JIMMA UNIVERSITY
INSTITUTE OF HEALTH
FACULTY OF PUBLIC HEALTH
DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES AND TECHNOLOGY

Determination of Indoor Air Pollutants and Self-Reported Health Problems among Workers working in Beauty Salons of Jimma town, Oromia, Ethiopia

By: Mihiretu Tagesse (BSc.)

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Determination of Indoor Air Pollutants and Self-Reported Health Problems among workers working in Beauty Salons of Jimma town, Oromia, Ethiopia

By: Mihiretu Tagesse

Advisors: 1. Gudina Terefe (Ph.D., Associate Professor)

2. Dessalegn Dadi (Ph.D., Assistant Professor)

3. Ms. Tizita Teshome (M.Sc, lecturer)

4. Ms. Mulunesh Deti (M.Sc, lecturer)

5. Berhanu Nigussie (Ph.D., Associate Professor)

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Jimma, Ethiopia

ABSTRACT

Background: In Beauty Salon, activities and use of diverse cosmetics are contributing factor for generation of air pollutants that compromise quality of indoor air. Studying about sources, characteristics, and types of indoor air pollutant has great public health importance. In Ethiopia, there was limited study addressing the determination of indoor air pollutants and their associated health effects among workers of the beauty salons**.**

Objectives: To assess indoor air pollutant concentrations and self-reported health problems among workers in beauty salons of Jimma town

Methods: This is community based cross-sectional study conducted in 87 beauty salons from May 13 to 24 /2019. The concentrations of coarse particulate matter ($PM_{10-2.5}$), total volatile organic compounds (TVOCs), nitrogen dioxide (NO_2), carbon dioxide (CO_2), room temperature (RT) and relative humidity (RT) was measured for a short time. Survey questionnaire was used to assess salon characteristics, personal care products, and reported health problem among workers. Correlation, one sample t-test and multiple linear regressions were performed for prediction of pollutants level.

Result: The mean concentration of $PM_{10-2.5}$, TVOCs, NO_2, CO_2, RT and RH was found to be (0.356mg/m^3,1190.02mg/m^3,0.0974mg/m^3,1333.9mg/m^3,26.22°c and 55.33%) respectively. Hair spray, nail care products and RT significantly predicted TVOCs concentration. Distance and NO_2 correlated negatively at *(rho=-0.38, p<0.05)*. Makeup products, RT, and RH significantly predicted $PM_{10-2.5}$. Customers and ventilation status were significantly predicted CO_2 concentration level. It was noticed that beauty salon activities were reported being associated with respiratory and eye problems, fatigue, back and leg pain.

Conclusion and recommendation: Indoor air pollutants in beauty salons were found above comfort level of human being as suggested by ASHRAE limit. Availing mechanical and natural ventilation and using PPE is highly recommended to reduce exposure of pollutants.

Keywords: Indoor air pollutants; coarse particulate, TVOCs; Beauty salon; Jimma town

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ACRONYMS AND ABBREVIATIONS

ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
CO_2	Carbon dioxide
COPD	Chronic obstructive pulmonary disease
EPA	Environmental protection Agency
IAQ	Indoor air quality
Nm	Nanometer
NO_2	Nitrogen dioxide
NIOSH	National institute for occupational safety and health
OT	Outdoor temperature
OC	Organic carbon
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of less than or equal to 2.5 micrometer
$PM_{10-2.5}$	Particulate matter with aerodynamic diameter between 10 and 2.5 micrometer
PM_{10}	Particulate matter with an aerodynamic diameter less than 10 micrometer
PPE	Personal protective equipment
RH	Relative humidity
RT	Room temperature
SPSS	Statistical Package for Social Scientists
TVOCs	Total volatile organic compounds
VIF	Variance inflation factor
WHO	World Health Organization

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Workplace is the most extensive exposure of humans for indoor air pollutants even though this is not considered well. Beauty salon is a work place for providing service of different cosmetology practices. This includes; practices like manicures, pedicures, application of artificial nails, special occasion hairstyling, shampooing, permanent waving, cutting, curling, coloring, highlighting, straightening and extension of hair (*Gonzalez 2007).* In the beauty salon, for performing these activates different cosmetic products such as solvents, glues, hardeners, hair sprays etc. are used. They may contain potentially hazardous chemicals like volatile organic compounds such as aromatics, esters , ketones, odorous terpenes, camphor and ammonium *(Goldin et al. 2014; Roelofs and Do 2012).* The chemicals used are emitted and remains in the air of the beauty salon, thus compromise the indoor air quality *(Moscato et al. 2005),* especially as many salons lack adequate mechanical ventilation systems, which complexes the problem more *(Mandiracioglu et al. 2009).*

The types and number of services offered, and application of cosmetics in beauty salons exert much greater effects on the concentration level of indoor air pollutants; particulate matter, TVOCs and CO_2 *(Rogula et al. 2018; Tsigonia et al. 2010).* In beauty salon *Gennaroet al. (2014)* identifed TVOCs as the most important pollutant and they reported that the level of concentrations can affected by the type of products used while the size of the environment, the efficiency of air exchange and the number of customers had less impact. In addition to TVOCs another study investigated existence of particulate matter and carbon dioxide (CO_2) in nail salons of Boston, United States (*Goldin et al. 2014).*The presence of these pollutants reported as agents for the changing the quality and composition of indoor air which affects the comfort, health and productivity of salon workers *(Ana et al. 2019*).

The Occupational health and indoor air quality problem in beauty salon is evident because of the generation of toxic chemicals to indoor air that harms the health of workers and customers *(Rogula-kopiec et al. 2018; Zhong 2018).* There is health problem associated with poor indoor air quality, direct chemical contact, poor ergonomic practice and unhygienic practice among beauty salon workers. Skin problem, respiratory disorders, carcinogenicity, reproductive and genotoxic effects have been associated with compounds released in beauty salons *(Galiotte et al.*

2008; Halliday-bell, Gissler, and Jaakkola 2009). Different studies reported as salon personnel often complain about eye, nose, throat, lung, and skin problem *(Leino et al. 1997; Roelofs and Do 2012*). It was also reported that workers in this sector were exposed to variety of physical, chemical, biological hazards as well as psychosocial stress which threaten their health during working days *(Bigambo 2016).* Different studies also concluded that the increase of prevalence of respiratory symptoms in nail salon workers is likely due to occupational exposure of chemicals in the nail care products *(Ana et al. 2019; Roelofs and Do 2012).*

1.2 Statement of the Problem

Indoor air pollutants are an observable problem in the sector of the beauty salon. Several studies have been conducted to investigate type of indoor air pollutants in the beauty salons. *Goldin et al. (2014)* measured the concentration of TVOCs, $PM_{2.5}$ and CO_2 in nail salons, and they found that the level of TVOCs exceed typical levels in residential and other occupational environments. Different studies also identified VOCs, formaldehyde, CO_2, and esters as contributing agents for poor indoor air quality of the beauty salons *(Tsigonia et al. 2010; Chang CJ et al. 2018).* In beauty salons, the presence of different hazardous chemicals was investigated by characterization of TVOCs. The studies by *Sung-Ae Park, et al. (2014), Tsigonia et al. (2010)* and *Hadei et al. (2018)* identified 13,14 and six specific VOCs in different beauty salons. *Zhong (2018)* measured the TVOCs concentration level in indoor air of beauty salon and indicated the level within range of 100mg/m^3 -3600 mg/m^3. In his study, personal measurements, represented exposures to workers and clients, were about twice of the area measurements for many VOCs. Information regarding to concentration level of $PM_{10-2.5}$ and NO_2 in beauty salon was limited although studies investigated different types of indoor air pollutants.

All the above studies showed indoor air pollutants were the problem in beauty salons. They concluded that performing tasks and presence of variety of cosmetic products was a factor for increased level of indoor air pollutant concentrations. Based on their findings, they recommended having appropriate local exhaust ventilation place, mechanical ventilation and development of strong policies regarding to cosmetics products and working environment. This is to ensure adequate health protection of both workers and customers by improving the quality of indoor air.

Besides, to activities and cosmetics products outdoor air is another contributing factor for the pollutants in beauty salons. Beauty Salons are usually located in public places and semi enclosed spaces like the roadside, at market places and other high-density areas in order to attract customers. This directs the way for outdoor source of pollutants. Different studies have reported measurements of IAPs, but there remain uncertainties as to the relationships between the toxic air pollutant concentrations and the different cosmetic practices. Investigating these relationships will determine the risk related with type of cosmetics, and the exposure health effects on customers and workers. To reduce effects, the way of mitigation methods like effects of PPE and different types of ventilation needs to be studied. The results of these studies can support the design of strategies for reducing exposure in these occupational environments.

High-risk environments need to be assessed for the types and concentrations of toxic air pollutants that result in human exposure. Although the beauty salon staffs are exposed to a vast number of chemicals during the whole workday, the IAQ and occupational health problem were poorly known. Specifically, reports on IAPs concentration and self-reported health problem among workers in beauty salons of Jimma town were insufficient, and even in Ethiopia as country level. In this study the concentration TVOCs, CO_2, NO_2, $PM_{10\text{-}2.5,}$ and reported health problems among workers were considered. Besides, comfort parameters (RT and RH) in indoor air of beauty salons were determined.

1.3. Significance of the study

Indoor air pollution is a visible problem in the beauty salon. This is because of use of different type of personal care products, which contains different types of chemical that emits indoor air pollutants in working area, beauty salon. The results from this study are important to know indoor air pollutants magnitude in beauty salons and then to recommend essential intervention methods for concerning bodies. The study will be important to strength existing Environmental, Occupational and Public health policy regarding contributing factors of indoor air pollution in working environment. This study contributes to existing knowledge and essential for different stakeholders, NGOs, professionals, individuals, and Minster of health, and labor and social affairs for purpose of decision-making and to undertakes intervention. This study is very important for further study of indoor pollutants nature and characterization in different beauty salon and another working environment.

CHAPTER TWO: LITERATURE REVIEW

2.1 Common Indoor Air Pollutants in Beauty Salons: Sources and Health Effects

2.1.1 Indoor Particulate Matter: Sources and Health Effects

Particulate matter was identified as one of the most harmful air pollutant(*Megido et al. 2016).* It consists of liquid droplets and solid fragments smaller than 10 µm suspended in the air, whose size, chemical composition, and shape are varied*(Bae and Hong 2018).* For regulatory purposes, environmental agencies all over the world usually classify PM into two groups according to its size: PM_{10} and $PM_{2.5}$ *(Damberg et al. 2016; Europe 2008).* Recently according to the US, EPA $PM_{10\text{-}2.5}$ indicates a particle size in a range of 10 to 2.5 micrometers, which referred as inhalable (or thoracic) coarse particles, and its daily standard was set as 70 µg/m^3rather than using PM_{10} daily standard of 150 µg/m^3*(Esworthy and McCarthy 2012).*

The class of PM_{10} particle mass includes both fine and coarse fractions of airborne particulate matter that normally arise from different sources. Fine particles are mainly particles from combustion processes or are formed within the atmosphere by chemical processes. On the other hand, coarse particles generally arise from natural sources (wind-blown soil, sea spray, and pollens), non-exhaust vehicle emissions, and road dust or from construction and quarrying activities. The following figure represents the fine and coarse mode of particle classification.

