OCCUPATIONAL SAFETY AND HEALTH ISSUES AFFECTING AIR TRAFFIC CONTROLLERS IN KENYA

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Occupational Safety and Health Issues Affecting Air Traffic Controllers in Kenya

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DECLARATION

This thesis is my original work and has not been submitted for a degree in any other University.

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This thesis has been submitted for examination with our approval as University Supervisors.

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DEDICATION

I dedicate this research work to God above all and to the loving memory of my late father Rev.Gerald Maina Kibethi who was my biggest motivator through my education journey. His unwavering support, guidance and encouragement has been the driving force behind my academic journey. His absence is deeply felt, but his influence continues to inspire me every day.

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ABBREVIATIONS AND ACRONYMS

AIP	Aeronautical Information Publication
AME	Aviation Medical Examiner
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
AWOS	Automated Weather Observing system
DOSH	Directorate of Occupational Safety and Health
EIA	Environmental Impact Assessment
FAA	Federal Aviation Administration
FIR	Flight Information Region
ICAO	International Civil Aviation Organization
ISO	International Organization for Standardization
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
JKIA	Jomo Kenyatta International Airport
KCAA	Kenya Civil Aviation Authority
KIA	Kisumu International Airport
MIA	Moi International Airport
MLAT	Multilateration
NACOSTI	National Commission for Science, Technology & Innovation
NIOSH	National Institute for Occupational Safety and Health
NTSB	National Transportation Safety Board
OSH	Occupational Safety and Health
OSHMS	Occupational Safety and Health Management System
PPE	Personal Protective Equipment
PEL	Personnel Licensing

RADAR	Radio Detection and Ranging
SMS	Safety Management System
SPSS	Statistical Package for Social Sciences
SRM	Safety Risk Management
TMA	Terminal Control Area
VCCS	Voice Communication and Control Systems
VOR	Very High Frequency Omnidirectional Range
WHO	World Health Organization
WMSDs	Work related Musculoskeletal Disorders

ABSTRACT

Air traffic control (ATC) is central to a safe, efficient, and effective aviation system. It comprises three interdependent components, the human element, namely the air traffic controller (ATCO), operational equipment, both airborne and ground based, and established procedures. These components must function in harmony to prevent collisions and maintain adequate separation between aircraft. Occupational safety and health (OSH) issues in air traffic control (ATC) arise from risks associated with the work environment, work organization, personal factors, and operational procedures. The occupational safety and health act of 2007 requires employers to provide a safe workplace that is free from health risks and supported by adequate welfare arrangements. This study evaluated the occupational safety and health (OSH) issues affecting air traffic controllers (ATCOs) in Kenya and was conducted across seven major manned airports. The research was guided by the Theory of the Risk Management Process as outlined in the International Organization for Standardization (ISO) 31000 principles and guidelines. A quantitative descriptive research design was adopted. From a target population of 172 controllers, a sample of 64 respondents was selected. Data were collected using measurement instruments, structured questionnaires and observation checklists. Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS), applying descriptive statistics, Pearson correlation, and chi square tests to examine relationships between workplace factors and health outcomes. The findings established that occupational safety and health (OSH) among air traffic controllers (ATCOs) is significantly influenced by the combined effects of the work environment, work organization, operational procedures, and personal factors. In the work environment, inadequacies in lighting, including glare, equipment serviceability, emergency preparedness infrastructure, and elevated noise levels negatively affected safety, health, and operational efficiency. These conditions contributed to fatigue, stress, and reduced performance. Within work organization, deficiencies in shift scheduling, break allocation, and ergonomic considerations were shown to increase physical strain, reduce alertness, and heighten the likelihood of human error. Headaches were reported by 77.0% of respondents, back pain by 68.8%, and disrupted sleep by 48.4%. A strong positive correlation, $r = 0.726$, was observed between prolonged sitting and screen time. For operational procedures, although emergency procedures were generally effective, gaps in sensitization and limited controller involvement in procedure design reduced effectiveness in routine operations and increased cognitive workload. Personal factors, including attitude, risk perception, and limited adherence to ergonomic practices such as proper posture and adequate breaks, further influenced health outcomes. Notably, 85.7% of respondents relied on self-medication rather than seeking professional support. Inferential analysis showed statistically significant associations between equipment unserviceability and stress, $\chi^2 = 6.24$, $p < 0.05$, stress and help seeking behavior, $\chi^2 = 23.3$, $p < 0.001$, and back pain and posture deterioration, $\chi^2 = 28.96$, $p < 0.001$. The study concludes that while the occupational safety and health (OSH) challenges affecting air traffic controllers (ATCOs) in Kenya are significant, they are consistent with risks recognized within international aviation safety frameworks. However, gaps remain in implementation, enforcement, and contextual adaptation of these standards. The study therefore recommends improving physical working conditions, optimizing organizational systems, enhancing participatory procedure development, and strengthening individual awareness and training to promote safer, healthier, and more effective air traffic control (ATC) operations.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Air traffic controllers (ATCOs) play an active role in ensuring the aviation system's safety. Managing air traffic is the primary purpose of this profession and entails making split-second decisions with strict deadlines. An air traffic control (ATC) job encompasses preventing collision between aircraft, ensuring expedition and orderly traffic flow, and providing alerting and flight information service (ICAO, 2025a).

The air traffic control system comprises three key components: the human element (air traffic controller), the equipment (onboard the aircraft and on the ground), and the procedures. These components must operate in harmony to maintain safe aircraft separation and ensure overall system efficiency. Due to the safety-critical nature of this role, Air traffic control is widely recognized as one of the most cognitively demanding professions, requiring sustained concentration, rapid decision-making, and continuous monitoring of dynamic airspace conditions.

These operational demands expose controllers to significant levels of stress and fatigue, which have been widely identified as major threats to both human performance and aviation safety. Studies have shown that high workload, complex airspace structures, and prolonged duty periods contribute significantly to mental fatigue, impairing attention, memory, and decision-making capacity (Kumar, 2016; Sonati *et al.*, 2016). Similarly, Tharikh and Hamzah (2020) emphasize that inadequate rest, poor shift scheduling, and high workload adversely affect controller well-being and performance. Fatigue in safety-critical professions has been associated with reduced alertness, slower reaction times, and increased likelihood of operational errors, which may compromise aviation safety.

Fatigue in ATC is further compounded by shift work and disruption of the body's natural circadian rhythm. Controllers frequently work rotating shifts, including night duties, which interfere with normal sleep patterns and recovery cycles. According to World Health Organization (2022) such disruptions are associated with sleep disorders, reduced cognitive efficiency, and long-term health risks. In a high-risk operational environment such as ATC, even minor lapses in attention due to fatigue can result in serious safety consequences.

In Kenya, air traffic control services are provided under the regulatory framework of the Kenya Civil Aviation Authority (KCAA), which operates in alignment with international standards set by the International Civil Aviation Organization (ICAO). ICAO provides globally harmonized standards and recommended practices (SARPs) that guide the safe and efficient management of international air navigation. Key provisions such as ICAO Annex 11 (Air Traffic Services) and ICAO Annex 19 (safety management) outline requirements for air traffic service provision and the implementation of safety management systems (SMS), respectively. The adoption of these standards ensures that Kenya's ATC operations meet global safety benchmarks, enabling safe coordination of aircraft across international airspace while maintaining high levels of operational safety.

At the national level, occupational safety and health within ATC is further supported by the occupational safety and health act (OSHA), 2007, which mandates employers to provide a safe working environment, conduct risk assessments, and implement measures to protect employees from workplace hazards. While ICAO Annexes primarily focus on aviation operational safety through technical and procedural standards, OSHA (2007) provides a broader legal framework addressing employee welfare, workplace conditions, and health protection across all sectors. These frameworks are complementary: ICAO ensures the safety of air navigation systems, while OSHA safeguards the well-being of personnel operating within those systems.

In the United States of America (USA), through a memorandum of understanding, the Federal Aviation Administration (FAA) allowed the OSH department to enforce specific OSH standards on hazard communication, bloodborne pathogens, and occupational noise exposure to improve workplace safety for cabin crew members. This has greatly enhanced the safety and health of cabin crew members in the USA without compromising aviation safety (Federal aviation administration, 2023).

The risks in ATC arise from what, how, when, and for how long the air traffic controllers interact with systems within their work environment, including equipment, procedures, and organizational structures. These risks may originate from factors such as lighting, noise, equipment serviceability, workload, shift schedules, procedural clarity, and individual behaviors. Therefore, effective management of occupational safety and health in ATC requires a comprehensive approach that addresses work environment, work organization, operating procedures, and personal factors. This study focuses on these key areas to evaluate their impact on the safety and health of air traffic controllers in Kenya. The findings of this study will provide valuable insights to other Scholars and Kenya civil aviation authority (KCAA) management on the required intervention to ascertain controllers' safety and address health issues.

1.2 Statement of the Problem

Air traffic controllers (ATCOs) operate in a demanding environment that requires sustained concentration, rapid decision-making, accurate communication, and continuous situational awareness. These tasks are often performed under shift work systems that include early morning, afternoon, and overnight duties. Such rotating schedules disrupt the body’s natural circadian rhythm, leading to sleep deprivation, reduced alertness, slower reaction times, and impaired cognitive performance. Over time, chronic fatigue associated with irregular work hours can negatively affect both controller health and operational safety.

In addition to work organization challenges, the physical control room environment presents occupational hazards that may compromise controller performance. Noise in control rooms whether from communication equipment, operational alarms, or external aircraft activity can interfere with concentration and two-way communication, increasing mental workload and the likelihood of operational errors. Visual strain is also a significant concern, as controllers spend prolonged periods focusing on RADAR displays, screens, and flight progress strips under varying lighting conditions. Poor lighting, glare, and extended screen exposure can contribute to eye fatigue, discomfort, and reduced visual efficiency.

These factors are particularly important to ATCOs because their role is safety-critical; even minor lapses in attention or judgment can have serious consequences for aviation safety. Despite this, occupational safety and health (OSH) research has largely focused on industries such as agriculture, healthcare, engineering, and road transport, with limited emphasis on the combined effects of shift work, noise exposure, visual strain, and operational procedures within air traffic control. In Kenya, few published studies have examined these occupational risks in relation to ATCOs. This study therefore seeks to investigate the safety and health issues affecting Air Traffic Controllers in Kenya, with a focus on work environment, work organization, personal factors, and operating procedures.

1.3 Justification of the Study

The aviation industry plays a vital role in economic development by enabling trade, tourism, investment, and efficient business operations. Air transport supports national productivity by connecting markets and facilitating global mobility. At the center of this system are Air Traffic Controllers, whose responsibilities require precision, resilience, and sustained mental performance to ensure the safety and efficiency of air navigation.

Given the safety-critical nature of ATC work, understanding the occupational factors that affect air traffic controller safety, health and performance is essential. Shift work and sleep disruption can lead to fatigue and reduced vigilance, while noise exposure in control rooms may impair communication and concentration. Similarly, prolonged screen exposure and inadequate lighting can result in visual strain, affecting accuracy and decision-making. These issues are not merely matters of workplace comfort; they directly influence operational effectiveness and aviation safety outcomes.

Although occupational safety and health issues have been widely studied in other sectors, there remains limited research focusing on the unique demands of air traffic control, particularly in the Kenyan context. Existing studies often isolate stress and fatigue without fully addressing the broader interaction between environmental, organizational, and procedural factors. This study is therefore justified in filling this gap by generating evidence on the occupational risks faced by Kenyan ATCOs.

The findings may contribute to global knowledge on OSH in aviation, inform policy and intervention strategies, and support the Kenya civil aviation authority (KCAA) in implementing targeted measures to safeguard controller well-being. Ultimately, promoting a healthier ATC workforce strengthens aviation safety and enhances the reliability of the national air transport system.

1.4 Objectives

1.4.1 Main Objective

To investigate the safety and health issues affecting air traffic controllers in Kenya.

1.4.2 Specific Objectives

i. To determine the impact of the work environment on air traffic controllers in Kenya.
ii. To assess the influence of work organization on air traffic controllers in Kenya.
iii. To evaluate the effect of operating procedures on air traffic controllers in Kenya.
iv. To establish the impact of personal factors on air traffic controllers in Kenya.

1.5 Research Questions

i. What is the impact of the work environment on air traffic controllers in Kenya?
ii. What is the influence of work organization on air traffic controllers in Kenya?
iii. What is the effect of operating procedures on air traffic controllers in Kenya?
iv. What is the impact of personal factors on air traffic controllers in Kenya?

1.6 Scope of the Study

The focal point for this study was on air traffic controllers working in 7 out of the 9 manned airports in Kenya. It involved determining the impact of work environment, organization, operating procedures and personal factors on Air Traffic Controllers in Kenya.

1.7 Conceptual Framework

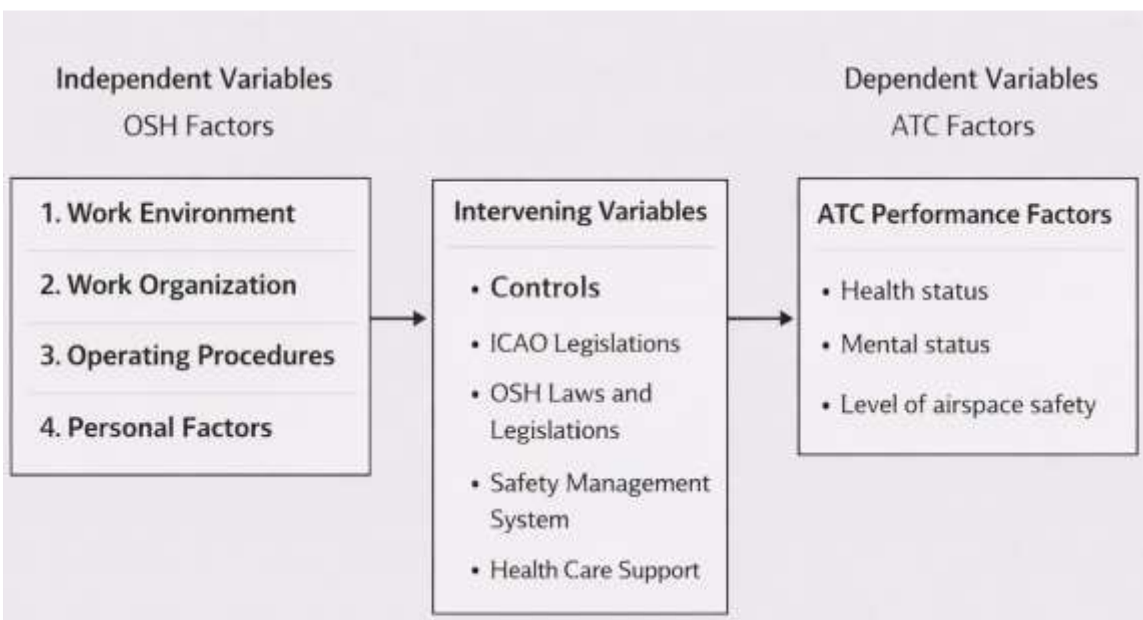

Figure 1.1: Conceptual Framework on how Occupational Safety and Health Issues Affect Air Traffic Controllers

Figure 1.1 shows the causal variables which contribute to occupational safety and health risks. The potential causal factors contributing to the occupational safety and health risks that could eventually affect the controller's health status, mental status, and level of airspace safety include the work environment, work organization, operating procedures, and personal factors.

The parameters considered under work environment were: lighting, noise, equipment serviceability, extreme weather conditions, provision of washroom for both genders, working at height, insect-vector control, availability of restrooms, canteen, and gym facilities. While the parameters considered under work organization included shift work schedules, workload (including work demands, time pressure, hours of work,) training & communication, job design & workspace, management support, reward & recognition, equipment arrangement, the number of displays, sitting time per shift and screen time per shift. The parameters considered under operating procedures included: clarity of procedures, multiple inconsistent procedures, and procedures in an emergency. Finally, personal factors such as attitude, risk perception, personality, work habits and posture were also reviewed.

KCAA has adopted Intervention and prevention measures such as laws and legislation from OSH, ICAO & Safety Management System (SMS), and incorporating health care support in the work environment, work organization, and operating procedures. These controls are in place to minimize Occupational safety and health risks in the Air Traffic Control profession.

1.8 Study Limitation

The study was conducted within a relatively short period of time. Extending the duration of the study could have provided more comprehensive findings by capturing variations under different air traffic conditions and operational environments.

In addition, the airports included in the study were geographically dispersed, with considerable distances between them. This made data collection both costly and time-intensive, thereby posing logistical challenges during the research process.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Principle

2.1.1 Theory of Safety Risk Management (SRM)

Safety Risk Management (SRM) is a systematic process that involves identifying hazards that may affect the safety of persons, assessing the risks associated with those hazards, implementing appropriate control measures, and continuously monitoring and reviewing the effectiveness of those controls. According to ISO 31000:2018 shown in Figure 2.1, developed by the International Organization for Standardization (ISO, 2018), risk management provides a structured and comprehensive approach to managing uncertainty in organizational operations.

Safety Risk Management (SRM) has been widely adopted by organizations as a proactive strategy for improving occupational safety and employee health. The framework enables organizations to develop appropriate solutions to risks by considering the nature and complexity of their operations. In Air Traffic Control (ATC), where operational decisions are made in real time and under high-pressure conditions, the application of SRM is essential for maintaining both safety and efficiency. The ATC environment is characterized by complex systems, human–machine interaction, and dynamic traffic situations, all of which present potential operational and occupational hazards. As such, the risk management process plays a critical role in identifying weaknesses within aviation infrastructure, control room conditions, staffing arrangements, and operational procedures, thereby preventing incidents and minimizing adverse outcomes. Through this process, risks are mitigated by reducing, avoiding, or transferring them within acceptable safety margins.

The safety risk management process consists of three key components: hazard identification, risk assessment, and risk mitigation. As defined in ISO 31000:2018, risk is the effect of uncertainty on objectives and is typically expressed in terms of likelihood and severity. In the context of air traffic control, this uncertainty may arise from factors such as equipment failure, fatigue, communication breakdown, environmental conditions, or procedural deviations. A hazard, on the other hand, is defined as anything capable of causing harm to persons or the environment, as outlined in the occupational safety and health act (OSHA, 2007). Similarly, the International Civil Aviation Organization (ICAO) in Annex 19 defines a hazard as any condition that could potentially lead to an aircraft accident or incident. Within ATC operations, hazards may include excessive workload, poor workstation design, high noise levels, or inadequate staffing all of which can affect controller performance and ultimately aviation safety. Therefore, integrating safety risk management into ATC operations supports the systematic identification and control of risks that threaten both controller well-being and the safe flow of air traffic.

