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# Occupational Health Hazard and Safety Measures Among Aluminum Smelters in Saki, Oyo State: A Cross-Sectional Study

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***ABSTRACT****: Aluminum is widely used in the production of cookware due to its exceptional malleability, high thermal conductivity, lightweight properties, durability, affordability, and widespread availability. These characteristics make it economically advantageous for artisanal aluminum cookware manufacturers. This study investigated occupational health hazards and safety practices among aluminum smelters in the Saki East and Saki West Local Government Areas of Oyo State, Nigeria. A total of 225 artisanal aluminum cookware workers participated by completing structured questionnaires, which collected data on their work history and health-related hazards. Heart Rate (HR) was measured every 10 minutes using a digital stethoscope (3M™ Littmann® CORE). Simultaneously, Core Body Temperature (CBT) was recorded hourly using an electronic digital thermometer (4000 Series, range: 31.6–42.2 °C) over an eight-hour work period. The analysis of the data revealed that the majority of participants were male. Heat strain was the most frequently reported symptom, affecting 23% (59) of respondents, followed by muscle cramps (18%, 45 respondents) and racing heartbeat or palpitations (14%, 36 respondents). Outdoor temperatures ranged from 101 to 108 °F, while average body temperatures varied between 89 and 99 °F, with a mean of 83.57 ± 0.12 and a standard deviation of 7.5469. Awareness of occupational hazards varied among respondents: 168 (65.9%) were aware of health risks, while 87 (34.1%) were not. In terms of knowledge levels, 36 (27.3%) had a good understanding of hazards and safety measures, 64 (48.5%) had fair knowledge, and 32 (24.2%) had poor knowledge. The study concludes that interventions by regulatory agencies are essential for improving the workplace conditions, health, and safety of artisanal aluminum cookware workers.*

***Keywords: Artisanal aluminum cookware, Health rate, Core body temperature, Heat strain.***

## 1. INTRODUCTION

Foundry work is fundamental to human history and technology [1]. It represents one of the oldest industrial sectors, with metal casting among the most basic metallurgical processes. This process typically involves pouring molten metal into a mold that is shaped to create the desired final product [1,2]. Foundries employ various metallurgical techniques to extract and refine metals from ores. Molding, melting, and casting operations generate heat, noise, dust, fly ash, and oxides of nitrogen, sulfur, and metals [2]. Within the context of the Nigerian small-scale manufacturing sector, the metalworking industry, including aluminum cookware, significantly contributes to the productive structure of the economy due to its technological content and added value [3]. The artisanal aluminum cookware industry utilizes recycled aluminum alloys sourced from waste materials in building construction, including siding, doors, and windows, as well as automobile components such as discarded pistons, damaged engine blocks, and manifolds. Additionally, waste packaging materials like beverage cans and electrical components are repurposed for the production of various aluminum cookware [4]. The annual average production has increased due to the growth of the artisanal cookware sector, which represents the primary demand for recycled aluminum products used in manufacturing cooking pots, charcoal pots, and other household utensils [6].