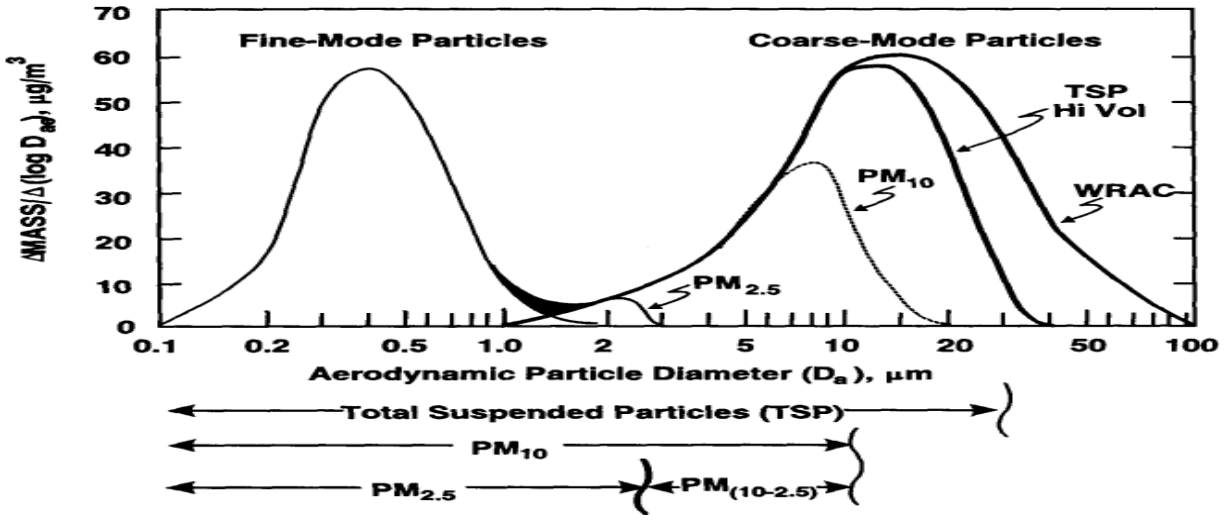

Figure: 1 Schematic representation of Size distribution of PM in ambient air *(USEPA, 1996)*

Different scholars' investigated the presence of indoor particulate matter and its impacts on air quality condition of a beauty salon. Many Studies explored both coarse and fine particulate matter indoor air of the beauty salon and they found greater value in indoor room than outdoor environment. The reasons for this increment were identified as using cosmetics and detergents, and presence of biological matter, such as filings of nails and hard nail gels, tiny hair snippets, and epidermis in the beauty salons *(Ana et al. 2019; Esworthy and McCarthy 2012; Rogula et al. 2018).*

Cosmetics contain volatile organic compounds like hydrocarbons, alcohols, esters, phenols, acid and others *(Andersen 2008; Nohynek et al. 2010; Williams et al. 2016).*The interaction of these chemicals with particle matter in the indoor air increases the concentration of particulate matter more indoor air of beauty salon. The study by *Rogula et al. (2018)* investigated the high concentration of OC bounded particulate matter in indoor air of beauty salon than outdoor air of the same beauty salon. Besides, to this they compare both OC and EC concentration in beauty salon and got result of high formation OC than EC. Finally, they said that the use of cosmetics in indoor air increase particulate matter which is bounded to organic carbon. They found investigated presence of elemental carbon bound particulate matter was affected by outdoor sources like road traffic and another combustible source.

The coarse factors have a positive relationship with temperature. This could be attributed to the fact that higher temperatures are often associated with drier soil conditions, which in turn can lead to enhanced dust re-suspension*(Barmpadimos et al. 2012; Vardoulakis and Kassomenos 2008).*

Many studies have shown that exposure for particulate matter for a long *(Crouse et al. 2012; Koulova and Frishman 2014), and* Short *(Lu et al. 2015)* term has causal effects on cardiovascular toxicological and respiratory health problem. Both epidemiological *(Chang, Peng, and Dominici 2011*) and *(Becker et al. 2003)* test have demonstrated health effects of PM_{10} and $PM_{2.5}$ well, but limited studies for coarse PM. Some studies gave shreds of evidence of strong negative health effects too because of the exposure of coarse PM, although they have been studied less extensively *(Barmpadimos et al. 2012; Ostro et al. 2009).*

Another study conducted by *Zanobetti and Schwartz (2009*) investigated the acute effect of coarse PM on the increased risk of death for all causes, all cardiovascular disease, myocardial infarction, stroke, and respiratory mortality. They confirmed the presence of biologically

plausible strong association of coarse particles and mortality. A different study also founded effects of long-time exposure for coarse PM can result on increase of higher asthma prevalence and for morbidity of US children (*Keet, Keller, and Peng 2018).* Coarse PM can deposit in the upper airways involved in obstructive lung diseases such as asthma and chronic obstructive pulmonary disease. There is emerging evidence that indicated short-term coarse PM exposure association with Cardiovascular and respiratory morbidity (*Peng et al. 2008*). Also long-term coarse PM exposure was associated with decreased lung function and increased bronchitis symptoms in children (*Puett et al. 2009; Zhang et al. 2002).* The existence of real health hazard from indoor particulate matter was investigated on the workers of the beauty salons who are working in poor air quality salons*(Ana et al. 2019; Rogula-kopiec et al. 2018).*

2.1.2. Indoor Total Volatile Organic Compounds: Sources and Health Effects

Total volatile organic compounds are a total sum amount of all VOC in the air, and its measurement is effective for evaluating indoor air quality. They are the compounds with the greatest interest in beauty salons almost most of personal care product contains volatile organic compounds. So that, VOCs are used in assessing indoor air quality because of their ubiquity, diffusion properties and emission from many sources; it may be used like "descriptors" that can be more adequate in characterizing anthropogenic pollution *(Bacaloni, Insogna, and Zoccolillo 2011).* The study by *Tsigonia et al.(2010)* identified aromatics (toluene, xylene), esters and ketones (ethyl acetate, acetone, *etc*.), odorous terpenes (pinene, limonene, camphor, methanol) and, camphor as main volatile organic compounds in the beauty salons. The workers may be exposed to high concentrations of a mixture of volatile organic compounds at levels that can cause symptoms or discomfort. Different scholars described the concentration level of VOC in the beauty salon can be influenced by number of treatments, ventilation, the number and type of products *(Bigambo 2016; Gennaro et al. 2014; Goldin et al. 2014; Tsigonia et al. 2010).* Different study in households of Michigan (USA) showed that increase of TVOC is also because of attached garage, recent renovations, older residences, smoking inside, fewer windows and doors, higher CO_2 concentrations and a lower level of ventilation *(Meciarová et al. 2017).*

Another negligible source of VOCs is human breath. Researchers studied that the concentration of VOCs in human breath and identified the major VOCs such as isoprene, acetone ethanol, methanol, and other alcohols, in human breath of healthy individual. However, they suggest that

human breath emissions are generally not taken into account in indoor air studies of VOC*(Fenske et al. 2011).*

As different studies investigated the concentration level of VOC and comfort parameters in beauty salon is influenced by type, number, and frequency of tasks *(Hadei et al. 2018; Meciarová et al. 2017; Tsigonia et al. 2010).* By another study the same thing was found, and ventilation was recommended to improved indoor air quality *(Goldin et al. 2014).* Beauty salons with better partial had lower concentrations of VOCs, and with poor ventilation were reported with high concentrations of CO_2*(Lu et al. 2015). Zhong (2018)* measured TVOC in indoor air of beauty salons and was found within range of 100mg/m^3 -3600 mg/m^3 in 15 out of 17 beauty salons. In his study, personal measurements, representing exposures to workers and clients, were about twice those of the area measurements for many VOCs. He showed that short and long-time exposure of volatile organic compounds could cause acute and chronic health effects in beauty salons workers and customers. Improving ventilation and restrictions of VOCs compositions were recommended as strategy to reduce exposures to salon workers and clients *(Zhong 2018).*

The health risk assessment showed that benzene, formaldehyde, and acetaldehyde represent a possible cancer risk in the beauty salons. In addition, toluene, ethyl benzene, and xylene had negligible non-carcinogenic risks *(Hadei et al. 2018).*

Recently researchers investigated another health risk of prenatal TVOCs exposure. They concluded that prenatal exposure to volatile organic compounds restricts fetal development and adversely influences infants' life. These show that the effect of TVOCs exposure during pregnancy may influence the development of infants after birth. This study highlighted the relationship between prenatal TVOCs exposure and postnatal neurodevelopment, but the biological mechanism needs further research *(Chang et al. 2017).*

2.1.2.1 Chemical ingredients in beauty salon products and their potential health effects:

Researchers who have sampled air contaminants from beauty salon have consistently found that workers are exposed to multiple potentially hazardous VOCs. Exposure to these chemicals above the permissible level for frequent time cause negative health effects.

