($p = 0.011$). Permanent workers were provided with personal protective equipment (PPE) while temporary workers were not. The qualitative data helps to understand the workers and administrative personnel attitude and thinking regarding chemical hazards and PPE.

Conclusions: The findings revealed that permanent workers have higher proportion of positive response on knowledge and attitude towards chemical health hazards than temporary workers. However, practice in use of PPE depended on access to PPE. Few temporary workers were provided with PPE.

Keywords: Attitude, Chemical hazard, Knowledge, Particleboard factory, Personal protective equipment, Permanent worker, Practice, Temporary worker

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Background

Particleboard is a wood product which is increasingly produced and used in Ethiopia. It is manufactured from lignocellulosic materials, primarily in the form of discrete particles, combined with urea formaldehyde resin and bonded together under heat and pressure. Particleboard is used, for instance in production of office tables, shelves and interior wall partitioning [1, 2]. The manufacturing sector, comprising wood, metal, food, textile, leather and construction industries, accounts for 6.9% of the national work force in Ethiopia [3].

Work in the wood industry is associated with exposure to wood dust [4–11], and in the particleboard industry the workers might also be exposed to formaldehyde from glue resin [12–14]. Exposure to wood dust may cause acute irritation of the skin, eyes and airways [15, 16] and may also be associated with chronic respiratory symptoms [16–18]. Formaldehyde may also cause respiratory problems [14, 19]. Wood dust and formaldehyde are classified as carcinogenic (Group 1) by International Agency for Research on Cancer [20, 21].

The hierarchy of occupational hazard control from the most effective to the least effective can be described as: Elimination, substitution, engineering control, administrative control and PPE [22]. To reduce exposure to wood dust, the most effective control measures may not be present, or not work sufficiently. As a result, in many workplaces PPE is recommended as an immediate control measure, as the expense of providing PPE is relatively low and can quite easily be provided. The cost of face mask, coverall, glove, and other PPEs is covered by the employer. Workers in the wood industry are recommended to wear appropriate face masks and eye protection in areas with high dust and formaldehyde exposure. Coveralls and industrial gloves are needed to protect the skin [23, 24].

It is important for the workers to be informed about the health hazards and why control measures are necessary. Otherwise, workers do not always wear PPE, even in high risk situations at work. However, information alone might not be sufficient to change the attitude and practice of workers. A model called "Knowledge, Attitude and Practice" (KAP) has been developed to describe and understand these challenges better. The KAP model consists of a triad of interactive factors [25] and can help us to understand why the workers do not adhere to specific advice or rules by evaluating their behavioural determinants [26].

A study done in the United States revealed that use of PPE was negatively affected by lack of comfort and fitness, young age and lack of safety training [27]. Studies have shown that the use of PPE varies from 10 to 82% depending on accessibility, adequacy, affordability, fitness to the user and its discomfort [28–32]. A study done in Nigeria indicates that workers' adherence to use of PPE was low because of shortage, inconvenience and the perception of PPE as unnecessary. Safety training played a significant role in increasing knowledge about PPE and health problems in the wood industry [33].

KAP studies done among farm workers in Ethiopia showed that 85% of the workers do not receive training on chemical pesticides, only 10% of the workers were using full PPE and the attitude and practice of handling chemical pesticides were poor [34]. The knowledge level of the participants on safety issues was affected by gender, safety training and work regulations [35]. Furthermore, use of PPE was affected by safety training, education, work regulation and their knowledge of safety information [35, 36]. In the textile industry, employment status was a determinant for PPE use, since permanent workers apply safe practice to a greater extent than temporary workers [35].

There are several gaps in occupational safety and health in Ethiopia, such as lack of trained manpower, weak implementation of policy and regulation and limited research, all of which reduce the possibility of identifying, assessing and controlling hazards. This shows us that there is a long way to go to address occupational safety and health [37].

The knowledge among workers in the Ethiopian wood industry about exposure to dust and formaldehyde and their health effects has not been studied. More knowledge on KAP is needed for implementation of control measures in this type of industry. Another aspect is that in the particleboard factory, as well as in other industries in Ethiopia, there are both permanent and temporary workers. The number of temporary workers is in general increasing and several studies show that they are at higher risk of occupational injuries and diseases than permanent workers [38–42].

The aims of this study were to describe the KAP concerning chemical health hazards among particleboard workers, with focus on their use of PPE and to compare the KAP among temporary and permanent workers. It is hypothesized that temporary workers are less protected than permanent workers. Studying the KAP in this industry is important in planning preventive measures to reduce health problems related to chemical hazards.

Methods

A cross-sectional study design was used to collect structured questionnaire-based data from two of the largest particleboard factories in Ethiopia. The factory situated in northern Ethiopia has 663 workers and was established in 2005. The factory located in southern Ethiopia was established in 2002 and has 249 workers. The production lines in these factories are similar, comprising 10 sections: chipping, flaking, drier, boiler, blending, forming, pressing, trimming, sanding and sizing. In addition, there are workers with miscellaneous tasks who are working in all sections: cleaners and workers in the machine control room [1, 2], quality control and maintenance. The face mask currently used as personal protective equipment is shown in Fig. 1.

Production workers were the source of population for the study. The required number of participants was calculated with the purpose of describing use of PPE, using a single population proportion taking into account a 54% practice of using PPE obtained from a study done in Ethiopia among textile workers [35]. The output of the formula with 95% confidence interval, 5% level of significance and finite population correction gave 167 workers.

To plan the study, the factories and its leadership were visited. After obtaining permission to perform the study, we asked the management to provide the list of workers in each work shift (morning, evening and night). There were 8 working hours per shift.

Study participants were interviewed in a quiet and private place near their work by 10 trained bachelor environmental health professionals. After the interview the participants were also allowed to give their own comments about the working environment.

The questionnaire employed for data collection was developed by reviewing KAP questions from published articles in textile, petrochemical and other industries [26, 35, 43]. The questions were constructed in a way that addresses the hazards expected from the wood industries in the study. The proportion of questions were; 31 closed ended and 19 open-ended for workers and 12 closed ended and 12 open-ended for administrative personnel. Qualitative information was collected from worker and management staff using open-ended questions. The full data collection questionnaire is found as Additional file 1 for this article. The researcher also performed a workplace visit to observe the actual use of PPE and the type of PPE.

Information was collected from the workers in November and December 2016 using a structured questionnaire-based interview asking for sex (M/F), age (years), education (highest grade completed), profession, employment status (permanent/temporary), working section, number of service years, total working hours per day. In addition, the main body of the questionnaire contains knowledge, attitude and practice-related questions with no (N) or yes (Y) response options and some open-ended questions as indicated in as additional file 1. Completeness of the questionnaire and consistency was checked at the end of each day of the data collection.

The interview was based on qualitative and quantitative questions prepared in English and translated to Amharic by a translator, and then translated back from Amharic to English by another translator, to check the consistency. Pre-testing of the questionnaire was done on 5% of the sample population in one of the factories before the main study. Due to this test some questions were modified slightly before starting the actual data collection. Data were coded and entered in EpiData version 3.1.

A knowledge score was calculated as the sum score of 8 items weighing one point each. This score (0–8) consisted of knowledge of relevant chemical hazards at their workplace (2 items: dust and formaldehyde), relevant health effects from the chemical hazards (3 items: respiratory, eye and skin problems) and recommended personal protective equipment (3 items: coverall, face mask and gloves).

Fig. 1 Face mask currently in use among particleboard workers in Ethiopia

Ethics

The study received ethical permission from regional committee for Medical and Health Research Ethics, Western Norway on June 2, 2016 with IRB ref.: IRB00006245 and from the Ethiopian Ministry of Science and Technology on October 7, 2016 with Ref. No. 3.10/148/2016. Written consent from the study participants and consent from factory management was assured before data collection.

Statistics

Data was exported from EpiData version 3.1 to the statistical package SPSS, version 25 for analysis. Chi-square tests were used for comparing categorical variables. *T* tests were used to compare means of continuous variables. Correlation was used to analyse the association between knowledge score, age and service years. Multiple linear regression was used to analyse the association between employment status (permanent vs. temporary) and total knowledge score while adjusting for variables significantly associated with knowledge score in univariate analysis ($p < 0.05$). Content analysis was applied to analyse collected data from open-ended questions. The qualitative data provides supplementary information from administrative personnel on the general working environment, chemical hazards and PPE.

Results

General characteristics of the study population

From 167 people invited, 159 (95%) workers (89 and 70 from the two factories) responded to the questionnaire. The remaining 5% of the respondents did not want to participate in the interview. In addition to the data collected from the production workers, qualitative information was collected from 13 management personnel (7 and 6 from the two factories).

There was no statistical difference between the employees from the two factories in terms of sex distribution ($p = 0.3$), age ($p = 0.078$), service years ($p = 0.097$), and consequently the data from the two factories were merged in the following analysis. However, educational status was significantly different between the two study sites ($p < 0.001$).

The arithmetic mean age of the respondents was 28 ($SD = 6$) years and the average service years of the respondents was 3.7 [3] years. Eight people had worked in another similar factory with service years ranging from 1 to 20. The majority of the respondents among both permanent and temporary workers were men (94% vs 87%). The permanent workers were older than the temporary workers (29 vs 26 years, $p = 0.001$), and among the permanent workers a considerably higher fraction had at least vocational education (90%) than among the temporary workers (11%) (Table 1).

Knowledge about chemical hazards

Permanent workers had significantly more knowledge than temporary workers about 10 of total 12 topics related to chemical hazards (Table 2). A high fraction of the permanent workers had knowledge of some chemical hazards (87%), health effects (80%) and relevant PPE (100%). Formaldehyde was the chemical factor mentioned by the highest fraction of both permanent and temporary workers (Fig. 2). Respiratory problems were mentioned more often than eye problems, while only a few workers mentioned skin problems. Coveralls, followed by face mask and gloves, were mentioned most often as relevant PPE. The primary sources of information about occupational health mentioned by the highest fraction of permanent workers were health workers, senior workers and radio/TV (Fig. 3). Only four of the temporary workers mentioned any sources of such information. Few permanent workers got information from the Internet.

In univariate analyses employment status and education level were both significantly associated with the knowledge score while sex and age were not (Table 3). Mean knowledge score was 3.7 ($SD = 2.4$) among permanent and 1.2 ($SD = 2.1$) among temporary workers, respectively. There was no correlation between the knowledge score and service years ($r = 0.015$; $p = 0.847$) or between the knowledge score and age ($r = 0.049$; $p = 0.452$).

Further analysis using multivariate regression showed that employment is significantly associated with the knowledge score while adjusting for education. When

Table 1 Demographic characteristics of permanent and temporary particleboards workers in Ethiopia

Variable		Total *n* (%)	Employment status ($n = 159$)	
			Permanent ($n = 121$) *n* (%)	Temporary ($n = 38$) *n* (%)
Sex	Male	147(92)	114(94)	33(87)
	Female	12(8)	7(6)	5(13)
Education	Grade 1–10	46(29)	12(10)	34(89)
	Vocational and above	113(71)	109(90)	4(11)
Service year	Mean (*SD*)	3.7(3.0)	4(3.0)	2.5(2.4)
Age	Mean (*SD*)	28(6.0)	29(6.0)	26(5.0)

Table 2 Knowledge about chemical hazards and protective measures among permanent and temporary particleboard workers in Ethiopia

Variable	Total *n* (%)	Employment status($n = 159$)		*p* value
		Permanent ($n = 121$) *n* (%)	Temporary ($n = 38$) *n* (%)	
Know some chemical hazards	130(82)	105 (87)	25 (66)	0.007
Know some health effects	114(72)	97 (80)	17 (45)	< 0.001
Know some relevant types of PPE	144(91)	121(100)	23(61)	< 0.001
Know hazards other than chemicals	115(72)	93 (77)	22 (58)	0.038
Emergency exit is important	84(53)	81 (67)	3 (8)	< 0.001
Know material safety data sheet	35(22)	34 (28)	1 (3)	0.002
Know/understand sign and symbols of safety	75(47)	71 (59)	4 (11)	< 0.001
Know any safety rule in this workplace	89(56)	83 (69)	6 (16)	< 0.001
Know job rotation reduces exposure to chemical hazard	113(71)	97 (80)	16 (42)	< 0.001
Know break time during work reduces exposure to chemical hazard	140(88)	108 (89)	32 (84)	0.59
Have information on occupational health	63(40)	59(49)	4(11)	< 0.001
Know the factory has obligation to maintain workers' health	143(90)	110 (91)	33 (87)	0.676

age and sex were included in the multivariate analysis, the results were the same.