## 2. LITERATURE REVIEW

Despite advancements in foundry technology and materials, core processes and their associated hazards often remain unchanged. Workers in foundries are frequently exposed to common air pollutants, including smoke, dust, and suspended particulate matter (SPM), as well as hazards such as hot metal, fire and explosions, extreme temperatures, ionizing and non-ionizing radiation, noise and vibration, inhalable agents, and skin contact with chemicals [7,8]. Additionally, significant quantities of particulate matter are released during the preparation of mold and core sand, melting and pouring processes, and material handling [9]. The potential health effects of increased heat stress experienced by individuals using artisanal aluminum cookware include discomfort, fainting due to heat, heat stroke, prickly heat, irritability, dehydration, heat rash, reduced concentration, heat cramps, decreased tolerance to chemicals and noise, and heat exhaustion [5]. These conditions represent the most severe forms of heat-related illness, with heat stroke being life-threatening and potentially causing permanent damage to the heart, kidneys, and brain. The severity of these effects is exacerbated during hot seasons [9,10]. Cooling mechanisms are often inadequate for maintaining a stable core temperature when the body loses excessive fluid due to heat exposure. This can lead to physiological heat strain, resulting in various heat-related illnesses that vary in severity [21]. Kongerud and Søyseth [11] offer an in-depth review of respiratory disorders linked to occupational hazards in the aluminum production industry. Evidence from cross-sectional studies shows a higher occurrence of respiratory symptoms with increased exposure and longer periods of employment. However, the limitations of these study designs make it difficult to establish clear causal relationships. When it is not possible to prevent or mitigate heat exposure through other means, appropriate personal protective equipment (PPE) must be provided. PPE can complement other control measures, including eyewear such as ultraviolet glasses and radiant energy-reflective face shields, non-flammable, heat-reflective clothing and gear, water-cooled bodysuits or vests, and protective gloves and footwear [12,13]. Molten metal presents a significant hazard in foundry environments. Workers who handle or work near molten metal are at risk of contact with splashes and exposure to radiant heat. These hazards can lead to severe burns in melting and pouring areas. Eye damage, including cataracts, may result from sparks and exposure to infrared and ultraviolet (UV) radiation [14-16]. The flowchart in Figure 1 illustrates the scrap aluminum casting process, which includes the collection of recycled aluminum, pretreatment, melting, mold preparation using green sand, pouring of the molten metal, collection of cast samples, and subsequent inspections [17]. This study, therefore, investigates the occupational health hazards and safety practices among aluminum smelters in the Saki East and Saki West Local Government Areas of Oyo State, Nigeria.

## 3. RESEARCH METHODOLOGY

A cross-sectional study was conducted to assess the occupational health risks among foundry workers in the Saki East and Saki West local government areas, including Ago-Amodu,