Table 1: Products, chemicals in product and health effects of chemicals in Beauty salons

(Bigambo 2016; Roelofs and Do 2012)

Type of products	**Chemicals in the product**	**Symptoms of Exposure**	**Potential Long Term Effect**
Nail hardener, nail polish, keratin hair straightness	Formaldehyde or methylene glycol	Breathing problems, coughing, wheezing, skin rashes, eye nose, throat irritation	Cancer , dermatitis
Nail polish, nail glue, hair dye, wig glue/hairpiece bonding	Toluene	Breathing problems, chest tightness, eye, nose, throat irritation	Liver damage, kidney damage, birth defects, pregnancy loss
Artificial nails	Methyl methacrylate	Headaches, confusion	Loss of smell, reproductive toxin
Hair extension glue, lace wig glue	Styrene	Vision problems, trouble concentrating, tiredness	Cancer
Hair extension glue; lace wig glue	1,4 Dioxane	Eye and nose irritation	Cancer, liver damage, kidney damage
Disinfectants, cleaners	Ethylene glycol, monobutyl ether	Headache, eye and nose irritation	Reproductive toxin
Disinfectants	Dimethylbenzylamm	Skin, eye, and nose	Asthma

	onium chloride	irritation	
Hair dye, black henna tattoos	p-phenylenediamine	Skin irritation	Dermatitis
Permanent wave solution	Glyceryl thioglycolate	Skin irritation	Dermatitis
Hair bleaching	Ammonium persulphate	Eye, skin and nose irritation, coughing, shortness of breath	asthma
Nail polish remover, hairspray	Acetone	Eye, skin and throat irritation, dizziness	Eye, skin and throat irritation, dizziness
Artificial nails	Ethyl methacrylate	Eye and skin irritation	
Nail glue remover	Acetonitrile	Eye, skin and throat irritation, face flush, chest tightness, nausea	Weakness, exhaustion
Nail polish, nail polishremover, wig glue/hairpiece bonding	Butyl acetate,ethyl acetate orisopropyl acetate	Eye, skin and throat irritation, headaches, dizziness	Eye, skin and throat irritation, dermatitis
Nail primer, eyelash glue	Meth acrylic acid	Skin burns, eye, nose and throat, irritation	Kidney damage, dermatitis, toxin
Nail Polish	Dibutylphthalate	Nausea, dizziness, eye and skin irritation	reproductive toxin, birth defects

2.1.3. Indoor Nitrogen Dioxide Sources and Health Effects

Nitrogen dioxide is the most important and ubiquitous oxide of nitrogen. Nitrogen dioxide exposure results in delayed injury without provoking immediate warning symptoms because it is less soluble in water. High indoor NO_2 levels exposure frequently occurs in an urban area and is significantly associated with the risks for increased frequency of both respiratory symptoms and reduced lung function *(Cibella et al. 2015).* Irritation of the eyes, nose, and throat are the principal health effects of exposure to NO_2 at the levels usually encountered *(Gold 1992).* Exposure to moderate concentrations produce cough, dyspnea, and chest pain, and high concentration can lead to producing pulmonary edema, which can be fatal *(Ayres, Forastiere, and Heinrich 2012).* In addition, nitrogen dioxide exposure aggravates preexisting diseases like asthma and COPD. Health effects after a single exposure of NO_2 for patients with chronic obstructive pulmonary disease (COPD) and asthma have shown that NO_2 is harmful to the upper and lower respiratory tract including the bronchiole and alveoli *(Brauer et al. 2002).*

2.1.4. Carbon Dioxide Sources and Health Effects

Carbon dioxide (CO_2) is primarily a by-product of human metabolism and is constantly emitted into the indoor environment by building occupants. Therefore, the major sources of indoor carbon dioxide in beauty salons are customers and workers. It does not cause severe health effects but stands as a significant index of indoor air quality since it is influenced by the number of persons in a room and the rate of air changes*(Tsigonia et al. 2010).* Another study also describes the level of indoor CO_2 should used as an indicator of indoor air quality and surrogate for the ventilation rate *(Palareti et al. 2016).* High level of CO_2 concentration points to insufficient ventilation of indoor space. Generally, an indoor CO_2 concentration less than 1000 ppm indicates the existence problem of adequate fresh air supply. In crowded and under-ventilated rooms, CO_2 levels may rise to 2000 to 5000 ppm *(Gold 1992).* Another study investigated that the concentrations of CO_2 higher than normal range in the hairdressing areas of the salons. This is because of the over crowdedness of beauty salon with customers *(Al-Marshad 2016).*

2.2 Comfort Parameters

Comfort parameters such as temperature and humidity are important in maintaining good IAQ *(Davis, et al. 2016).* Thermal comfort can be affected by room air temperature, the temperature of the surrounding surfaces, air movement, relative humidity and the rate of air exchange

(Ormandy and Ezratty 2012). Relative humidity is the amount of water vapor that the air is holding compared to the amount it can hold at a specific temperature *(Spengler, Samet, & McCarthy, 2001).* Temperature and RH were found to increase concentrations of air pollutants because of the dense air holding the pollutants *(Bentayeb et al. 2015).* Release of pollutants levels special VOCs into the environment relied on the combination of temperature and humidity effects. The evaporation of the VOCs increased with increasing temperature and relative humidity. High RH (vapor) would prevent VOCs from absorbed by the surface of particles, dust, or residential objects. The main reason for VOCs combined effects is its adsorption effect and solubility decrease to the surfaces of all kinds of materials indoors *(Zhou et al. 2017).*

2.3 Knowledge, Practice and Attitudes towards cosmetic use and application

Cosmetic products are widely used in daily life. Cosmetics are mixture substances intended to be placed in contact with the external parts of the human body or with the teeth and the mucous membranes of the oral cavity. They are used for purpose of cleaning, perfuming, protecting, changing appearance or keeping body parts in good condition (*European Union, 2009).* Knowledge, attitude and practice of peoples towards use of cosmetics vary from one to another. This influences exposure level of people for the chemicals found in the cosmetics products. Children, pregnant women, and beauty salon workers are the most frequently exposed groups for cosmetics and they need special care.

Marie et al. (2016) reported that fifty-five percent of the pregnant women in their study considered cosmetics use as a risk during pregnancy and they changed the type of cosmetics after conceiving baby *(Marie, Cabut, and Vendittelli 2016).*

Another study recommends increasing public awareness about indoor exposure to organic compounds especially among pregnant women and mothers of newborn children is very important because their exposure for VOC has not a short time effect, but it has long time and teratogenicity effect *(Chang et al. 2017).*

2.4 Different guidelines

There is no national established indoor air quality standard in our country. Standards from different international organization like ASHRAE, WHO, US EPA and NOSHA described in Table 2.

Table 2 : Guidelines for indoor air quality parameters

Pollutant Type	**Value**	**Country, Organization**	**Reference**
	1 000 ppm (Ceiling Level)	Malaysia,DOSH	*Tang and Al–Ajmi, 2006*
	600 ppm (High Comfort Level)	**US,**ACGIH	*(Air Duct Cleaners, 2013)*
Carbon Dioxide (CO_2)	No more than about 700 ppm (1 800 mg/m^3) above the outdoor ambient level	US,ASHRAE	*(ANSI/ASHRAE, 2004)*
	No more than about 800ppm(1440mg/m3) for beauty salon	US, ASHRAE	*(ANSI/ASHRAE, 2010)*
	<800 ppm (Preferred)	US, IDPH	*(Schuh, 2000)*
	600 ppm (High Comfort Level)	US, NIOSH	*(ANSI/ASHRAE, 2004)*
	700 ppm above the outdoor level	US, TDH	*(TDH,2003)*
	800 ppm (Allowable air concentration levels)	US EPA	*(Environmental Policy Working Group, 1999)*
	1000 ppm	WHO	*(ANSI/ASHRAE, 2013)*

	1 ppm (1 800 μg/m^3) as 15–min average 37 600 μg/m^3 IDLH)	US, NIOSH	*(ANSI/ASHRAE, 2013)*
NO_2	5 ppm (Ceiling Level)	US, OSHA	*(ANSI/ASHRAE, 2013)*
	0.053 ppm (TWA)	US EPA	*(ANSI/ASHRAE, 2013)*
	200 μg/m^3 (Comfort Level)	Public Works Canada	*(Air Duct Cleaners, 2013)*
TVOCs	200 μg/m^3+outside air concentration	US EPA	*(ANSI/ASHRAE, 2013)*
$PM_{10-2.5}$	70 μg/m^3 daily average	US, EPA	*(Esworthy and McCarthy 2012)*
Temperature	22.5–26.0 °C in summer, and 20.0–23.5 °C in winter (Comfort Level)	ASHRAE	*(TSI, 2013)*
Humidity	40–60% in summer, and 30–60% in winter (Comfort Level)	ASHRAE	*(Air Duct Cleaners, 2013)*

2.5 Conceptual Frame Work

The conceptual framework is very important to link the dependent variables and with predicting variables

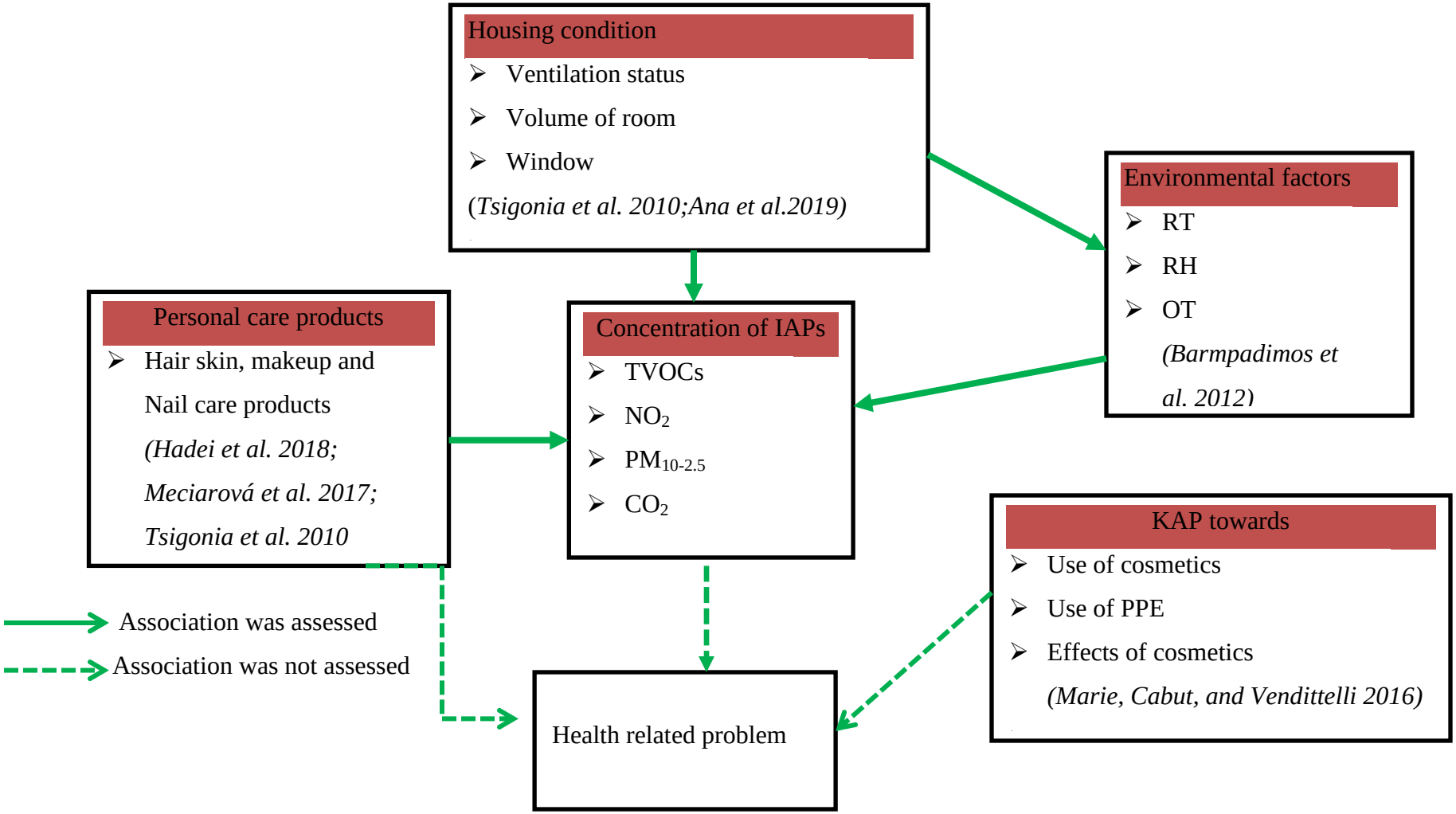

Figure 2 Conceptual framework of the study developed after reviewing literatures

CHAPTER THREE: OBJECTIVES

3.1. General Objective

To assess indoor air pollutant concentration and self-reported health problems among workers working in beauty salons of Jimma town, 2019

3.2. Specific Objectives

- To determine the concentration of $PM_{10-2.5}$, NO_2, TVOCs and CO_2 in the beauty salons of Jimma town
- To identify factors associated with the concentrations of indoor air pollutants in the beauty salons of Jimma town
- To assess self-reported health problems among beauty salons workers of Jimma town

CHAPTER FOUR: METHODS AND MATERIALS

4.1. Study area

The study was conducted in Jimma town, which is located at 354 km from Addis Ababa, Ethiopia. It found at altitude of 1700m above sea level with average annual temperature in between [11°c, 29°c] with humidity of 67% (https://www.timeanddate.com/weather/ethiopia/jimma/climate) According to the 2007 G.C census, the total population of town was estimated at 120,569, and recently the town has over 199,443 populations. In the town, there are 119- female beauty salons.