Attitudes related to chemical hazards

Higher proportion of permanent workers had significantly positive response than temporary workers on 6 of 11 topics on attitude related to reduction of chemical hazards and the general working environment (Table 4). A higher proportion of temporary (82%) than permanent workers (38%) believed that all PPE has the same level of protection. For four attitude-related questions there were no significant difference between permanent and temporary workers.

Practices of workers related to chemical hazards

Provision of PPE, as perceived by the permanent workers varied from monthly to annually and many workers did not know about the schedule of PPE distribution (Table 5).

From the total 159 workers 103 (66%) were using at least one type of PPE during work. All permanent workers responded that the factory provides PPE and 98

Fig. 2 Type of chemical hazards, health problem and personal protective equipments stated by permanent and temporary particleboard workers in Ethiopia

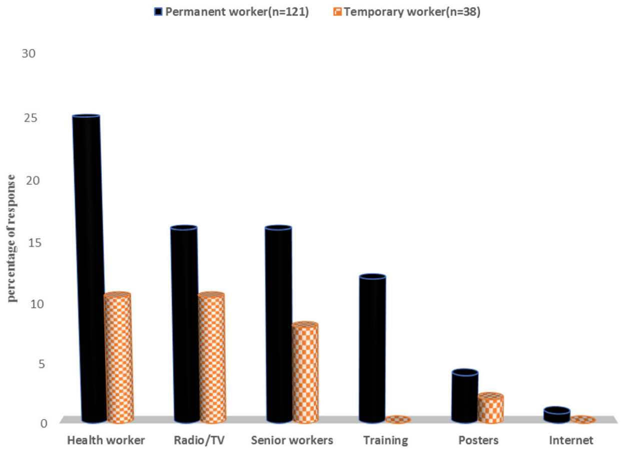

Fig. 3 Sources of information about occupational health among permanent and temporary particleboard workers in Ethiopia

(81%) workers reported they used at least one PPE during work irrespective of its quality. Among temporary workers, only 3 (7.9%) reported that the factory management provides PPE, while the remaining 35 (92.1%) did not get PPE from the factory. They reported using other options like buying from the market. Seven (18.4%) temporary workers reported using at least one type of PPE during work irrespective of its quality. Neither permanent nor temporary workers were using the full set of PPE during work. The practice of PPE use during work among permanent workers was significantly higher than among temporary workers (81% vs 18.4%) ($p < 0.001$).

To use PPE, permanent workers were motivated by supervisor 58 (54%), by safety personnel 12 (11%), by colleagues 8 (7.4%), self-motivation 76 (70%) and health professionals 2 (1.8%). The reasons for not using any type of PPE were reported to be lack of access (59%), lack of knowledge of its importance (33%), not comfortable (3.9%), not useful (1.9%), and 1.9% said that PPE was easily damaged.

During the workplace visit we observed that the PPE used did not have any specification like production date, intended use and protection level. This makes it difficult to evaluate the quality of the PPE. There was also a common understanding among the workers that the available face mask has no protective value.

The visiting health institution for medical check-up was reported by 25% of the permanent workers and 37% of the temporary workers, which was not statistically different. Attending some safety training about occupational hazards was reported by 10 and 0% of the permanent and temporary workers respectively. However, both permanent and temporary workers reported that there was no scheduled or regular training about occupational hazards in the factories.

Information from administrative personnel

The information collected from 13 administrative personnel was obtained from persons with different positions (general manager, deputy manager, production manager, technique manager, quality control, safety coordinator, logistic and supply and health professional). All stated dust and formaldehyde as chemical hazards found in the factory. They also mentioned that the availability of safety guidelines, good lighting, good ventilation and good communication between workers and the

Table 3 Association between the knowledge score, employment, sex, age and education among particleboard workers in Ethiopia

Variable	Univariate analysis		Multivariate analysis	
	β	*p* value	β	*p* value
Intercept			−1.5	0.07
Employment (0 = Temporary 1 = Permanent)	2.4	< 0.001	1.7	0.011*
Sex (0 = Male 1 = Female)	−0.98	0.203		
Age (0 = 19–27 1 = 28–50)	0.4	0.307		
Education (0 = grade 1–10, 1 = Vocational and above)	2.1	< 0.001	0.96	0.112

Table 4 Attitudes of particleboard workers about overall workplace hazards and safety in Ethiopia

Variable	Total n (%)	Employment status (n = 159)		p value
		Permanent (n = 121) n (%)	Temporary (n = 38) n (%)	
Workplace is hazardous to health	132(83)	100(83)	32(84)	1
I should use PPE during work	155(98)	120(99)	35(92)	0.06
Employer has responsibility to reduce exposure of hazards	143(90)	109(90)	34(90)	1
All PPE has same level of protection	77(48)	46(38)	31(82)	< 0.001
I should follow workplace safety rule	143(90)	118(98)	25(66)	< 0.001
PPE is relevant in workplace	153(96)	119(98)	34(90)	0.04
Employer should supply PPE	153(96)	118(98)	35(92)	0.296
I should always use PPE	148(93)	112(93)	36(95)	0.925
Safety training is relevant	137(86)	113(93)	24(63)	< 0.001
Safety professionals are relevant	150(94)	118(98)	32(84)	0.007
Feel satisfied with my work	117(74)	96(79)	21(55)	0.006

employer reduces exposure to chemical hazards. Seven responded that job rotation reduces exposure to chemical hazards. All said that PPE is given to every worker, but the schedule they reported varied, also within the factories. Six respondents thought that all PPE has the same level of protection, and that the factory simply purchases PPE that is available in the market without any quality consideration. Six respondents stated that new PPE is given immediately to the worker when they lose or damage it. The administrative personnel stated that there is regular supervision to obtain safe working practices in the factory. They also mentioned that the safety committee assures the supply of PPE and creates awareness among workers. Ten individuals stated that safety training is given to workers. However, the response on the frequency of the training varies.

Discussion

Permanent workers have more knowledge about chemical and other occupational hazards than temporary workers in particleboard factories. Of the total workers, 82% know some type of chemical hazards. The permanent workers were more interested in controlling exposures from hazardous chemicals than the temporary workers. Almost all permanent workers and few temporary workers used at least one PPE during work. However, the quality of the PPE was questionable and only few temporary workers reported that PPE was provided by the factory.

In this study, permanent workers had more knowledge about chemicals and other hazards than temporary workers. This might be because temporary workers start their jobs as helpers i.e. assisting permanently hired workers without prior training on occupational health and safety. For example, helpers in the chemical section assist the chemist in handling bags, cleaning the machines and controlling filters, pumps, hoses and blenders. They also check the glue kitchen and report when there is anything out of control. Our finding is in line with a descriptive study done in Nigeria among 200 textile workers which shows that permanent employment was a determinant for knowledge about workplace hazards [44]. Several studies on the association between injuries and employment status have shown that the risk of injuries among temporary workers is higher compared to that among permanent workers [38–42]. High risk of injuries among temporary workers might indicate the workers have less knowledge about different occupational hazards and the employer has given them less attention. In our study 82% of the total workers knew some types of chemical hazard. This is in line with a study done in Nigeria among 200 dye workers, which indicated that 74% had knowledge about workplace hazards [44]. This Nigerian study also indicated that

Table 5 Schedule for provision of personal protective equipment as reported by the permanent particleboard workers (n = 121)

Type of PPE	Frequency of distribution(n = 121)				
	I do not know	Annually	Semi-annually	Quarterly	Monthly
Safety glass	37	22	30	30	2
Face mask	32	22	30	35	2
Gloves	58	20	25	16	2
Coverall	11	26	79	5	–

permanent employment was a determinant for knowledge of workplace hazards when adjusted for education [44], mirroring a finding in our present study.

High educational status was associated with a high knowledge score. This finding is also in line with a cross-sectional study done in Nigeria on 290 health care workers showing that the level of education is related to knowledge about workplace hazards [36]. A study done in Colombia also supports these finding as it indicates that level of education was a determinant for knowledge of dengue disease and its transmission [29].

The temporary workers did not show the same attitude to reducing chemical hazards in the factory as the permanent workers. The finding is in line with a study in Nigeria showing that permanent employment was a determinant for attitude of workers towards workplace hazards [44]. In our study, the majority of the workers' attitudes about the means and how to behave to reduce chemical hazards was high (74% and above) and this finding is also in agreement with a study done in Nigeria, which indicates that 81% had a positive attitude about the workplace hazards and their control measures [44].

In our study 66% of the workers used at least one type of PPE during work. However, to protect from the workplace hazards, the workers need to wear a complete set of PPE. There was a common understanding among the workers that the available PPE, mainly face mask, did not have any protective value. On top of this, temporary workers were not getting a PPE supply. This perception of lacking supply of PPE probably has its own negative effect on the practice of using PPE during work. These findings are in line with a study done in India and Ethiopia showing that non-use/use of safety material was due to unavailability/availability [28, 30]. The quality of the PPE was another bottleneck problem for utilization. The respondents who have access to that PPE reported that the PPE was easily damaged and out of use within a short period of time. Due to this they don't believe it protects from exposure. This perception is similar to the perception of the workers in Nigeria, which indicates that workers think the PPE is useless in terms of hazard protection [33]. Our finding is also in agreement with different studies demonstrating workers' lower practice of PPE due to low access and unsuitability in different work settings [31, 32, 34]. However, a study done in Ethiopia among textile workers showed better frequency of PPE use, which is contrary to our finding. The reasons mentioned for better frequency in that study were: difference in workplace conditions, different level of awareness, difference in data collection tool and availability of PPE [28].

Permanent workers have better practice than temporary workers. This finding is in line with the results from a cross-sectional study among 560 Ethiopian textile workers regarding knowledge and safety [35]. In our study only 10% of the permanent workers and none of the temporary workers attended safety training, which might affect PPE use [27, 35]. Although many of the workers (87%) know some chemical hazards, their practice was poor due to the negative attitude about the existing PPE in terms of hazard protection. This finding is in line with a cross-sectional study in India among 216 garment workers indicating a wide gap between their knowledge and practice of use of PPE during work [31].

Permanent workers' response on the schedule of different PPE was inconsistent and differed from the responses obtained from administrative personnel in the same factories. Some of the respondents even did not know the schedule of PPE supply. This might indicate irregularities in the supply of PPE. On top of this, PPE such as face masks were not marked with quality information and with such lacking information it was difficult to evaluate its actual quality. In our study, 56% of the workers were vocationally trained which is different from other studies, where the educational status of the workers was either primary [28] or secondary [35].

Information collected from the administrative personnel indicated that they were aware of the existence of different hazards like dust and formaldehyde. However, there were no safety personnel that could monitor and assure safety practice in the factories. This has an impact on the technical requirements to consider when ordering PPE. The administrative workers in charge of supplying logistics and equipment to the factory workers also purchase safety materials, however without the competence needed to order PPE according to the required quality. Most of the administrative personnel believed that all PPE has the same level of protection.

Findings of this study can inform the employers to give equal attention both for permanent and temporary workers' safety and health protection. Employers may undertake such strategies as eliminating or minimizing chemical exposures in the physical work environment through engineering controls or redesigning production processes. Furthermore, providing safety and health training (both pre-employment and periodic) and instituting other necessary administrative controls (e.g. job rotation, facilities for meals and rest breaks) could help in reducing chemical exposures. Although the last resort in the hierarchy of controls, provision of adequate PPE is necessary to protect workers. The study findings might also help policy makers to expand the KAP knowledge and promote the safety and health of workers in the wood industry. For future research, an exposure assessment intervention study could be considered.

A strength of the study is the high response rate. The limitations of the cross-sectional study design will presumably not affect the reliability of the data collected because the information has no health variable and does not study any causal relationship between exposure and health. However, it could clearly have been an advantage to obtain information more than only once. The questionnaire was developed by reviewing KAP articles [26, 35, 43] and a pre-test was done before data collection. This may increase the validity of the study. Qualitative information and self-reports collected from both production workers and management personnel might expand the KAP, both from the worker and management perspective. However, the workplace assessment could have been improved by systematically collected objective data on for instance the use of PPE. This is an option for future studies. Although the data collection was performed one by one in a place without others listening, there might be still a response bias. Study participants can either disclose or hide the information. This study was targeted on large wood manufacturing industries. It might be difficult to generalize the results for small scale, medium scale and less formal wood manufacturing industry, for which the situation could be different.