Before conducting risk assessment, it is essential to establish the context within which the organization operates. ISO (2018) explains that this involves understanding both the internal and external environments. The internal context includes organizational goals, policies, procedures, culture, and employee expectations, while the external context encompasses regulatory requirements, stakeholder expectations, and prevailing market conditions.

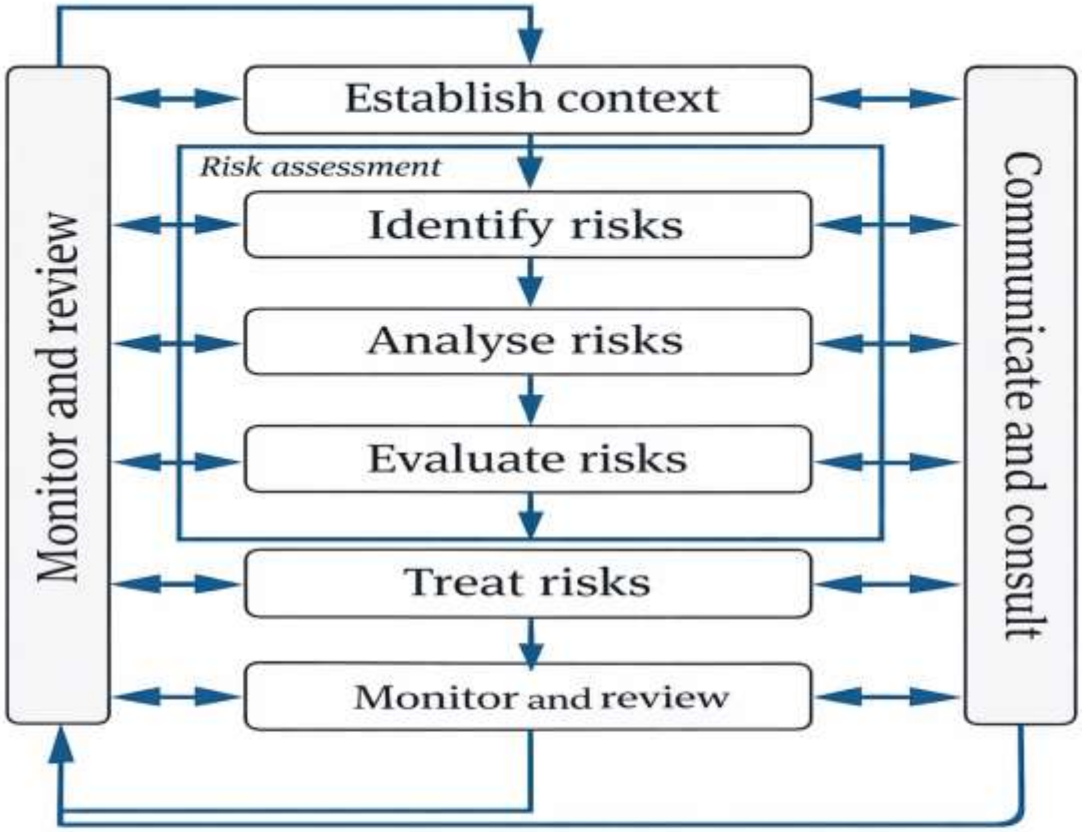

Figure 2.1: The ISO 31000:2018 Risk Management Process

Source: ISO 31000 Standards, 2018

Risk assessment begins with hazard identification, where all potential hazards associated with organizational activities are documented, often in a hazard log. According to ISO (2018), risk assessment involves three stages: risk identification, risk analysis, and risk evaluation. Risk identification determines potential events that may hinder the achievement of organizational objectives. Risk analysis then examines the causes, consequences, likelihood, and severity of these risks, as well as existing control measures. This process also determines the level of residual risk. Finally, risk evaluation compares the analyzed risks against established criteria to determine their acceptability and prioritize mitigation actions.

Following risk evaluation, a risk profile is developed to summarize all identified risks and their respective rankings. ISO (2018) notes that this enables management to allocate resources effectively by prioritizing risks that pose the greatest threat to organizational objectives. As a result, organizations can enhance their operational efficiency and effectiveness through targeted risk mitigation strategies.

Organizations may respond to risks in different ways depending on their potential impact. According to ISO (2018), risk treatment involves selecting and implementing appropriate measures to mitigate risks. These measures may include avoiding, reducing, transferring, or accepting the risk. The chosen risk treatment option should aim to minimize or eliminate the risk while considering the cost-benefit implications and ensuring compliance with applicable legal and regulatory requirements.

Monitoring and review are essential components of the risk management process. The International Civil Aviation Organization (ICAO, 2018), in its Safety Management Manual (Doc 9859), emphasizes that organizations must continuously evaluate their risk management performance against established safety performance targets. These targets are derived from organizational objectives and are measured using safety performance indicators. This process allows organizations to assess the effectiveness of their risk management systems and identify areas for improvement.

Finally, communication and consultation with stakeholders are critical throughout the risk management process. ICAO (2018) highlights that engaging stakeholders provides valuable insights that support informed decision-making and effective prioritization of risk mitigation measures. Incorporating stakeholder perspectives ensures that risk management strategies are comprehensive, inclusive, and aligned with organizational and operational needs.

2.2 Occupational Safety and Health Concepts

2.2.1 Work Environment

A work environment refers to the overall setting in which employees carry out their duties, including the physical, social, psychological, and organizational conditions that influence their performance and well-being. It involves factors such as workspace design, safety measures, equipment, lighting, noise levels, workplace relationships, communication, and management support. According to the World Health Organization (2022), a healthy work environment is one where employees and management work together in a continuous improvement process to protect and promote workers' health, safety, and well-being. Such an environment is essential for enhancing productivity, job satisfaction, and organizational success, while reducing stress, absenteeism, and health-related challenges.

Stroeve *et al.* (2023) examined the human factors and workload implications associated with automation and equipment failures in air traffic management systems. The study established that equipment malfunctions and automation interruptions increase controller workload by requiring rapid intervention, heightened monitoring, and continuous decision-making under time pressure. The authors further observed that such failures can reduce situational awareness, increase mental fatigue, and elevate stress levels among air traffic controllers, particularly in high traffic-density environments. The study emphasizes that reliable and well-maintained air traffic management equipment is essential not only for operational safety but also for supporting controller performance and psychological well-being.

According to World Health Organization (2022), the physical work environment encompasses all aspects of the workplace that can be detected by either human or electronic sensors. This includes exposure to various elements such as chemicals, lighting, noise, vibration, air quality, furniture, processes, and materials present in the workplace that could potentially impact employee safety, health, and overall well-being. Some of the hazards that can be found in the physical work environment include exposure to chemicals such as solvents, pesticides, asbestos, carbon monoxide, silica, or smoke; physical exposure to noise, radiation, vibration, excessive heat, or nanoparticles; biological exposure to hepatitis B, malaria, HIV, pandemic threats, food or waterborne pathogens, lack of clean water, toilets, and hygiene facilities; ergonomic hazards such as excessive force, awkward posture, repetition, heavy lifting, and forced inactivity/static postures; and mechanical hazards such as machine hazards related to nip points, cranes, and fork trucks. Hierarchy of controls including elimination, substitution, engineering control, administrative controls, or use of PPE, are used to prevent exposure to hazards.

The way an organization is structured and the interactions that take place between employees can have a significant impact on the well-being of workers. This includes factors such as the organization's values, beliefs, and practices, as well as its policies on issues like diversity and respect, in essence, the psychosocial work environment. Some of the psychosocial hazards that can arise in such an environment include bullying and harassment, lack of support for healthy lifestyles, and discrimination based on factors like gender, ethnicity, sexual orientation, or religion.

In addition to the organizational culture stressors, psychosocial hazards may also arise from inconsistent application of fundamental worker rights, such as maternity leave and non- discriminatory hiring practices, as well as fear of job loss due to company restructuring. To address these hazards, surveys and interviews may be more effective than traditional inspections, as they can provide insight into the employees' experiences and perceptions of the work environment (Mohsan *et al.*,2021).

According to the Engineering Toolbox, recommended illumination levels vary depending on the type of workspace and task demand. Table 2.1 summarizes typical lighting requirements for different working environments.

Table 2.1: Lighting Levels for Different Workspaces

Activity	Illumination (Lux, lumen/m^2)
1. Warehouses, homes, theatres, archives	150
2. Easy office work, classes	250
3. Normal office work, PC work, study library, groceries, show rooms, laboratories	500
4. Supermarket, mechanical workshops, office landscapes	750
5. Normal drawing work, detailed mechanical workshops, operation theatres	1000
6. Detailed drawing work, very detailed mechanical work	1500-2000

Source: Engineering Toolbox (Engineering Toolbox, n.d.)

Lighting levels play a significant role in a working environment of air traffic controllers. Lighting in control rooms can be focused or unfocussed. Focused lighting is used to illuminate the controller's position while unfocussed lighting is designed for general housekeeping. It is recommended that focused lighting should be balanced to minimize glare and shadows for visual comfort. Adequate lighting enhances contrast between objects and improves readability of information displayed on control panels, screens and charts. Federal aviation administration recommends that an average of 200 Lux is required for focused daytime lighting and 100 Lux for night lighting.

Table 2.2: Common Sound Levels

Noise Source(s)	Sound Levels (dBA)	Note
1. Shotgun, rifle, handgun, fireworks (at 3ft.)	≥160	Impulse sound
2. Airplane (taking off)	140	Harmfully loud
3. Car horn, symphony concert, baby crying	100	Regular exposure of more than one-minute risks permanent hearing loss. Physical discomfort. Maximum vocal effort.
4. Freeway traffic (at 50 ft), urban housing with major avenue (Ldn), Inside a car, TV audio	**70**	Interferes with telephone conversation. EPA Ldn for lifetime exposure without hearing loss
5. Normal conversation sewing machine	60	Intrusive interference with human speech begins at about 60 dBA
6. Quiet office, library, quiet residential area, rural residential (Ldn)	40	

Notes: Ldn=day-night average sound level

Source: Federal Aviation Administration charts

Sound levels recorded in different operational environments are presented in Table 2.2. An air traffic control environment should maintain noise levels that do not interfere with effective two-way communication or expose controllers to potentially harmful sound levels over prolonged periods. Achieving this standard can be challenging, particularly in control rooms with multiple active workstations, communication systems, alarms, and occasional intrusion of external aircraft noise. In such settings, excessive or uncontrolled noise may hinder message clarity, leading to misinterpretations or delayed responses, thereby reducing the effectiveness of instructions issued to pilots. Beyond communication challenges, persistent noise can also diminish situational awareness and contribute to elevated stress levels among controllers (Pawlak *et al*., 2022).

According to the National Institute for Occupational Safety and Health (NIOSH, 2019), noise exposure levels below 70 dBA are considered safe for continuous occupational exposure without risk of hearing damage. Exposure levels between 70 and 85 dBA are associated with a gradual risk of hearing impairment over extended periods, particularly with prolonged daily exposure (NIOSH, 2019). Once noise levels exceed 85 dBA, this is regarded as the occupational action level, where the use of hearing protection is recommended for individuals exposed for approximately eight hours per day (NIOSH, 2019). At levels above 90 dBA, the risk of noise induced hearing loss increases significantly, and the use of hearing protection becomes mandatory to prevent permanent auditory damage (NIOSH, 2019). These thresholds are particularly relevant in air traffic control settings, where sustained exposure to elevated noise can affect not only hearing health but also operational performance and safety.

2.2.2 Work Organization

World Health Organization (2022) defines work organization as a non-physical hazard that causes work related stress. These hazards include work demands, time pressure, reward and recognition, workloads, shift work schedules, hours of work, sitting time per shift, screen time per shift, support from supervisors, job clarity, job design and workspace, job training, and communication at the workplace.

Work organizations can improve working conditions, increase productivity, and enhance the quality and performance of employees (International Labour Organization, 2019). Any workplace design should be done to suit the work environment, needs, and characteristics of workers and processes. Work organization through appropriate design helps eliminate barriers that may hinder workers’ effectiveness and efficiency, resulting in a human-centered and ergonomically sound working environment (Subotic *et al.*, 2014).

Shift work is an essential subset of work organizations whose safety and health effects should be determined. While some organizations would require their employees to work in shifts or extended work hours, some employees consider this a means to earn a little more. Some employers consider reducing staffing levels to cut costs. Making an extra coin increases employees' need to work in shifts and extended hours. From a safety and health perspective, day work hours are different from night work hours. Night shifts and extended night work hours can be considered the most challenging and hazardous (World Health Organization, 2009). It is also important to note that due to the nature of work done by air traffic controllers, shift time will be related to the screen time and sitting time. Sitting for long may cause an increase in heart related ailments, obesity, and premature death (World Health Organization, 2022). World Health Organization (2022) recommends an increase in physical activities and interventions that aim to reduce sitting time at the workplace.

Stress related to shift oriented work could be caused by poor roster design, mental and physical demands of the type of work involved, family and social responsibilities, and disrupted circadian rhythms (Åkerstedt & Wright, 2022). Most employees may resort to alcohol and other substance abuse to overcome stress and fatigue (Kumar, 2016). This can be hazardous to employees' safety and health, mainly if the work involved is sensitive and requires attention. According to Costa (1996), a rapid rotation of a 3-way shift, especially one employed in developing air traffic controllers' roster, should adopt a morning shift, followed by an afternoon shift and eventually a night shift. This is considered a forward rotation that allows the body to adjust with minimal disruptions to circadian rhythms. The rest time between shifts is also adequate in this shift rotation.

In air traffic control (ATC), teamwork comes in handy, including normal work conditions, increased traffic conditions, and abnormal situations such as aircraft accidents. Workspace must always be designed and organized to suit teamwork in ATC. It makes coordination between different ATC units easier and faster (Tharikh & Hamzah, 2020). Teamwork in ATC reduces the workload of a controller to manageable levels (International Civil Aviation Organization, 2025).

According to Majumdar and Ochieng (2002), several things can determine controller workload. The situation in the airspace could determine the controllers' workload. This will depend on the type of air traffic and the sector dynamics in that airspace. The state of the equipment also plays a critical role in determining a controller's workload. The equipment considered is the air traffic management (ATM) equipment on the ground or the aircraft's onboard equipment. Finally, age, experience, and health can also be essential when evaluating the controllers' workload.

As part of implementation efforts within work organization, the Civil Aviation (Personnel Licensing) Regulations, 2022, specifically Regulation 149, reinforces the importance of integrating health management into operational systems (Kenya Civil Aviation Authority, 2025). By requiring air traffic controllers to hold a valid Class 3 medical certificate and undergo periodic medical assessments, the regulation ensures continuous monitoring of fitness for duty. This supports effective workforce planning, reduces health related risks, and strengthens organizational responsibility for maintaining the employee well-being and aviation safety.

2.2.3 Operating Procedures

Operating procedures are vital for the consistency and effective operation of any organization. All employees must be well trained on these procedures at the recruitment level before deployment. The clarity of these procedures determines how they are interpreted and applied. These procedures need to be well documented and made available to all users for continuity. In engineering, a copy of operating procedures must be provided to the user of any process or equipment before the handover of a project. The procedures must be precise and sequential for optimal use during the operation or maintenance of such installation. These procedures must be always maintained up to date to remain relevant. They must therefore be reviewed periodically, and any changes documented. The employees or users affected by the change must be well trained on the change procedure well in advance before implementing the change. A risk assessment should be done on the new procedures to avoid introducing unknown risks detrimental to the set goals and objectives.

Operating procedures provided for air traffic control are mainly developed from standards and recommended practices provided in various ICAO annexes and documents. Local operating procedures are also designed for use in specific airspace depending on the needs and the airspace classification. Air traffic controllers undergo training to ensure adherence to this procedure before deployment to work at a given airport. After that, the ATC trainee cadets must work under senior rated controllers to gain on-job exposure before undertaking a rating exam. (ICAO personnel licensing regulations, 2018). Upon passing, they are permitted to perform a specific function. The procedures developed for use in ATC aim to improve airspace safety and security. Ambiguous or multiple inconsistent procedures are known to be one of the sources of stress in the ATC profession.

2.2.4 Personal Factors

Some personal factors affect the overall safety and health of controllers if controls are not put in place. These factors include personality, attitude, risk perception and posture. These factors influence behavior in complex ways. While Some of these characteristics such as personality are fixed; others such as attitudes, perception and posture may be changed or improved (Federal Aviation Administration, 2023).

Air traffic controllers' attitude towards unsafe acts and conditions has a great effect on flight safety. While ATCOs professional mistakes happens every day, the attitude influences the ability to recognize the error, learn from it and avoid such errors in the future. Personality influences risk perception of an individual regardless of the profession (Federal Aviation Administration, 2023).

Workplace ergonomics is essential for reducing work-related musculoskeletal disorders. Poor posture such as slouching while sitting, which compresses the spine, can lead to low back pain, neck and shoulder problems (Dinar *et al.*, 2018). Improper typing styles and poor body posture among white-collar professionals are associated with musculoskeletal problems, which can be mitigated by implementing ergonomic interventions such as the use of adjustable chairs, computer screens, and desks. According to Nurhayati *et al.,* (2020) ATCOs are exposed to the risk of work-related musculoskeletal disorders (WMSDs) and physical fatigue which could be as a result of prolonged sitting and bad posture during their work hours. This study recommended immediate remedial actions to reduce the risk of WMSDs and physical fatigue among ATCOs. Some of the mitigations suggested included ergonomics implementation among ATCOs and training on proper sitting posture.

2.3 Legal Framework

2.3.1 International Civil Aviation Organization (ICAO) Regulations

The International Civil Aviation Organization (ICAO) provides standards and recommended practices (SARPs) for all member states that are signatories to the Chicago convention. These standards guide contracting states in developing national aviation regulations suited to their operational environments. In Kenya, the Kenya civil aviation authority (KCAA) has adopted these provisions to regulate aviation activities in line with international requirements.

The civil aviation (personnel licensing) regulations, 2022, which are aligned with ICAO Annex 1, outline the requirements for licensing and certification of aviation personnel involved in safety-related functions. These include pilots, air traffic controllers, and aircraft maintenance engineers.

The personnel licensing (PEL) regulations provide specific provisions governing air traffic controllers' working conditions. Regulation 109 stipulates limits on working hours, prohibiting controllers from performing duties for more than 24 consecutive hours within a 7-day period except in emergencies. It also restricts duty time to a maximum of 10 consecutive hours or 10 hours within a 24-hour period, unless a rest period of at least 8 hours is provided (ICAO, 2022).