4.2. Study design and period

A cross-sectional study was conducted from May 13 to 24 /2019.

4.3. Source Population

All female beauty salons in Jimma town are source population.

4.4. Study Population

All female beauty salons those full filled the eligibility criteria.

4.5. Inclusion and Exclusion Criteria

All female beauty salons in the town were included in this study. The Beauty salons attached to small micro industries like a garage, furniture, and those beauty salons with only hair extension or *shiruba* (*local language*) services were excluded from the study. From the total (119) of the beauty salons, 32 were excluded.

4.6. Sample size and Sampling frame

The total number of beauty salon was taken from Jimma town trade and industry office. As they gave, the number of female beauty salon in the town was 119. Using exclusion criteria 87 beauty salons were eligible for this study and the rest were excluded.

4.7 Data collection

4.7.1. For the survey

A semi-structured questionnaire adapted from different published articles and from review of cosmetics practices, products and risks in Africa (*ARSO Central Secretarit 2015)*.This questionnaire was used for assessment of socio-demographic characteristics, housing condition, type of services, KAP towards use of cosmetic, working time and experiences of workers in

beauty salon. The questionnaire prepared in English language and transcribed by data collectors (four Environmental health professionals: two females and two males) and then filled to questioner.

4.7.2. Measurement of Indoor Air pollutants and comfort parameters

For Temperature and relative humidity: *Thermo hygrometer* (CAAL model 303C; Asun Test Ltd., Shenzhen, China) used to measure RH, OT and RT of indoor air. It can measure in the range of RH (10-95 %) and RT (-20- 40^{o}c). It has 3-meter length cable with temperature probe, which is important for sensing of outdoor temperature.

For TVOC, NO_2 and CO_2: *Aeroquals500 (AEROQUAL series 500*; Aeroqual Limited, Auckland, New Zealand) which is an easy-to-use, and has different interchangeable portable sensor that used to measure the concentration of TVOC, CO_2, and NO_2. It is operating within temperature range of 0^{o}c to 40^{o}c, and RH of 15 to 90%. The concentration of each pollutant with a 2-min logging interval time was measured continuously for six minutes and the average value within this time interval was recorded in the notebook of professional. This was entered to personal computer using statistical software. The sampler was calibrated according to the manufacturer's procedure, at a flow rate of 0.03 m^3/h (0.5 l/min). The instrument used a photo ionization detector (PID), non-dispersive infrared (NDIR) and gas-sensitive electrochemical (GSE) sensor for TVOCs, CO_2 and NO_2 respectively.

For TVOCs: When the sampled air is passed through the inlet, ionization of the VOCs molecules by UV absorption occurs, and a detector counts the ions. Its detection range is 0-1000ppm

For CO_2: Infrared light, a narrow band-pass filter, and photodiode used to measure the intensity of light at the gas absorption band. The light intensity is proportional to the gas concentration.

For NO_2: The sensor generates nano-amp currents proportional to the gas concentration

For Coarse particulate matter: Micro dust aerosol monitoring system (Pro 880 nm, Casella Cel, UK) was used to measure $PM_{10\text{-}2.5}$ µm for continuous 6 min within logging time of 1 second. This instrument displays the maximum and average value on the screen within length of specified time. This displayed value was recorded on the professional notebook and entered personal computer using statistical to software. Measurements of pollutants in the beauty salons were taken at a height of 1.5 meters above floor level which is breathing zone and 1 meter from windows and door (*Hadei et al.2018; Ebrahemzadih et al.2018*)

4.8. Variables

4.8.1. Dependent variables

- Concentration of NO_2
- Concentration of $PM_{10-2.5}$
- Concentration of TVOCs
- Concentration of CO_2
- Self-reported health problem

4.8.2. Independent variables

- Environmental factors like temperature and humidity
- The volume of the salon
- Ventilation status
- A distance of beauty salon from road
- personal care products (hair, nail, makeup and skincare)
- Number of clients
- KAP towards cosmetics use

4.9. Data analysis

The data was processed and analyzed in SPSS version 23 (IBM Corporation, NY, USA) at a significance level of $P < 0.05$. Frequencies with percentages were used to summarize categorical variables, mean with standard deviation and median with IQR were used to summarize continuous variables. The results were presented using tables, text and graphs. Because of the continuous nature of the dependent variables, multiple linear regressions were used to identify the association between dependent and independent variables.

Before analysis, all necessary assumptions of linear regression like linearity, normality, homosccedesity, multicollinearty were checked using scatter plot, kolmogrovo-Smirnov, levenes test and VIF respectively. Besides, to kolmogrovo-Smirnov test histograms, tests of skewness and residual analysis indicated that coarse PM, TVOCs and NO_2 were not normally distributed data. For this reason, coarse PM and TVOCs were log-transformed to fit the assumptions and checked again for all assumptions of linear regression analysis. For NO_2, non-parametric test like the sign test was used because it did not fit assumption even after trail of all types of transformation. One-sample t-test was used to compare values with the NIOSH and ASHRAE

permissible limits. Correlations between pollutant levels were performed by determining Pearson correlation coefficients (TVOCs, RH, coarse and CO_2), and Spearman correlation coefficients (NO_2) at $p < 0.05$. At last, multiple linear regressions performed for prediction of pollutant levels in the beauty salon. Variables with p-value less than 0.25 from bivarite analysis were selected as candidate for multiple linear regressions analysis. Insignificant variables removed from model by stepwise selection method. The only significant independent variables were included in the reporting model and then final model with greater value of adjusted R^2selected *(Olejnik et al. 2010)*

4.10. Data Quality Assurance

The quality of data is very important for the validity of the analysis. For this reason, pretest was performed on the questionnaire. Then well-qualified and trained data collectors on questionnaires and professionals of air sampler instruments were properly recruited. Prior to use instruments correctly insertion of sensor head to top of monitor and presence of fully charged battery checked for all instruments. After the data was collected, by using instruments and structured questioners, it was checked for the completeness and consistency, and then edited, coded and entered to personal computer by using Epidata 3.1. Besides, day-to-day supervision implemented to maintain minimum errors of measurements.

4.11. Ethical considerations

Ethical clearance was obtained from Jimma University institutional review board after department of Environmental health sciences and technology confirmed all contents of the proposal. This clearance letter delivered to Jimma town Administrative office to get further permission to reach study population. Before starting study necessary information about; absence of any risk related to instruments used, issue of confidentiality and right of respondents were clearly described. For this, one-page subject information sheet and informed consent letter were attached to each questionnaire.

4.12. Dissemination plan

The purpose of this study is to contribute to existing knowledge and solve the problems of society. The finding from this study submitted to department of Environmental health sciences and technology, postgraduate school, Jimma town administrative office, health office, trade and industry, and others. Publication in national or international journals is also considered.

CHAPTER FIVE: RESULT

5.1 Socio-Demographic Characteristics

The summary of the socio-demographic characteristics is described in Table 3. In all beauty salon, the majority of the respondents were females (93.1%), and (60.9%) of them were married. Among married, more than half of the respondents (52.8%) reported as they worked during pregnancy. The average age of respondents was (26.69 ± 6) years. Generally, the largest proportion (64.4%) of respondents had completed secondary school education followed by college and above education (27.6%).

Table 3: Socio-Demographic Characteristics beauty workers in Jimma town, Ethiopia, 2019

Variable		N (%)
Sex	Female	81 (93.1)
	Male	6 (6.9)
Age		26.69 ± 6[a]
Education	Primary(1-8)	7 (8)
	Secondary(9-12)	56 (64.4)
	College and above	24 (27.6)
Marital status	Married	53 (60.9)
	Unmarried	34 (39.1)
Worked during pregnancy	Yes	28 (52.8)
	No	25 (47.2)
Pregnant women worked	Until 2nd trimester	5 (17.9)
	Until 3rd trimester	6 (21.4)
	Overall the time	17 (60.7)

[a] mean ± SD

5.2 Salon characteristics

Totally, eighty-seven beauty salons were participated in this study. The volume of the salons varied widely in our study population, as shown here in range of (1.86–320 m^3). The mean volume of salon was (38.79 ± 42.4) m^3.The two-third of beauty salon was found within distance of 120 meters from the main road (paved road).The median (50 meters) and mean (180 meters) of distance from edges of beauty salon showed that most of the beauty salons are beside of different vehicle movement areas. This was also confirmed at data collection period by onsite

observation. All beauty salons were using natural ventilations like windows and door. Among all salons, 57.5 % of salons have windows, and only 23% allows for cross ventilation that permits good entrance and movement of outdoor air. In addition to natural ventilation, only seven (8%) of the salons were using artificial ventilation system.

5.3 Occupational History and PPEs Used by Salon Workers

Work experience and reported health problems are described in the Table 4. The average work experience of the respondents was (4.92 ± 4.97) years, and (49.4%) of them reported as they are spending more than eight hours per day. Although hand gloves (93.1%) and gown (80.6%) were reported as mostly used, none of the workers reported about using of the full component of PPE. Respiratory mask and eye goggle were least used PPE with respondents that was 19.4 % and 2.8% respectively.

Table 4: Occupational history and PPEs used by beauty salon workers in Jimma town, Ethiopia, 2019

Variable		N (%)	
Work experience in years		4.92 ± 4.97 [a]	
Time spent in the salon per day	<8 hr.	21 (24.14)	
	8 hr.	23 (26.45)	
	>8 hr.	43 (49.4)	
Working days per week		6.24 ± 0.9 [a]	
		Yes	No
PPE used	Glove	67(93.1)	5(6.9)
	Respirator	14(19.4)	58(80.6)
	Gown	58(80.6)	14(19.4)
	Goggle	2 (2.8)	70(97.2)

Role of respondents

The role of respondents in the beauty salon is described in the Fig 3. One respondent can have more than one role in beauty salon. Multiple responses are possible and sum of percentage can greater than 100.