Conclusion

This study shows that most workers know about chemical hazards, associated health effects, and preventive measure to reduce chemical exposures. Permanent workers reported more safety-conscious responses to attitude-related questions. Use of PPE was higher among permanent workers; however, temporary workers were not always provided with PPE. Both permanent and temporary workers should be equally privileged in all the safety and health services delivered by the workplace. A systematic qualitative study is needed for future work. This could be combined with an exposure assessment intervention study.

Additional file

Additional file 1: English-language data collection tool. The full data collection questionnaire for this paper is added as a supplementary file. (DOC 120 kb)

Abbreviations

CI: Confidence Interval; IRB: Institutional Review Board; KAP: Knowledge Attitude and Practice; M/F: Male/Female; N/Y: No/Yes; PPE: Personal Protective Equipment; *SD*: Standard deviation; US: United States

Acknowledgements

We would like to acknowledge the Norwegian Educational Loan Fund (Lånekassen) and NORHED Project for financial support. We also extend our appreciation to the factory management and workers for their cooperation during the study.

Funding

Funding for this research was from Norwegian Educational Loan Fund (Lånekassen), and NORHED Project cooperation between University of Bergen (Norway), Addis Ababa University (Ethiopia) and Muhimbili University of Health and Allied Sciences (Tanzania). The funding bodies have no role in in the design of the study, collection, analysis, and interpretation of data and in writing the manuscript.

Availability of data materials

The dataset used during the current study is available from the corresponding author on reasonable request.

Authors contribution

AAA initiated and designed the study, collected, analysed the data and drafted the manuscript. MB initiated and designed the study, analysed data and drafted the manuscript. BEM initiated and designed the study, analysed data and drafted the manuscript. All authors have read and approved the manuscript.

Ethics approval and consent to participate

The study protocol was reviewed and approved by the Regional Committee for Medical and Health Research Ethics, Western Norway and from the Ethiopian Ministry of Science and Technology. Study participants were informed about the purpose of the study, confidentiality of their information, duration of the interview and the possibility to withdraw from the interview at any time. Written consent was assured before data collection. The confidentiality of every person's information was secured as the questionnaires were assigned a number, not the name of the respondent. The questionnaires were locked down in a safe place that was accessible only to the researcher.

Consent for publication

Not applicable.

Competing interests

The authors declare they have no competing interests.

Publisher's Note

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Received: 25 July 2018 Accepted: 12 April 2019
Published online: 27 April 2019

References

1. Maichew Particleboard Manufacturing PLC [http://www.2merkato.com/directory/17560-maichew-particleboard-manufacturing-plc].
2. Environmental protection authority: particle board manufacturing in: Wood Products Industry,. USA; 2002: 29.
3. Central Statistical Agency: Key findings on the 2013 national labour force survey. In. Addis Ababa; 2013.
4. Gioffre A, Marramao A, Ianno A. Airborne microorganisms, endotoxin, and dust concentration in wood factories in Italy. The Annals of occupational hygiene. 2012;56(2):161–9.
5. Magagnotti N, Nannicini C, Sciarra G, Spinelli R, Volpi D. Determining the exposure of chipper operators to inhalable wood dust. The Annals of occupational hygiene. 2013;57(6):784–92.
6. Rongo LM, Msamanga GI, Burstyn I, Barten F, Dolmans WM, Heederik D. Exposure to wood dust and endotoxin in small-scale wood industries in Tanzania. J Expo Anal Environ Epidemiol. 2004;14(7):544–50.
7. Sriproed S, Osiri P, Sujirarat D, Chantanakul S, Harncharoen K, Ong-artborirak P, Woskie SR. Respiratory effects among Rubberwood furniture factory Workers in Thailand. Archives of Environmental & Occupational Health. 2013;68(2):87–94.

8. Schlunssen V, Jacobsen G, Erlandsen M, Mikkelsen AB, Schaumburg I, Sigsgaard T. Determinants of wood dust exposure in the Danish furniture industry--results from two cross-sectional studies 6 years apart. The Annals of occupational hygiene. 2008;52(4):227–38.
9. Scarselli A, Binazzi A, Ferrante P, Marinaccio A. Occupational exposure levels to wood dust in Italy, 1996-2006. Occup Environ Med. 2008;65(8):567–74.
10. Rongo LM, Besselink A, Douwes J, Barten F, Msamanga GI, Dolmans WM, Demers PA, Heederik D. Respiratory symptoms and dust exposure among male workers in small-scale wood industries in Tanzania. J Occup Environ Med. 2002;44(12):1153–60.
11. Ayalew E, Gebre Y, De Wael K. A survey of occupational exposure to inhalable wood dust among workers in small- and medium-scale wood-processing enterprises in Ethiopia. The Annals of occupational hygiene. 2015;59(2):253–7.
12. Jafari MJ, Rahimi A, Omidi L, Behzadi MH, Rajabi MH. Occupational exposure and health impairments of formaldehyde on employees of a wood industry. Health Promotion Perspectives. 2015;5(4):296–303.
13. Mäkinen M, Kalliokoski P, Kangas J. Assessment of total exposure to phenol-formaldehyde resin glue in plywood manufacturing. Int Arch Occup Environ Health. 1999;72(5):309–14.
14. Malaka T, Kodama AM. Respiratory health of plywood workers occupationally exposed to formaldehyde. Arch Environ Health. 1990;45(5): 288–94.
15. Osman E, Pala K. Occupational exposure to wood dust and health effects on the respiratory system in a minor industrial estate in Bursa, Turkey. Int J Occup Med Environ Health. 2009;22(1):43–50.
16. Sripaiboonkij P, Phanprasit W, Jaakkola MS. Respiratory and skin effects of exposure to wood dust from the rubber tree Hevea brasiliensis. Occup Environ Med. 2009;66(7):442–7.
17. Bislimovska D, Petrovska S, Minov J. Respiratory symptoms and lung function in never-smoking male workers exposed to hardwood dust. Open access Macedonian journal of medical sciences. 2015;3(3):500–5.
18. Lofstedt H, Hagstrom K, Bryngelsson IL, Holmstrom M, Rask-Andersen A. Respiratory symptoms and lung function in relation to wood dust and monoterpene exposure in the wood pellet industry. Ups J Med Sci. 2017; 122(2):78–84.
19. Mathur N, Rastogi S. Respiratory effects due to occupational exposure to formaldehyde: systematic review with meta-analysis. Indian Journal of Occupational and Environmental Medicine. 2007;11(1):26–31.
20. International Agency for Research on Cancer. Arsenic, metals, Fibres, and dusts: a review of human carcinogens. In., vol. 100 C. France: Lyon; 2012. p. 527.
21. International Agency for Research on Cancer. Chemical agents and related occupations: a review of human carcinogens. In., vol. 100 F. France: Lyon; 2012. p. 628.
22. Hazard Prevention and Control [https://www.osha.gov/shpguidelines/hazard-prevention.html].
23. Health and Safety Executive: Wood dust. In. United Kingdom: HSE.
24. Goverment of Western Australia Department of Commerce: 2015. In.; controlling wood dust hazards at work.
25. Badran IG. Knowledge, attitude and practice the three pillars of excellence and wisdom: a place in the medical profession. East Mediterr Health J. 1995;1(1):8.
26. Geer LA, Curbow BA, Anna DH, Lees PS, Buckley TJ. Development of a questionnaire to assess worker knowledge, attitudes and perceptions underlying dermal exposure. Scand J Work Environ Health. 2006;32(3): 209–18.
27. Lombardi DA, Verma SK, Brennan MJ, Perry MJ. Factors influencing worker use of personal protective eyewear. Accid Anal Prev. 2009;41(4):755–62.
28. Tadesse S, Kelaye T, Assefa Y. Utilization of personal protective equipment and associated factors among textile factory workers at Hawassa town, southern Ethiopia. Journal of occupational medicine and toxicology (London, England). 2016;11:6.
29. Diaz-Quijano FA, Martinez-Vega RA, Rodriguez-Morales AJ, Rojas-Calero RA, Luna-Gonzalez ML, Diaz-Quijano RG. Association between the level of education and knowledge, attitudes and practices regarding dengue in the Caribbean region of Colombia. BMC Public Health. 2018;18(1):143.
30. Haldiya KR, Sachdev R, Mathur ML, Saiyed HN. Knowledge, attitude and practices related to occupational health problems among salt workers working in the desert of Rajasthan, India. J Occup Health. 2005;47(1):85–8.
31. Parimalam P, Kamalamma N, Ganguli AK. Knowledge, attitude and practices related to occupational health problems among garment workers in Tamil Nadu, India. J Occup Health. 2007;49(6):528–34.
32. Paramasivam P, Raghavan PM, Srinivasan PD, Kumar GA. Knowledge, attitude, and practice of dyeing and printing workers. Indian Journal of Community Medicine : Official Publication of Indian Association of Preventive & Social Medicine. 2010;35(4):498–501.
33. Kalu OOJEE, Hosea PO. Utilization of personal protective Equipments (PPEs) among wood factory Workers in Calabar Municipality. S Nige Int J. Sci Res. 2013.
34. Negatu B, Kromhout H, Mekonnen Y, Vermeulen R. Use of chemical pesticides in Ethiopia: a cross-sectional comparative study on knowledge, attitude and practice of farmers and farm Workers in Three Farming Systems. The Annals of occupational hygiene. 2016;60(5):551–66.
35. Tetemke DAK, Tefera Y, Sharma HR, Worku W. Knowledge and practices regarding safety information among textile workers in Adwa town, Ethiopia. Sci Postprint. 2014;1(1):5.
36. Aluko OO, Adebayo AE, Adebisi TF, Ewegbemi MK, Abidoye AT, Popoola BF. Knowledge, attitudes and perceptions of occupational hazards and safety practices in Nigerian healthcare workers. BMC Research Notes. 2016;9:71.
37. Kumie A, Amera T, Berhane K, Samet J, Hundal N. G/Michael F, Gilliland F: occupational health and safety in Ethiopia: a review of situational analysis and needs assessment. Ethiop J Health Dev = Ya'Ityopya Tena Lemat Mashet. 2016;30(1 Spec Iss):17–27.
38. Foley M. Factors underlying observed injury rate differences between temporary workers and permanent peers. Am J Ind Med. 2017;60(10):841–51.
39. Benavides FG, Benach J, Muntaner C, Delclos GL, Catot N, Amable M. Associations between temporary employment and occupational injury: what are the mechanisms? Occup Environ Med. 2006;63(6):416–21.
40. Waenerlund AK, Virtanen P, Hammarstrom A. Is temporary employment related to health status? Analysis of the northern Swedish cohort. Scandinavian journal of public health. 2011;39(5):533–9.
41. Saha A, Ramnath T, Chaudhuri RN, Saiyed HN. An accident-risk assessment study of temporary piece rated workers. Ind Health. 2004;42(2):240–5.
42. Roquelaure Y, LeManach AP, Ha C, Poisnel C, Bodin J, Descatha A, Imbernon E. Working in temporary employment and exposure to musculoskeletal constraints. Occup Med. 2012;62(7):514–8.
43. Langkulsen U, Vichit-Vadakan N, Taptagaporn S. Safety and health in the petrochemical industry in Map Ta Phut, Thailand. J Occup Health. 2011; 53(5):384–92.
44. Okafoagu NC, Oche M, Awosan KJ, Abdulmulmuni HB, Gana GJ, Ango JT, Raji I. Determinants of knowledge and safety practices of occupational hazards of textile dye Workers in Sokoto, Nigeria: a descriptive analytic study. J Public Health in Africa. 2017;8(1):664.

International Journal of
Environmental Research and Public Health

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Article

High Prevalence of Respiratory Symptoms among Particleboard Workers in Ethiopia: A Cross-Sectional Study

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Received: 31 May 2019; Accepted: 16 June 2019; Published: 18 June 2019

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Abstract: Work in the wood industry might be associated with respiratory health problems. The production of particleboard used for furniture making and construction is increasing in many countries, and cause dust, endotoxin and formaldehyde exposure of the workers. The aim of the study was to assess the prevalence of respiratory symptoms and to measure lung function among Ethiopian particleboard workers using Eucalyptus trees as the raw material. In total 147 workers, 74 from particleboard production and 73 controls, participated in the study. Mean wood dust in the particleboard factories was measured to be above recommended limit values. Particleboard workers had a mean age of 28 years and the controls were 25 years. They had been working for 4 and 2 years, respectively. Lung function test was done using spirometry following American Thoracic Society (ATS) recommendations. Respiratory symptoms were collected using a standard questionnaire of ATS. Particleboard workers had higher prevalence of wheezing, cough, cough with sputum production, phlegm, and shortness of breath compared to controls. Lung function status was similar in the two groups. The symptoms might be related to the work in the factories. Longitudinal studies are recommended to explore the chronic impact of work in particleboard factories on respiratory health.