Regulation 110 addresses fatigue management by prohibiting controllers from working when they are aware or reasonably suspect that fatigue may impair their performance. Employers are also prohibited from assigning duties to personnel who may be fatigued to the extent that operational safety could be compromised.

Regulation 149 requires air traffic controllers to hold a valid Class 3 medical certificate before engaging in operational duties. It further mandates periodic medical assessments to identify health risks and ensure continuous monitoring of controllers' fitness for duty.

Implementation of ICAO safety provisions under the Civil Aviation (Personnel Licensing) Regulations, 2022 is often constrained by both operational and human factors. Although fatigue management and duty time limits are established through Regulations 109 and 110, evidence shows that in safety-critical environments, employees may still experience significant occupational stress and fatigue due to high workloads, demanding schedules, and insufficient recovery time, particularly where staffing levels are limited. Research further indicates that staffing shortages and operational pressures can lead to extended shifts or reduced compliance with optimal rest requirements, weakening the effectiveness of fatigue risk management systems (Åkerstedt & Wright, 2022).

In addition, implementation of Regulation 149 on medical certification is affected by psychosocial and organizational barriers (ICAO, 2022). Literature shows that employees in high-risk occupations often avoid seeking professional help due to stigma, fear of career consequences, and confidentiality concerns. A multicenter study by Huang *et al*. (2025) found that self-stigma and workplace culture significantly reduce help-seeking behavior, while broader reviews also highlight trust deficits and reliance on informal coping strategies. In aviation contexts, such barriers limit transparency, hinder early identification of human factor risks, and reduce the effectiveness of safety management systems. Combined with staffing constraints, these challenges undermine both compliance with regulatory requirements and the broader goal of maintaining optimal safety and employee well-being.

2.3.2 Safety Management System (SMS) Implementation

The International Civil Aviation Organization (ICAO, 2025b), in Annex 19, defines safety as the state in which risks associated with aviation activities are controlled and reduced to an acceptable level. The same Annex defines the Safety Management System (SMS) as a systematic approach to managing safety that includes the development of policies, procedures, organizational structures, and clearly defined accountabilities.

The framework for implementing SMS is also provided in ICAO Annex 19 (ICAO, 2025b). It requires that the system be tailored according to the size, complexity, and nature of aviation operations. ICAO standardizes the requirement for SMS implementation across all member states, which are required to ensure compliance within all aviation service providers. SMS originated as a tool for improving occupational safety and health in high-risk industries such as oil and gas but has since been adopted in aviation. Over time, it has evolved into a comprehensive system integrating technological, organizational, social, and psychological approaches to safety management. The concept is strongly influenced by Reason's Swiss Cheese Model, which explains how accidents occur due to failures across multiple layers of defense (ICAO, 2025b).

The standards for SMS implementation and maintenance are provided in ICAO Annex 19 (ICAO, 2025b). Performance of SMS varies among states, and the level of maturity depends on the complexity of each aviation system. ICAO requires that states ensure SMS implementation by air traffic service providers and all other aviation stakeholders. The SMS framework comprises four key components: safety policy and objectives, safety risk management, safety assurance, and safety promotion through training and communication of safety information (ICAO, 2025b).

However, despite the importance of SMS in improving aviation safety, several challenges affect its implementation in air traffic control operations. These include underreporting of incidents due to fear of blame, high workload and staffing shortages that limit participation in safety activities, and inadequate training and management support for SMS programs. In developing aviation systems, limited technological and financial resources may also hinder effective safety assurance and reporting systems (ICAO, 2025b). Studies have further shown that poor working conditions and operational pressure negatively affect the performance and wellbeing of air traffic controllers, which may compromise effective SMS implementation (Akca & Meltem, 2017).

2.3.3 Occupational Safety Health (OSH) Regulation

The Occupational Safety and Health Act apply to all workplaces where any person is at work, whether temporarily or permanently. The Act seeks to secure the safety, health, and welfare of persons at work and to protect them from risks arising from work activities. Under its general provisions, the Act outlines the duties of an occupier in ensuring the safety, health, and welfare of all persons in the workplace. These duties include providing and maintaining safe plant, work systems, and procedures that are free from health risks. The Act further requires occupiers to provide adequate information, training, instruction, and supervision necessary to ensure workplace safety and health. In addition, occupiers must provide and maintain safe and risk-free means of access to and exit from the workplace. The Act also requires the provision of adequate workplace facilities and welfare arrangements for employees. Furthermore, employers are required to undertake risk assessments concerning the safety and health of persons employed, and to use the findings of these assessments to develop preventive measures that ensure chemicals, machinery, equipment, tools, and workplace processes remain safe under all intended conditions of use (Occupational Safety and Health Act, 2007).

A recent body of evidence highlights that implementation of occupational safety and health (OSH) requirements in safety-critical environments such as aviation is often constrained by organizational, staffing, and psychosocial factors. Studies in air traffic control contexts show that despite formal OSH frameworks, challenges such as limited staffing levels, high workload, and extended duty cycles frequently undermine compliance with safety requirements, leading to fatigue and reduced recovery time among personnel (Åkerstedt & Wright, 2022). Staffing shortages in particular have been identified as a persistent structural issue that increases overtime, disrupts rest opportunities, and weakens the effectiveness of risk mitigation systems in aviation operations (Akca & Meltem, 2017). In addition, Akca and Meltem (2017) noted that organizational constraints such as inadequate resources, time pressures, and weak safety culture further limit the effective implementation of safety regulations in the workplace. These findings from previous studies suggest that even where regulatory provisions under the occupational safety and health act are well established, practical implementation in air traffic control environments is often compromised by workforce limitations and organizational pressures that affect both safety compliance and employee well-being.

2.4 Air Traffic Control (ATC) Concepts

The International Civil Aviation Organization (ICAO, 2025a), in Doc 4444, states that the functions of air traffic controllers vary based on their operating positions, namely aerodrome control, approach control, and area control.

An aerodrome controller maintains a continuous watch on all visible flight operations in the vicinity of the aerodrome. This controller is also responsible for visual flight rules (VFR) flights within the control zone and issues clearances to ensure a safe and orderly flow of traffic. Coordination is also crucial at this control position, including notifying aircraft of any failure or irregular operation of devices used for aerodrome guidance services. They also provide alerting services through coordination with rescue and fire-fighting services, as well as meteorological information to aircraft upon request (ICAO, 2025a). These responsibilities ensure the safe landing, departure, and overall management of aircraft in the aerodrome environment (ICAO, 2025a).

An approach controller's primary responsibility is to provide standard separation between controlled flights within a terminal control area and control zone. They also notify aircraft of any irregular operation of aerodrome facilities, provide flight information and alerting services, and initiate overdue action for aircraft at the destination aerodrome. Where RADAR is in use, they monitor air traffic, provide RADAR separation, and apply RADAR vectoring to resolve conflicts and expedite traffic flow (ICAO, 2025a). These functions are essential in maintaining efficiency and safety within the terminal airspace structure (ICAO, 2025a).

An area controller's primary responsibility is to provide standard separation between controlled flights outside the terminal control area but within the Kenyan Flight Information Region (FIR). They facilitate seamless aircraft transfer from the Kenyan FIR to another FIR, ensuring proper coordination between all units concerned. When employing RADAR, they provide RADAR monitoring, RADAR separation, and vectoring to resolve conflicts within their control area (ICAO, 2025a). These duties support the orderly and continuous management of en-route traffic across wider airspace sectors (ICAO, 2025a).

2.5 Previous Related Studies

Occupational safety and health (OSH) have been widely studied across various sectors globally, regionally, and within Kenya. In Kenya, extensive research has been conducted in sectors such as civil engineering and healthcare. According to the directorate of occupational safety and health (DOSH), the construction sector is the second most hazardous after transport. Kemei (2016) found that most construction accidents in Nairobi occurred during peak financial periods, with only 1% of project budgets allocated to OSH. The study emphasized the need for stronger management commitment, adequate resource allocation, and enhanced staff training to mitigate workplace risks. In the medical sector, Kumar (2016) identified long working hours, denied leave, and outdated equipment as key contributors to stress and burnout, recommending improved work environments, better human factors training, and adequate rest periods.

At the regional level, studies across Africa indicate that occupational safety and health challenges are often linked to resource constraints, limited enforcement of safety regulations, and inadequate infrastructure. Research in Sub-Saharan Africa has shown that high workload, aging equipment, and limited ergonomic interventions significantly contribute to occupational stress and reduced performance in safety-critical industries, including aviation-related operations. These challenges are further compounded by gaps in safety management system implementation and inconsistent regulatory compliance across some developing aviation environments (International Labour Organization, 2019). Overall, these findings align with global evidence suggesting that developing regions experience heightened occupational risks due to both operational demands and systemic limitations in OSH implementation.

In the agricultural sector, Molina-Guzmán *et al.* (2020) reported that workers are highly exposed to machinery-related accidents, vehicle incidents, and hazardous conditions such as noise, chemicals, and vibrations. The study recommended increased automation and continuous risk assessment to manage emerging hazards associated with technological advancements.

Several studies have specifically focused on air traffic control (ATC). Nurhayati *et al.* (2020) assessed physical fatigue and the risk of work-related musculoskeletal disorders (WMSDs) among air traffic controllers, finding that poor posture and prolonged sitting contributed significantly to neck, back, and shoulder pain. Similarly, Tharikh and Hamzah (2020) applied the Wellbeing Theory and emphasized the importance of ergonomic assessments and human-factor-based shift scheduling in improving controller performance and well-being.

Saralee (2018) examined the effects of lighting and noise on controller performance and situational awareness, concluding that inadequate lighting and noise interference negatively affect attention and communication between controllers and pilots. In support of this, Melan and Cascino (2018) found that reduced air traffic improved sleep quality and alertness among controllers, while unfavorable work schedules negatively impacted family life and overall well-being.

Sonati *et al.* (2016) in a study conducted in Brazil, identified physical inactivity, sleep deprivation, and social isolation as major risk factors affecting the health and performance of air traffic controllers. The study recommended increased physical activity, improved diet, and adequate rest before night shifts. Bryan *et al*. (2016), in their analysis of a runway excursion incident in the United States, highlighted the risks associated with ambiguous communication and fatigue, recommending clearer leadership structures and standardized radio phraseology.

In Kenya's transport sector, George (2016) observed that workers are exposed to hazards such as noise, air pollution, and long working hours, which negatively affect their social well-being. The study emphasized the importance of gender mainstreaming and regulation of working hours to enhance employee welfare.

Subotic *et al.* (2014) investigated the impact of equipment failure in ATC operations and found that such events significantly increase stress levels among controllers, even when flight safety is not directly compromised. The study proposed a recovery model incorporating improved equipment design, enhanced recovery procedures, and specialized training. Earlier, Giovanni (2000) linked the demanding ATC work environment in Italy to stress-related conditions such as headaches, ulcers, and chronic fatigue, recommending the implementation of stress management strategies to prevent long-term health effects.

2.5.1 Research Gap

Existing literature on occupational safety and health (OSH) has extensively examined workplace risks across various sectors globally, including construction, healthcare, agriculture, and aviation. Studies such as those by Kumar (2016), Sonati *et al.* (2016), and Tharikh and Hamzah (2020) have largely focused on stress, fatigue, and ergonomic challenges among air traffic controllers, with particular emphasis on work environment factors such as workload, shift work, noise, and lighting. Similarly, studies conducted in Kenya, including Kemei (2016) and findings from the Directorate of occupational safety and health (DOSH), have primarily concentrated on high-risk sectors like construction and transport, with limited attention to aviation-specific occupational risks.

At the regional level, available literature highlights general occupational safety challenges in Sub-Saharan Africa, particularly resource limitations, inadequate enforcement of safety regulations, and infrastructural constraints. However, these studies rarely provide a detailed examination of aviation-specific occupational health risks, particularly in air traffic control environments.

Although previous studies on air traffic control have explored isolated factors such as work environment (Saralee, 2018), shift work and wellbeing (Melan and Cascino, 2018) fatigue and musculoskeletal disorders (Nurhayati *et al.*, 2020), and equipment-related stress (Subotic *et al.*, 2014), most of them focus on single dimensions of occupational risk. There is limited integration of multiple risk domains within ATC, particularly the combined influence of work environment, work organization, operating procedures, and personal factors.

Furthermore, in the Kenyan context, there is a notable scarcity of empirical studies that comprehensively assess occupational safety and health issues affecting air traffic controllers. Existing studies have not sufficiently examined how the interaction of physical, organizational, procedural, and human factors collectively influence controller safety, health, and operational performance.

Therefore, this study addresses this gap by providing an integrated assessment of occupational safety and health issues affecting air traffic controllers in Kenya, focusing on the combined effects of work environment, work organization, operating procedures, and personal factors. This holistic approach contributes to bridging the gap between fragmented global studies and the limited context-specific evidence available in Kenya’s aviation sector.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Research Design

A quantitative descriptive research design was used in this study. A cross-sectional descriptive survey was used to collect data. It involved use of a questionnaire administered either manually or electronically to the sample at a definite time.

3.2 Study Area and Population

In Kenya, we have a total of 9 manned airports. It is a combination of both international and domestic airports (Aeronautical Information Publication, 2025).

International airports are set up for border controls and customs inspections therefore have customs and immigration offices set up. International airports are built with bigger terminals, longer & stronger runways and are well equipped with approach aids. In Kenya the international manned airports include Moi International airport, Eldoret international airport, Kisumu international airport, Jomo Kenyatta International airport, Malindi airport, Wajir airport, Wilson airport and Lokichogio airport (Aeronautical Information Publication, 2025).

Domestic airports allow flight operation within the same country. They are built in a manner conducive for local travel mostly characterized by small visual runways. In Kenya Diani airport is the only manned domestic airport.

The sample was obtained from the total population of 182 controllers working in selected airports in Kenya. Table 3.1 presents the population distribution from which the sample was drawn. The variation in the number of air traffic control (ATC) personnel across stations is attributed to differences in operational complexity, traffic volume, and the classification of each aerodrome. Jomo Kenyatta International Airport (JKIA), being the busiest international hub, has a higher number of controllers due to increased traffic demand, multiple operating positions, and more shift coverage requirements compared to the other airports.

Table 3.1: Population of Air Traffic Controllers (ATCOs) Employed in Kenya

S/No	Station Name	No. of ATC employees
1	Moi International Airport	36
2	Malindi Airport	8
3	Diani Airport	6
4	Kisumu Airport	7
5	Eldoret International Airport	7
6	Jomo Kenyatta International Airport	86
7	Wilson Airport	22
8	Wajir Airport	5
9	Lokichogio airport	5
	Total population	**182**

Source: Kenya Civil Aviation Authority, 2022

3.3 Sampling Method

Purposive sampling was used to select 7 airports from the population of 9 as shown in table 3.2. Purposive sampling is a non-probability type of sampling where the researcher uses their judgment to determine the population to be considered for the study. Wajir and Lokichogio airports were exempted from this study since the air traffic controllers working in these stations work for a temporary period of 1 year after which they are posted in the other stations.

Table 3.2: Sample Frame of Air Traffic Controllers Used in the Study

S/No	Station Name	No. of ATC employees
1	Moi International Airport	36
2	Malindi Airport	8
3	Diani Airport	6
4	Kisumu Airport	7
5	Eldoret International Airport	7
6	Jomo Kenyatta International Airport	86
7	Wilson Airport	22
	Total Population	**172**

3.4 Sample Size Determination

Random sampling was used to select the respondents using Yamane's formula. Proportionate distribution was then used to obtain the sample size in each airport.

Yamane's formula (Yamane, 1967) is considered appropriate for sample selection in a quantitative research design where the population is small.

$$n = \frac{N}{1 + N(\propto)^2} \qquad \textbf{\textit{(1)}}$$

Where; N = target population, α = margin error and n = sample size

The margin error applicable for this formula include 3%, 5%, 7%, and 10%

10% was used for the purposes of this research since it provided a practical balance between statistical adequacy and field accessibility while still ensuring representativeness of the population. From equation 1;

$$n = \frac{172}{1+172(0.1)^2} = 63.24$$

Therefore, total respondents considered for this study was 64 air traffic controllers.

The sample was distributed using proportionate distribution as shown in table 3.3.

Where the sample size for each airport was given by;

$$\left(\frac{Population\ of\ a\ specific\ station}{Total\ Population\ for\ the\ study}\right) * sample\ size \qquad (2)$$

Table 3.3: Sample Distribution in the Selected Airport Sites

S/No.	Station Name	Population	$\left(\frac{Population}{Total\ Population}\right)*n$	Sample size (n)
1	Moi International Airport	36	13.4	13
2	Malindi Airport	8	2.98	3
3	Diani Airport	6	2.23	2
4	Kisumu Airport	7	2.60	3
5	Eldoret International Airport	7	2.60	3
6	Jomo Kenyatta International Airport	86	32	32
7	Wilson Airport	22	8.19	8
Total Population		172		64

3.5 Research Instruments

3.5.1 Work Environment

Noise and lighting measurements in the air traffic control environments were conducted between May 2023 and August 2023 across selected control units to capture variability in workload, traffic intensity, and operational conditions.

Noise levels were measured using a calibrated sound level meter (serial number: 10225185), with an accuracy of ±1.5 dB, consistent with Class 1/2 occupational noise measurement standards. The instrument was configured to A-weighting (dBA) and set to slow response mode, appropriate for assessing stable and continuous operational noise typical of control room environments. Measurements were taken at the controller's working position at approximately 1.2 m above floor level to reflect actual exposure conditions. The study directly recorded two noise parameters: equivalent continuous sound level (Leq) and maximum sound level (Lmax). Leq represented the integrated energy-equivalent average exposure during each measurement period, while Lmax captured the highest instantaneous noise levels associated with peak operational events such as radio communication, aircraft coordination, and alerting signals.

Measurements were conducted during two operational periods within the study timeframe: daytime (10:00–13:00) and night-time (22:00–01:00), where applicable. Daytime measurements captured peak operational traffic across all facilities, while night-time measurements were limited to units with active night operations. Facilities without night operations were recorded as not applicable (N/A), reflecting absence of exposure rather than missing data. Noise results were compared against the Federal Aviation Administration (FAA) recommended communication range of 55–65 dBA, which represents optimal ambient conditions for speech intelligibility in air traffic control environments.