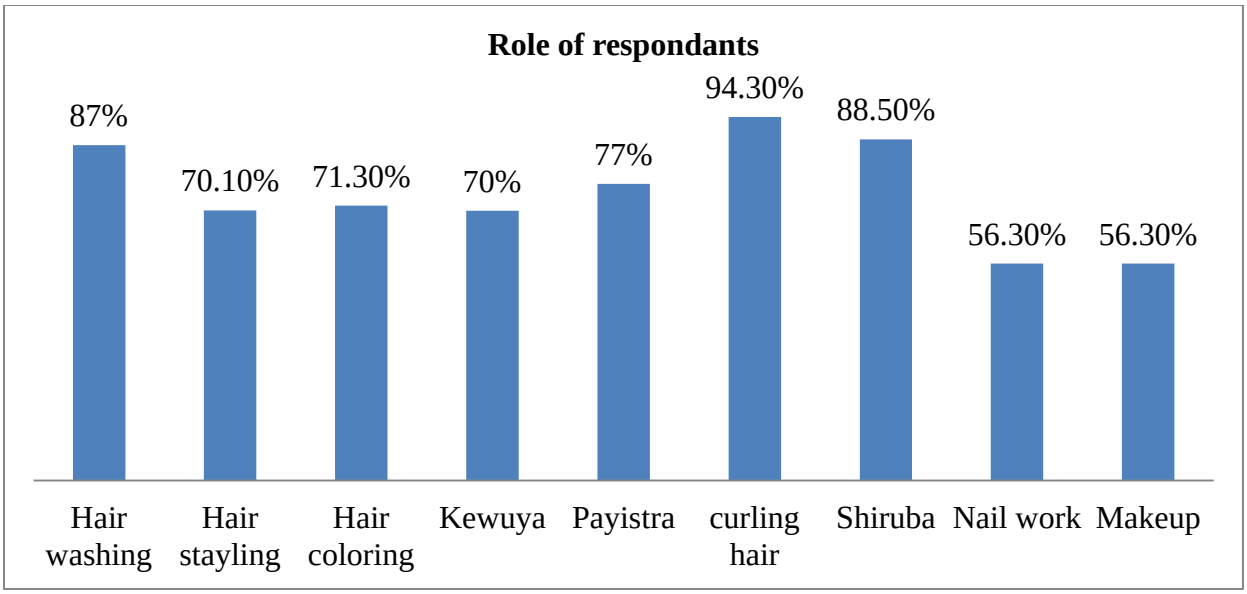

Figure 3: Role of beauty salon workers of Jimma town, Ethiopia, 2019

5.4 Self-Reported Health problems

Almost half (49.4%) of respondents reported the presence of health problems after starting work in beauty salon. The most highly reported problem was respiratory health problems (34.5%) and followed by fatigue (14.9%). All self-reported health problems are listed in the Figure 4.

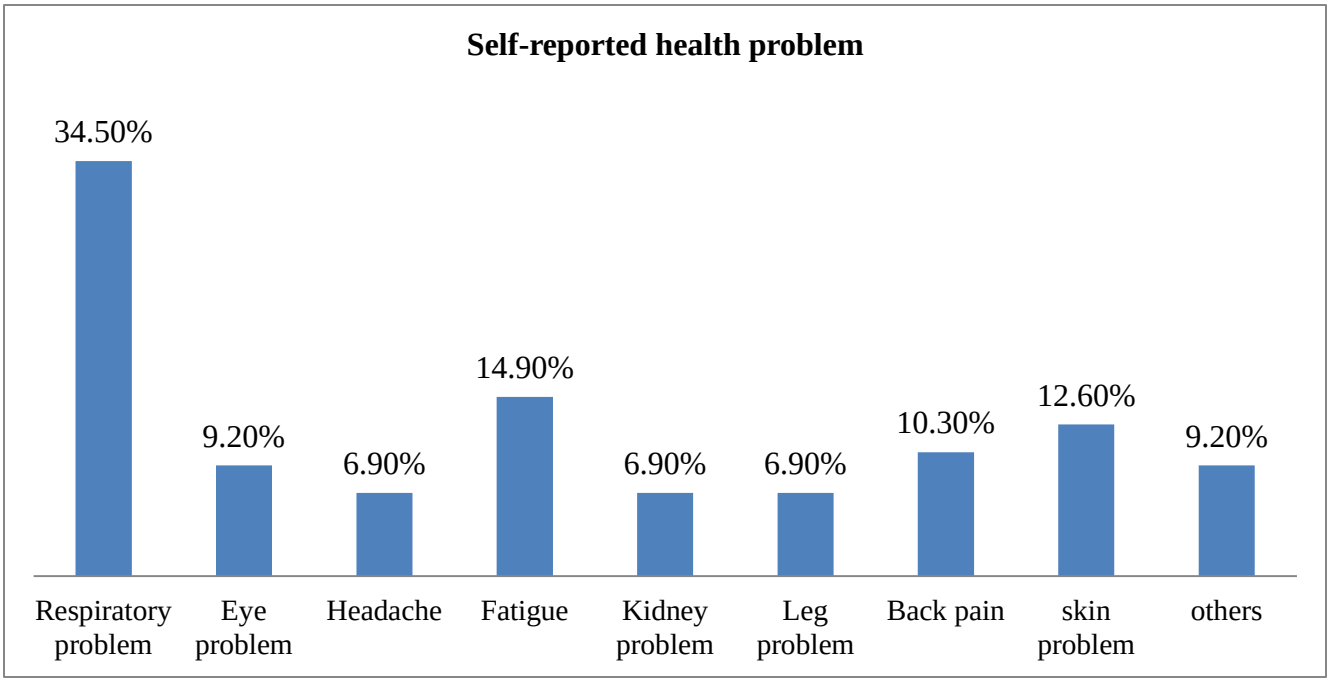

Figure 4: Self reported health problems among beauty salon workers in Jimma town, 2019

5.5 Personal care products used in the salons

In the beauty salons customers were requested the types of personal care services used in the beauty salons. Hair care products were used by all beauty salons followed by skin care products (96.6%). Percentage of all Personal care products used by salons is described in the Fig 4.

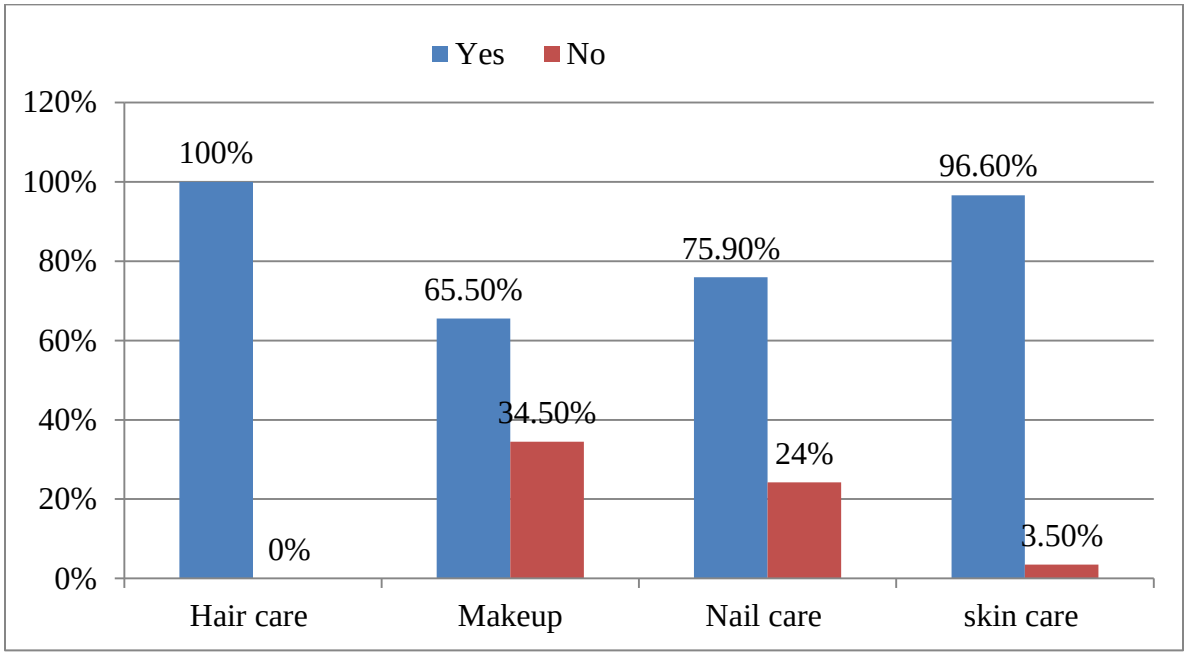

Figure 5 : Types of Personal care services request in beauty salons of Jimma town, Ethiopia,2019

Different types of cosmetics product used within each PCP request category and they are described in Table 5. Most of the salons (above 85%) were using hair care products like Shampoo, hair conditioner, treatments, perm, dye, moisturized cream, oil, food, henna powder and placentyne lotion. Nearly ¾ of beauty salons have nail polish and nail polish remover, and 2/3 of the has nail hardener. Around half of beauty salons use makeup products; foundations, face powder, powder cake, eye shadow etc. From skin care products facial scrub was mostly used in beauty salons (95.4%), and other products (face mask, facial cleanser, sunscreen and facial oil) was found in ¼ of the beauty salons. All type of cosmetic products used in beauty salons are described in the following table.