Keywords: Ethiopia; lung function; particleboard factory workers; respiratory symptoms

1. Introduction

Wood dust is a complex substance and one of the hazards generated from processing of various wood types for a wide range of applications [1,2]. Workers exposed to wood dust may develop different respiratory health problems [3,4] including reduced lung function [5–7]. An endotoxin component in the cell walls of gram-negative bacteria [8,9] might be present as a part of organic dust and may induce inflammatory responses in the airways [8,10,11]. In addition, formaldehyde that is added to the urea resin for gluing of wood products is associated with respiratory health problems [12,13] and decrements in lung function [14]. A range of biologically active compounds like quinones, terpenes, stilbenes, phenols, tannins, and flavonoids might also be released during wood processing [2].

In Ethiopia the manufacturing sector, comprising wood, metal, food, textile, leather and construction industries, accounts for 6.9% of the national work force [15]. Eucalyptus, an evergreen hardwood tree, is the main raw material for production of particleboard in Ethiopia [16] and is used for furniture like office tables and shelves, for interior wall partitioning [17,18] and construction [17,19]. The Eucalyptus tree is cheap, locally available, has rapid growth, and is adaptable to a range of climates and soil types. This makes it a promising source of inputs as the native wood species are diminishing due to deforestation. Despite the increasing production of furniture in Ethiopia [16] little is known about safety measures and occupational health in these workplaces [20]. In previous studies from the wood industry including particleboard production, the workers have been exposed to other types of trees [6,21]. More knowledge on the respiratory health of the particleboard workers exposed to dust from the Eucalyptus tree is needed to evaluate the need of occupational preventive measures in Ethiopia and other developing countries.

The international literature about the prevalence of respiratory health symptoms among wood workers varies greatly. For example, the prevalence of respiratory symptoms reported in Thailand and Iran varies from 15.5% to 41% [3,7]. Decrement in lung function among wood workers is reported in studies done in Thailand, Pakistan, Iran and Sweden [3,6,7,21,22], while other studies done in Poland and Denmark do not show any effect on lung function [23,24]. Thus, the international literature is not conclusive regarding the respiratory health for wood workers, and a study among particleboard workers using Eucalyptus trees as raw materials in Ethiopia is needed.

The aim of this study was to assess the prevalence of respiratory symptoms and to measure lung function among particleboard factory workers of Ethiopia and compare the findings with a control group from water bottling factories with low exposure to dust. The findings might help to fill the research gaps on respiratory health among particleboard workers which can be applied to prevent respiratory disease at these workplaces.

2. Materials and Methods

2.1. Study Design and Period

A cross-sectional study was performed to assess respiratory symptoms and to measure lung function among workers from two of the largest particleboard factories in Ethiopia which use Eucalyptus trees as raw material. One of the factories was established in 2005, is situated in northern Ethiopia and has 663 workers. The other factory was established in 2002 and is located in southern Ethiopia and has 249 workers. The particleboard factories are found in urban areas and selected both from North and South. A control group was established of workers employed in a water bottling factory, with a total of 339 workers from northern Ethiopia. The controls were selected from a factory considered to have low dust concentration in the work environment. The study period of this paper was from May 2017 to August 2017.

2.2. Exposure Measurements

Personal inhalable dust was sampled in the breathing zone of the workers using a conductive plastic inhalable conical sampler (CIS, JS Holdings, Stevenage, UK) [25] mounted with a 37 mm glass-fiber (GFA) filter (Whatman International Ltd, Maidstone, UK) using an air flow of 3.5 L/min Side Kick Casella (SKC) pump for 2 to 4 hours sampling duration per shift. In total, 76 workers in particleboard production were selected for repeated sampling of inhalable dust (n = 152). From the control group, i.e., the water bottling factory, 8 repeated samples were taken (n= 16). Inhalable dust was analyzed using gravimetric method in a room with controlled climatic conditions (22 °C, 45% relative humidity; desiccation ≥24 h) with an analytical balance with 0.1 µg readability (Mettler-Toledo Ltd, Greifensee, Switzerland) and the concentration was estimated in mg/m^3. Endotoxin was analyzed using the Kinetic Amoebocyte Lysate test (Kinetic-QCL endotoxin kit, BioWhittaker, Walkersville, MA, USA) and the concentration was estimated in EU/m^3.

The geometric mean, arithmetic mean and range of inhalable dust for particleboard workers was 4.66 mg/m^3, 9.17 mg/m^3, and 0.47–184 mg/m^3, respectively. For the control group the figures were 0.21 mg/m^3, 0.24 mg/m^3, and 0.02–0.4 mg/m^3, respectively.

The geometric mean, arithmetic mean and range of endotoxin for particleboard workers was 62.2 EU/m^3, 245.6 EU/m^3, and 0.9–9202.2 EU/m^3, respectively; while for the control group it was 0.66 mg/m^3, 0.75 EU/m^3, and 0.3–2.3 EU/m^3, respectively. The concentration of formaldehyde measured with Dräger-Tubes by color tubes in the particleboard factories using "worst-case" sampling strategy ranged from <0.2 ppm to 5 ppm.

2.3. Study Population and Sample Size

The required number of participants for this study was calculated using OpenEpi software (http://www.openepi.com/SampleSize/SSMean.htm) sample mean difference by taking into consideration forced expiratory volume in one second (FEV_1) as main output of interest with 95% power, 95% confidence interval and 5% level of significance. The FEV_1 for exposed (3.77 L/s, SD = 0.99) and control group (4.29 L/s, SD = 0.86) was taken from a previously study done among particleboard workers in Ethiopia [26]. The estimated number of participants needed was 166 workers (83 from exposed and 83 from control groups).

2.4. Data Collection

To plan the study, the factories and their leadership were visited. After obtaining permission to perform the study, we asked the management to provide a list of workers in each work shift during the first phase of data collection as stated in a previously published paper [27] aimed to assess workers knowledge, attitude and practice regarding chemical hazards and personal protective equipment. Before the actual data collection, randomly selected participants were informed about the objective of the study, its relevance, and how to perform the interview and lung function measurements and asked for written consent to participate in the study.

2.4.1. Respiratory Symptom Assessment

The interview of respiratory symptom assessment was done in a quiet and private place by six trained bachelor environmental health professionals.

Information on respiratory symptoms was collected using a validated standard questionnaire from the American Thoracic Society (ATS) [28]. The information collected were data on sex (M/F), age (years), education (highest grade completed), uses biomass fuel as sources of energy at home(Y/N), availability of separate kitchen (Y/N), number of service years in the present industry, occupational history in dusty working environment, and smoking (Y/N). The workers were also asked about their history of past respiratory illness (Y/N). If they had experienced any diseases, they were asked to tell what type it had been.

Questions about respiratory symptoms were asked like this; whether the workers in the last 12 months have/had: cough (Y/N), cough with sputum production (Y/N), phlegm (Y/N), episode of cough and phlegm (Y/N), wheezing (Y/N), shortness of breath (Y/N). The interviewed participants were also observed if they were using personal protective equipment (PPE) mainly face mask during the study.

The interview was based on questions prepared in English and translated to Amharic by a translator, and then translated back from Amharic to English by another translator, to check the consistency. Pretesting of the questionnaire was done on 5% of the sample population in one of the factories before the main study. The data collection tool was modified to suite the Ethiopian context. Information such as marital status and race were excluded from the questionnaire. Additional information about the use of biomass fuel as source of energy for cooking, availability of separate kitchen at home were added to the data collection tool.

2.4.2. Lung Function Test

Prior to performing the lung function measurements, the participants ID, age, sex, standing height (m) and weight (kg) were measured as recommended by the American Thoracic Society [29], and combined with the interview described in 2.4.1. Lung function test was done in sitting position using Spirometry (Minispir light with Winspiro software, Medical International Research (MIR), Rome, Italy) connected to a Laptop following American Thoracic Society guidelines [29]. The spirometry measurements were performed prior to the morning shift that started at 6:00 a.m. The lung function measurements were done by the trained researcher until the trial generated three acceptable maneuvers. From the three records of lung function test, the best trial was kept and used for the data analysis. The lung function parameters considered were FVC, FEV_1, FEV_1/FVC ratio and $FEF_{25–75\%}$. The FEV_1/FVC ratio < 70% was the cutoff point for air flow limitations as stated by Global Initiative for Chronic Obstructive Lung Disease [30].

2.5. Data Management and Analysis

Collected data were checked for completeness and missing values at the end of each day of data collection. Data was exported from EpiData version 3.1 (EpiData Association, Odense, Denmark) to the statistical package SPSS, version 25 (International Business Machines Corporation (IBM), Armonk, NY, USA) for analysis. Lung function parameters were normally distributed. Descriptive statistics were used to summarize demographic and anthropometric data. Pearson chi-square or Fisher's exact tests (if the expected value was less than 5) were used to test for difference in categorical variables, while an Independent *t*-test was used to compare means of continuous variables between exposed and controls. Poisson regression analysis was used to determine the prevalence ratio of cough between particleboard workers and water bottling workers while adjusting for educational status, previous work in dusty environment, age and availability of separate kitchen. Prevalence ratio (PR) was chosen instead of prevalence odds ratio (POR) due to the high respiratory symptom prevalence in this study [31].

Multiple linear regression was applied to analyze differences in lung function between the particleboard workers and the controls while adjusting for age, height, previous respiratory illness, availability of separate kitchen and use of biomass fuel as source of energy.

2.6. Ethical Approval

Ethical clearance for the study was obtained from the Regional Committee for Medical and Health Research Ethics, Western Norway on June 2, 2016 with IRB ref: IRB00006245 and from the Ethiopian Ministry of Science and Technology on October 7, 2016 with Ref. No. 3.10/148/2016. Study participants were informed about the purpose of the study, confidentiality of their information, duration of the interview, lung function measurement procedure and the possibility to withdraw from the study at any time they wanted. Written consent both from each of the study participants and consent from factory management was assured before data collection.

The questionnaire and spirometry results were stored with only ID numbers of the participants, not their names. The data were locked in a safe place accessible only to the researcher to keep every person's information confidential.

3. Results

3.1. Characteristics of the Study Population

From 166 people who were invited, 157 workers (94.5%) (83 particleboard workers and 74 water bottling workers) participated in the study. The remaining 5.5% did not want to participate in the study. Among the 157 who participated, one person from the particleboard workers could not properly perform the lung function measurement and we therefore discarded his lung function data. The majority, 147 (93.6%), of the participants in the study were males and used in the final analysis. Due to their low number, the females (5.7%)—eight participants from exposed and one participant from the water bottling factory—were excluded from the further analyses since gender differences are recognized for respiratory symptoms as well as for lung function [32–34]. The exposed group was older than the controls (28 vs. 25 years; $p = 0.006$) and had more service years than the controls (4 vs. 2 years; $p < 0.001$). The exposed groups were also more educated than controls (Table 1) and had higher body weight (63 vs. 56 kg; $p < 0.001$). The exposed and the control groups had the same average height (1.70 m). All of the study participants were neither smokers nor using proper personal protective devices such as face masks that can protect them from dust and other chemical exposures.

Table 1. Demographic and anthropometric characteristics of 74 particleboard workers (Exposed) and 73 water bottling workers (Controls) in Ethiopia.

Variable		Exposed	Controls	*p*-Value
Continuous variables		AM (SD)	AM (SD)	
Age (years)		28 (7)	25 (7)	0.006 [a]
Service year (years)		4 (3)	2.2 (2)	<0.001 [a]
Height (m)		1.70 (0.05)	1.70 (0.05)	0.634 [a]
Weight (kg)		63 (10)	56 (6)	<0.001 [a]
Body Mass Index		21.8 (3.1)	19.4(1.9)	<0.001 [a]
Categorical variables		*N* (%)	*N* (%)	*p*-value
Education	Grade 1–10	17(23)	60 (82)	<0.001 [b]
	Vocationally trained and above	57(77)	13 (18)	
Availability of separate kitchen		47 (64)	28(38)	0.002 [b]
Uses biomass fuel for cooking		22 (30)	59 (81)	<0.001 [b]

AM: Arithmetic Mean; SD: Standard Deviation; [a] Independent *t*-test; [b] Pearson chi square; *N*: frequency of observations (counts).

The majority (64%) of the exposed group had separate kitchens and only 30% used biomass fuel for cooking.

Some respondents in the exposed group had a history of previous illness such as bronchitis ($n = 12$), asthma (7), pneumonia (3) and tuberculosis (3), but such illnesses were not reported in the control group. In total, 18 (24%) participants had previous disease, of which 4 had more than one diagnosis.