Lighting intensity was measured using a calibrated lux meter (serial number: 200401318), with an accuracy of ±3%. Illuminance levels were recorded in lux (lx) at the flight progress strip area and controller workstation surfaces, which represent critical visual task zones. Measurements were taken at working height to reflect actual visual working conditions experienced by controllers. The study recorded average illuminance

(Eavg) during daytime operations (10:00–13:00) and corresponding night or low-light conditions (22:00–01:00) where applicable. Minimum illuminance (Emin) was not separately analyzed, as the focus was on compliance with recommended occupational lighting standards. Night lighting measurements were only conducted in facilities with night operations, while non-operational night periods were classified as not applicable (N/A).

Accordingly, the study focused on representative operational exposure levels (Leq and Lmax for noise, and Eavg for lighting) to assess environmental conditions affecting communication, visibility, and performance in air traffic control environments. Variability across stations and time periods was used to describe operational exposure ranges.

A structured checklist was also used to record observed environmental and facility conditions, including noise and lighting levels, working at height (mobile control tower operations), availability of sanitation facilities by gender, insect and vector control measures, exposure to extreme weather conditions, and availability of rest rooms, canteens, and gym facilities.

Additionally, a structured questionnaire was administered to collect data on the impact of equipment serviceability and extreme weather conditions (hot or cold) on air traffic controllers. Respondents rated their level of agreement using a five-point Likert scale ranging from strongly agree to strongly disagree, with all participants responding to a standardized set of questions.

3.5.2 Work Organization

To investigate the impact of various factors on air traffic control officers (ATCOs), a structured observational checklist was used to record job design characteristics, workspace conditions (including sitting arrangements, types of seats, and operational processes), and equipment layout in control rooms. This included the number of displays, sitting time per shift, and screen time per shift.

Data were collected during the study period between May 2022 and August 2023. The observations were conducted at different times within this period to capture operational conditions across varying levels of air traffic demand, which typically range from moderate levels in May to peak activity by August, as reported by respondents.

The data collection was therefore not a single one-time observation but was carried out within the defined study period to reflect operational variability associated with seasonal traffic fluctuations.

In addition, a survey was done in form of questionnaire to collect data on the effects of shift work schedules, workload (work demands, time pressure, hours of work), training, communication, management support, and reward and recognition. The questionnaire was administered to respondents either in person or virtually, and each received the same set of questions to rate their level of agreement on a 5-point scale ranging from strongly agree to strongly disagree (Strongly agree-5, Agree-4, neutral-3, disagree-2 & strongly disagree-1).

3.5.3 Operating Procedures

Air traffic control (ATC) procedures are subject to constant evolution in response to the rapidly changing technological landscape of the aviation industry. To evaluate the impact of ATC procedures on the safety and health of air traffic controllers (ATCOs) a survey was done in form of questionnaire to gather data from respondents was used. Questionnaires were filled by each participating controller using the same set of questions, and they were required to indicate their level of agreement on a 5-point scale ranging from strongly agree to strongly disagree. Each statement addressed an occupational safety and health (OSH) issue related to procedures.

3.5.4 Personal Factors

The study also examined the influence of personal factors such as attitudes, risk perception, personality traits, work habits, and posture on the safety and health of

ATCOs. Data were collected using a structured questionnaire in which respondents indicated their level of agreement on a five-point Likert scale from strongly agree to strongly disagree. The items targeted OSH-related personal characteristics affecting performance and well-being.

In addition, an observational checklist was used to assess controllers' working posture within the control rooms, providing supplementary data on ergonomic practices.

3.6 Ethical Consideration

Initially, authorization to conduct the study was obtained from Jomo Kenyatta University of Agriculture and Technology (JKUAT), Graduate school. Recruitment of the respondent was done in a manner that promotes ethical considerations whereby, confidentiality and privacy of respondents was ensured, as no personal information was collected through the research instrument, and no form of coercion or undue influence was exerted. During recruitment, respondents were required to give their consent to participate in the study by signing a consent form as attached in appendix III. The participation of any respondent in the study was voluntary and had a right to refuse to participate or to withdraw from the study at any moment during the research.

Privacy of the respondents was ensured by collecting only information essential for this research. Most questionnaires were transmitted virtually hence providing a private space required by the respondents to provide the information required without interfering with their privacy. Where a questionnaire was transmitted face to face, a private space was created where only one respondent was allowed at a time.

Confidentiality was ensured through signing of the consent provided in appendix III. All the data collected virtually was stored in the researcher's private computer and any other data collected manually was safely stored away from work premises. Therefore, confidentiality and privacy of the respondents was ensured hence the researcher was provided with the protection and care that was needed in carrying out this research.

Finally, ethical approval (TUM SERC MSC/007/2023) was sought from an Ethical Review Committee prior to commencement of the research process. Thereafter, a research license (829298) was obtained from national commission for science, technology and innovation (NACOSTI) to conduct the study in accordance with Kenya's applicable research regulations.

3.7 Data Processing and Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. This is the analytical software highly recommended for social sciences. The tools that were used to report data collected included mean, median, standard deviation, percentage, frequency, and correlation between variables and chi-squared test. The Chi-square test was used to test associations between the categorical variables at a 95% confidence level ($\alpha = 0.05$). For each significant association, the effect size was calculated using Cramér’s V, with thresholds of 0.10 (small), 0.30 (medium), and 0.50 (large).

This was presented using tables and charts. Sound levels and lighting levels measured were analyzed and compared with the recommended measurements.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Response Rate

A survey was carried out on all of the 64 ATCO respondents as planned. All the questionnaires were filled online while the checklists were filled at the respective workstations. The response rate was 100% from all the airports as planned.

4.2 Demographic Characteristics

The demographic characteristics of the respondents were analyzed and summarized in Table 4.1. The findings indicate that the air traffic control workforce in Kenya is generally mature, highly educated, and experienced, although there are notable concerns regarding gender imbalance and limited representation of younger personnel. This may partly be attributed to the licensing requirements of the profession, where air traffic controllers are required to attain the minimum licensing age of 27 years as provided under the Civil Aviation (Personnel Licensing) Regulations (2022).

In terms of gender distribution, the majority of respondents were male (65.6%), while females accounted for 34.4%. This reflects a gender imbalance within the profession, although female representation in this study is higher compared to global estimates reported by ICAO (2021), where women constitute approximately 21.1% of air traffic controllers. Despite this improvement, the findings suggest the need for continued efforts to promote gender inclusivity in the profession.

The age distribution shows that most respondents were between 36 and 45 years (51.6%), followed by those aged 26 to 35 years (40.6%). Notably, there were no respondents below 25 years and only 7.8% were above 45 years. This indicates a relatively mature workforce with substantial operational experience, but also highlights a limited pipeline of younger entrants, which may pose challenges for future workforce sustainability and succession planning.

With regard to education level, the results indicate a highly qualified workforce. Nearly half of the respondents (48.4%) held a bachelor's degree, while 28.1% had attained a master's degree. Additionally, 9.4% held postgraduate diplomas and another 9.4% postgraduate certificates, with only 4.7% having diploma-level qualifications. This aligns with the technical and safety-critical nature of air traffic control, supporting findings by Sobieralski and Hubbard (2019), who classify air traffic controllers among highly skilled professionals.

Analysis of marital status revealed that the majority of respondents were married (62.5%), while 32.8% were single and 4.7% were separated. The high proportion of married respondents suggests the presence of significant family responsibilities, which may interact with work-related stress, particularly given the demanding and irregular nature of shift work in air traffic control.

In terms of professional experience, most respondents (46.9%) had between 10 and 20 years of experience, followed by 28.1% with 5 to 10 years and 15.6% with less than 5 years. Only 9.4% had more than 20 years of experience. This distribution further supports the observation of a mature and experienced workforce, although the relatively low proportion of highly experienced and entry-level controllers may have implications for mentorship and knowledge transfer.

Regarding operational competency, a large proportion of respondents (48.4%) held three ratings, while 40.6% held two ratings. A smaller proportion held four (7.8%) or five (3.1%) ratings. In the air traffic control profession, controllers can only operate in positions for which they are rated and validated. Therefore, a higher number of ratings reflects greater operational flexibility and experience. The findings suggest that most respondents had attained an optimal number of ratings (three or more), indicating seniority and suitability for higher responsibilities within the system.

Overall, the demographic profile suggests a well-qualified and experienced workforce capable of supporting safe and efficient air traffic operations. However, the observed gender imbalance, limited entry of younger personnel, and concentration of experience within a specific age bracket highlight the need for strategic workforce planning to ensure long-term sustainability of the profession.

Table 4.1: Demographic Characteristics

		Percentage Representation
Gender	Male	65.6%
	Female	34.4%
Age	18-25	-
	26-35	40.6%
	36-45	51.6%
	Above 45	7.8%
Marital Status	Single	32.8%
	Married	62.5%
	Divorced	-
	Widowed	-
	Separated	4.7%
Education Level	Certificate	-
	Diploma	4.7%
	Bachelor's degree	48.4%
	PGC	9.4%
	PGD	9.4%
	Master's Degree	28.1%
	Doctorate	-
ATC Experience in Years	<5yrs	15.6%
	5-10yrs	28.1%
	10-20yrs	46.9%
	above 20yrs	9.4%

4.3 Work Environment Factors Affecting Air Traffic Controllers in Kenya

The first specific objective was to determine the impact of the work environment on air traffic controllers in Kenya. The respondents were required to choose one of the five given options (Strongly agree-5, Agree-4, neutral-3, disagree-2 & strongly disagree-1) from a list of predetermined statements. The responses were analysed, discussed, and presented in Table 4.2.

Table 4.2: Responses on Work Environment Factors Affecting Air Traffic Controllers

WORK ENVIRONMENT	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)	Mean	Std. Dev	Decision (perception)
Noise affects my concentration when working	4.7	6.3	12.5	37.5	**39.1**	4.0	1.2	High
Lighting levels affects my efficiency when working	-	4.7	10.9	40.6	**43.8**	4.2	0.8	High
Equipment serviceability affects my work efficiency	-	-	1.6	17.2	**81.3**	4.3	0.4	High
Equipment unserviceability increases my workload & stress	-	-	-	12.5	**87.5**	4.4	0.3	High
Availability of gym, restrooms and canteen has helped me in reducing stress and improving work morale	9.4	18.8	**37.5**	18.8	15.6	3.1	1.2	Low

[1]*Weighted Average-4.00*

[2]*low perception decision was reached if the mean <weighted average and high perception decision was reached if the mean >weighted average*

The data analysis detailed in Table 4.2 shows that the majority of the respondents perceived the work environment as having a significant effect on air traffic controllers. In particular, respondents indicated that lighting levels affected their efficiency while working, equipment serviceability affected work efficiency, and equipment unserviceability increased workload and stress levels. These findings suggest that the operational environment and reliability of equipment are important determinants of controller performance and psychological well-being. Air traffic controllers rely heavily on surveillance, communication, and automation systems to maintain situational awareness and ensure safe aircraft separation. Consequently, equipment failures or reduced serviceability may increase cognitive workload and operational pressure during task execution. Similar findings were reported by Subotic *et al.* (2014), who observed that equipment failures requiring controller intervention increase mental workload and complexity of operations, even where flight safety is not immediately compromised. Recent studies by Stroeve *et al.* (2023) further indicate that interruptions associated with equipment malfunction can negatively affect controller attention management, decision-making, and workload regulation within high-density traffic environments.

Respondents further demonstrated a relatively high perception that noise affected their concentration while working. This perception may be attributed to the elevated noise levels that were measured during the study. The measured values indicate the presence of environmental noise conditions that may interfere with communication clarity and concentration during operations. Similar observations were reported by Saralee (2018), who found that elevated control room noise levels can negatively influence communication efficiency, attention, and task performance among air traffic controllers. More recent findings by Pawlak et al. (2022) also established that persistent occupational noise exposure in aviation operational environments contributes to mental fatigue and reduced cognitive performance.

Conversely, respondents demonstrated a relatively low perception that the availability of gym facilities, restrooms, and canteens contributed to stress reduction and improved work morale. Observations also revealed limited availability of welfare facilities across the sampled workstations, with none of the stations having a canteen near the operational work area. Some respondents reported resting on poorly maintained mattresses placed on the floor, while others remained seated throughout the shift without adequate rest. Although several stations had gym facilities installed, respondents indicated that shift schedules limited their ability to utilize them effectively. These findings suggest that the existing welfare infrastructure may not adequately support recovery and well-being among controllers working under demanding operational schedules. Similar findings were reported by Mohsan *et al.* (2021), who established that workplace welfare facilities and recovery opportunities significantly influence employee morale, fatigue levels, and psychological well-being in safety-critical occupations. These factors of work environment were analyzed and discussed further below.

4.3.1 Equipment Serviceability

The analysis of the relationship between perceived equipment unserviceability and reported work-related stress among air traffic control officers (ATCOs) revealed a clear association. Out of the 30 controllers who reported experiencing stress, 24 (80%) indicated that equipment unserviceability contributed to their stress, while 6 (20%) did not attribute their stress to equipment-related issues. In contrast, among the 34 controllers who reported not being stressed, 17 (50%) indicated that they still worked with unserviceable equipment, while the remaining 50% reported no exposure to such conditions, as shown in Table 4.16.

A Chi-square test confirmed a statistically significant association between equipment unserviceability and reported work-related stress among ATCOs ($\chi^2 = 6.24$, $p = 0.00125$). The effect size, as measured by Cramér's V (0.31), indicated a moderate relationship between the two variables. These results suggest that exposure to unserviceable equipment is more frequently associated with higher reported levels of stress among controllers.

These findings are consistent with existing literature on operational strain in air traffic control environments. Subotic, Majumdar, and Ochieng (2014) observed that while equipment failures may not always directly compromise flight safety, they increase operational pressure on controllers, particularly when immediate human intervention is required to restore system functionality. Similarly, Costa (2000) reported that inadequate or malfunctioning equipment contributes to increased cognitive workload and psychological strain in air traffic control operations. Research by Stroeve *et al*. (2023) further supports this perspective, noting that automation limitations and equipment failures in air traffic management significantly affect human performance by increasing workload demands and reducing system predictability, thereby elevating controller stress levels. Additionally, recent aviation operational guidance from the Federal Aviation Administration (2023) emphasizes the role of reliable systems in supporting workload stability and operational efficiency in control environments.

Overall, the findings align with prior studies indicating that equipment reliability is closely linked to workload demands and stress experiences among ATCOs in operational settings

4.3.2 Noise Measurement Results (dBA)

Noise levels across the air traffic control units are presented in Table 4.3 in terms of equivalent continuous sound level (Leq) and maximum sound level (Lmax) measured during daytime (10:00–13:00) and night-time (22:00–01:00). The results show that daytime Lmax values were highest at JKIA Tower (85 dBA), Wilson Tower (79 dBA), and JKIA Enroute (78 dBA), indicating frequent peak operational noise events associated with aircraft coordination, radio communication, and alerting activities. These peak levels demonstrate intermittent high-intensity exposure conditions typical of busy operational control environments.

In terms of Leq, JKIA Tower recorded the highest daytime value (79 dBA), followed by JKIA Enroute (66 dBA) and JKIA Approach (59 dBA). These values indicate that sustained noise exposure in major control units frequently exceeds the FAA recommended communication range of 55–65 dBA, suggesting potential challenges to speech intelligibility and communication efficiency during peak operational periods. Lower Leq values were recorded in smaller aerodrome towers such as Malindi (49 dBA), Diani (54 dBA), and KIA Tower (45 dBA), indicating relatively quieter operational environments with improved compliance to communication comfort thresholds.

Night-time measurements, where applicable, showed a general reduction in both Leq and Lmax values across all stations. For example, JKIA Tower recorded a night Leq of 58 dBA compared to 79 dBA during daytime, while JKIA Enroute reduced from 66 dBA to 44 dBA. This reflects reduced traffic intensity and operational workload during off-peak hours. Several stations recorded no night operations (N/A), indicating absence of exposure rather than missing data. Overall, the results indicate that major operational hubs (JKIA Tower, Enroute, and Approach sectors) consistently experience higher noise exposure levels compared to other control units, particularly during daytime peak traffic periods.

These findings are consistent with Saralee (2018), who observed that noise levels above 60 dBA can negatively affect controller concentration and communication efficiency. Similarly, Pawlak *et al.* (2022) reported that sustained occupational noise exposure in aviation environments contributes to increased cognitive fatigue, reduced attention span, and impaired decision-making among air traffic controllers. Pruksaritanon (2018) further noted that elevated noise levels in air traffic control environments can reduce situational awareness and degrade operational performance in communication-intensive tasks.

Overall, the combined results from instrument-measured Leq and Lmax values indicate that noise remains a significant occupational stressor in air traffic control environments. Elevated exposure in key operational facilities, particularly during peak periods, suggests potential risks to communication clarity, situational awareness, and controller performance. This highlights the need for continuous noise monitoring, improved acoustic design of control rooms, and operational strategies aimed at reducing peak noise exposure in high-traffic control units.

Table 4.3: Measured Sound Levels in Control Rooms (A-Weighted dBA)

Control Room	Daytime Lmax (10:00–13:00) (dBA)	Daytime Leq (10:00–13:00) (dBA)	Night Lmax (22:00–01:00) (dBA)	Night Leq (10:00–13:00) (dBA)	Exposure Interpretation	FAA Recommended Range (dBA)
1. JKIA Tower	85	79	62	58	High daytime exposure with elevated peaks	55–65
2. Wilson Tower	79	72	N/A	N/A	High daytime variability; no night operations	55–65
3. MIA Tower	69	64	59	51	Moderate exposure with occasional peaks	55–65
4. Diani Tower	61	54	N/A	N/A	Low to moderate stable environment	55–65
5. Malindi Tower	57	49	N/A	N/A	Within acceptable communication range	55–65
6. Eldoret Tower	58	50	35	32	Low exposure with minimal night activity	55–65
7. KIA Tower	59	45	30	27	Low exposure; minimal operational noise	55–65
8. JKIA Approac h	68	59	58	46	Moderate to high operational workload	55–65
9. JKIA Enroute	78	66	61	44	High exposure with frequent coordination demand	55–65
10. MIA Approac	68	59	52	43	Moderate exposure with intermittent	55-65

Control Room	Daytime Lmax (10:00–13:00) (dBA)	Daytime Leq (10:00–13:00) (dBA)	Night Lmax (22:00–01:00) (dBA)	Night Leq (10:00–13:00) (dBA)	Exposure Interpretation	FAA Recommended Range (dBA)
h					peak	

4.3.3 Light Measurement in Lux

Lighting intensity in the air traffic control rooms, as presented in Table 4.4, was assessed in terms of average illuminance (Eavg) recorded during daytime (10:00–13:00) and night-time (22:00–01:00) operations where applicable. Measurements were taken at controller workstation areas and flight progress strip zones, which represent critical visual task environments. The results show that daytime illumination levels varied considerably across the control units, with an overall average of approximately 181 lux, and recorded values ranging from 11 lux to 294 lux. While most control rooms recorded acceptable daytime lighting conditions, several operational areas including JKIA Approach, JKIA Enroute, and MIA Approach recorded values below 200 lux. These levels fall below recommended occupational lighting standards for control room visual tasks, indicating potential limitations in visibility during operational duties.