Table 5: Type of cosmetic products used in beauty salons of Jimma town, Ethiopia, 2019

		N (Beauty salon)	Yes (%)	No (%)
Hair care products	Shampoo	87	100	0
	Hair conditioner	87	98.9	1.1
	Hair treatment	87	88.5	11.5
	Hair moisturizer	87	90.8	9.2
	Hair food	87	96.6	3.4
	Hair oil	87	96.6	3.4
	Placentyne lotion	87	94.3	5.7
	Hair spray	87	36.8	63.2
	Hair glue	87	21.8	78.2
	Hair dye	87	71.3	28.7
	Perm	87	80.5	19.5
	Hair color	87	93.1	6.9
	Henna powder	87	85.1	14.9
	Gel	87	14.9	85.1
Nail care products	Nail Polish	87	74.7	25.3
	Nail Primer	87	44.8	55.2
	Nail polish remover	87	72.4	27.5
	Nail hardener	87	68.9	31
	Finger nail glue remover	87	21.8	78
Makeup products	Foundation	87	50.6	49.4
	Face powder	87	57.5	42.5
	Powder cake	87	44.8	55.2
	Eyes shadow	87	36.8	63.2
	Mascara	87	57.5	42.5
	Liquid eyebrow	87	63.2	36.7
Skincare products	Face mask	87	12.6	87.3
	Face scrub	87	95.4	4.5
	Facial cleanser	87	24	76
	Facial oil	87	33.3	66.7
	Vaseline	87	34.5	65.5
	Sunscreen	87	35.6	64.4

5.6 Knowledge, attitude and practice towards the use of cosmetics

From all respondent, only 10.3% said that cosmetics have importance beyond the purpose of beautification. They described mental satisfaction, health of hair, skin safety and protection as some importance of cosmetics use. In opposite to this, majority (89.9%) of the respondents stated that cosmetics have not importance beyond beautification purpose. Knowledge of respondents for effects of cosmetics on children and pregnant women were assessed, and 72(82.8 %) of the respondents have knowledge about the effects of cosmetics use on pregnancy and children. Among them 42(58.3%) described that cosmetics use can cause negative health effect at late pregnancy time, which is after 6 month, and 19(26.4%) of the respondents described that cosmetics use can cause negative health effect after three month of a pregnancy. All respondents described the absence of health problem at first trimester of the pregnancy. Only seven (8%) of the respondent said that cosmetic has health effect at all the time during pregnancy. From all respondents 81(93.1%) and 76(87.4%) have knowledge about dilution effects of ventilation on cosmetics and importance of PPE use to prevents exposure respectively.

5.7 Concentrations levels of Indoor air pollutants and comfort parameters

Table 6: Average concentrations distribution for IAPs and comfort parameter in mg/m^3, ^oc and %

Parameter	N	minimum	maximum	mean	SD
Coarse PM	87	0.001	3.231	0.356	0.6089
TVOC	87	724.44	2238.72	1190.02	381
NO_2	87	0.01	0.92	0.0974	0.112
CO_2	87	829	2017	1333.92	282.4
RT	87	22.8	29.9	26.222	1.81
RH	87	42	64	55.33	5.62

Salons with cross ventilation had low mean concentration of TVOCs, NO_2 and CO_2, but salons with cross ventilation had high concentration of coarse PM. This is described below in Fig 6.

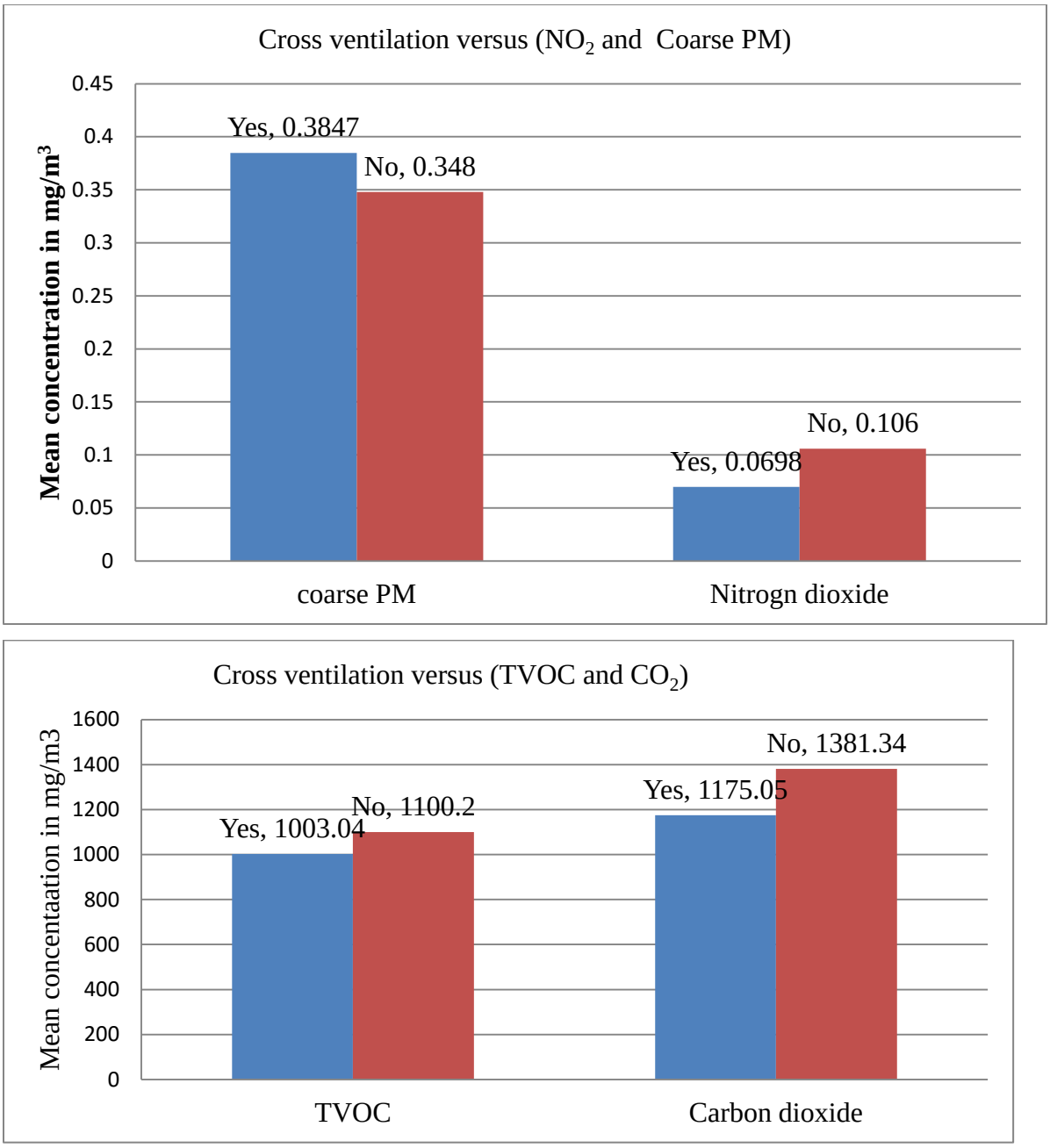

Figure 6: Cross ventilation and Indoor Air Pollutants mean concentration level in beauty salon of Jimma town, 2019

5.8 Correlation of indoor air pollutants

Correlation for IAPs and others parameters are described in Table 7. Outdoor and RT was strongly correlated (r=0.931), and RH was negatively correlated with OT and RT. Coarse particulate in the beauty salons was correlated with temperature; OT *(r= 0.288, p<0.05* and RT *(r=0.27, p<0.05)*. TVOC was negatively correlated with RT & OT, and positively with RH. NO_2

was slightly correlated *(rho= -0.38)* with distance of beauty salon from edge of road. This might be from outdoor source because of vehicles. Carbon dioxide was correlated with number of customers within beauty salon.

Table 7: Correlation Table for Indoor Air Quality parameters and other variables

Parameters	OT	RT	RH	CO_2	$PM_{10-2.5}$	TVOC	NO_2(rho)	Distance	customers
OT	1	0.93**	-0.74*	0.011	0.288*	-0.46**	-0.17	-0.002	
RT		1	-0.82**	0.006	0.27*	-0.517*	-0.14	0.011	0.17
RH			1	0.182	-0.08	0.465**	0.087	0.045	-0.099
CO_2				1	0.138	-0.045	0.008	-0.02	0.249*
$PM_{10-2.5}$					1	0.224*	0.053	-0.081	0.198
TVOC						1	0.203	-0.068	-0.09
NO_2							1	-0.38*(rho)	-0.009
Distance								1	
customers									1

** Correlation is significant at the 0.01 level, * correlation is significant at the 0.05 level

One sample t-test

The mean of RH and CO_2 was significantly less than the standard limit of ASHRAE. However, the mean value RT and TVOC was greater than hypothesized value. This is described in Table 8.

Table 8: One sample t-test table

Variable	**t-test**	**p-value**	**Mean difference**	**95% CI**	**Test value**
RH	-7.74	<0.001	-4.667	[-5.87, -3.47]	60%(*ASHRAE,2010)*
RT	1.14	0.257	0.222	[-0.16,0.61]	26^0c *(ASHRAE,2010)*
CO_2	-3.5	0.001	-106.1	[-166.3,-45.9]	1440mg/m^3*(ASHRAE,2010)*
TVOC	29.067	<0.001	1189.82	[1108.5,1271]	0.2mg/m^3(*Mølhave 1991*)

In all beauty salons, the concentration of NO_2 was less than NIOSH short time limit standard, which is 1.88mg/m^3. The IQ1, median and IQ3 value for NO_2 was 0.059, 0.085 and 0.098 mg/m^3.

5.9 Multiple linear regression analysis

Bivariate linear regression was used to select candidate variables for multiple linear regressions. From bivariate analysis predicting variables with p-value ≤ 0.25 were selected as candidate for linear regressions analysis. This is described below in the Table 9

Table 9: Bivariate analysis for candidate variable selection

	P- vale from bivariate analysis		
Variable	CO_2	Log10tcoarse PM	Log10tTVOC
Volume of room	0.726	0.594	0.396
Window status	<0.001*[c]	0.366	0.12[a]
Cross ventilation	0.005*[c]	0.201[b]	0.049[a]
Distance from the main road		0.459	0.893
RT	0.956	0.12[b]	<0.0001[a]
OT	0.917	0.07*[b]	<0.001[a]
RH	0.092*[c]	0.065 [b]	0.01[a]
NO_2		0.25[b]	0.168[a]
CO_2		0.204[b]	0.168[a]
Log Transformed PM coarse			0.037[a]
Log Transformed TVOC		0.037[b]	
Customers #	0.02*[c]	0.065[b]	0.376
Hair care products			
Hair conditioner		0.537	0.069[a]
Hair treatment		0.651	0.0647[a]
Hair moisturizer cream		0.853	0.001[a]
Hair food		0.448	0.559
Hair oil		0.524	0.927
Placentyne lotion		0.848	0.37
Hair spray		0.168 [b]	0.05 [a]
Hairstyling spray		0.276	0.684
Hair glue		0.091 [b]	0.693
Hair dye		0.163[b]	0.61
Perm		0.047[b]	0.697
Hair color		0.524	.701
Henna Powder		0.984	0.804

Gel	0.109*[b]	0.249[a]
Makeup care products	0.018[b]	0.96
Foundation	0.0102*[b]	0.949
Face powder	0.011*[b]	0.989
Powder cake	0.008*[b]	0.943
Eye shadow	0.013*[b]	0.941
Mascara	0.011*[b]	0.980
Liquid eyebrow	0.019*[b]	0.972
Lip protestants	0.018*[b]	0.997
Makeup remover	0.015*[b]	0.989
Skincare products		0.521
Face mask	0.82	0.512
Facial scrub	0.922	0.482
Facial cleansers	0.873	0.537
Facial oil	0.648	0.736
Petroleum gel	0.361	0.622
Sunscreen	0.763	0.763
Nail care products		0.015[a]
Nail polish	0.532	0.019*[a]
Nail primer	0.471	0.129*[a]
Nail polish remover	0.515	0.164*[a]
Nail Hardener	0.497	0.185*[a]
Fingernail glue	0.416	0.183*[a]
Fingernail glue remover	0.321	0.214*[a]

[a] candidates' variables for multiple linear regression of TVOC

[b]candidates' variables for multiple linear regression of coarse PM

[c]candidates' variables for multiple linear regression of CO_2

****[a],*[b] and *[c] variables removed because of multicollinearity***

5.9.1 Predictors for indoor air pollutants

After identifying candidate variables multiple linear regressions analysis were performed to find predicting variable of the concentration level of indoor air pollutants. The out puts for each pollutant from SPSS are described in the Table 10.