3.2. Respiratory Symptoms

The prevalence of all recorded respiratory symptoms was significantly higher among the exposed (range 24–45%) than the controls (2.7–15%) (Table 2). A separate analysis was performed, excluding the participants from the particleboard factories who had previous respiratory diseases ($n = 18$). The results were still the same, except for cough which did not show any significant difference between the groups when these 18 persons were excluded (result not shown).

The prevalence ratio of cough among the exposed group was 1.56 (95% CI; 0.61, 3.95) compared to the controls when adjusted for education status, previous work in dusty environment, past history of respiratory illness, age, use of biomass fuel for cooking and availability of separate kitchen.

Table 2. Prevalence of respiratory symptoms among 74 particleboard workers (Exposed) and 73 water bottling workers (Controls) in Ethiopia.

Variable	Exposed *N* (%)	Controls *N* (%)	*p*-Value
Cough	29 (39)	11 (15)	0.001 [a]
Cough with sputum production	23 (31)	4 (5.5)	<0.001 [b]
Phlegm	20 (27)	2 (2.7)	<0.001 [b]
Wheezing	33 (45)	2(2.7)	<0.001 [b]
Shortness of breath	18 (24)	2 (2.7)	<0.001 [b]

N: frequency of observations (counts); *n*: number of study participants; [a] Chi square test; [b] Fisher exact test.

3.3. Lung Function

Lung function (FEV_1/FVC) between the exposed group and the controls was significantly different ($p = 0.004$) when no adjustments were made (Table 3).

Table 3. A comparison of lung function status among particleboard workers (n = 74) and controls (n = 73) in Ethiopia, both using t-test and multivariate regression; adjusting for age, height, previous respiratory illness, availability of separate kitchen and use of biomass fuel as source of energy.

Lung Function Parameters	Exposed	Controls	p [a]	(Exposed vs. Controls) [b]	
				β (SE)	p
FVC – AM (SD)	4.96 (0.37)	4.93 (0.39)	0.608	0.02 (0.03)	0.453
FEV_1 – AM (SD)	4.10 (0.30)	4.12 (0.30)	0.743	0.012 (0.02)	0.519
$(FEV_1/FVC) \times 100$ – AM (SD)	82.36 (1.54)	83.14 (1.75)	0.004	−0.045 (0.11)	0.697
$FEF_{25–75\%}$ – AM (SD)	4.27 (0.37)	4.38 (0.35)	0.073	0.007 (0.02)	0.709

FVC: Forced Vital Capacity; FEV_1: Forced Expiratory Volume in one second; $FEF_{25–75\%}$: Forced Expiratory Flow 25–75%; AM: Arithmetic Mean; SD: Standard Deviation; [a] Independent t-test; β: unstandardized Beta; SE: standard error; [b] multivariate analysis.

However, in multiple regression models the difference in lung function between exposed and control groups was not significant when adjusting for age, height, previous respiratory illness, availability of separate kitchen and use of biomass fuel as source of energy (Table 3). All participants had FEV_1/FVC values > 70%, indicating that none of the workers had airflow limitation. The same result was obtained when 18 participants with previous respiratory diseases were excluded from the analysis, both for the crude comparison of the groups and the regression analysis (result not shown).

4. Discussion

Workers in the particleboard manufacturing factories in Ethiopia had significantly higher prevalence of respiratory symptoms compared to water bottling workers (controls). The lung function values were not significantly different between the two groups when adjusting for age, height, previous respiratory illness, availability of separate kitchen and use of biomass fuel as source of energy.

The present study showed a higher prevalence of cough among particleboard workers than the controls. This finding agrees with studies done among wood workers in Tanzania, Macedonia, Iran and Sweden [3,4,21,35]. The increased prevalence of phlegm and wheezing among particleboard workers in our study was also in compliance with the findings among parquet manufacturing workers in Macedonia and sawmill workers in Iran [3,4]. Furniture manufacturing workers in Thailand had an increased risk of wheezing and breathlessness compared to office workers [7,12] which is also consistent with our finding.

A high prevalence of past history of respiratory illness (24%) was reported among particleboard workers but not in controls. However, the causes of past respiratory illnesses were not investigated. It may emanate from wood working activities or other dusty environments as some of the particleboard workers had worked in other dusty environment than the controls but can also be due to other unknown reasons.

Lung function was not significantly different between the particleboard workers and the control group. Our finding agrees with findings in Iran and Pakistan [3,22] which showed an insignificant difference in lung function between exposed and control groups. In our finding, all workers had a FEV_1/FVC > 70%. This is similar with findings in Iran, Macedonia, Poland and Pakistan which showed that the mean FEV_1/FVC ratio was higher than 70% among the study participants [3–5,22,23]. However, the result of our study is in contrast with studies done among Danish furniture workers which shows a reduced lung function [24]. According to the recommendation of Global Initiative for Chronic Obstructive Lung Disease (GOLD) the ratio of FEV_1/FVC < 70% confirms the presence of persistent airflow limitation [30].

We also evaluated the $FEF_{25–75\%}$ values in this study, as low $FEF_{25–75\%}$ value might be associated with asthma [36]. The dust in the particleboard factory is made of organic particles as it comes from the Eucalyptus tree, and organic dust is known to cause asthmatic conditions [37]. However, the reason for the lack of reduced lung function variables in the particleboard factories in this study, might be that the workers had been working in the factories for very few years. The present study showed a high level of dust exposure. The geometric mean level of dust was 4.66 mg/m^3, which is higher than the recommended limit values for inhalable wood dust of 1 mg/m^3 [38]. Endotoxin was also documented in the particleboard factories, although the exposure levels were below the recommended health based standard of 90 EU/m^3 set by the Dutch experts [9]. Formaldehyde was also measured in the particleboard factories, with a wide range of exposure (<0.2–5 ppm). However, the exposure time of the workers in the particleboard factories might be too short for the development of chronic lung diseases detectable by spirometry. The average service time for dust and chemicals for these workers was short, only 4 years.

To our knowledge this is the first study done among workers manufacturing particleboard from Eucalyptus to assess the prevalence of respiratory symptoms and to measure lung function status. We selected a control group from a water bottling factory, not from the general population to reduce bias that can be attributed due to baseline characteristics such as socio-demographic and economic differences. Another strength of the study is the high response rate of the participants. Furthermore, multiple regression and poisson regression was applied to control for possible confounders for lung function and respiratory symptoms. The lung function measurements were done using calibrated and sensitive portable spirometry equipment following American Thoracic Society recommendation, which should increase the validity of these results. The data collection was performed addressing one-by-one workers in a place without others listening, to reduce any possible information bias. However, there might still be a bias present, as the workers in the particleboard factory may have reported more symptoms due to their wish for an improved work environment. The size of such a bias is unknown to us. Also, the workers may have caused a recall bias in the respiratory symptom assessment, as symptoms might not be easy to remember.

Our results were based on a cross sectional study and share the limitation of this study design. The study is not conclusive concerning any cause–effect relationship between inhalable wood dust, endotoxin and formaldehyde exposure in the particleboard factories and respiratory symptoms. Longitudinal studies are needed to confirm a possible relationship between these factors. There could also be other unknown predictors present, which are not addressed in the present study [39]. Also, the study might suffer from a healthy worker effect and young age of the workers which may affect the validity of the result regarding the lung function parameters. Studies where the workers have longer service time would be of interest.

The particleboard workers that did not use proper personal protective equipment (PPE) mainly face mask during work. The absence of proper PPE in this working environment with high dust exposure may cause respiratory health problems of the workers in the future. With the present knowledge about the high dust levels in these factories, respiratory health protection is recommended among the workers, to avoid the development of any adverse health effects due to the dust exposure.

The finding is limited to male particleboard workers due to the low number of female production workers. Therefore, the finding is valid only for male particleboard workers with similar work settings in developing countries.

5. Conclusions

Particleboard workers in Ethiopia, exposed to wood dust, endotoxin and formaldehyde, had higher prevalence of respiratory symptoms than the controls, i.e., water bottling workers. However, lung function did not appear to be different among particleboard workers and controls. A longitudinal study is recommended to explore the cumulative impact of dust, endotoxin and formaldehyde exposure on respiratory health of particleboard workers. However, we also recommend respiratory health protection of workers with high dust exposure levels, as this type of protection was not used in the factories.

Author Contributions: A.A.A. initiated and designed the study, collected, analyzed and interpreted the data, and drafted the manuscript. M.B. initiated and designed the study, analyzed and interpreted data, and drafted the manuscript. B.E.M. initiated and designed the study, analyzed and interpreted data, and drafted the manuscript. All authors have read and approved the final manuscript.

Funding: This research was funded by Norwegian Educational Loan Fund (Lånekassen), and NORHED Project a cooperation between the University of Bergen (Norway), Addis Ababa University (Ethiopia) and Muhimbili University of Health and Allied Sciences (Tanzania).

Acknowledgments: We would like to acknowledge the Norwegian Educational Loan Fund (Lånekassen) and NORHED Project for financial support. We also extend our appreciation to the factory management and all production workers for their cooperation during the study. We would like to express our sincere gratitude to Lemlem Karl Hospital for allowing us to use their portable digital weight measuring equipment during data collection.

Conflicts of Interest: The authors declare they have no competing interests.

References

1. The National Institute of Occupational Health and Safety. Wood Dust. Available online: http://www.cdc.gov/niosh/pel88/wooddust.html (accessed on 1 December 2018).
2. International Agency for Research on Cancer. *Arsenic, Metals, Fibres, and Dusts: A Review of Human Carcinogens*; IARC: Lyon, France, 2012; p. 527.
3. Neghab, M.; Jabari, Z.; Kargar Shouroki, F. Functional disorders of the lung and symptoms of respiratory disease associated with occupational inhalation exposure to wood dust in Iran. *Epidemiol. Health* **2018**, *40*, e2018031. [CrossRef] [PubMed]
4. Bislimovska, D.; Petrovska, S.; Minov, J. Respiratory symptoms and lung function in never-smoking male workers exposed to hardwood dust. *Open Access Maced. J. Med Sci.* **2015**, *3*, 500–505. [CrossRef] [PubMed]
5. Badirdast, P.; Rezazadeh Azari, M.; Salehpour, S.; Ghadjari, A.; Khodakarim, S.; Panahi, D.; Fadaei, M.; Rahimi, A. The effect of wood aerosols and bioaerosols on the respiratory systems of wood manufacturing industry workers in Golestan Province. *Tanaffos* **2017**, *16*, 53–59. [PubMed]
6. Thetkathuek, A.; Yingratanasuk, T.; Demers, P.A.; Thepaksorn, P.; Saowakhontha, S.; Keifer, M.C. Rubberwood dust and lung function among Thai furniture factory workers. *Int. J. Occup. Environ. Health* **2010**, *16*, 69–74. [CrossRef] [PubMed]
7. Sripaiboonkij, P.; Phanprasit, W.; Jaakkola, M.S. Respiratory and skin effects of exposure to wood dust from the rubber tree Hevea brasiliensis. *Occup. Environ. Med.* **2009**, *66*, 442–447. [CrossRef] [PubMed]
8. Liebers, V.; Raulf-Heimsoth, M.; Brüning, T. Health effects due to endotoxin inhalation (review). *Arch. Toxicol.* **2008**, *82*, 203–210. [CrossRef] [PubMed]
9. Dutch Expert Committee on Occupational Safety. *Endotoxins: Health-Based Recommended Occupational Exposure Limit*; Health Council of the Netherlands: The Hague, The Netherlands, 2010; 100p.
10. Ljubičić Ćalušić, A.; Varnai, V.M.; Čavlović, A.O.; Šegvić Klarić, M.; Beljo, R.; Prester, L.; Macan, J. Respiratory health and breath condensate acidity in sawmill workers. *Int. Arch. Occup. Environ. Health* **2013**, *86*, 815–825. [CrossRef]
11. Farokhi, A.; Heederik, D.; Smit, L.A.M. Respiratory health effects of exposure to low levels of airborne endotoxin—A systematic review. *Environ. Health* **2018**, *17*, 14. [CrossRef]
12. Thetkathuek, A.; Yingratanasuk, T.; Ekburanawat, W. Respiratory symptoms due to occupational exposure to formaldehyde and MDF dust in a MDF furniture factory in Eastern Thailand. *Adv. Prev. Med.* **2016**, *2016*, 11. [CrossRef]
13. Mathur, N.; Rastogi, S.K. Respiratory effects due to occupational exposure to formaldehyde: Systematic review with meta-analysis. *Indian J. Occup. Env. Med.* **2007**, *11*, 26–31. [CrossRef]
14. Malaka, T.; Kodama, A.M. Respiratory health of plywood workers occupationally exposed to formaldehyde. *Arch. Environ. Health* **1990**, *45*, 288–294. [CrossRef] [PubMed]
15. Central Statistical Agency. *Key Findings on the 2013 National Labour Force Survey*; The Federal Democratic Republic of Ethiopia Central Statistical Agency: Addis Ababa, Ethiopia, 2013.
16. Forum for Environment. *Ethiopian Environment Review*; Forum for Environment: Addis Ababa, Ethiopia, 2010; p. 227.