Night-time illumination levels were significantly lower, with an overall average of approximately 6.5 lux, and values ranging between 1 lux and 30 lux. These readings were consistently below the recommended 100 lux threshold for night-time control room operations, suggesting inadequate lighting conditions across all stations during night operations. This was particularly evident in remote control and approach sectors where lighting levels were extremely low, potentially affecting visibility and visual task performance. Although supplementary or task lighting systems were present in most facilities, field observations indicated that they were either insufficient or not consistently utilized during operational periods, contributing to variability in lighting adequacy across control rooms.

The quantitative findings were supported by questionnaire responses, where 43.8% of respondents strongly agreed and 40.6% agreed that lighting conditions affected their efficiency during work. This indicates a strong perceived relationship between lighting adequacy and operational performance among air traffic controllers.

These findings are consistent with the Federal Aviation Administration (2023), which emphasizes that inadequate lighting in air traffic control environments can lead to reduced visual performance, increased eye strain, fatigue, and elevated stress levels. Similarly, Pruksaritanon (2018) observed that poor illumination conditions in control environments negatively affect situation awareness and increase cognitive workload, thereby reducing overall operational efficiency.

Overall, the results demonstrate a clear convergence between measured lighting deficiencies, controller perceptions, and established literature, indicating that inadequate illumination particularly during night operations may compromise visual task performance, situational awareness, and operational efficiency in air traffic control environments.

Table 4.4: Measured Light Levels (Lux) in Control Rooms

Control Rooms	Daytime Lighting (10:00-13:00) Eavg (Lux)	Recommended Day Lighting Level (Lux)	Night Lighting (22:00-01:00) Eavg (Lux)	Recommended Night Lighting Level (Lux)
1. JKIA Tower	238	200	30	100
2. Wilson Tower	294	200	N/A	100
3. MIA Tower	235	200	3	100
4. Diani	226	200	N/A	100

Control Rooms	Daytime Lighting (10:00-13:00) Eavg (Lux)	Recommended Day Lighting Level (Lux)	Night Lighting (22:00-01:00) Eavg (Lux)	Recommended Night Lighting Level (Lux)
Tower				
5. Malindi Tower	237	200	N/A	100
6. Eldoret Tower	233	200	2	100
7. KIA Tower	219	200	2	100
8. JKIA Approach	37	200	4	100
9. JKIA Enroute	72	200	4	100
10. MIA Approach	11	200	1	100

Table 4.5 presents the analysis of observed and reported effects of lighting in control rooms. The findings show that 95.1% of respondents reported experiencing glare from the various screens used during operational duties. This indicates that glare is a widespread issue affecting nearly all air traffic controllers within the sampled control environments.

These findings align with Saralee (2018), who noted that continuous exposure to screen glare can lead to significant eye strain among air traffic controllers, potentially affecting visual comfort and sustained attention during operations. Similarly, Pruksaritanon (2018) found that excessive glare and poor visual ergonomics in air traffic control environments negatively affect operator performance and situation awareness, thereby increasing visual fatigue and reducing overall efficiency in task execution.

Further results indicated that 61.7% of respondents reported that anti-glare glasses were not provided for use at work. Among the 38.3% who reported having anti-glare glasses, all indicated that they had acquired them from eye hospitals due to previously developed eye-related conditions, with costs covered through organizational medical insurance. This suggests that the provision of protective visual aids is largely reactive rather than preventive.

The findings also highlight that personal protective equipment (PPE) represents the last line of defense within the hierarchy of controls. This implies that reliance on PPE alone does not eliminate the underlying exposure to glare but instead mitigates its effects after exposure has already occurred. Overall, the results indicate a strong presence of screen-related visual strain among controllers, consistent with established literature on visual ergonomics and operational performance in air traffic control settings.

Table 4.5: Responses on Light Variables in the Control Rooms

Light variables	YES (%)	NO (%)
1. Anti-glare screens have been provided for use at work	4.9	95.1
2. Anti-glare glasses are provided for use at work	38.3	61.7
3. Anti-glare windows or blinds are provided for the tower screens	40.7	59.3
4. Do you take regular breaks from the screen	32.8	67.2
5. Do you find yourself using a screen the whole shift	95.2	4.8
6. Do you find the screens irritable either due to glare or reflections from outside	73.0	27.0

The control towers across all stations were observed to be constructed predominantly using glass structures. Table 4.5 further shows that 59.3% of respondents reported experiencing reflected glare within the control rooms. This condition was attributed to the absence of blinds or anti-glare systems to regulate sunlight penetration into the working environment. As a result, direct and reflected sunlight created visual disturbances for air traffic controllers during operations. Such glare was reported to interfere with visual clarity, making it difficult for controllers to accurately observe and track aircraft movements, particularly during critical phases of flight such as take-off and landing. In addition, 80% of respondents indicated that the orientation of the control tower relative to sun rays negatively affected their ability to maintain clear visual surveillance of air traffic, as shown in Figure 4.1.

These findings are consistent with Saralee (2018), who noted that glare in air traffic control environments increases the risk of operational errors and reduces situational awareness among controllers. Similarly, Pruksaritanon (2018) emphasized that poor visual conditions, including glare and excessive brightness contrasts, significantly impair situation awareness and degrade performance in air traffic control tasks by increasing visual fatigue and reducing the accuracy of visual monitoring activities.

Overall, the results indicate that reflected glare within glass-structured control towers presents a recurring visual challenge that may interfere with effective aircraft monitoring and situational awareness during high-demand operational phases.

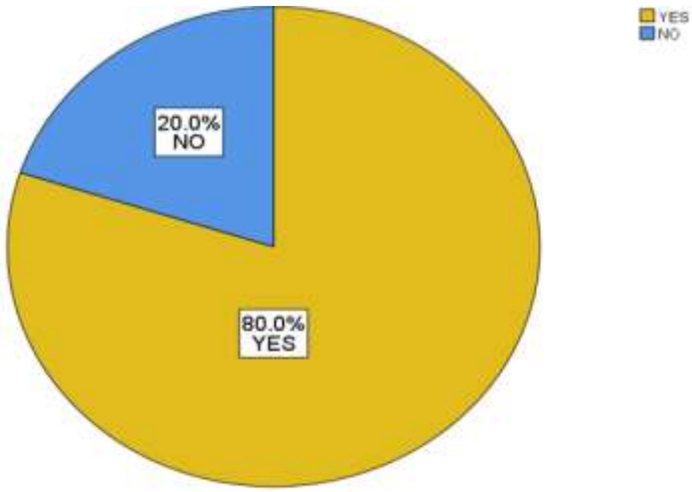

Figure 4.1: Reported Difficulty in Observing Traffic Due to Sun Glare in the Control Tower

Respondents were asked to identify equipment they considered to be affected by glare within their respective workstations, as shown in Table 4.6. Thirty-four respondents identified RADAR screens, with the majority of these responses originating from JKIA (70.6%). Fifteen respondents identified AWOS displays, with JKIA accounting for the highest proportion at 40%. Additionally, 13 respondents selected VCCs, 69.2% of whom were from JKIA, while 10 respondents identified CRONOS systems, which were reported across all airports studied.

Despite the presence of glare across different equipment types, Table 4.5 indicates that 95.2% of respondents reported using screen-based systems throughout their entire shift. Furthermore, 67.2% indicated that they were unable to take breaks away from screens during duty periods. Respondents explained that opportunities for breaks were largely dependent on air traffic density, suggesting that workload intensity directly influenced screen exposure duration. In addition, 73% of respondents reported that the screens were irritating, either due to direct glare from the equipment or reflections from sunlight entering the control environment.

These findings align with Saralee (2018), who established that air traffic control tasks require sustained high levels of attention and are highly dependent on appropriate visual conditions. The study further noted that inadequate lighting control, including glare and reflections, can increase eye strain and distract controllers, thereby reducing situational awareness within control tower environments.

The findings are also supported by Pruksaritanon (2018), who found that visual disturbances such as glare and poor lighting conditions negatively affect performance and situational awareness in air traffic control tasks. The study emphasized that continuous visual exposure without adequate mitigation increases cognitive and visual fatigue, ultimately affecting the accuracy and efficiency of operational decision-making.

Overall, the results suggest that prolonged screen exposure combined with glare and reflections contributes to sustained visual strain, which is consistent with established evidence on human performance limitations in air traffic control environments.

Table 4.6: Respondents Identification of Equipment with Glare Per Station

WorkStation	Experience glare from RADAR? (%) N=34	Experience glare from Cronos? (%) N=10	Experience glare from VCCs? (%) N=13	Experience glare from AWOS? (%) N=15
1. EIA	2.9	10.0	7.7	13.3
2. JKIA	70.6	20.0	69.2	40.0
3. KIA	-	10.0	-	6.7
4. MALINDI	-	20.0	7.7	6.7
5. MIA	14.7	20.0	15.4	33.3
6. WILSON	11.8	20.0	-	-

4.3.4 Availability of Different Facilities in Control Rooms

Data collected on the availability of welfare facilities in control rooms, as presented in Tables 4.7 and 4.8, indicated clear differences between control towers and ground-floor control rooms. In all control tower workstations, it was observed that only one toilet facility was available, which was shared by both male and female personnel. Additionally, no shower facilities were present within the control towers. This reflects limited provision of basic welfare amenities within the elevated control tower environments.

In contrast, control rooms located on the ground floor were observed to have more adequate welfare facilities, including sufficient toilet facilities and showers that catered for both male and female staff. This suggests a more comprehensive provision of welfare infrastructure in ground-based operational areas compared to control towers.

When compared with Federal Aviation Administration (2023) guidance, which recommends at least two unisex restroom facilities for control room environments, control tower facilities fall below the recommended standard, while ground-floor control rooms generally align more closely with the expected provision levels.

Table 4.7: Responses on Availability of Different Facilities in Control Tower

Work Environment variables	JKIA Tower	Wilson Tower	MIA Tower	Diani Tower	Malindi Tower	Eldoret Tower	KIA Tower
1. Provision of washrooms for both genders	No	No	No	No	No	No	No
2. Availability of restrooms	No	Yes	No	No	No	No	No
3. Availability of canteen	No	No	No	No	No	No	No
4. Availability of gym facilities	No	Yes	Yes	No	No	Yes	Yes

Work Environment variables	**JKIA Tower**	**Wilson Tower**	**MIA Tower**	**Diani Tower**	**Malindi Tower**	**Eldoret Tower**	**KIA Tower**
5. Regular (monthly) fumigation of control rooms	No	Yes	Yes	No	No	Yes	Yes
6. Regular (twice a day) Cleaning of Floors carpets	No	Yes	No	Yes	No	Yes	No
7. Availability of alternative emergency exits	No	Yes	No	No	No	No	No

Table 4.8: Responses on Availability of Different Facilities other Control Rooms

Work Environment variables	JKIA Approach	JKIA Enroute	MIA Approach
1. Provision of washrooms for both genders	Yes	Yes	Yes
2. Availability of restrooms	Yes	Yes	Yes
3. Availability of canteen	No	No	No
4. Availability of gym facilities	No	No	Yes
5. Regular (monthly) fumigation of control rooms	No	No	Yes
6. Regular (twice a day) Cleaning of Floors carpets	No	No	No
7. Availability of Safe Emergency exits	Yes	Yes	Yes

4.3.5 Regular Fumigation and Cleaning of Control Rooms

The findings presented in Tables 4.7 and 4.8 show that only 50% of the control rooms were cleaned and fumigated regularly. Observations further revealed dust accumulation on keyboards, RADAR systems, communication equipment, and other operational surfaces within some control rooms. These findings indicate inconsistencies in environmental hygiene and maintenance practices across the sampled workstations. Since air traffic control rooms contain sensitive operational equipment such as RADAR systems, AWOS, communication systems, and computers, accumulation of dust, dirt, and debris may affect equipment reliability and functionality during operations.

In addition, inadequate cleaning and fumigation may increase the presence of bacteria, viruses, insects, rodents, and other contaminants within the work environment, potentially affecting the health and well-being of controllers. The findings therefore suggest that environmental sanitation is closely linked to both occupational health and operational efficiency within air traffic control facilities. Similar observations were reported by Occupational Safety and Health Act (2007), which noted that poor workplace hygiene and inadequate environmental maintenance increase the risk of illness, reduce employee well-being, and may interfere with the performance of sensitive operational staff.

4.3.6 Availability of Safe Emergency Exits

Observations showed that all the control towers had only one exit route, except at Wilson Airport, which had an escape chute installed as an alternative means of escape. The presence of a single exit route in most towers indicates limited evacuation options in the event of an emergency or blockage of the primary exit. This may increase evacuation difficulty during incidents such as fire outbreaks, structural failures, or smoke accumulation within the tower environment.

The findings further showed that all available emergency exits in the control rooms were clearly labelled with directional arrows, indicating compliance with basic emergency signage requirements. However, observations revealed limited emergency lighting along evacuation routes in several stations, which may affect visibility during power outages or smoke-filled conditions. Similar findings have been reported in occupational safety studies, which indicate that inadequate emergency escape infrastructure and poor visibility during emergencies can increase evacuation time and compromise occupant safety in critical operational facilities (Occupational Safety and Health Act, 2007).

4.3.7 Work at Height

KCAA has a mobile ATC tower at Diani airport as shown in photo 1 below. This can be considered as working at height. Twelve of the respondents reported to have worked at Diani airport at some point. 25% of these respondents reported that the tower was unstable and was likely to fall. A further 90% indicated that they had not witnessed any checks or maintenance on the tower while on duty.

Plate 4.1: Diani Control Tower, Kenya

Source: Kenya Civil Aviation Authority

The study finds lack of maintenance of the mobile control tower a safety concern to the controllers since the mechanical operations of the tower are not assured. The instability of the mobile control tower reported by the respondents indicates fear among the controllers due to the possibility of falling while at work. Therefore, it is paramount for the civil aviation authority to ensure there is frequent mechanical checks by approved safety personnel. Additionally, although no measurements were done to determine the ground stability, there should be a stable ground on which the mobile tower is placed, with proper levelling, anchoring, and reinforcement to prevent shifting or vibration during operations, as well as protection from strong winds which may cause instability or overturning.

4.4 Work Organization Factors Affecting Air Traffic Controllers in Kenya

The second specific objective sought to determine the influence of work organization on air traffic controllers in Kenya. Respondents were required to select one of five response options (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, and 1 = Strongly Disagree) based on a series of predetermined statements. The responses were analyzed and presented in Table 4.9. The analysis presented in Table 4.9 indicates that most respondents perceived work organization factors as having a significant influence on air traffic controllers. In particular, respondents strongly perceived that having fewer displays with multiple integrated functions would improve work efficiency. It was observed that controllers simultaneously used multiple displays to perform different operational tasks, increasing the complexity of their work environment. These findings are consistent with Subotic *et al.* (2014), who concluded that handling multiple equipment systems simultaneously increases operational complexity and cognitive workload among air traffic controllers. The need to process information from several sources, coordinate multiple tasks, and prioritize operational activities contributes to increased mental fatigue and workload demands.

Similarly, respondents reported experiencing loss of sleep following night shifts and perceived that shift duration was largely equivalent to continuous screen exposure time. These findings align with Melan and Cascino (2018), who established through experimental analysis that reduced workload levels, particularly lower aircraft traffic intensity, were associated with improved sleep quality and increased alertness among controllers.

Conversely, respondents generally showed low perception regarding the influence of certain organizational factors on their work performance. For example, many respondents indicated that airspace design contributed to workload reduction, consoles were adequately designed to provide sufficient workspace and legroom, and equipment arrangement was ergonomically suitable for operational activities. Additionally, most respondents did not perceive themselves as being overwhelmed by traffic density as traffic volume increased.

Overall, the findings suggest that while certain aspects of work organization, particularly multiple equipment usage, prolonged screen exposure, and night shift schedules, were perceived to influence controller workload and fatigue, other organizational and ergonomic factors were viewed more positively within the operational environment.

Table 4.9: Responses on Work Organization Factors Affecting Air Traffic Controllers

Work Organization Variables	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)	Mean	Std. Dev	Decision (Perception)
1. Airspace design enables reduction in workload	7.8	29.7	20.3	40.6	1.6	2.9	1.0	Low
2. Consoles are designed to allow enough space while working	7.8	28.1	14.1	45.3	4.7	3.1	1.1	Low
3. Overwhelmed by traffic as the traffic density increases	1.6	26.6	31.3	28.1	12.5	3.2	1.0	Low
4. Few displays with multiple functions will improve work efficiency	-	3.1	7.8	59.4	29.7	4.2	0.7	High
5. Equipment arrangement suits your operation while working	6.3	28.1	21.9	40.6	3.1	3.0	1.0	Low
6. Experience loss of sleep a night after doing a night shift	4.7	9.4	7.8	48.4	29.7	3.9	1.1	High
7. Sitting time almost equals shift time	-	1.6	3.1	53.1	42.2	4.4	0.6	High
8. Screen time almost equals shift time	-	3.1	6.3	53.1	37.5	4.3	0.7	

[1]*Weighted Average-3.63*

[2]*low perception decision was reached if the mean <weighted average and high perception decision was reached if the mean >weighted average*

4.4.1 Association between Sitting Time and Screen Time in Hours Per Shift

Table 4.10 presents the relationship between sitting time per shift and screen time per shift among air traffic controllers. Respondents reported that the duty schedule consisted of a three-shift rotation totaling 26 hours, distributed as a 6-hour morning shift, a 7-hour afternoon shift, and a 12-hour night shift. The findings showed that the mean sitting time and mean screen time were both approximately 18 hours. This indicates that, on average, controllers spent about 18 hours seated in front of operational screens during the total duty cycle.

The minimum sitting time recorded was 9 hours, while the maximum was 25 hours. Similarly, the minimum screen time recorded was 8 hours, with a maximum of 25 hours. The median sitting and screen time was 18 hours, while the mode was 24 hours. These findings suggest that the majority of controllers spent prolonged periods seated and continuously engaged with operational screens, often with minimal interruptions during duty periods.