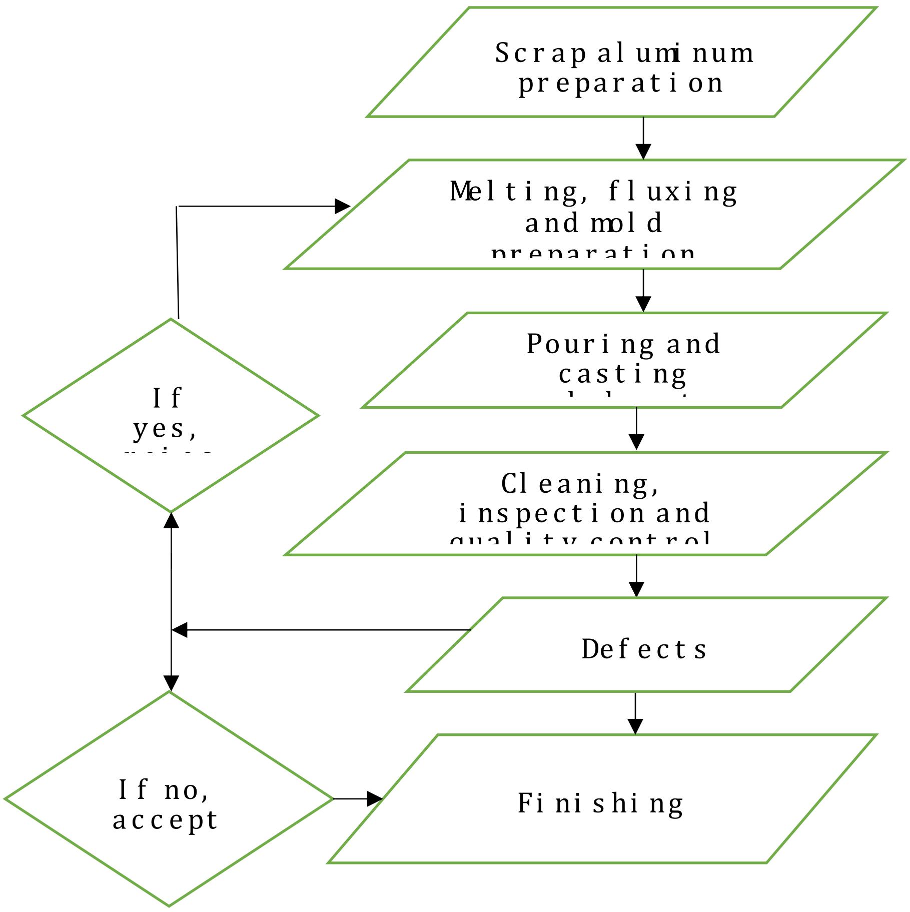


*Figure 1. Flowchart of the scrap aluminum casting process*

Sepeteri, Ogooro, Oje-Owode, Agbonle, Wewe, and Asabari, over three months from January 1, 2025, to March 31, 2025. The researcher took into account the peak summer temperatures in the Saki Local Government areas, which last for five months (November to April), as this is crucial for the study. Consequently, an in-depth evaluation of heat stress and strain was performed. Figure 2 presents an aerial view of Saki township in Oyo State, depicting Saki West, Atisbo Local Government area, and several other districts. Figure 3 illustrates the local pit furnace used for melting, refining, and treating recycled aluminum alloys. A pre-formulated questionnaire was employed to assess the hazards associated with artisanal cookware within the selected local government areas. Due to its efficiency and convenience in data collection and resource management [16,17], questions regarding compliance with health and safety regulations at the foundry were administered to the participants. Additionally, oral interviews were conducted with the participants. Interviewing can serve as a method for both positivist and phenomenological research. In positivist research, interviews typically consist of closed questions, while phenomenological research often employs unstructured or semi-structured interviews with open-ended questions. Given that this research was phenomenological in nature, both formal and informal, semi-structured and open-ended interviews were utilized. Participants completed the questionnaire

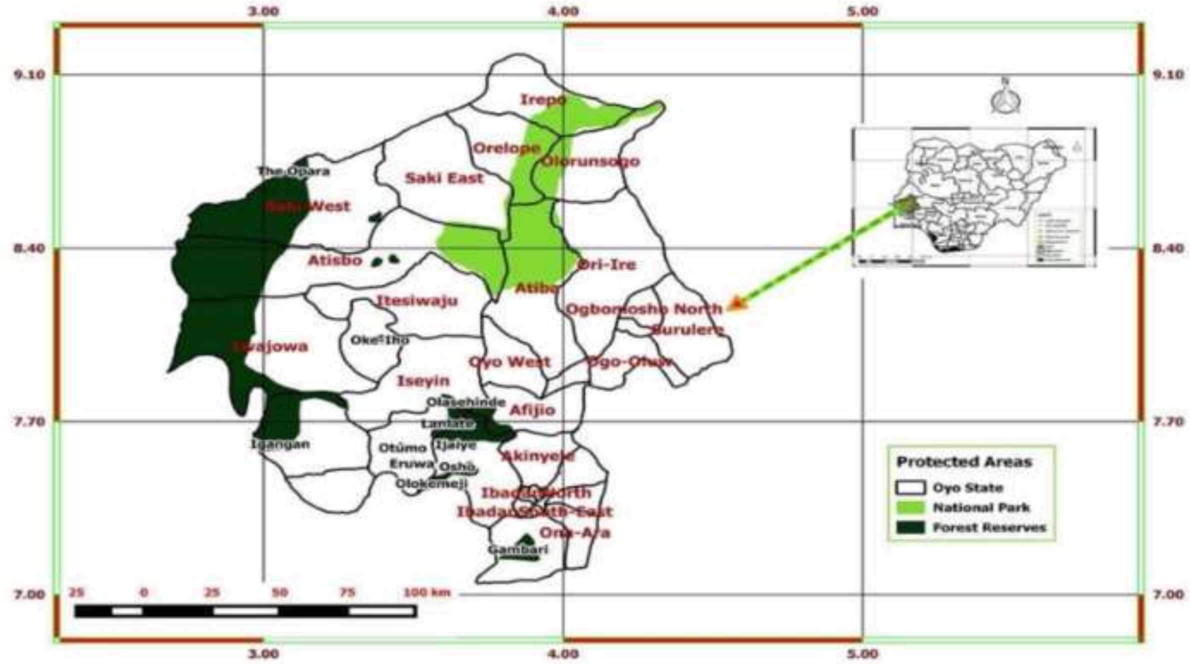


*Figure 2: Map of Oyo State Showing Saki-West and Atisbo Local Government Areas*


*Figure 3: Melting and Casting of Aluminum Cookware*

regarding their medical history, work history, and symptoms experienced during working hours.