17. 2Merkato.com. Maichew Particleboard Manufacturing PLC. Available online: http://www.2merkato.com/directory/17560-maichew-particleboard-manufacturing-plc (accessed on 22 February 2016).
18. Environmental Protection Agency. Particleboard manufacturing. In *Wood Products Industry*; Environmental Protection Agency: Washington, DC, USA, 2002; p. 29.
19. MIDROCK Ethiopia. *Awassa Chipwood Plant Project*; MIDROCK Ethiopia: Addis Ababa, Ethiopia, 2009.
20. Kumie, A.; Amera, T.; Berhane, K.; Samet, J.; Hundal, N.; G/Michael, F.; Gilliland, F. Occupational health and safety in Ethiopia: A review of situational analysis and needs assessment. *Ethiop. J. Health Dev. Ya'ityopya Tena Lemat Mashet* **2016**, *30*, 17–27.
21. Lofstedt, H.; Hagstrom, K.; Bryngelsson, I.L.; Holmstrom, M.; Rask-Andersen, A. Respiratory symptoms and lung function in relation to wood dust and monoterpene exposure in the wood pellet industry. *Upps. J. Med. Sci.* **2017**, *122*, 78–84. [CrossRef] [PubMed]
22. Meo, S.A. Lung function in Pakistani wood workers. *Int. J. Environ. Health Res.* **2006**, *16*, 193–203. [CrossRef] [PubMed]
23. Baran, S.; Swietlik, K.; Teul, I. Lung function: Occupational exposure to wood dust. *Eur. J. Med. Res.* **2009**, *14* (Suppl. 4), 14–17.
24. Jacobsen, G.H.; Schlunssen, V.; Schaumburg, I.; Sigsgaard, T. Cross-shift and longitudinal changes in FEV1 among wood dust exposed workers. *Occup. Environ. Med.* **2013**, *70*, 22–28. [CrossRef] [PubMed]
25. Tatum, V.L.; Ray, A.E.; Rovell-Rixx, D.C. The performance of personal inhalable dust samplers in wood-products industry facilities. *Appl. Occup. Environ. Hyg.* **2001**, *16*, 763–769. [CrossRef] [PubMed]
26. Nigsti, A. *Pulmonary Function Test and Pulseoximetry in Chip Wood Factory Workers of Maichew, Tigray Region*; Addis Ababa University: Addis Ababa, Ethiopia, 2014.
27. Asgedom, A.A.; Bratveit, M.; Moen, B.E. Knowledge, attitude and practice related to chemical hazards and personal protective equipment among particleboard workers in Ethiopia: A cross-sectional study. *BMC Public Health* **2019**, *19*, 440. [CrossRef]
28. American Thoracic Society. *Standards for epidemiologic surveys in chronic respiratory disease. Recommended Respiratory Disease Questionnaires for Use with Adults and Children in Epidemiological Research*; American Thoracic Society: New York, NY, USA, 1978.
29. Miller, M.R.; Hankinson, J.; Brusasco, V.; Burgos, F.; Casaburi, R.; Coates, A.; Crapo, R.; Enright, P.; van der Grinten, C.P.M.; Gustafsson, P.; et al. Standardisation of spirometry. *Eur. Respir. J.* **2005**, *26*, 319–338. [CrossRef]
30. Global Initiative for Chronic Obstructive Lung Disease. *Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease (2018 Report)*; Global Initiative for Chronic Obstructive Lung Disease: Fontana, WI, USA, 2018.
31. Tamhane, A.R.; Westfall, A.O.; Burkholder, G.A.; Cutter, G.R. Prevalence odds ratio versus prevalence ratio: Choice comes with consequences. *Stat. Med.* **2016**, *35*, 5730–5735. [CrossRef]
32. Moore, V.C. Spirometry: Step by step. *Breathe* **2012**, *8*, 232–240. [CrossRef]
33. Garcia-Rio, F.; Calle, M.; Burgos, F.; Casan, P.; Del Campo, F.; Galdiz, J.B.; Giner, J.; Gonzalez-Mangado, N.; Ortega, F.; Puente Maestu, L. Spirometry. Spanish Society of Pulmonology and Thoracic Surgery (SEPAR). *Arch. De Bronconeumol.* **2013**, *49*, 388–401. [CrossRef]
34. Pinkerton, K.E.; Harbaugh, M.; Han, M.K.; Jourdan Le Saux, C.; Van Winkle, L.S.; Martin, W.J., 2nd; Kosgei, R.J.; Carter, E.J.; Sitkin, N.; Smiley-Jewell, S.M.; et al. Women and lung disease. Sex differences and global health disparities. *Am. J. Respir. Crit. Care Med.* **2015**, *192*, 11–16. [CrossRef] [PubMed]
35. Rongo, L.M.; Besselink, A.; Douwes, J.; Barten, F.; Msamanga, G.I.; Dolmans, W.M.; Demers, P.A.; Heederik, D. Respiratory symptoms and dust exposure among male workers in small-scale wood industries in Tanzania. *J. Occup. Environ. Med.* **2002**, *44*, 1153–1160. [CrossRef] [PubMed]
36. Raji, H.; Haddadzadeh Shoushtari, M.; Idani, E.; Tavakol, H.; Afrakhteh, S.; Dastoorpoor, M.; Borsi, S.H. Forced expiratory flow at 25–75% as a marker for airway hyper responsiveness in adult patients with asthma-like symptoms. *Tanaffos* **2018**, *17*, 90–95. [PubMed]
37. Douwes, J.; McLean, D.; Slater, T.; Pearce, N. Asthma and other respiratory symptoms in New Zealand pine processing sawmill workers. *Am. J. Ind. Med.* **2001**, *39*, 608–615. [CrossRef] [PubMed]

38. American Conference of Governmental Industrial Hygienists. *Threshold Limit Values and Biological Exposure Indices*; ACGIH: Cincinnati, OH, USA, 2019.
39. World Health Organization. Risk Factors for Chronic Respiratory Diseases. Available online: https://www.who.int/gard/publications/Risk%20factors.pdf (accessed on 12 June 2019).

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

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Our ref.: 2016/628d
IRB ref: IRB00006245

Date: 2nd of June 2016

To whom it may concern,

Re: REC Letter of Confirmation

I am writing in reference to a request from Project Manager Bente Elisabeth Moen via e-mail dated the 1st of June 2016, regarding a Letter of Confirmation in English.

The Regional Committee for Medical and Health Research Ethics, Section D, South East Norway, reviewed the Research Project "Dust exposure and associated respiratory health problems among particle board workers in Ethiopia" (Norwegian title: *Støv og luftveisplager i sponplateindustri*) during its meeting on the 27th of April 2016. The Project Manager is Bente Elisabeth Moen and the Institution Responsible for Research is the University of Bergen.

The Research Project was granted approval on the 20th of May 2016, on the conditions that the Consent Form was revised in accordance with the Committee's comments and that there was made a separate Consent Form for the control group. The revised Consent Form and the new Consent Form to controls was received by e-mail on the 26th of May 2016.

Confirmation
We hereby confirm that the conditions in the Approval Letter dated the 20th of May are fulfilled and that the above-mentioned Research Project is approved.

Ethics Committee System
The Ethics Committee System in Norway consists of seven Independent Regional Committees with authority to either approve or disapprove Medical Research Studies conducted within Norway, or by Norwegian Institutions, in accordance with the Act on Medical and Health Research (2008).

Please do not hesitate to contact the Regional Committee for Medical and Health Research Ethics Section South East D (REK Sør-Øst D) if further information is required, as we are happy to be of assistance.

Yours faithfully,

Finn Wisløff
Chair of the Regional Committee for Medical
& Health Research Ethics of South East Norway,
Section D

Ingrid Dønåsen
Higher Executive Officer

The Federal Democratic Republic of Ethiopia
Ministry of Science and Technology

MoST

ቁጥር Ref. No. 3.10/148/2016

ቀን Date: Oct 7-2016

To: Addis Ababa University , Ethiopian Institute of Water Resources

Addis Ababa

Re: Dust Exposure and Associated Respiratory Health Problems Among Particle Board Workers in Ethiopia

Dear Sir/Madam//Mr./Mrs./Dr,

The National Research Ethics Review Committee (NRERC) has reviewed the aforementioned project protocol in an expedited manner. We are writing to advise you that NRERC has granted

Full Approval

To the above named project, for a period of **one year (October 7, 2016- October 6, 2017).** All your most recently submitted documents have been approved for use in this study. The study should comply with the standard international and national scientific and ethical guidelines. Any change to the approved protocol or consent material must be reviewed and approved through the amendment process prior to its implementation. In addition, any adverse or unanticipated events should be reported within 24-48 hours to the NRERC. Please ensure that you submit biannual progress report once in six months and annual renewal application 30 days prior to the expiry date.

We, therefore, request you as PI and your esteemed organization to ensure the commencement and conduct of the study accordingly and wish for the successful completion of the project.

With regards,

Yohannes Sitotaw
Secretary of NRERC

CC. _ NRERC chairperson
_ Mr. Akeza Awelom

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Annex IIIA. English Version questionnaire for Assessment of Knowledge, attitude and practice related to chemical hazards and personal protective equipment among particleboard workers in Ethiopia.

Verbal consent form:

Good day,

My Name is ………………………………………….. Akeza Awealom Asgedom, a PhD student at University of Bergen, Norway and his team are conducting research in your factory. The purpose of the study is to know about the knowledge, attitude and practice towards chemical hazards and personal protective equipment in particleboard workers and employers. You are selected to participate in the study and your cooperation is very important for success of the study. The interview has no any connection with your private life. All information obtained in the study will be kept confidential and used for research purpose only. The questionnaire and collected data will not made available to the factory management. If you feel uncomfortable you are free to stop the interview at any time. I will ask you some questions related to sociodemographic, knowledge, attitude and practice. If there is a gap on Knowledge, attitude and practice it will be worthy to make interventions. The interview will take 20-25 minutes. We are also asking permission if we can take a picture while you are working. If you need further information you can contact the Principal investigator (Akeza Awealom Asgedom) whose Phone number is +251910637190.

Are you willing to participate in the study and answer the questions?