A Pearson correlation analysis was conducted to examine the relationship between sitting time and screen time among the 64 respondents. The results revealed a statistically significant strong positive correlation between the two variables ($r = 0.726$, $p < 0.01$). This indicates that an increase in screen time per shift was associated with a corresponding increase in sitting time per shift. In addition, Table 4.9 shows that the majority of respondents (53.1%) agreed that screen time and sitting time were nearly equal during a shift. This perception reflects the nature of air traffic control work, which requires controllers to maintain continuous situational awareness and sustained monitoring of operational displays throughout duty periods.

These findings are consistent with Subotic *et al.* (2014), who reported that continuous interaction with multiple systems and prolonged monitoring tasks increase cognitive workload and operational demands among air traffic controllers. Similarly, Stroeve *et al.* (2023) noted that sustained interaction with automated systems and continuous visual monitoring contribute to increased workload and mental fatigue in air traffic management environments. The prolonged sedentary nature of the work, combined with continuous screen exposure, may therefore contribute to both physical and cognitive strain among controllers.

Overall, the findings demonstrate a close relationship between prolonged sitting and extended screen exposure in air traffic control operations, reflecting the sustained monitoring demands required to maintain operational situational awareness.

Table 4.10: Relationship between Sitting Time and Screen Time

	Sitting time per shift(hours)	Screen time per shift(hours)
Mean	18.25	18.39
Median	18.00	18.00
Mode	24	24
Range	16	17
Minimum	9	8
Maximum	25	25

4.4.2 Shift Work Affecting Rest after A Shift Rotation

The analysis presented in Table 4.11 indicates that 34.4% of respondents disagreed that the available work schedules allowed for sufficient rest following a shift rotation. This suggests that a considerable proportion of air traffic controllers perceived the existing shift arrangements as inadequate in providing adequate recovery time between duties. In addition, the majority of respondents (43.8%) agreed that shift work negatively affected their social life outside the workplace. These findings indicate that irregular and rotating work schedules may interfere with personal routines, family interactions, and social activities among controllers.The findings are consistent with George (2016), who reported that maintaining a healthy work–life balance is particularly challenging for shift workers due to irregular working hours and changing duty schedules. Similarly, Melan and Cascino (2018) found that variations in workload and shift patterns influence sleep quality and alertness among air traffic controllers, with demanding schedules contributing to fatigue and reduced recovery periods.

Overall, the findings suggest that shift work arrangements in air traffic control operations may have notable effects on rest patterns and social well-being, consistent with existing literature on the impact of irregular work schedules in safety-critical occupations.

Table 4.11: Responses on Shift Work

Shift related variables	**Strongly disagree (%)**	**Disagree (%)**	**Neutral (%)**	**Agree (%)**	**Strongly agree (%)**	**Mean**	**Std. Deviation**
1. Shift work schedules allow for enough rest after a rotation.	18.8	34.4	14.1	21.9	10.9	2.7	1.3
2. Shift work schedules affect social life outside work.	4.7	3.1	6.3	43.8	42.2	4.16	1.0

Further analysis presented in Figure 4.2 shows that 48.4% of respondents agreed that they experienced loss of sleep after working night shifts. This suggests that nearly half of the controllers perceived night duty schedules as having a negative effect on their normal sleep patterns and recovery periods.

These findings are consistent with Sonati *et al.* (2016), who reported that shift work involving irregular working hours is strongly associated with sleep disturbances and disrupted sleep quality. In safety-critical professions such as air traffic control, insufficient sleep may contribute to fatigue, reduced alertness, impaired concentration, and decreased cognitive performance during operational tasks.

Similarly, Melan and Cascino (2018) observed that workload intensity and operational schedules significantly influence sleep quality and alertness among air traffic controllers. Their findings indicated that demanding schedules and irregular shift patterns may reduce opportunities for adequate physiological recovery.

Overall, the findings suggest that night shift operations are associated with sleep disruption among controllers, consistent with existing literature linking shift work to fatigue and reduced operational alertness in air traffic control environments.

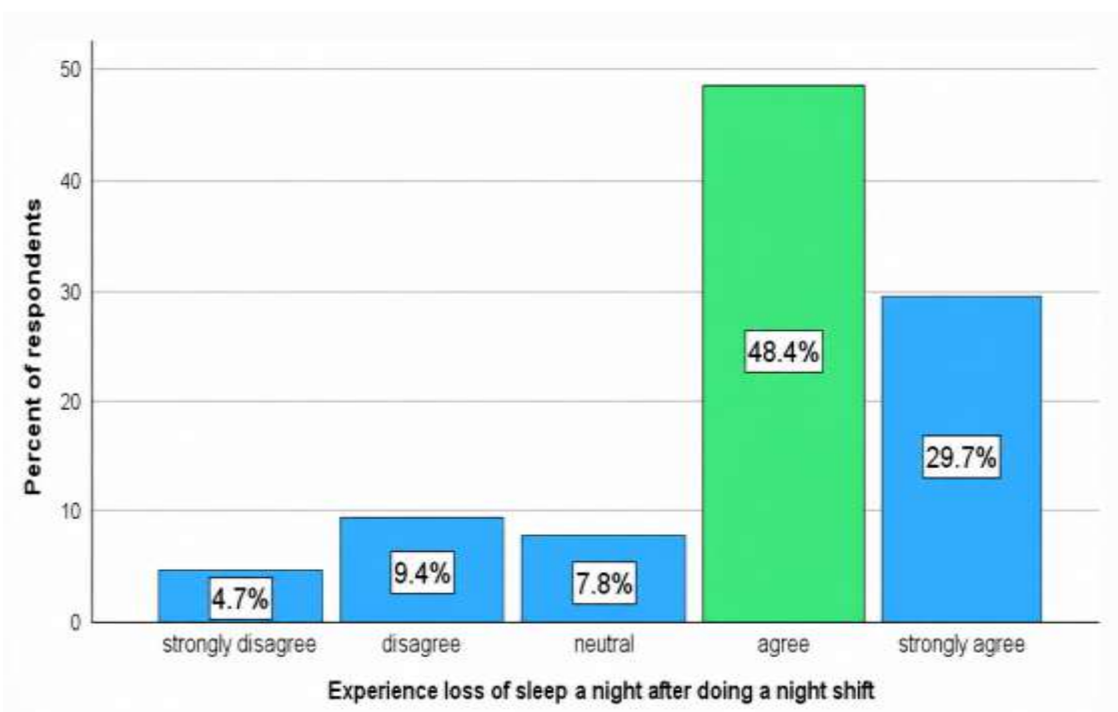

Figure 4.2: Percentage of Respondents that Experience Loss of Sleep after Night Shifts

Further analysis was conducted to determine how shift work affected controllers operating at different airports, as shown in Figure 4.3. The findings indicated that controllers working at stations with night shift operations, particularly at Jomo Kenyatta International Airport and Moi International Airport, perceived the rest periods provided after shift rotations as inadequate.

In contrast, controllers working at Wilson Airport, which operated under a three-way day shift system, generally reported that the available rest periods were adequate. This suggests differences in perceived fatigue and recovery opportunities between stations operating continuous night shifts and those using daytime-only rotational schedules.

The findings further showed that only one day off was typically provided following a night shift rotation at both JKIA and Mombasa International Airport. This may contribute to reduced recovery time following prolonged or irregular working hours associated with night operations.

These findings are consistent with Sonati *et al.* (2016), who found that shift work involving irregular schedules and night duties contributes to sleep disturbances and fatigue among workers. Similarly, George (2016) reported that rotating and irregular work schedules negatively affect recovery, social well-being, and work–life balance among shift workers. Melan and Cascino (2018) also observed that workload intensity and operational scheduling significantly influence sleep quality and alertness in air traffic control environments.

Overall, the findings suggest that controllers working in stations with night shift operations experience greater challenges related to rest and recovery compared to those operating under daytime rotational systems.

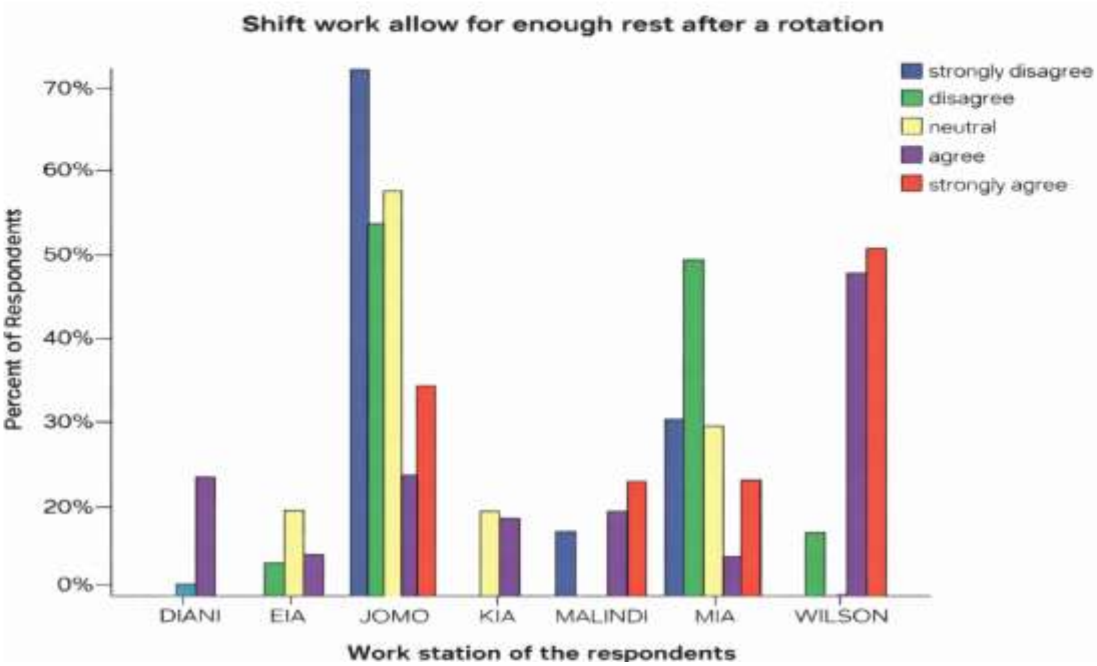

Figure 4.3: Perception of Respondents in Percentage per Station on Rest after a Shift Rotation

4.5 Operating Procedures Affecting Air Traffic Controllers

The third specific objective sought to determine the influence of work procedures on air traffic controllers in Kenya. Respondents were required to select one of five response options (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree) based on a series of predetermined statements. The responses were analyzed and presented in Table 4.12.

The analysis presented in Table 4.12 indicates that most respondents highly perceived that some air traffic control procedures appeared to be multiple and inconsistent. This suggests that procedural complexity and variability may influence operational workload and the efficiency of task execution within control environments. These findings are consistent with Bryan *et al.* (2016), who reported that effective supervisory leadership and organizational ethical practices are important in minimizing ambiguous procedures and improving procedural consistency within the workplace. In operational environments such as air traffic control, unclear or inconsistent procedures may increase cognitive demands and contribute to operational uncertainty.

Similarly, respondents perceived that the availability of emergency procedures helped reduce controller workload and associated stress. This suggests that clearly defined emergency protocols may support operational confidence and improve the management of unexpected situations within ATC environments.

Conversely, the majority of respondents demonstrated low perception regarding some procedural practices within the organization. For instance, respondents generally perceived that sensitization and communication of new procedures were not always conducted promptly. In addition, many respondents indicated low perception regarding the involvement of operational ATCOs in the design of procedures and airspace routes.

These findings align with Subotic *et al.* (2014), who emphasized that operational complexity and procedural demands increase cognitive workload among controllers, particularly when coordination and adaptation to multiple systems or changing procedures are required. The findings also correspond with Stroeve *et al.* (2023), who noted that procedural and automation-related complexities in air traffic management can influence workload, predictability, and human performance.

Overall, the findings suggest that procedural clarity, consistency, and communication are important factors influencing workload perception and operational efficiency among air traffic controllers.

Table 4.12: Responses on Operating Procedures Affecting Air Traffic Controllers

Procedures variables	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)	Mean	Std Dev	Decision (perception)
1. Sensitization of new procedures is promptly done	7.8	28.1	17.2	**42.2**	4.7	3.0	1.1	Low
2. ATCOs on the desk at station level are involved when designing procedures	14.1	26.6	25.0	**34.4**	-	2.8	1.0	Low
3. Some procedures in ATC appear to be multiple and inconsistent	-	4.7	23.4	**64.1**	7.8	3.8	0.7	High
4. Emergency procedures provided reduce workload and the stress associated with it.	7.8	17.2	15.6	**56.3**	3.1	3.3	1.0	High

[1]*Weighted Average-3.23*

[2]*low perception decision was reached if the mean <weighted average and high perception decision was reached if the mean >weighted average*

4.6 Personal Factors Affecting Air Traffic Controllers

The fourth specific objective sought to determine the effect of personal factors on air traffic controllers in Kenya. Respondents were required to select one of five response options (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree) from a list of predetermined statements. The responses were analyzed, discussed, and presented in Table 4.13.

Table 4.13 presents responses related to personal factors affecting air traffic controllers. The analysis showed that the majority of respondents either agreed or strongly agreed with most of the statements presented. Most of the statements focused on personality, attitude, coordination, communication, and risk perception, all of which were perceived to influence stress levels and overall aviation safety.

The findings indicate that respondents highly perceived personal factors as influencing air traffic control operations. For example, respondents perceived that unsafe acts affected both aviation safety and human safety, while attitudes toward colleagues limited effective coordination during operations. Respondents also perceived that attitudes toward management limited the effectiveness of open-door communication in addressing workplace issues and that the personality of trainers influenced the overall quality of ATCO training. In addition, respondents highly perceived that the personalities of colleagues affected teamwork and coordination within shifts. Furthermore, respondents indicated that organizational audits focused more on aviation safety than on the occupational safety and health of controllers.

These findings are consistent with guidance from the International Civil Aviation Organization (2022) in Annex 1 on Personnel Licensing, which outlines competency standards, training requirements, and certification processes necessary for controllers to safely perform operational duties. Similarly, International Civil Aviation Organization (2025a), through Procedures for Air Navigation Services -Air Traffic Management (Doc 4444), emphasizes the importance of effective coordination and communication between ATC units to ensure safe and efficient air traffic flow. In addition, International Civil Aviation Organization Annex 19 on Safety Management highlights the importance of fostering a just culture within aviation systems to promote openness, learning, and continuous safety improvement. These frameworks demonstrate the critical role of training, communication, coordination, and organizational culture in supporting both aviation safety and the mental well-being of controllers.

On the other hand, the majority of respondents demonstrated low perception regarding certain personal factors affecting controllers. For instance, there was limited recognition that positive attitudes toward just culture could improve operational efficiency, that interactions with difficult pilots could increase stress levels and affect safety, and that risk perception during errors or emergency situations could heighten stress. Additionally, sitting posture was perceived to vary depending on traffic density and operational demands at a given time.

However, ICAO Annex 19 (2025b) emphasizes that in organizations where just culture is effectively implemented, operational errors should be reported promptly for learning purposes without fear of punishment, thereby reducing the likelihood of recurrence. Furthermore, as controllers gain operational experience, they become more confident in handling emergencies and more proficient in communication practices such as read-backs and hear-backs, which contribute to reduced operational errors and improved situational awareness (ICAO, 2025b).

Overall, the findings suggest that personality traits, attitudes, interpersonal relationships, communication practices, and organizational culture are important personal factors influencing coordination, stress perception, and operational safety among air traffic controllers.

Table 4.13: Responses on Personal Factors Affecting Air Traffic Controllers

Personal Factors Variables	**Strongly disagree (%)**	**Disagree (%)**	**Neutral (%)**	**Agree (%)**	**Strongly agree (%)**	**Mean**	**Std. Dev**	**Decision (Perception)**
1. Unsafe acts affect safety	-	3.1	3.1	42.2	**51.6**	4.4	0.7	High
2. Attitude towards just culture increases efficiency of operation	1.6	7.8	10.9	**48.4**	31.3	4.0	0.9	Low
3. Attitude towards colleagues limits efficient coordination	1.6	3.1	7.8	**56.3**	31.3	4.1	0.8	High
4. Attitude towards management limits open door policy	-	1.6	7.8	**59.4**	31.3	4.2	0.6	High

Personal Factors Variables	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)	Mean	Std. Dev	Decision (Perception)
of handling issues								
5. Attitude towards difficult pilot increases stress and affects overall aviation safety	1.6	6.3	15.6	**65.6**	10.9	3.8	0.8	Low
6. Risk perception on possibility of making errors in ATC increases stress	-	6.3	15.6	**51.6**	26.6	4.0	0.8	Low
7. Risk perception on possibility of handling an emergency increases stress	-	7.8	14.1	**56.3**	21.9	3.9	0.8	Low
8. Personality of a trainer in ATC affects the overall training of an ATCO	-	1.6	7.8	**45.3**	45.3	4.3	0.7	High
9. Personality of colleagues affects coordination spirit within a shift	-	3.1	9.4	**54.7**	32.8	4.2	0.7	High
10. Audits concentrates on Aviation safety and hardly on safety and health of controllers	1.6	4.7	12.5	**45.3**	35.9	4.1	0.9	High
11. Sitting posture is determined by the density of traffic at any given time	1.6	10.9	6.3	**51.6**	29.7	4.0	1.0	Low

[1]*Weighted Average-4.09*

[2]*low perception decision was reached if the mean <weighted average and high perception decision was reached if the mean >weighted average*

Table 4.14 presents observations from the checklist alongside respondents' perceptions of ergonomic conditions within the control rooms. Ergonomics refers to the design of workspaces, equipment, and tasks to fit the worker, with the aim of improving comfort, efficiency, and safety while reducing physical strain and risk of injury (Akca & Meltem, 2017). The findings showed that the majority of controllers (95.3%) performed most of their duties while seated, reflecting the sedentary nature of air traffic control operations. However, 54.7% of respondents indicated that ergonomically designed chairs, intended to support proper posture and reduce musculoskeletal strain were not available in the control rooms. Where such chairs were available, respondents further reported that they were insufficient in number to accommodate all controllers on duty at any given time. Additionally, 85.9% of respondents reported that they had at some point been required to sit on broken chairs despite the critical nature of their operational responsibilities. It was also observed that controllers spent prolonged periods typing on RADAR keyboards during operations. Such repetitive movements, combined with prolonged sitting and inadequate ergonomic support, may contribute to repetitive strain injuries, including musculoskeletal discomfort and conditions such as carpal tunnel syndrome.