Symptoms of interest included muscle cramps, headaches, lightheadedness or dizziness, nausea or vomiting, racing heartbeat or palpitations, unsteady gait, confusion or disorientation, and heat stress or strain. Participant heart rate (HR) and core body temperature (CBT) were measured using a digital stethoscope (3M™ Littmann® CORE), and CORE) Electronic digital electronic (4000 Series Model, 31.6 - 42.2 °C). The participants CBT throughout CBT were monitored working day. The HR monitors were attached to the upper arm of arms participants before starting work, the start of work after 10 minutes until minutes, remaining in place closing time end of the workday (approximately 8 hours).

## 4. DATA ANALYSIS AND PRESENTATION

The data collected were analyzed both qualitatively and quantitatively [18,19]. The raw data were systematically organized to facilitate analysis. Data collected through questionnaires (quantitative) were represented in a response category for each item. The analysis employed descriptive statistics, frequencies, and percentages. Since the data were interval, scores from each question were summed to obtain the total score for each participant. Consequently, a target population of 400 artisanal aluminum cookware producers was established. The study included the participation of the foundry head, junior workers, and subordinates.

## 5. RESULTS AND DISCUSSION

A total of 255 responses were recorded. The personal characteristics of the participants are summarized in Table 1. The majority of participants were male. The age range of respondents was between 18 and 60 years. Among them, 32 participants (13%) were aged 21-30 years, while 66 participants (26%) were aged 31-40 years. It was observed that a significant percentage of those involved in the artisanal aluminum cookware industry were in their younger years. Additionally, a larger proportion of participants were educated, with 152 individuals (60%) having completed higher education, while only 19 participants (7%) had received only primary education. The study indicates that work hours typically ranged from 8 to 10 hours, with 128 participants (50%) working for 8 hours and 55 participants (22%) working more than 8 hours per day. A small number of participants, 35 (14%), had undergone apprentice training for 2 years or less, while 220 participants (86%) had more than 2 years of apprenticeship training. These findings suggest that the artisanal aluminum cookware industry is predominantly male, with a well-educated workforce dedicated to their craft through long working hours and extensive training. This combination of factors may contribute to the quality and reputation of the products in this sector.

| Variables | Filters | Frequency | Percentage |
|---|---|---|---|
| **Gender** | Male | 255 | 100 |
| | Female | 0 | 0 |
| **Age (years)** | ≤20 | 42 | 17 |
| | 21 – 30<br>31 - 40<br>41 – 50 | 32<br>66<br>52 | 13<br>26<br>20 |
| | 51 – 60 | 34 | 13 |
| | >60 | 29 | 11 |
| **Level of Education** | Primary | 19 | 7 |
| | secondary | 84 | 33 |
| | Tertiary | 152 | 60 |
| **Work Experience (years)** | ≤5 years | 12 | 5 |
| | 6 – 10 | 43 | 17 |
| | 11– 15<br>16 – 20<br>>21 | 72<br>97<br>31 | 28<br>38<br>12 |
| **Working period per day (hours)** | ≤5 | 72 | 28 |
| | 5 - 8 | 128 | 50 |
| | ≥8 | 55 | 22 |

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| | | | |
|---|---|---|---|
| **Apprenticeship training (years)** | ≤ 2 | 35 | 14 |
| | ≥ 2 | 220 | 86 |
| **Total** | | 255 | 100 |

*Table 1. Socio-demographic Characteristics of the Respondents*

The prevalence of symptoms reported during working hours is shown in Table 2. The most common symptoms reported were heat strain, affecting 23% (59) of the respondents, followed by muscle cramps, reported by 45 participants (18%). Additionally, 14% (36) of respondents reported experiencing a racing heartbeat or palpitations, 13% reported an unsteady gait, 12% (31) reported lightheadedness or dizziness, 11% (27) reported headaches, and 9% (23) reported nausea or vomiting. Participants' heart rate (HR) and core body temperature (CBT) were measured and are presented in the study.

| **Symptom** | **Number (%)** |
|---|---|
| **Racing heartbeat or palpitations** | 36 (14) |
| **Headache** | 27 (11) |
| **Muscle cramps** | 45 (18) |
| **Lightheadedness or dizziness** | 31 (12) |
| **Confusion or disorientation** | 0 (0) |
| **Unsteady walk** | 34 (13) |
| **Nausea or vomiting** | 23 (9) |
| **Heat strain** | 59 (23) |