A. Yes, I agree to participate, let him/her sign and continue.

   Signature_______________ Date ___________

   Confirmed by supervisor: Sign. _________________ Date____________

B. No, I do not agree to participate. Stop, Give thank you.

S.No.	Category	Questions	Response
1	**Sociodemographic**	1. Code	
		2. Site	A. Maichew B. Hawassa
		3. Sex	A. Male B. Female
		4. Age (Years)	
		5. Highest grade completed?	
		6. What is your Profession?	
		7. Type of employment?	A. Permanent B. Temporary
		8. Working section?	A. Chipping B. Flaking C. Chemical D. Forming E. Trimming F. Sanding G. Others,
		9. Service year in this factory?	
		10. Service year in another factory (if applicable)	
		11. Total working hours per day	
2	**Knowledge**	12. Do you know the type of chemical hazards arsing from this factory?	A. Yes B. No, Skip to Q# 14
		13. If yes for Q.# 12, can you list some of them?	A. Dusts B. Formaldehyde C. Other, specify---------
		14. Do you know a health hazards that could arise from chemical exposures?	A. Yes B. No, Skip to Q# 16
		15. If yes, for Q.# 14 can you mention some of the health problems?	
		16. Do you know hazards other than chemicals?	A. Yes B. No
		17. Is emergency exit important	A. Yes B. B. No
		18. Is break time during work important to reduce exposure to chemical hazards?	A. Yes B. No
		19. Is job rotation important for reducing exposure to chemical hazards?	A. Yes B. No

		20. Do you know about material safety data sheet?	A. Yes B. No, Skip to Q# 22
		21. If yes, for Q.# 20, Can you explain it?	
		22. Do you understand the sign and symbols posted in the wall?	A. Yes B. No, Skip to Q# 24 C. Not applicable
		23. If yes, for Q.# 22, can you explain the symbols with their meaning?	
		24. Do you know any work place safety rule?	A. Yes, describe some B. No
		25. Do you know what personal protective equipment is?	A. Yes B. No, Skip to Q#29
		26. If yes, for Q.# 25, can you mention those you know with their use?	
		27. Is personal protective equipment releavant in your work place?	A. Yes B. No, Skip to Q# 29
		28. If yes, for Q.# 25 who should wear personal protective eqipment?	
		29. Do the factory/employer has an obligation to maintain workers safety and health?	A. Yes B. No C. I do not know
		30. Do you have any source of information about occupational health and safety at work place?	A. Yes B. No, Skip to Q# 32
		31. If yes for Q.# 30 what are the sources of informations you know?	
3	**Attitude**	32. Do you believe that working in this factory is hazardous?	A. Yes B. No
		33. Do you think as an employee you should always use PPE during work?	A. Yes B. No
		34. Do you believe that your employer is responsible for reducing exposure to chemical hazards?	A. Yes B. No
		35. Do you think that all PPE has the same level of protection?	A. Yes B. No
		36. Do you believe that you should follow safety rules?	A. Yes B. No
		37. Do you believe that personal	A. Yes, justification.

		protective equipment relevant in work?	B. No
		38. Do you believe that employer should supply PPE?	A. Yes B. No
		39. Do you believe that safety training is relevant for workers?	A. Yes B. No
		40. Do you believe that Health/safety professional are relevant in your work place?	A. Yes B. No
		41. Do you feel satisfied with your work?	A. Yes B. No
4	**Practice**	42. Where do you get personal protective equipment?	
		43. Do you use personal protective equipment during work?	A. Yes B. No, Skip to Q#49
		44. If yes, for Q. # 43, why you use them?	A. They protect from hazard B. The factory ordered us to use them C. I am not sure D. Others, specify
		45. If no, for Q. # 43, why do not you use them?	
		46. Who encourages you to use personal protective equipment?	A. Supervisor B. Safety personnel C. Collegues D. Others, specify
		47. How often is personal protective equipment supplied?(Specify by type)	
		48. What do you do if your personal protective equipment is lost/torn?	A. Buy new one B. Request new one C. Nothing to do D. Others, specify
		49. Do usually made medical check ups?	A.Yes B. No
		50. Do you usually attend safety training?	A.Yes B. No

Annex IIIB. English Version 2 questionnaire for the Assessment of Knowledge, attitude and practice related to chemical hazards and personal protective equipment among administrative personnel in Ethiopian particleboards.

S.No.	Questions	Response
1	Code	
2	Site	A. Maichew B. Hawassa
3	Age	
4	Sex	A. Male B. Female
5	Responsibility	
6	Educational level	
7	Profession	
8	What are the chemical hazards occurred in your factory?	
9	What do you do when workers face hazards from the work environment?	
10	Is there safety committee in your factory?	A. Yes B. No, Skip to Q#12
11	If yes, for Q. # 10 what is their function?	
12	Can availability of safety guideines redues exposure to chemical hazards?	A.Yes B. No
13	Can job rotation reduce exposure to chemical hazards?	A. Yes B. No
14	Can break time during work reduce exposure to chemical hazards?	A.Yes B. No
15	Is good communication important in reducing exposure to chemical hazards at work?	A.Yes B. No C. I do not know
16	Is proper lighting important in reducing exposure to chemical hazards at work?	A.Yes B. No C. I do not know
17	Is good ventilation important in reducing exposure to chemical hazards at work?	A.Yes B. No C. I do not know
18	Do you supply safety material to workers?	A.Yes, which type?

		B. No, why?
19	How often do you supply personal protective equipment?	
20	Do you think all type PPE have the same level of protection?	A.Yes B. No
21	What are the considerations when you purchase PPE?	
22	What do you do if workers lost/torn their personal protective equipment?	
23	Is there any safety training given for workers?	A.Yes B. No, Skip to Q#25
24	Id yes for Q# 23, How often and who gives the training?	
25	Is there regular supervision and follow up to workers on safety rules and practices?	A.Yes B. No
Thank you for your participation!		

Annex IIIሀ. <u>አማርኛ መጠይቅ: የዕውቀት ኣመለካከት እና ትግበራ/የእውቀት , ዝንባሌ እና ልማድ ስለኬሚካልና አደጋዎች የግል የድህንነት መከላከያ መሳርያዎች በፓርትክልና ቦርድ ችፑድ ሰራተኞችና ኣሰሪዎች</u>

የመስማማት መፈረምያ ቅፅ

መልካም ቀን,

ስሜ..................................ይባላል። አኽዛ አወዓሎም አስገዶም በበርገን ዩንቨርስቲ የ3ኛ ዲግሪ ተማሪና ሌሎች አብረዉት የሚሰሩ በጋራ በመሆን በፋብርካችሁ ጥናት እያካሄዱ ይገኛሉ። የጥናቱ ዋና ዓላማ የሰራተኞቹና አሰሪዎች በኬሚካል አደጋዎችና የግል የድህንነት መከላከያ አደጋዎች መሳርያዎች ያላቸው የእውቀት , ዝንባሌ እና ልማድ ለማወቅ ነው። እርስዎ በጥናቱ እንድሳተፉ ተመርጠዋል። የእርስዎ ትብብር ለጥናቱ ስኬት ወሳኝ ሚና አለው። የሚሰጡት መረጃ ከግል ህይወትዎ ምንም ዓይነት ግንኙነት የለዉም። ማንኛውም የሚሰጡት መረጃ በምስጥር እንደሚያዝና ቃለ መጠይቁ ካልተመቸዎት በፈለጉበት ሰዓት ማቋረጥ እንደሚችሉ ላረጋግጥሎት እወዳለሁ። ስለ ማህበራዊና ዲሞግራፊያዊ ገፅታ, የእውቀት , ዝንባሌ እና ልማድ አንዳንድ ጥያቄዎች እጠይቆታለሁ። በጥናቱ የተገኙ ክፍተቶች ክፍተቱ መሰረት በማድረግ ከሚከተለው የአስተዳደር አካል በመነጋገር መፍትሄ ለማመቻቸት ይረዳል። መጠይቁ በአማካይ 20-25 ደቂቃ ይወስዳል። ተጨማሪ መረጃና ማብራሪያ ማግኘት ከፈለጉ ዋናው ተመራማሪ አኽዛ አወዓሎም አስገዶም በስልክ ቁጥር (+251910637190) ደውለው መጠየቅ ይችላሉ። በዚህ መጠይቅ ለመሳተፍ ፍቃደኛ ኖት?

ሀ. አዎን , እኔ ለመሳተፍ እስማማለሁ መጠይቁ ቀጥል

ፊርማ.................................... ቀን.................

ያረጋገጠው................................ ፊሪማ...........................ቀን........................

ለ. ፍቃደኛ አይደለሁም, (አመሰግናለሁ ብለህ አቋርጥ)

ተ.ቁ.	ክፍል	ጥያቄዎች	መልስ
1	**ማህበራዊና ዲሞግራፊያዊ**	1. ኮድ	
		2. ፋብሪካው የምገኝበት ቦታ	ሀ. ማይጨው ለ. ሃዋሳ
		3. ፆታ	ሀ. ወንድ ለ. ሴት
		4. ዕድሜ (በዓመት)	
		5. ያጠናቀቁበት የትምህርት ደረጃ በዓመት?	
		6. የሙያ ዓይነት?	
		7. የቅጥር ሁነታ?	ሀ. ቋሚ ለ.ግዚያዊ
		8. የምሰሩበት ዩኒት/ክፍል?	ሀ. ችፐንግ ለ. ፍለክንግ ሐ. ኬሚካል መ. ፎርሚንግ ረ. ትሪሚንግ ሰ. ሳንዲንግ ሸ. ሌላ (ይግለፁ),
		9. በዚህ ፋብሪካ ለስንት ዓመት ሰርተዋል?	
		10. በሌላ ተመሳሳይ ፋብሪካ ለስንት ዓመት አገልግለዋል?	
		11. በቀን ስንት ሰዓት ይሰራሉ?	
2	**እውቀት**	12. ከዚህ ፋብሪካ የምመነጩ የኬሚካል ኣደጋዎች ያውቃሉ?	ሀ. አዎ ለ. አላውቅም, ወደ ቁ.14 ቀጥል
		13. ለጥያቄ ቁ.12, አዎ ከሆነ መልሶ, የተወሰኑት መግለፅ ይችላሉ?	ሀ. የእንጨት ብናኝ ለ. ፎርማልድሃይድ ሐ. ሌላ (ይግለፁ)
		14. ለኬሚካል ኣደጋዎች በመጋለጥህ ልያጋጥሙ የምችሉ የጤና ችግሮች ያውቃሉ?	ሀ. አዎ ለ. አላውቅም, ወደ ቁ.16 ቀጥል
		15. ለጥያቄ ቁ.14, አዎ ከሆነ መልሶ, የተወሰኑት መግለፅ ይችላሉ?	
		16. ከዚህ ፋብሪካ የሚመነጭ ከኬሚካል ዉጭ ሌሎች ኣደጋዎች ያውቃሉ?	ሀ. አዎ ለ. አላውቅም
		17. የአደጋ ግዜ መዉጫ ጠቃሚ ነው	ሀ. አዎ

		ይላሉ?	ለ. አላውቅም
		18. በስራ መካከል ዕረፍት መውሰድ ጉዳት ለመቀነስ ይጠቅማል ወይ?	ሀ. አዎ ለ. አላውቅም
		19. በተለያዩ ክፍሎች የስራ ዝዉዉር ማድረግ ጉዳት ለመቀነስ ይጠቅማል ወይ?	ሀ. አዎ ለ. አላውቅም
		20. ስለ ቁሳዊ ድህንነት መረጃ ፅሁፍ የምታቀው ነገር ካለ ብትገልፅልን? (Do you know about material safety data sheet?)	ሀ. አዎ ለ. አላውቅም, ወደ ቁ.22 ቀጥል
		21. ለጥያቄ ቁ.20, አዎ ከሆነ መልሶ, ማብራራት ይችላሉ?	
		22. በግድግዳው የሚለጠፉ ምልክቶች መልዕክቱ ያውቋቸዋል?	ሀ. አዎ ለ. አላውቅም, ወደ ቁ.24 ቀጥል ሐ. ለዚህ አይመለከትም
		23. ለጥያቄ ቁ.20, አዎ ከሆነ መልሶ, ምልክቶቹና የያዙት መልዕክት ማብራራት ይችላሉ?	
		24. በስራ ላይ ስለሚደረገው የድህንነት ደንብ የምያውቁት ነገር አለ?	ሀ. አዎ (ይግለፁ) ለ. አላውቅም
		25. ስለ የግል መከላከያ መሳሪያዎች የምያውቁት ነገር አለ?	ሀ. አዎ (ይግለፁ) ለ. አላውቅም, ወደ ቁ.29 ቀጥል
		26. ለጥያቄ ቁ.25, አዎ ከሆነ መልሶ, የምያውቁት በመዘርዘር ጥቅማቸው ማብራራት ይችላሉ?	
		27. የግል መከላከያ መሳሪያዎች ለፋብርካቹ ጠቃሚ ነው?	ሀ. አዎ (ይግለፁ) ለ. አላውቅም, ወደ ቁ.29 ቀጥል
		28. ለጥያቄ ቁ.25, አዎ ከሆነ መልሶ, መሳሪያዎቹ ማን ማን ነው መጠቀም ያለበት?	
		29. ፋብርካው ለሰራተኞች ጤናቸውና ድህንነታቸው የማስጠበቅ ሀላፍነት እንዳለው ያውቃሉ?	ሀ. አዎ ለ. አላውቅም ሐ. ኃላፊነት የለውም
		30. ስለ ሰራተኞች ጤናና ድህንነት መረጃ ምንጭ ታውቃለህ?	ሀ. አዎ ለ. አላውቅም, ወደ ቁ.32 ቀጥል