These findings are consistent with Nurhayati *et al.* (2020), who reported that air traffic controllers are exposed to work-related musculoskeletal disorders (WMSDs) and physical fatigue due to prolonged sitting, repetitive tasks, and poor sitting posture during operational duties. Similarly, Stroeve *et al.* (2023) noted that sustained interaction with operational systems and continuous monitoring tasks increase both physical and cognitive workload in air traffic management environments. Prolonged sedentary work combined with repetitive keyboard use may therefore contribute to physical discomfort and fatigue among controllers.

The findings also correspond with the observations in Table 4.10, which demonstrated prolonged sitting and screen exposure among controllers during shifts. Collectively, these results suggest that the operational demands of air traffic control involve extended sedentary work patterns and repetitive physical activities that may influence the physical well-being and comfort of controllers within the workplace.

Table 4.14 Responses on Ergonomic Factors

EGORNOMICS	YES (%)	NO (%)
1. Do you have ergonomic chairs in the control room	45.3	54.7
2. Have you ever found yourself sitting on a broken chair at work	85.9	14.1
3. Do you find yourself sitting most of the time during the shift	95.3	4.7

4.6.1 Health Related Responses

Respondents were asked questions related to health conditions associated with their work environment, and the responses were analyzed in Tables 4.15 and 4.16. The findings showed that 77% of respondents reported experiencing mild headaches after a shift, indicating a notable level of post-duty physical discomfort among controllers.

In addition, 68.8% reported back pain. Among these, 91% also experienced posture deterioration during periods of high traffic compared to 20% among those without back pain, as shown in Table 4.16. A Chi-square test revealed a statistically significant association between back pain and posture deterioration, χ^2 (1, N = 64) = 28.96, $p < 0.001$, with Cramér's V = 0.67 indicating a strong relationship.

Although 80% of respondents reported the availability of ergonomic chairs in control rooms, musculoskeletal problems were still common, suggesting that availability alone may not eliminate physical strain in air traffic control operations. These findings align with Costa (2000), who noted frequent musculoskeletal disorders among air traffic controllers due to prolonged static postures and workload. Similarly, Nurhayati et al. (2020) highlighted that prolonged sitting, repetitive movements, and poor posture increase the risk of work-related musculoskeletal disorders (WMSDs). Stroeve et al. (2023) further observed that sustained monitoring and system interaction increase both physical and cognitive workload in air traffic management environments.

Overall, the findings indicate that prolonged sitting, posture deterioration, and operational workload are key contributors to physical discomfort and musculoskeletal strain among air traffic controllers, with many respondents also reporting reliance on self-medication for symptom management.

Table 4.15: Responses on Health Conditions of Air Traffic Controllers

Health related problems	**YES (%)**	**NO (%)**
1. Do you experience hearing problems as identified by Aviation medical examiner (AME)?	9.7	90.3
2. Do you experience mild headaches after a shift?	77.0	23.0
3. Stress related illnesses such as depression & High blood pressure have been identified by AME?	31.1	68.9
4. Are you suffering from stress related to the work you do?	47.6	52.4
5. Have you had any back pains that you did not experience before being employed as an ATCO?	68.8	31.3
6. Have you developed any eye or vision problems, as identified during aviation medical examinations (AME), after joining Air Traffic Control that were not present before employment??	38.1	61.9

Table 4.16: Distribution of Health and Behavioural Outcomes among Air Traffic Controllers (N=64)

Variable	Category	Frequency (n)	Percentage (%)
1. Work-related stress	Yes	30	47.6
	No	34	52.4
2. Stressed due to unserviceable equipment	Yes	24	80
	No	6	20
3. Help seeking behaviour for stressed workers	Self treatment	26	85.7
	Professional help	4	14.3
4. Help seeking behaviour for non-stressed workers	Self treatment	9	26.7
	Professional help	25	73.3
5. Back pain	Yes	44	68.8
	No	20	31.2
6. Posture deterioration for ATCOS with back pain	Yes	40	91
	No	4	8
7. Posture deterioration for ATCOs without back pain	Yes	4	20
	No	16	80

Table 4.15 shows that 47.6% of respondents reported experiencing stress related to their work. Figure 4.4 further indicates that among the 52.4% of controllers who experienced stress from either work-related or home-related factors, only 14.3% considered it necessary to seek medical assistance. A Chi-square analysis confirmed a statistically significant association with a large effect between stress and self-treatment (χ^2 (1, N = 64) = 23.3, $p < 0.001$, Cramér's V = 0.60), indicating a strong tendency for stressed controllers to manage symptoms independently rather than seek formal medical support.

These findings are consistent with Kumar (2016), who reported that professionals working in high-responsibility and safety-critical environments often avoid seeking medical or psychological help due to concerns about stigma, confidentiality, or perceived implications for their professional standing. This suggests that stress management behaviors in such environments may be influenced not only by symptom severity but also by occupational culture and perceptions surrounding help-seeking.

In addition, Table 4.15 shows that 31.1% of respondents reported stress-related illnesses such as depression and hypertension, while 38.1% reported eye-related problems as identified by Aviation Medical Examinations (AME). Although these proportions are below 50%, it is notable that more than 90% of respondents were aged between 26 and 45 years. This suggests that a relatively young workforce is already reporting stress-related and physical health concerns. Costa (2000) similarly noted that prolonged exposure to operational stressors in air traffic control may contribute to cumulative health effects over time, with potential for increased prevalence of stress-related conditions if exposure remains unmanaged.

Furthermore, 9.7% of respondents reported experiencing hearing-related problems as identified by AME records. These cases were distributed across all airports, suggesting that they may not be directly linked to occupational exposure but could also be influenced by external or non-work-related factors.

Overall, the findings indicate that stress and related health conditions are present among air traffic controllers, with a notable tendency toward self-management of symptoms rather than formal medical intervention.

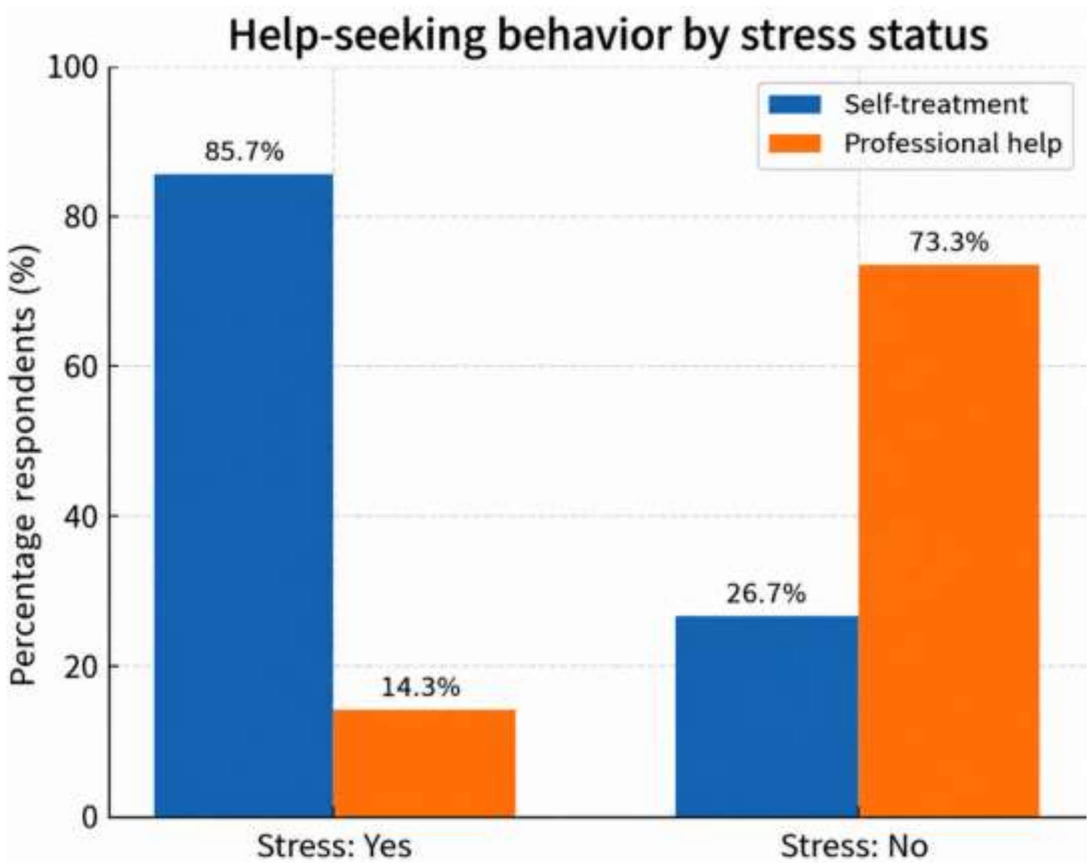

Figure 4.4: Stress from Home or Work versus Seeking Help

4.6.2 Training and Management Support

The analysis presented in Table 4.17 indicates that the majority of respondents held a generally low perception of the training and management support provided to air traffic controllers. In particular, respondents indicated that training was not consistently or promptly conducted following procedural or operational changes. There was also a perception that training gaps were not systematically identified and prioritized, which may compromise continuous professional development within air traffic control operations.

Further, respondents expressed low agreement that adequate training was provided in key areas such as stress management, mental health awareness, and occupational safety and health for all air traffic controllers (ATCOs). Similarly, there was a low perception that ATCOs had received sufficient training on proper sitting posture, an important ergonomic factor in reducing fatigue and musculoskeletal strain in a high-concentration working environment. In addition, respondents indicated that the Kenya Civil Aviation Authority (KCAA) did not have a fully effective performance appraisal system for controllers, and that reward and recognition mechanisms such as, incentives for effectively handling emergency situations were not consistently implemented. There was also a perception that management did not sufficiently prioritize equipment serviceability, which is critical for ensuring operational efficiency and safety in air traffic services.

These findings are contrasted by standards set by the International Civil Aviation Organization (ICAO, 2022), particularly in Annex 1 on Personnel Licensing, which emphasizes that structured training and strong management support are essential in air traffic control due to the safety-critical nature of the profession. ICAO (2022) further notes that effective training systems enhance controller competence, improve stress management capacity, strengthen communication, and promote adaptability, resilience, and a supportive operational environment.

On a positive note, respondents indicated a high perception that communication channels exist and are effective for addressing ATCO concerns. It was also noted that management provides support and listens to controllers through professional bodies, and that considerations of staff needs and responsibilities are taken into account during postings and transfers. However, the overall mean score of less than 4 (Agree) suggests that improvements are required across most aspects of training and management support in order to enhance operational effectiveness and well-being among air traffic controllers.

Table 4.17: Responses on Training and Management Support

	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)	Mean	Std. Dev	Decision (perception)
1. Training is promptly done when there is change.	18.8	46.9	15.6	14.1	4.7	2.24	1.1	Low
2. Training gaps are prioritised when training ATCOS	26.6	56.3	17.2	-	-	1.9	0.7	Low
3. Training on stress, mental, health & safety and health is prioritized on all ATCOs	37.5	45.3	10.9	4.7	1.6	1.9	0.9	Low
4. ATCOs have been well trained on sitting posture at work	34.4	51.6	10.9	1.6	1.6	1.8	0.8	Low
5. Communication channels are available and working	18.8	32.8	29.7	18.8	-	2.48	1.0	High
6. KCAA has an appraisal tool that works for controllers	51.6	26.6	17.2	4.7	-	1.75	0.9	Low
7. Reward & recognition is provided for in the appraisal tool	45.3	39.1	12.5	3.1	-	1.7	0.8	Low
8. Reward is provided for handling emergencies impeccably	54.7	42.2	3.1	-	-	1.5	0.6	Low
9. Management prioritizes equipment serviceability	15.6	46.9	26.6	10.9	-	2.3	0.9	High
10. Management supports & listens to ATC through available professional bodies.	6.3	25.0	34.4	31.3	3.1	3.0	1.0	High
11. Management considers needs & responsibilities during postings and transfers	14.1	23.4	32.8	28.1	1.6	2.8	1.1	High

[1] *Weighted Average-2.26*

[2] *low perception decision was reached if the mean <weighted average and high perception decision was reached if the mean >weighted average*

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

This study established that the occupational safety and health (OSH) of air traffic controllers (ATCOs) is significantly influenced by the combined effects of the work environment, work organization, operating procedures, and personal factors.

In terms of the work environment, inadequacies in lighting (including glare), equipment serviceability, emergency exits, and elevated noise levels were found to negatively impact both safety and health, contributing to increased fatigue, stress, and reduced operational efficiency. These findings are consistent with international provisions outlined by the International Civil Aviation Organization (ICAO, 2018) and the Federal Aviation Administration (FAA, 2023), which emphasize the importance of maintaining optimal physical working conditions to support safe and effective air traffic control operations.

Regarding work organization, deficiencies in shift scheduling, break allocation, and ergonomic considerations were shown to contribute to fatigue, reduced alertness, and physical strain, thereby increasing the likelihood of human error and negatively affecting overall performance. These issues are addressed within ICAO guidelines on fatigue management and human performance, as well as FAA recommendations on workload management and duty time limitations, which advocate for structured work-rest cycles aligned with human circadian rhythms.

For operating procedures, the findings indicate that although procedures are generally effective during emergency situations, gaps in sensitization and limited user involvement in their design and implementation reduce their effectiveness in routine operations and increase cognitive workload among controllers. ICAO frameworks, particularly those related to Safety Management Systems (SMS), emphasize continuous review, stakeholder engagement, and training to ensure procedures remain relevant, clear, and user-centered.

Finally, personal factors, including attitude, risk perception, and limited adherence to ergonomic practices such as proper posture and adequate breaks, were found to further influence the health outcomes of ATCOs. These findings align with international human factors principles promoted by ICAO and FAA, which highlight the role of individual behavior, awareness, and training in maintaining both safety and well-being in safety-critical environments.

Overall, the study concludes that while the OSH challenges identified among ATCOs in Kenya are significant, they are not unique and are comprehensively addressed within existing international aviation safety frameworks. However, gaps remain in the effective implementation, enforcement, and contextual adaptation of these guidelines. Therefore, improving working conditions, optimizing organizational practices, enhancing participatory procedure design, and strengthening individual awareness within the framework of established ICAO and FAA guidelines are critical in promoting the safety, health, and operational effectiveness of ATCOs.

5.2 Recommendations

1. KCAA should upgrade and routinely maintain ATC control room infrastructure to ensure compliance with occupational safety standards and improve lighting, noise control, and equipment serviceability.
2. KCAA should implement targeted noise monitoring and mitigation strategies in ATC control rooms, including routine measurement of operational noise levels, enforcement of compliance with NIOSH and FAA exposure thresholds, and

installation of effective sound attenuation measures to reduce intermittent external aircraft noise intrusion into controller workstations.

3. KCAA should adopt evidence-based shift scheduling systems that align with circadian principles and incorporate mandatory rest breaks to reduce fatigue among air traffic controllers.
4. KCAA should institutionalize regular ergonomic assessments and workstation improvements to reduce musculoskeletal strain and enhance operational efficiency.
5. KCAA should strengthen operating procedures through participatory review processes supported by regular simulation-based training and continuous feedback mechanisms.
6. KCAA should enhance safety culture and well-being through human factors training and structured wellness programs targeting stress management, fatigue reduction, and mental health support.

5.3 Further Research

The scope of this study was limited to air traffic controllers in Kenya. Further research on factors affecting ATCOs on an international level could help make an informed decision on all controllers in general.

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APPENDICES

Appendix I: Survey Questionnaire

OCCUPATIONAL SAFETY AND HEALTH ISSUES AFFECTING AIR TRAFFIC CONTROLLERS IN KENYA.

My name is Eng. Annastacia Waitima Maina. I am student at JKUAT pursuing MSC. Occupational safety and health. As part of the requirement of this degree, I am undertaking research on the occupational Safety and Health Issues affecting Air Traffic Controllers in Kenya. You are therefore invited to participate in this study which touches on a profession in which you are part of. The results of this research will provide valuable insights to KCAA to ascertain controller's safety and address health issues. Your participation is voluntary and will be treated with outmost confidentiality.

WORK ENVIRONMENT

Please indicate your level of agreement with the following statements by placing a tick next to the appropriate response [√].

(5-Strongly agree; 4- Agree; 3-Neutral; 2- Disagree; 1- Strongly Disagree)

PART 1

DEMOGRAPHIC INFORMATION

Please tick [√] the most suitable answer in this section.

1. Which station do you work in?

MIA[ ] **JOMO[ ]** **KIA[ ]** **WILSON[ ]**
MALINDI[ ] **DIANI[ ]** **EIA[ ]**

2. Which other stations have you worked in since you got employed as an ATCO?

MIA[ ] MALINDI[ ] **JOMO[ ]** **KIA[ ]** **WILSON[ ]**
DIANI[ ] **EIA[ ]** **WAJIR [ ]**
LOKICHOGIO[ ]

3.Which one station would you love to work in?

MIA[ ] MALINDI[ ] **JOMO[ ]** **KIA[ ]** **WILSON[ ]**
DIANI[ ] **EIA[ ]** **WAJIR [ ]**
LOKICHOGIO[ ]

4. Kindly select the most probably reason for you choice in 3 above.
   a) The station has good management [ ]
   b) The station is less stressful [ ]
   c) The town in which the station is located has vast opportunity for personal growth [ ]
   d) The station is in close proximity of my home and family. [ ]
5. What is your gender?

Male [ ] Female [ ]

6. What is your marital status?

   Single [ ] Married [ ] Divorced [ ] Widowed [ ]

7. What is your age bracket?

   18 – 25yrs[ ] 25–35yrs[ ] 35– 45yrs[ ] Above 45 yrs [ ]

8. What is your highest level of education?

   Certificate[ ] Diploma [ ] Bachelor's Degree [ ] Post graduate [ ]

9. How many years have you been an ATCO?

   Less than 5yrs[ ] 5–10yrs[ ] 10– 20yrs[ ] Above 20 yrs [ ]

10. How many ratings do you have?

    One 1[ ] Two 2[ ] Three 3[ ] Four 4[ ]

    Five 5[ ]

11. Which control position have you worked in for the last 1 year? (Tick [√] all the answers that are applicable)

    TWR [ ] **APPROACH RADAR[ ]**

    ENROUTE RADAR[ ] **FLIGHT INFORMATION CENTRE [ ]**

PART 2

WORK ENVIRONMENT

Please indicate your level of agreement with the following statements by placing a tick next to the appropriate response [√]. (5-Strongly agree; 4-Agree; 3-Neutral; 2- Disagree; 1- Strongly Disagree)

S/NO	Noise, lighting, Equipment serviceability, extreme weather in control room, Availability of rest room, canteen, and gym facilities	5	4	3	2	1
1	Internal or external noise affects your concentration levels when working.					
2	Lighting levels in the control rooms affects your Efficiency when working.					
3	CNS equipment serviceability affects your work Efficiency.					
4	CNS equipment unserviceability increases your workload and stress levels.					
5	Equipment serviceability is prioritized by the management at KCAA.					
6	The management has been able to control the extreme weather conditions (hot or cold) in the control rooms through proper air conditioning.					
7	Availability of gym facilities, restrooms and canteen has helped in reducing the stress levels and improving work morale.					