*Table 2. Prevalence of Symptoms Reported During Working Hours*

Heat strain refers to the physiological response of the body to heat stress. As shown in Table 2, 23% (59) of the respondents experienced heat strain. This condition typically results in heavy sweating, fatigue, muscle cramps, and reduced endurance among workers in the artisanal aluminum cookware industry. Heat strain can lead to muscle breakdown, which may result in kidney damage due to extreme exertion in high temperatures. The cognitive and performance effects associated with artisanal aluminum cookware include reduced concentration and decision-making abilities, increased reaction times, task reallocation or delays, and a higher error rate. Heat strain poses a significant occupational hazard in foundry workshops due to the extreme environmental conditions and physical demands involved. Artisanal aluminum cookware is particularly susceptible to heat strain because of factors such as the presence of molten metal, high ambient temperatures, direct physical contact with hot objects, and radiant heat sources. These conditions create a high potential for inducing heat strain among foundry operators [5]. The temperatures can reach extreme levels due to the heat generated by furnaces and molten metal, leading to elevated environmental temperatures that can exceed the body's ability to regulate its internal temperature. Consequently, this increases the risk of heat stress at a rapid pace [10].

The physical activities involved in artisanal aluminum cookware production, such as lifting, pouring, casting, and handling equipment, significantly increase metabolic heat production. As physical exertion intensifies, the body generates more internal heat, thereby heightening the risk of heat strain. Additionally, artisans often experience excessive sweating during these tasks, which can lead to substantial fluid loss and dehydration [20]. Dehydration impairs the body's ability to regulate temperature and can result in heat exhaustion or even heat stroke. Prolonged exposure to hot conditions without adequate rest periods contributes to the accumulation of heat strain. Furthermore, insufficient training in recognizing the symptoms of heat stress and strain, as well as improper responses to early warning signs (such as dizziness or fatigue), can exacerbate the issue. A lack of awareness often leads to delays in implementing preventive or corrective measures [18,20]. Therefore, preventive strategies should prioritize reducing heat exposure and muscle fatigue to enhance worker health and safety. The daily outdoor temperature conditions were recorded from January 15 to January 29, 2025, and are summarized in Table 3. The temperature range observed was between 70°F and 84°F. The average body temperature range was characterized as 66°F to 69°F, with a mean of 68.31 ± 0.55 and a standard deviation of 0.9465. Participants were considered unacclimatized if they remained idle for more than two hours during the working period, which spanned from 8 a.m. to 6 p.m. The average heart rate of the participants is also presented in Table 3.

| Days | Environmental Temperature (°F) | Average Artisanal Body Temperature (°F) | Average Artisanal Heart Rate (BPM) |
|---|---|---|---|
| **1** | 101-103 | 98 | 86.29 |
| **2** | 101–104 | 99 | 94.36 |
| **3** | 101–103 | 99 | 80.57 |
| **4** | 102–105 | 98 | 88.03 |
| **5** | 102–105 | 98 | 82.54 |
| **6** | 104–107 | 99 | 77.86 |
| **7** | 102–105 | 98 | 84.26 |
| **8** | 103–106 | 98 | 74.38 |
| **9** | 105–108 | 99 | 91.47 |
| **10** | 104–107 | 99 | 86.02 |
| **11** | 104–107 | 99 | 69.17 |
| **12** | 103–107 | 99 | 72.59 |
| **13** | 103–108 | 99 | 80.16 |
| **14** | 103–107 | 99 | 93.67 |
| **15** | 104-107 | 99 | 86.52 |
| **16** | 105–108 | 98 | 92.04 |

*Table 3. Peculiar Temperature Conditions and Heart Rate During the Evaluation Period*

The physically demanding tasks involved in artisanal aluminum cookware production—such as lifting heavy metal scraps, pouring molten metal, and enduring heat stress—significantly impact heart rate. Intense physical activity naturally elevates heart rate more than lighter tasks, as the body exerts greater effort to regulate temperature. This increased cardiovascular strain highlights the necessity for proper safety measures, including strategies to minimize heat stress, scheduled rest breaks, and adequate hydration. These practices not only safeguard worker health but also improve productivity and manufacturing precision [6]. The results indicate that, despite the extremely high environmental temperatures, the artisans' body temperature remained relatively constant each day. This stability is attributed to the human body's ability to regulate its temperature. In contrast, the heart rate exhibited more variability from day to day, likely due to differing levels of activity. Therefore, the data suggests that elevated temperatures do not necessarily lead to an increase in heart rate, and the body is capable of maintaining a stable temperature.