Predictors for TVOC: The model explains 35.7 % of the variance in TVOC, and this is statistically significant at p<0.001. Room temperature is negatively associated with TVOC such that, adjusting for the other variables in the model, for one unit increase in RT, $\log TVOC$ is predicted to decrease by 0.034 units, and this association is statistically significant (p<0.001). The presence hair spray and nail care service increases the $\log TVOC$ by 0.09 and 0.056 respectively.

Predictors for coarse PM: The model explains 15.6 % of the variance in coarse PM, and this is statistically significant at p=0.01. Room temperature and RH is positively associated with coarse PM. One unit increase for RT by considering other variables constant$\log PM$ is significantly predicted to increase by 0.212 units, and this is statistically significant (p=0.001). For one unit increase of RH the $\log PM$ predicted to increase by 0.048. Considering other variables as constant for the absence of makeup products the $\log PM$decreased by 0.329.

Predictors for CO_2: The model explains 17.6 % of the variance in CO_2, and this is statistically significant at p<0.05. Customers and cross ventilation is positively associated with CO_2. For increase of customer by one, the CO_2 predicted to increase by 27.68 units. The average difference in cross and not cross ventilation is 167.8 mg/m^3

Table 10: Multiple linear regression outputs

IAPs	***Parameter***	***Coefficients B***	***Std. error***	***p-value***	***95% CI For B***	***Adi R^2***
	Constant	4.125	0.16	<0.001	[3.806,4.44]	0.357
TVOCs	*RT*	-0.034	0.006	<0.001	[-.046,-.022]	
	Hair spray	-0.09	0.033	<0.001	[-.155, -.024	
	Nail care products	-0.056	0.025	0.029	[-.106,-.006]	
coarse	*constant*	-8.71	2.58	0.001	[-13.82,-3.56]	0.156
PM	*RT*	0.212	0.061	0.001	[0.09,0.33]	
	Makeup	-0.329	0.135	0.017	[-0.598,-0.06]	
	RH	0.048	0.02	0.017	[0.009, .087]	
CO_2	*constant*	960.56	114.3	<0.001	[755.7,1122]	0.176
	Cross ventilation	167.8	63.6	<0.001	[96.8,317.9]	
	customer	27.68	13.4	0.042	[6.49, 57.37]	

CHAPTER SIX: DISCUSSION

Although the beauty salon workers were exposed to varieties of potentially hazardous chemicals, in this study no one reported for using of full components of PPE while working. Among respondents, 76(87.4%) knew about the benefits of PPEs, but the majority of them were not using it during onsite observations. Most of respondents reported as they were using hand gloves and gown at time of hair dying for the safety of their hands and clothes. However, this is not protective way of using PPE. Respiratory mask (19.4%) and eye goggle (2.8%) were reported as least used equipment's that indicated the workers were poorly protected from pollutants those could harm eye and respiratory system. In line with this study, different studies investigated low coverage use of PPE among beauty salon workers*(Hammam et al. 2014; Mandiracioglu et al. 2009).*The study by *Ana et al. (2019*) also indicated that only 29.2% of hair salon workers used any type of PPE in Ibadan, Nigeria. In conclusion, most respondents were not using PPE as well in protective ways so that they are highly likely exposed to chemicals present in the beauty salons.

Different studies identified presence of chemicals emission in the beauty salons from nail work, hair care, body makeup and skincare products which could harm the health of workers in the environment of working *(Ana et al. 2019; Gennaro et al. 2014; Goldin et al. 2014; Tsigonia et al. 2010).* In the present study, about half (49.4%) of the respondents reported the presence of health problems like skin, respiratory problem, eye and kidney problem, and low back and leg pain. All cases reported, except kidney problem are indicative and expected from the work nature of beauty salons, where the long-time standing, inhalation of emitted pollutant and skin contact with chemical is practiced at most of the working time within a day. This is in line with study by *Mandiracioglu et al. (2009)* which described reported disease like back pain(27%), headaches (5.8%), varicose (15.5%), and fungal infection (1.1%) among hairdresser and barbers. *Ana et al. (2019)* described presence of health-related problems like catarrh, cough, low back pain, hand pain and leg pain among half (48.4%) of salons workers. Another study also investigated musculoskeletal diseases (88.64%) followed by dermatitis (73.86%) among cosmologies in hair salons of Dar Es Salaam, Tanzania *(Bigambo 2016).* In this study the problem of kidney was reported by six respondents (6.95%) needs further study to confirm the association of beauty salon occupation and kidney diseases. Some researchers explained that specific VOC exposure was related with kidney dysfunction, but they recommended human studies with follow up

design to confirm this finding *(Chang et al. 2010).* Some scholars found the effect nail primer, nail polish, hair dye and other cosmetics product on kidney problem *(Okereke et al. 2015; Osadolor, Igharo, and Onyeogalu 2016).* Current study has limitation to conclude this finding, so that the characterization of chemicals and their health effects on beauty salon workers needs further studies.

Concentrations of pollutants in salons with different building characteristics were compared. Floor area and volume of salons were not significant to affect the air pollutant concentrations ($p > 0.05$). However, the type and the way of ventilation were significant on concentrations of pollutants. Acceptable general ventilation in work places is important irrespective of the potential contaminants in the indoor air. In this study, most of the salons did not allow cross ventilation this indicated absence adequate general ventilation. In (92%) of the salons, there was no artificial ventilation, which is important for maintaining good quality of indoor air. *Ana et al. (2019)* described that reliance on only natural ventilation might expose workers to many health problems. Absence of enough amounts of artificial ventilators might be factor for the increase of indoor air pollutants. Salons with cross ventilation have low mean concentration of NO_2, CO_2 and TVOC, but salons without cross ventilation has high mean concentration of similar pollutants, which is described in Fig 5.This is because of the effect of general ventilation. This finding is supported by another study which investigated the effect of inadequate ventilation on the level of pollutants during indoor air quality assessment of beauty salons (Gennaro et al. 2014). They reported that salons with good ventilation have a low concentration of VOC and vice versa. In contrast with these findings, the concentration level of coarse PM in this study is high in the salons with cross ventilation. This might be because of other factors that affect coarse PM like TVOC, temperature and others.

The mean RT ($26.22 \pm 1.8 C^{o}$) in beauty salons was significantly higher than the ASHRAE limit (Table 4). Different studies investigated that the temperature scale of beauty salon was above the comfort level of ASHRAE *(Ana et al. 2019; AS Hassan 2010; Park, Gwak, and Choi 2014).* The value of RT was positively correlated *($r=0.932$ at $p< 0.05$)* with OT level. This study is in line with the study of *Nguyen, Schwartz, and Dockery (2014)* which investigated presence of positive correlation between OT and RT in Greater Boston, MA, USA. In 94.25% of the beauty salons, the values of I/O ratio were greater than one. This might be because of the activities performed in the salons. The mean indoor RH (55.33 ± 5.62) values among selected salons were within range

of the comfort level ASHRAE (30–60%). However, 15(17.24%) of beauty salon were found above this limit level. Room temperature and RH were highly correlated *(r= -0.735 at p<0.05).* This finding is similar to the finding of *Ana et al. (2019)* who explained the negative correlation between RT and RH with (*r= -0.911 at p=0.01).*This is because of the presence of high water vapor in warm air than cool air.

For a long time, indoor carbon dioxide concentration level was used as an indicator of indoor air quality. Although CO_2 is a good indicator of pollution caused by sedentary human beings, it is often a poor general indicator of real IAQ. Because it does not recognize many perceivable pollution sources not producing CO_2 *(Olesen 2004).* The mean value (1333.92 mg/m^3) of carbon dioxide was found below the ASHRAE recommended limit of carbon dioxide, which is 1440 mg/m^3. However, in 28(32.2%) of the salon the CO_2 value was found greater than ASHRAE recommended level value for beauty salon *(ASHRAE 2010).* This is not described, as indoor air quality is perfectly good. The instantaneous short time measurement in beauty salon showed that concentration of CO_2 was below ASHRAE standard 62 guideline limits (Ana et al. 2019). Different study investigated the mean concentration of CO_2 above the limit of ASHRAE standards' limit *(Goldin et al. 2014; Roelofs and Do 2012).*This might be because of the number of customers or materials and methods used in the studies.

Ventilation status and number of customers in the salons significantly predicted the concentration level of CO_2. As shown in Table 10 the concentration level of CO_2 decreases for cross ventilation, and increases with number of customers. This finding is supported by another study which referred the concentration of CO_2 was dependent in customers number and ventilation status *(Laura J. Goldin et al. 2014; Roelofs and Do 2012; Tsigonia et al. 2010).* This is because human beings are known source of carbon dioxide, and the level is influenced by adequate ventilation, which allows entrance of fresh.

Coarse particulate matter was weakly correlated with OT and RT. It was more correlated by outdoor temperature than indoor temperature. This might be because the effect of outdoor temperature on the generation of dust particle. This is supported by another study that described the effect of OT in re-suspension of drier soil particles which can contribute to indoor particulate matter *(Barmpadimos et al. 2012).* Although coarse PM highly correlated with OT, RT significantly predicted it. This indicated the effect of beauty salon activities on the concentration

of coarse PM. In addition, in this study the concentration level coarse PM and RH was positively correlated. *Hernandezet al. (2017)* investigated natural deposition process of PM in high and low level of RH. They said that PM were positively correlated up to75% of RH and negatively at high RH. In this study, RH was found below 64%, so the existence of positive relation is supported with preexisting knowledge. The concentration level of PM and TVOC was correlated *(r=0.224, p=0.05*) which is indictor of indoor contribution of particulate matter. The study by Ana et al. (2019) investigated the positive correlation between PM_{10} and TVOC(*r=0.209, p<0.05).* In this study, coarse particulate matter was significantly predicted by cosmetics special for makeup products. This is supported by others studies. From analysis of suspended particulate matter in beauty salon *Rogula-kopiec et al. (2018)* invistagated increase of organic and elemental carbon bonded to particulate matter. They concluded that cosmetics and activities in the beauty salon have impact on concentration level and characteristics of particulate matter *(Rogula-kopiec et al. 2018).* For comparison, there was no available standard for indoor coarse particulate matter and this limit to compare finding.