WORK ORGANIZATION

Please indicate your level of agreement with the following statements by placing a tick next to the appropriate response [√]. (5-Strongly agree; 4- Agree; 3-Neutral; 2- Disagree; 1- Strongly Disagree)

S/NO	Shift work schedules, workload, training & communication, Reward & recognition, job design & workspace, management support, Equipment arrangement, Number of displays screen time and sitting time	5	4	3	2	1
1	The shift work schedules allow for enough rest after a rotation.					
2	Shift work affects my social life outside the work environment.					
3	I experience loss of sleep the night after doing a night shift.					
4	I feel overwhelmed by traffic as the traffic density increases.					
5	I can adjust and work comfortably even as traffic levels increases.					
6	Airspace design is done in such a way that it reduces the controllers' workload.					
7	Automation and new equipment installed have helped reduce the					
8	Training is promptly done whenever there is a new or change in procedure or equipment.					
9	Training gaps identified in the appraisals are given priority while training ATCOs.					
10	Training on stress management, mental health and other safety and health trainings are					

11	Communication channels between the management and ATCOS on any issues affecting them are available and working.
12	KCAA has an appraisal tool that works for controllers.
13	Reward and recognition for extemporary work done by controllers is provided for by the management in the appraisal tool.
14	A reward is provided for ATCOs able to handle an emergency impeccably despite criticism for a few gaps identified when handling an incident or accident.
15	The consoles provided for in the control rooms are well designed to allow for a leg space, good organization of the equipment and enough workspace while working.
16	The management listens and support ATC through the professional organizations available (KATCA).
17	Management considers ATCOs needs and responsibilities during postings and transfers from one station to another.
18	Equipment arrangement in the control room suits your operation while working.
19	The number of displays in the control rooms are too many for efficient use by one controller at any given time.
20	Few displays with multiple functions will help improve your efficiency while working.
21	Most of the ATC work is done while sitting done. (Sitting time almost equals shift time)
22	Most of the ATC work involves use of variety of screen displays. (Screen time almost equals shift time)

OPERATING PROCEDURES

Please indicate your level of agreement with the following statements by placing a tick next to the appropriate response [√]. (5-Strongly agree; 4- Agree; 3-Neutral; 2-Disagree; 1- Strongly Disagree)

S/NO	Clarity of procedures, multiple inconsistent procedures, procedures in case of an	5	4	3	2	1
1	Sensitization of new procedures is done before implementation to improve their clarity during implementation					
2	ATCOs working in an airspace where new procedures are being designed are involved to ensure clear procedures are designed.					
3	Some ATC procedures provided for implementation appear to be multiple and					
4	Procedures provided for in case of an emergency assist the controller in handling emergency with minimal stress while reducing the workload associated with such					

PERSONAL FACTORS

Please indicate your level of agreement with the following statements by placing a tick next to the appropriate response [√]. (5-Strongly agree; 4- Agree; 3-Neutral; 2- Disagree; 1- Strongly Disagree)

S/NO	Attitude, risk perception, personality, work habits, posture	5	4	3	2	1
1	ATCOs attitude towards unsafe acts and conditions has a great effect on flight safety.					
2	Attitude towards just reporting culture in aviation safety increases efficiency of					
3	Attitude towards colleagues limits efficient coordination.					
4	Attitude towards management limits open door policy available at KCAA on seeking help on personal problems affecting					
5	Attitude towards difficult pilots increases stress and affects the overall aviation safety.					
6	The risk perception associated with possibility of making omission or commission errors in ATC increases stress while on duty.					
7	The risk perception associated with possibility of handling an emergency in ATC increases stress while on duty.					
8	Personality of a trainer in ATC affects the overall training of an ATCO.					
9	Personality of colleagues affects coordination spirit within a shift which encourages single persons operation in the shift.					

10	Workplace audits concentrates on how an ATCO affects aviation safety and hardly considers how the work practices affect the ATCOs safety and
11	The sitting posture is determined by the density of traffic in ATC at any given time.
12	ATCOs have been well trained on ergonomics and proper sitting posture while at work.

Appendix II: Checklist

This section is to be filled by the researcher together with the research participates at the workstation. It will involve observation, measurement and engaging the respondents with questions.

S/NO	**Noise, Lighting, equipment serviceability, provision of washroom for both genders, working at height, insect-vector control, Extreme weather conditions Availability of gym, canteen facilities and restroom**	**YES**	**NO**	**N/A**
1	Do you have health problems related to hearing that have been identified by the aviation doctor any time during the aviation medical check-ups that you did not experience before being employed as an ATCO? The noise level recorded is -------------------			
2	Do you have eye problems that have been identified by the aviation doctor any time during the aviation medical check-ups that you did not have before being employed as an ATCO? The lighting level measured is……………….			
3	Have your station experienced an equipment unserviceability (unavailability) for a period exceeding 1 year.			
4	Do you have washrooms (toilet and bathroom) for both male and female available for use near the control rooms?			

5 (a)Have you ever worked in a mobile control tower? (yes or no)………

(b)While on duty has the mobile control tower been inspected and maintained and have daily checks been carried out?

6 If your answer in 5(a) was yes, would you consider the control tower to be unstable and likely to collapse and fall down?

7 Regular fumigation is done in the control rooms to ensure vector control of insects

8 Do you get mild headaches after continuously working in a highly air-conditioned (cold) control room?

9 Do have a fully functional gym facility at your station?

10 Do you have a fully equipped rest room that can be used during the rest time periods.

11 Do you have a canteen has been provided at the workplace with basics such as ladies pads, soft drinks and other personal amenities that one would require while at work are sold?

S/NO	(work organization) Job design, workspace, Screen time & Sitting time	YES	NO	N/A
12	Are standard workstation items such as VHF radios and telephones within easy reach?			
13	Are floors and carpets in good condition?			
14	Do you think the job you do as an ATCO has a lot of duplication of roles that can be solved by job re- design and automation? (example; creating a flight plan has to be done by every ATS unit)			
15	Do you have emergency exits that you could consider safe to use in case of an emergency?			
16	Do you find yourself using a screen the whole shift? What is the estimated total screen time in hours per shift (B, C & DA)……………………………			
17	Anti-glare screens have been provided for all the screens provided for use at work?			
18	Are you provided with anti-glare glasses for use at work?			
19	Does the job allow you to take regular breaks from the screen?			
20	a) Is the tower in the station you are currently working in provided with sun-antiglare 'windows'? b) Considering your answer in 20 a) Does the tower setting with respect to sun rays position affect your sight for traffic?			
21	Do you find yourself sitting most of the time during the shift? What is the estimated sitting time per shift (B, C & DA)……………………………………………..			
22	Do you find any of the screens used at work irritable to use either due to glare or reflections from the outside light? If your answer is yes, Could you name the screen(s) in question? Example (VCCS, RADAR, AWOS, MLAT, CRONOS etc) …………………………………………………………………………..			

S/NO	Attitude, personality & ergonomics	YES	NO	N/A
23	Stress related diseases such as depression, alcoholism & high blood pressure have been identified by the aviation doctor			

	during the compulsory aviation check-ups.
24	Do you find yourself taking alcohol while stressed other than approaching a colleague or the management for support?
25	Could you consider yourself to be an alcoholic?
26	Could you be suffering from stress related to the work you do?
27	Could you be suffering from stress related to your personal life?
28	Have you considered seeking help from a professional whenever you feel stressed?
29	Do you have ergonomic chairs (comfortable with a leg rest) in all control rooms in the station you work in?
30	Are there any ergonomic problems observed in the control rooms, associated with keyboard use, posture, or work habits?
31	Have you had any back or neck pains that you did not experience before being employed as an ATCO?
32	Do you do regular exercises after work or during your off days?
33	Have you ever found yourself sitting on a broken chair? (at times missing an arm rest or a head rest)

Appendix III: Respondent Consent Form

Research Title: Occupational Safety and Health Issues Affecting Air Traffic Controllers in Kenya

Introduction

This research study is being carried out by Annastacia Waitima Maina of Jomo Kenyatta University of Agriculture and Technology to investigate the safety and health issues affecting Air Traffic Controllers in Kenya.

Procedures

A cross-sectional descriptive survey will be used to collect data. It will involve using a questionnaire administered either manually or electronically to the sample at a definite time. The sample will be obtained from the total population of 182 controllers working in different airports in Kenya.

Risks and discomforts

There is no risks or discomforts involved in carrying out this research.

Benefits

The findings of this study will provide valuable insights to other Scholars and Kenya Civil Aviation Authority (KCAA) management on the required intervention to ascertain controllers' safety and address health issues.

Confidentiality

Confidentiality of the respondents will be ensured in that no personal information will be required in the applicable research instrument, where identifiable data about the respondents' work stations or qualification is collected, only the research team will be able to interact with such. All the data collected virtually will be stored in the researcher's private computer and any other data collected manually will be safely stored away from work premises.

The results and findings from this research will be shared in the final thesis for purposes of providing valuable insights to other Scholars and Kenya Civil Aviation Authority (KCAA) management on the required intervention to ascertain controllers' safety and address health issues.

Participation

Your participation as a respondent in this study is voluntary. There will be no coercion or undue influence exercised. It is therefore your right to refuse to participate or to withdraw from the study at any moment during the research.

Informed Consent form

I have read the forgoing information, or it has been read to me. I have been given the opportunity to ask questions about the study and these have been answered to my satisfaction. I consent voluntarily on my behalf/charges behalf to be a participant in this study.

You are making a decision to participate or not to participate.

Appending your signature below indicates your willingness to participate having understood the information provided in this information sheet.

Signature………………………… Date………………………..

Time ………………………….. Relationship to subject …………………..

I have accurately read or witnessed the reading of the consent form to the potential participant and the individual has had opportunity to ask questions. I confirm that consent to participate was given freely.

Signature of Witness……………………….

Signature of Investigator………………….

Questions about the Research

Any questions about this study may be addressed to the following,

Annastacia Waitima Maina

P O Box 99641-80107, Mombasa

Mobile:0711106714

or,

Director,

BPS-JKUAT

P O Box 62000-00200, Nairobi

Email: director@bps.jkuat.ac.ke

Secretary,

TUM-ERC

P O Box 90420, Mombasa – 80100

Email: erc@tum.ac.ke , tum.erc.2019@gmail.com

Appendix IV: JKUAT Research Approval

JOMO KENYATTA UNIVERSITY
OF
AGRICULTURE AND TECHNOLOGY

OFFICE OF THE DIRECTOR, GRADUATE SCHOOL

P.O. BOX 62000, 00200 • NAIROBI •KENYA•TEL: (067)-5870001-4• Email: director@bps.jkuat.ac.ke

REF: **JKU/2/11/EET32-5448/2015** 30TH JANUARY, 2023

ANNASTACIA WAITIMA MAINA
C/o IEET
JKUAT

Dear, Maina

RE: APPROVAL OF RESEARCH PROPOSAL AND APPOINTMENT OF SUPERVISORS

Kindly note that your MSc. research proposal entitled: **"OCCUPATIONAL SAFETY AND HEALTH ISSUES AFFECTING AIR TRAFFIC CONTROLLERS IN KENYA"** has been approved. The following are your approved supervisors:-

1. Dr. Charles Mburu
2. Prof. Ngugi Kamau

Yours sincerely,

PROF. LOSENGE TUROOP
DIRECTOR, GRADUATE SCHOOL

Copy to: Director, IEET
/cao

Appendix V: Ethical Approval by Ethics Review Committee

TECHNICAL UNIVERSITY OF MOMBASA
Office of the TUM Scientific Ethics Review Committee
NACOSTI/NBC/AC/02919, HHS-IRB00012027

REF: *TUM SERC MSC/007/2023* Date: 20/04/2023

TO: ANNASTACIA WAITIMA MAINA

Dear Sir/Madam,

RE: OCCUPATIONAL SAFETY AND HEALTH ISSUES AFFECTING AIR TRAFFIC CONTROLLERS IN KENYA

This is to inform you that ***TUM-SERC*** during its sitting of **28/03/2023,** reviewed and **approved** your above research proposal. Your application approval number is ***TUM SERC MSC/007/2023.*** The approval period is **20th April, 2023 - 20th April, 2024.**

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA will be used
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***TUM-SERC***
iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***TUM-SERC*** within 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to ***TUM-SERC*** within 72 hours
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to ***TUM-SERC.***

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://research-portal.nacosti.go.ke and also obtain other clearances needed.

Yours sincerely

Dr. VICTOR TUNJE JEZA.
Chair, TUM-SERC
Email: *tum.erc.2019@gmail.com*, *erc@tum.ac.ke*

TECHNICAL UNIVERSITY OF MOMBASA
20 APR 2023
ETHICS REVIEW COMMITTEE
APPROVED

SGS TUM is ISO 9001:2015 Certified

Technical University of Mombasa,
Tom Mboya Avenue P. O. Box 90420 - 80100, MOMBASA - KENYA.
TEL: (254) 41-2492222/3, FAX: (254) 41- 2495632, Mobile: (254) 0724-955377 | 0733 -955377
E-mail : info@tum.ac.ke, vc@tum.ac.ke, Website: www.tum.ac.ke

Appendix VI: NACOSTI Research License

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 829298

Date of Issue: 01/May/2023

RESEARCH LICENSE

This is to Certify that Miss.. Annastacia Waitima Maina of Jomo Kenyatta University of Agriculture and Technology, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kilifi, Kisumu, Kwale, Mombasa, Nairobi, Uasin-Gishu on the topic: Occupational safety and health issues affecting air traffic controllers in Kenya for the period ending : 01/May/2024.

License No: **NACOSTI/P/23/25741**

829298

Applicant Identification Number

Director General

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions

Appendix VII: LUX Meter Calibration Certificate

Page **1** of **2**

AVIOTEQ PRECISION LTD

APL

P. O. Box 3509 - 00506 Nairobi - Kenya.
Tel: +254 719 682464/+254 727 400315
Email: avioteqprecision@gmail.com

KENAS

ORIGINAL

CERTIFICATE NUMBER: APL-C6-23-013

CALIBRATION CERTIFICATE

A. CUSTOMER

COMPANY NAME	: *INDUSTRIAL ENVIRONMENT MANAGEMENT CONSULT. LIMITED*
ADDRESS	: *P.O. BOX 34378-00100 NAIROBI*
LOCATION	: *WESTLANDS, NAIROBI KENYA*

B. DEVICE INFORMATION

Name	: *LIGHT (LUX) METER*
Manufacturer	: *ATP*
Serial number	: *200401318*
Model	: *DT-880A*
Range	: -

CERTIFICATE INFORMATION

Cal sticker number	: *APL.C 10721*
Cal Location	: *APL LAB*
Cal Date	: *06/03/2023*

C. Calibration procedure: The unit has been calibrated according to the following documents:

i. Manufacturer's instructions manual.
ii. JCGM 100:2008 Evaluation of measurement data — Guide to the expression of uncertainty in measurement.

D. Calibration Standard and Traceability: The instrument was calibrated using a Multifunctional signal generator and a reference LUX meter, both traceable to national and international standards.

E. Environmental conditions: Calibration was carried out under controlled environmental conditions as indicated below:

Temperature:	23.5C	±1°C
Relative Humidity:	54 %	±10%

F. Results validation: This Certificate is valid until ***05TH FEBRUARY 2024.***

Calibration by	: D. ONDITI
Signature	:
Checked by	: J. JUMA
signature	:

Authorized/Validated By : **C. ORINA**

Signature : Date :06/03/2023

MANAGING DIRECTOR

Calibration certificate without signature and stamp is not valid. This certificate has been issued without any alteration and may not be reproduced other than in full except with the approval of the Managing Director, Avioteq Precision Ltd Calibration Laboratory

This Certificate only relates to the calibration status of the item/equipment whose details appear above.

Appendix VIII: Sound Level Meter Calibration Certificate

Page **1** of **2**

APL

AVIOTEQ PRECISION LTD

P. O. Box 3509 - 00506 Nairobi - Kenya.
Tel: +254 719 682464/+254 727 400315
Email: avioteqprecision@gmail.com

KENAS

ORIGINAL

CERTIFICATE NUMBER: APL-C6-23-015

CALIBRATION CERTIFICATE

A. CUSTOMER

COMPANY NAME	: *INDUSTRIAL ENVIRONMENT MANAGEMENT CONSULT. LIMITED*
ADDRESS	: *P.O. BOX 34378-00100 NAIROBI*
LOCATION	: *WESTLANDS, NAIROBI KENYA*

B. DEVICE INFORMATION

Name	: *SOUND LEVEL METER*
Manufacturer	: *EXTECH INSTRUMENTS*
Serial number	: *10225185*
Model	: *407730*
Range	: -

CERTIFICATE INFORMATION

Cal sticker number	: *APL.C10722*
Cal Location	: *APL LAB*
Cal Date	: *06/03/2023*

C. Calibration procedure: The unit has been calibrated according to the following documents:

i. Manufacturer's instructions manual.

ii. JCGM 100:2008 Evaluation of measurement data — Guide to the expression of uncertainty in measurement.

D. Calibration Standard and Traceability: The instrument was calibrated by a Sound decibel calibration tool, Traceable to both national and international standards.

E. Environmental conditions: Calibration was carried out under controlled environmental conditions as indicated below:

Temperature:	23.5C	±1°C
Relative Humidity:	54 %	±10%

F. Results validation: This Certificate is valid until ***05TH FEBRUARY 2024.***

Calibration by	: D. ONDITI
Signature	:
Checked by	: J. JUMA
signature	

Authorized/Validated By : **C. ORINA**

Signature : Date :06/03/2023

MANAGING DIRECTOR

Calibration certificate without signature and stamp is not valid. This certificate has been issued without any alteration and may not be reproduced other than in full except with the approval of the Managing Director, Avioteq Precision Ltd Calibration Laboratory

This Certificate only relates to the calibration status of the item/equipment whose details appear above.