The awareness of hazards and health issues related to artisanal aluminum cookware is summarized in Table 4. The study indicates that 168 respondents (65.9%) were aware of the hazards and health problems associated with their work, while 87 respondents (34.1%) were unaware. The most commonly recognized hazards among the participants included body pain, reported by 132 respondents (51.8%), dust and fumes, acknowledged by 146 respondents (64.9%), bronchitis, noted by 117 respondents (45.9%), and physical hazards (such as slips, trips, and falls), also reported by 117 respondents (52.0%). The least recognized hazard was urinary tract infection, mentioned by only 34 respondents (15.1%). The knowledge of protective device usage among artisanal aluminum cookware workers is summarized in Table 5. It was found that only 86 respondents (38.2%) were aware of the safety measures associated with their workplace. The most recognized safety practice among these workers was the use of nose masks, mentioned by 64 individuals (25.1%), followed by head coverings (67 mentions, 27.1%), face shields (32 mentions, 12.5%), and the least recognized safety device, safety goggles, with

only 10 mentions (3.9%). Additionally, 36 respondents (27.3%) demonstrated good knowledge of the hazards, health issues, and safety measures related to foundry work, while 64 respondents

(48.5%) had fair knowledge, and 32 respondents (24.2%) exhibited poor knowledge of these critical aspects.

| | | |
|---|---|---|
| **Awareness of hazards** | | |
| Yes | 168 | 65.9 |
| No | 87 | 34.1 |
| **Hazards mentioned*[1]** | | |
| Body pains | 132 | 51.8 |

| | | |
|---|---|---|
| Got burns | 98 | 38.4 |
| Asthma | 84 | 32.9 |
| Eye hitching | 56 | 22.0 |
| Visual impairment | 92 | 20.9 |
| Urinary tract infection | 34 | 15.1 |
| Dust and fumes | 146 | 64.9 |
| Skin diseases | 45 | 17.7 |
| Bronchitis | 117 | 45.9 |
| Musculoskeletal disorder | 86 | 38.2 |
| Physical hazards | 117 | 52.0 |

*Table 4. Knowledge of Hazards and Health Problems*

| | | |
|---|---|---|
| **Awareness of workplace safety practice** | | |
| Yes | 86 | 38.2 |
| No | 139 | 61.8 |
| **Work safety practices mentioned[1]*** | | |
| Heat-resistant gloves | 12 | 4.7 |
| Face shields | 32 | 12.5 |
| Nose masks | 64 | 25.1 |
| Head hats | 67 | 27.1 |
| Safety boots | 26 | 10.2 |
| Safety goggles | 10 | 3.9 |
| Overalls | 17 | 6.7 |
| **Knowledge score** | | |
| Poor | 32 | 24.2 |
| Fair | 64 | 48.5 |
| Good | 36 | 27.3 |

*Table 5. Knowledge of Protective Devices by the Respondents*

The study revealed inadequate safety practices among artisanal aluminum cookware manufacturers. The majority of respondents reported experiencing health issues related to body pain, exposure to dust and fumes, and various physical hazards. Artisanal aluminum cookware producers often address design challenges through reverse engineering, resulting in multiple product iterations. Their focus tends to be on immediate business needs, prioritizing profit over the enhancement of product quality and services. Additionally, there is a lack of essential equipment to assess product quality, a reliance on aluminum scraps for specific applications, and an absence of effective mechanisms for testing the usability of the manufactured items.

## 6. CONCLUSION AND RECOMMENDATION

Regulations regarding the use of safety measures, such as containment and personal protective equipment, should be established by the federal Ministry of Labour and Employment, in conjunction with the state Ministry of Health, to enhance safety practices. A robust pot-makers' association is essential, along with collaboration from occupational health management and the ministries of labour and health, to deliver occupational health services to this group of workers through the informal sector segment of the National Health Insurance scheme. Additionally, it is crucial to establish vocational training institutes where aluminum artisans can receive training on the use of modern tools and equipment to improve their work activities.

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[1]*Multiple responses allowed

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