		31. ለጥያቄ ቁ.30, አዎ ከሆነ መልሶ, ምንጮቹ መጥቀስ ይችላሉ?	
3	**ዝንባሌ**	32. የምሰራበት ክፍል ለጤናየ አስጊ ነው ብለው ያምናሉ?	ሀ. አዎ ለ. አላውቅም
		33. እንደ ሰራተኛ የግል መከላከያ መሰሪያዎች መጠቀም አለብኝ?	ሀ. አዎ ለ. አላውቅም
		34. አሴሪየ የኬሚካል አደጋዎች የመከላከልና መቀነስ ሀላፍነት እንዳለው አምናለሁ?	ሀ. አዎ ለ. አላውቅም
		35. ሁሉም የግል መከላከያ መሳርያዎች እኩል የመከላከል አቅም አላቸው?	ሀ. አዎ ለ. አላውቅም
		36. የድህንነት ደምብ መከተል አለብኝ ብለህ ታምናለህ?	ሀ. አዎ ለ. አላውቅም
		37. የግል መከላከያ መሳሪያዎች በስራ ገዜ ከተለበሱ ይጠቅማሉ ብለው ያምናሉ?	ሀ. አዎ, ምክንያት ለ. አላውቅም
		38. የግል መከላከያ መሳሪያዎች ማቅረብ የፋብሪካው ሀላፍነት ነው ብለው ያምናሉ?	ሀ. አዎ ለ. አላውቅም
		39. የድህንነት ስልጠና ለሰራተኞች ጠቃሚ ነው ብለው ያምናሉ?	ሀ. አዎ ለ. አላውቅም
		40. የጤናና ድህንነት ባለሙያዎች በዝህ ፋብሪካ ጠቃሚ ናቸው ብለው ያምናሉ?	ሀ. አዎ ለ. አላውቅም
		41. ባለኝ ሰራ ደስተኛ ነኝ ብለው ያምናሉ?	ሀ. አዎ ለ. አላውቅም
4	**ትግበራ**	42. የግል መከላከያ መሳሪያዎች ከየት ነው የምታገኙት?	
		43. የግል መከላከያ መሳሪያዎች በስራ ግዜ ይጠቀማሉ?	ሀ. አዎ ለ. አልጠቀምም, ወደ ቁ.49 ቀጥል
		44. ለጥያቄ ቁ.43, አዎ ከሆነ መልሶ, ለምንድነው የምጠቀሚቸው?	ሀ. ከአደጋ ይከላከልሉኛል ለ. አሪየ ስላዘዘኝ ሐ. እርግጠኛ አይደለሁም መ. ሌላ (ይግለፁ)
		45. ለጥያቄ ቁ.43, አልጠቀምም ከሆነ	

		መልሶ, ለምን አይጠቀሙም?	
		46. የግል መከላከያ መሳሪያ እንድትጠቀሙ የምያበረታታችሁ ማን ነው?	ሀ. ሱፐርቫይዘራችን ለ.. የድህንነት ባለሙያዎች ሐ. የስራ ባለደረቦቼ መ. ሌላ (ይግለፁ)
		47. የግል መከላከያ መሳሪያ በምን ያክል ግዜ ነው የምሰጣችሁ? (በዓይነት ይግለፁ)	
		48. የግል መከላከያ መሳሪያችሁ ስጠፋ ወይም ስያልቅ ምን ታደርጋላችሁ?	ሀ. እገዛለሁ ለ. ሌላ አዲስ እጠይቃለሁ ሐ. ምንም መ. ሌላ (ይግለፁ)
		49. የጤና ምርመራ ያደርጋሉ ወይ?	ሀ. አዎ ለ. አላውቅም
		50. የጤናና ድህንነት ስልጠና ይከታተላሉ ወይ?	ሀ. አዎ ለ. አልከታተልም
በጣም አመሰግናለሁ!			

Annex IIIለ. <u>አማርኛ መጠይቅ ስለ የእውቀትና ዝንባሌ በኬሚካልና አደጋዎች, የግል የድህንነት መከላከያ መሳርያዎች በፓርትክል ቦርድና ችፑድ አሰሪዎች</u>

ተ.ቁ	ጥያቄዎች	መልስ
1	ኮድ	
2	ፋብሪካው የምገኝበት ቦታ?	ሀ. ማይጨው ለ. ሃዋሳ
3	ዕድሜ (በዓመት)	
4	ፆታ	ሀ. ወንድ ለ. ሴት
5	ኃላፊነት	
6	የትምህርት ደረጃ	
7	ሙያ	
8	በፋብርካችሁ ልያጋጥሙ የምችሉ አደጋዎች ምንድን ናቸው?	
9	በሰራተኞች ላይ አደጋዎች ስደርሱ ምን ታደርጋላችሁ?	
10	የድህንነት ኮሚቴ በፋብርካችሁ አለ?	ሀ. አዎ ለ. የለም ወደ ቁ.12 ይቀጥሉ

11	ለጥያቄ ቁጥር 10 አዎ ከሆነ መልስዎ የኮሚቴው ዋና ተገባር ምንድን ነው?	
12	የድህንነት ደምብ በመኖሩ አደጋ ይቀንሳል ብሎ ያስባሉ?	ሀ. አዎ ለ. አላውቅም
13	በተለያዩ ክፍሎች እየተዘዋወሩ መስራት አደጋ ይቀንሳል ብሎ ያስባሉ?	ሀ. አዎ ለ. አላውቅም
14	በስራ መካከል ዕረፍት በመኖሩ አደጋ ይቀንሳል ብሎ ያስባሉ?	ሀ. አዎ ለ. አላውቅም
15	በሰራተኛና በፋብሪካው ኃላፊዎች ጥሩ ግኑኝነት መኖሩ አደጋ ይቀንሳል ብለው ያስባሉ?	ሀ. አዎ ለ. አይመስለኝም ሐ. አላውቅም
16	ጥሩ የመብራት አገልግሎት መኖሩ አደጋ ይቀንሳል ብለው ያስባሉ?	ሀ. አዎ ለ. አይመስለኝም ሐ. አላውቅም
17	ጥሩ የንፋስ/አየር እንቅስቃሴ መኖሩ ኣደጋ ይቀንሳል ብለው ያስባሉ?	ሀ. አዎ ለ. አይመስለኝም ሐ. አላውቅም
18	የግል መከላከያ መሳሪያዎች ለሰራተኞች ትሰጣላችሁ ወይ?	ሀ. አዎ, ምን ዓይነት መሳሪያዎች? ለ. አንሰጥም ለምን?
19	የግል መከላከያ መሳሪያዎች በየ ስንት ግዜው ነው የምትሰጧቸው?	
20	ሁሉም የግል መከላከያ መሳርያዎች እኩል የመከላከል አቅም አላቸው ብለው ያምናሉ?	ሀ. አዎ ለ. አላውቅም
21	የግል መከላከያ መሳሪያዎች ስትገዙ ታሳቢ የምታደጓቸው መለኪያዎች ምንድናቸው?	
22	ሰራተኞች የግል መከላከያ መሳሪያ ስጠፋባቸው/ስያልቅባቸው ፋብርካችሁ ምን ያደርጋል?	
23	ፋብርካችሁ ለሰራተኞች የድህንነት ስልጠና ይሰጣል ወይ?	ሀ. አዎ ለ. አይሰጥም ወደ ቁ.25 ቀጥል
24	ለጥያቄ ቁጥር 23 አዎ ከሆነ መልስዎ, መች መችና በማን ይሰጣል?	
25	ለሰራተኞች መደበኛ ሱፐርቭዥንና ኦረንቴሽን በድህንነት ደምቦችና ህጎች ይደረጋል ወይ?	ሀ. አዎ ለ. አላውቅም
በጣም አመሰግናለሁ!		

Annex IV. English version questionnaire for assessment of respiratory symptoms among particleboard workers (exposed) and water bottling workers (controls) in Ethiopia.

Verbal consent form

Good day,

My Name is …………………………………………… Akeza Awealom Asgedom, a PhD student at University of Bergen, Norway and his team are conducting research in your factory. The purpose of the study is to know about wood dust, endotoxin and formaldehyde exposure level and associated respiratory symptoms in particleboard workers. You are selected to participate in the study and your cooperation is very important for success of the study. I will ask you questions related to sociodemographic and respiratory symptoms. You are also needed for lung function measurement which is not harmful, and it can be easily performed. All information obtained in the study will be kept confidential and used for research purpose only. If the measurements have deviation from the expected normal values, it will be worthy for you to visit your health care worker in your clinic and making intervention on the assessed problems. The interview will take 15-20 minutes and you have full right to stop at any time if you want to stop. If you need further information you can contact the Principal investigator (Akeza Awealom Asgedom) whose Phone number is +251910637190.

Are you willing to participate and answer the questions?

A. Yes, I agree to participate ⟹ Continue

Signature________________ Date ____________

B. No, I do not agree to participate. ⟹ Stop, Thank you!

S.No.	Category	Questions	Response
1	**Sociodemographic**	1. Code	
		2. Group	A. Exposed B. Control
		3. Site	A. Maichew B. Hawassa
		4. Working section	A. Chipping B. Flaking C. Chemical D. Forming E. Trimming F. Sanding G. Others……
		5. Sex	A. Male B. Female
		6. Age (Years)	
		7. Highest grade completed?	
		8. Service year in this factory?	
		9. Is there separate kitchen in your home?	A. Yes B. No
		10. Do you use biomass fuel as a source of energy	A. Yes B. B. No
I am going to ask you questions pertain mainly to your chest. Please answer saying yes or no if possible.			
2	**Cough**	11. Do you usually have cough?	A.Yes B. No, Skip to Q# 13
		12. Do you usually cough as much as 4 to 6 times a day, 4 or more days out of the week?	A. Yes B. No
		13. Do you usually cough at all on getting up, or first thing in the morning?	A. Yes B. No
		14. Do you usually cough at all during the rest of the day or at night?	A. Yes B. No
		If Yes, for one or all of the questions from 11-14	
		15. Do you usually cough like this on most days for 3 consecutive months or more during the year?	A. Yes B. No
		16. For how many years have you had this cough?	

		17. Have you been awaken by an attack of coughing at any time in the last 12 months?	A.Yes B. No
3	**Cough plus sputum production**	18. Do you usually cough with sputum in the morning?	A. Yes B. No
		19. Do you usually cough with sputum in the day or at night?	A. Yes B. No
4	**Phlegm**	20. Do you usually bring up phlegm from your chest?	A. Yes B. No, skip to Q#22
		21. Do you usually bring up phlegm like this as much as twice a day, or more days out of the week?	A. Yes B. No
		22. Do you usually bring up phlegm at all on getting up, first thing in the morning?	A. Yes B. No
		23. Do you usually bring up phlegm at all during the rest of the day or night?	A.Yes B. No
		If the answer is yes to any of the questions from 20-23	
		24. Do you bring up like this on most days for 3 consecutive months or more during the year?	A. Yes B. No
		25. For how many years have you had trouble with phlegm?	
5	**Episode of cough and phlegm**	26. Have you had periods or episodes of increased cough and phlegm lasting for 3 weeks or more each year?	A. Yes B. No
6	**Wheezing**	27. Have you had wheezing or whistling in your chest at any time in the last 12 months?	A. Yes B. No
		27.1. Have you been at all breathless when the wheezing noise was present?	A. Yes B. No
		27.2. Have you had this wheezing or whistling when you did not have a cold?	A. Yes B. No
		28. Have you waken up with a feeling of tightness in your chest at any time in the last	A. Yes

		12 months?	B. No
7	**Shortness of breath**	29. Have you had an attack of shortness of breath that came on during the day when you were at rest at any time in the last 12 months?	A. Yes B. No
		30. Have you had an attack of shortness of breath that came on the following strenuous activity at any time in the last 12 months?	A. Yes B. No
		31. Have you been woken by an attack of shortness of breath at anytime in the last 12 months?	A. Yes B. No
		32. Are you troubled by shortness of breath when hurrying on the level or walking up slight hill?	A. Yes B. No
		If yes, for Q#32	
		32.1. Do you have to walk slower than people of the same age on the level because of breathlessness?	A. Yes B. No
		32.2. Do you ever have to stop for breath when walking at your own pace on the level?	A. Yes B. No
		32.3. Do you ever have to stop for breath after walking about 100 meter (few minutes) on the level?	A. Yes B. No
8	**History of past illness**	33. Have you had any respiratory illness?	A. Yes B. No
		33.1. If yes for Q#33, can you mention a disease confirmed by Doctor?	A. Bronchites B. Pneumonia C. Hay fever D. Emphysema E. Athma F. Chest operation G. Others, specify

9	**Occupational History**	34. Have you ever worked in dusty environment previously?	A. Yes B. No
		34.1. If yes for Q#34, where and for how long?	
10	**Tobacco smoking**	35. Have you ever smoked?	A. Yes B. No
		36. Do you now smoke cigarate (as of 1 month ago)	A. Yes (How many per day) B. No
11	**Anthropometric measurments**	37. Height (m)	
		38. Weight (Kg)	
		39. Body Mass Index	
Thank you for your cooperation !			

Graphic design: Communication Division, UiB / Print: Skipnes Kommunikasjon AS

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ISBN: 9788230840351 (print)
9788230848579 (PDF)