TVOC in the beauty salon is a known type pollutant because beauty salons have variety of cosmetics products that contains volatile compounds. In this study, the high TVOC concentration recorded due to activities and cosmetics products. The mean concentration of average TVOC was 1190mg/m^3 which is greater than the human being comfort level of TVOC;200µg/m^3(*ANSI/ASHRAE 2013;Mølhave 1991*). When compared with other studies, that measured TVOC for short time, the level of the concentration in this study was much higher with wide variation. The study by *Goldin et al. (2014*) in nail salon was found the median and maximum of TVOC as 11 and 87 mg/m^3 respectively. In this study median and maximum of TVOC was found 1171 mg/m^3 and 2238mg/m^3respectively. This shows high variation might be because of difference in cosmetic products, salon status and other factors. *Tsigonia et al. (2010)* found the short time measurement of TVOC in beauty salon in range of 0.1 to 14.5mg/m^3. In this study, TVOC was negatively correlated with temperature, and positively by RH as shown in Table 5.Similar study of TVOC in beauty salon investigated the negative correlation with temperature and positive with relative humidity(*Ana et al. 2019).* In contrast, another study had found positive correlation with temperature and negative correlation with relative humidity *(Hadei et al. 2018).* This difference might be because of presence diverse compounds with different boiling points. This might be reason for the variation of correlation. The average concentration of TVOC in this

study was higher than the other short time studies of VOC *(Goldin et al. 2014; Tsigonia et al. 2010).* Room temperature and presence of cosmetics products significantly predict the concentration of TVOC in the beauty salons. Therefore, lack of adequate ventilation is a significant concern because of the presence of high concentration level of IAPs that might have potentially hazardous chemicals in salon products and the common self-reported health problems among workers.

The median concentration (0.85mg/m^3) of NO_2 was significantly less than NIOSH short time limit standard, which is 1.88mg/m^3. Besides, all salons concentration of NO_2 values were less than NIOSH standard. Nitrogen dioxide has statistical significant correlation, *(rho=-0.38*), with distance from edge of road. This might be of because of the vehicle effects. This was described by another study which investigated relation between the distance and nitrogen dioxide(*Gilbert et al. 2003*). This indicated that there is possibility of exposure to workers and customers in beauty salons for outdoor air pollutant besides to indoor source of pollutants.

There is some limitation in this study. The total exposures to pollutants, characterization of pollutants and health risk estimation to specific compounds could not be determined. Last, the concentrations reported in our study represent short-term measurements and may not be representative of annual average or full shift work time exposures or conditions

CHAPTER SEVEN: CONCLUSION and RECOMMENDATIONS

7.1 CONCLUSION

Indoor air pollutants concentration levels; TVOCs and CO_2 in beauty salons were found above the comfort level of human being as suggested by ASHRAE limit. Due to this, the quality of indoor air was compromised which can affect workers working in beauty salons, and customers visiting for different services. Activities in the salon, cosmetics products and comfort parameters (RH and RT) are a factor significantly influences the concentration level of TVOCs. Some common self-reported health problems among workers were investigated with majority of respiratory health problem, which indicated the exposure effect of air pollutants on respiratory system of the workers. In addition, the workers for not using fully package of personal protective equipment (PPE) indicated they were ignorant or less informed of the risks involved in their work. Exposure to these IAPs in salons can be reduced to acceptable levels by through different strategies, which are discussed below in recommendations part.

7.2 RECOMMENDATIONS

Lack of adequate ventilation is a significant concern in beauty salon. Availing mechanical and natural ventilation in a way that allows cross ventilation is highly recommended to owners of beauty salon to reduce exposure for pollutants. Use of full component of personal protective equipment in protective manner is recommended to all beauty salon workers. In addition, there is an urgent need for health education of workers by public health agencies about the effects of chemicals in cosmetics products and the way of strategies for management of risks due to these chemicals. Regular inspection/supervision of occupational health issues in working environment is another recommendation for all stakeholders; health office, labor and social affairs office, and trade and industry office of Jimma town to reduce risks to workers and customers. Drug and food administration authorities recommended to strength monitoring and controlling system for type of ingredients in cosmetics products. For researchers and scientific community, further studies on full shift work time exposure, characterization of TVOCs and health risk estimation due to specific VOCs exposure for workers was recommended.

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Annex 1 Questionnaire

Jimma University, Faculty of Public health, Department of Environmental health sciences and technology

The questionnaire prepared to determine indoor air pollutants and self-reported health problem among workers working in beauty salon of Jimma town, Ethiopia.

Verbal consent and permission form before starting an interview

Greeting !

How are you, we are data collectors assigned from project team from Jimma university department of environmental health sciences and technology. Know we are going to collect information regarding indoor air pollutants sources and their health effects in beauty salon of Jimma town. This study is important for society including you, your family and community. To determine the magnitude of indoor air pollutants in your home we will use onsite reading instrument, which is not harmful for anybody including children and all age groups. All information has given by you will be kept strictly confidential. Your participation in this interview is without any obligation of me, but it is with your will. If there is any discomfort at time of interview, please fill free to drop it any time. Thanks very much for your response! Could I have permission to continue?

If yes, continue the interview

If no, write reason for refusal…….

And skip to next participant.

Interviewer: Name……signature …. …….

Date……Time started… Time completed…

Checked by Supervisor: Name…… Signature……Date……

Name of the interviewer: _____

Date of the interview: _____

Name of the supervisor: _____

Name of the kebele _____

Beauty salon Code _____

Housing condition

1. Ownership _____

    1. Private 2. Rented

2. Availability of license

    1. Licensed 2. Unlicensed

3. Age of the respondent _____year.

4. Sex of the respondent

    1. Male 2. Female

5. Marital status

    1. Married 2. Unmarried 3. Others

5. Educational level _____

6. Window to room size ratio

    1. Salon room size (Volume) _____m (length) * _____m (width)* _____m (height)

    2. Salon room window size (Area)_____ m^2

7. Ways of natural ventilation

    1. Cross 2. Parallel 3. Not at all

8. Artificial ventilation

    1. Yes 2. no

9. Distance from the main road (estimated) _____meter

Hair care products

11. Do customers request hair care products?

    1. Yes 2. No

12. If your response is yes to Q # 11, select from the following table (multiple answer is possible).

S. No	**Item**	**Requested**	
		Yes	No
1.	Shampoo		
2.	Hair conditioner		

3.	Hair treatment		
4.	Hair moisturizer creams		
5.	Hair food		
6.	Hair oil		
7.	Placentyne lotion		
8.	Hair spray		
9.	Hair styling spray		
10.	Hair glue		
11.	Hair dye		
12.	Hair relaxer cream (perm)		
13.	Hair color cream		
14.	Henna powder		
15.	Gel		
16.	Others please specify _____		

Makeup(s)

13. Do customers request makeup(s)?

1. Yes 2. No

14. If your response to Q #13 is yes, select from the following table (multiple answer is possible).

S. No	**Item**	**Requested**	
		Yes	No
1.	Foundation		
2.	Face powder		
3.	Powder cake		
4.	Eye shadow		
5.	Mascara		
6.	Liquid eyebrow		
7.	Lip protectants		

8.	Makeup remover		
9.	Others please specify _____		

Skin care product(s)

15. Do customers request to apply skin care product(s)?

1. Yes 2. No

16. If your response to Q # 15 is yes, select from the following table (multiple answer is possible).

S. No	**Item**	**Requested**	
		Yes	No
1.	Face mask		
2.	Facial scrub		
3.	Facial cleanser		
4.	Facial oils (moisturizer)		
5.	Petroleum gel (Vaseline)		
6.	Sunscreen		
7.	Others please specify _____		

Nail care products

17. Do customers request to apply nail care products?

1. Yes 2. No

18. If your response to Q #17 is yes, select from the following table (multiple answer is possible).

S. No	**Item**	**Requested**	
		Yes	No
1.	Nail polish		
2.	Nail primer		
3.	Nail polish remover		
4.	Nail Hardener		
5.	Finger nail glue		

6.	Finger nail glue remover		
7.	Others please specify _____		

Exposure and health risk assessment

19. What is your role in the beauty salon?

_____

_____

20. For how long do you stayed at work?

1. Per day _____ hours

2. Per week _____ days

21. Work experience in a beauty salon? _____ years

22. Do you face any health problems after started working in a beauty salon?

1. Yes 2. No

23. If yes for Q # 22, what kind of health problem?

1. Skin problem

2. Respiratory problems

3. Eye problem

4. Headache

5. Fatigue

6. Nausea

7. No health problem noticed

8. Others specify

_____

_____

24. Do you have under five years of child staying with you in a beauty salon?

1. Yes 2. No

25. Have you observed any health problem on your child?

1. Yes 2. No

26. If yes for Q # 25, what kind of health problem?

1. Skin problem

2. Respiratory problems

3. Eye problem

4. Headache

5. Fatigue

6. Nausea

7. No health problem noticed

8. Others specify

_____

_____

Knowledge

27. Does use of cosmetics has importance for health beyond beautification?

    1. Yes 2. No

28. If yes for Q # 27, please mention

_____

29. Do you know that all chemicals have human health effects?

    1. Yes 2. no 3. Sometimes

30. Do you know that use of cosmetics in the presence of children have health effect to them?

    1. Yes 2. No

31. Do you know that the use of cosmetics has effect on pregnancy?

    1. Yes 2. No

32. If yes for Q # 31, at what gestion (months of pregnancy)?

_____

33. Do you know that ventilation has dilution effect on concentration of cosmetics?

    1. Yes 2. No

34. Do you know that the use of personal protective devices prevent exposure to cosmetics?

    1. Yes 2. No

Attitudes

Disagree =1, I do not know =2, Agree =3

Items		**1**	2	3
35.	All cosmetics contain chemicals harmful to human health.			

36.	Applying cosmetics in an indoor environment results in health problem.			
37.	Exposure of under five children to cosmetics have harmful health effect.			
38.	Exposure of pregnant women to cosmetics is harmful for the mother.			
39.	Exposure of pregnant women to cosmetics is harmful for the mother and the baby.			
40.	Exposure of workers to cosmetics is harmful for their health.			
41.	Exposure of customers to cosmetics is harmful for their health.			
42.	Exposure to cosmetics in well ventilated indoor environment results in reduced health problem.			
43.	Exposure to cosmetics in less ventilated indoor environment increased the effect on human health.			
44.	Use of personal protective devices reduces the exposure to cosmetics.			

Practice

45. Have you ever worked in a salon during your pregnancy?

1. Yes 2. No

46. If yes for Q # 45, for how long (months) _____

47. Do you use personal protective devices at work?

1. Yes 2. No

48. If your response to Q # 47 is yes, select from the following table (multiple answer is possible).

S. No	**Item**	**Used**	
		Yes	Yes
1.	Glove		
2.	Respirator		
3.	Gown		
4.	Goggle		
5.	Others please specify _____		