HUMAN FACTORS AND ACCIDENTS OF AVIATION OPERATIONS IN EASTERN AFRICA

BY

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DECLARATION

I, Nassimbwa Florence, declare that this thesis is my original work and has not been presented to any University or institution of higher learning for any degree or any other award.

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APPROVAL

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LIST OF ARCRONYMS

ASMs	Aeromedical specialists
AME	Aviation Medical Examiners
ATPL	Airline Transport Pilot License
CRM	Crew Resource Management
EASA	European Union Aviation Safety Agency
FAA	Federal Aviation Administration
FDM	Flight Data Monitoring
HFACS	Human Factors Analysis and Classification System
HRD	Human Resource Development
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
KCAA	Kenya Civil Aviation Authority
PPL	Private Pilot License
NTSB	National Transportation Safety Bureau
SMS	Safety Management System
SACAA	South African Civil Aviation Authority
UCAA	Uganda Civil Aviation Authority
%	Percentage

DEFINITION OF TERMS

Accident means an occurrence that is associated with the operation of an aircraft and takes place between the time any person boards the aircraft with the intention of flight and such time as all such persons have disembarked.

Aerodrome is an airfield equipped with control tower and hangars as well as accommodations for passengers and cargo.

Air field is an area of ground where aircraft take off and land. It is smaller than an airport.

Airports is an aerodrome with extended facilities. The facilities include those for the passengers and the aircraft in terms of parking, maintenance, repair, hangar etc.

Circadian rhythms also known as the body clock, are the 24-hour cycles in which behavioural and physiological, processes occur in our bodies.

Distress is the feeling of unease resulting from daily concerns and worries.

Error is action or lack of action by a person which leads to a deviation from organization requirements.

Error management these are process of detecting and responding to errors with countermeasures that reduce or eliminate the consequences of errors and mitigate the probability of further errors or undesired states.

Evaluation in training is the systematic process of collecting information and data to determine the effectiveness of training.

Human error is a human action with unintended consequences.

Human factors is to do with the application of information we have about human beings, the abilities, limitations and characteristics, which information is used to design equipment for use, improve the environment in which they function, and the jobs performance.

Human performances are human capabilities and limitations which have an impact on the safety and efficiency of aeronautical operations.

Incidents are certain occurrence, which is not an accident but equally could affects the operation of aircraft and air side safety.

Jet lag or time zone change syndrome/ desynchronosis, occurs when people have sleep interruptions for example due to work shifts or rapid travel across different time zones.

Knowledge is the theoretical understanding of subject matter.

Training is the development of habits, attitudes, skills and knowledge.

Training and development is a process utilizing different methods to equip existing and new staff with skills required for the job.

Psychoactive substances are opioids, alcohol, sedatives, cannabinoids, hypnotics, cocaine, other psychostimulants, hallucinogens, and volatile solvents, excluding coffee and tobacco.

Psychoactive substances these are alcohol, opioids, cannabinoids, sedatives and hypnotics, cocaine, other psychostimulants, hallucinogens, and volatile solvents, whereas coffee and tobacco are excluded.

Risk is an occurance or threat of damage, liability, injury, loss, or a negative occurrence caused by internal or external vulnerabilities.

Skills is what a person should be able to do.

ABSTRACT

Safety performance is much poorer in developing countries when one compares to other countries worldwide, despite the fact that the aviation crews in these countries are trained with the aim of minimizing aviation accidents. The accidents are due to errors caused by failure in the human biological functionality which is totally related to our anthropometric limitations, physiology and anatomy, among others. These include; oxygen carrying capabilities/ hypoxia, hyperventilation, blind spots in the eye, disorientation in relation to the human's position in space, motion sickness, illusions, barotrauma, decompression sickness, circadian dysrhythmias, drugs/medication, sleep disorders, weight, fatigue, stress and many others. Therefor this study set out to investigate the human factor risks and accidents in Eastern Africa region aviation operations. A cross sectional research design was applied and quantitative data collected using a survey. The sampling procedure included both purposive and random sampling techniques used to draw a representative sample of aviation stake holders. Data from 42 Ugandan and Kenyan accident and incident final investigation reports from 2000- 2017 was analyzed. Results indicated that skill based errors in Kenya were 44% and in Uganda 50%, whereas decision errors in Kenya were 45% , Uganda 25% and perceptual errors and violation in Uganda were 25% and in Kenya 11% while exceptional violations were Kenya 77% and Uganda 81%. MLogit model showed significance at $P<0.001$, in the manner with which one flies, exceptional violation, supervisory violations and organizational processes. Examining of the current human factor risks in the region's aviation operations showed that there are risks in quality control analysis ($P= 0.023$) and troubleshooting abilities ($P= 0.02$). Quality control analysis and troubleshooting abilities had a significant effect on the ability to predict skills required for the job ($P < 0.05$). The significant aeromedical factors included sleep ($P=0.005$), high levels of anxiety ($P= 0.021$), shortness of breath (P=0.011) and cigarette smoking (P<0.001). The Geographical Information Systems (GIS) tool captured latent human factors risks through ranking 40 randomly selected airports in the region, while the distress thermometer captured active risks which included health, stress (domestic and work related), fitness, deadlines and time pressure, sleep disorders, fatigue and pain. It can be concluded that both Kenya and Uganda had high levels of unsafe acts, although Kenya had a higher percentage. Four significant aeromedical factors were captured in the existing aeromedical factors in the region. Consequently, training and its evaluation plus the use of a regional adaptive curriculum that increases individual's skills and reduces the emerging unsafe acts, and Uganda publicizing final accident and incident investigation reports on the responsible ministry (Works and Transport) website are recommended. Using the GIS tool and the distress thermometer to detect latent and active human factor risks pre-flight and on ground to assess the state of the crew members and environment before one embarks on a task is also recommended. Map of airports and aerodromes with high human factors risks in Kenya Map of airports and aerodromes with high human factors risks in Kenya Map of airports and aerodromes with high human factors risks in Kenya.

CHAPTHER ONE: INTRODUCTION

1.1 Background to the study

Aviation safety in Africa attracts significant attention from the International Civil Aviation Organization (ICAO) and the entire industry. ICAO's 2012 safety report shows that Africa has a high accident rate, with approximately 530,000 injuries per 1 million flights. These incidents and accidents are due to different factors. Notably, 70% of accidents are due to errors committed by the human and this is as a result of failure in our biological functionality which is totally related to our anthropometric limitations, physiology and anatomy. In context, these include oxygen carrying capabilities/ hypoxia, hyperventilation, blind spots in the eye, disorientation in relation to our position in space and motion sickness, illusions, barotrauma, decompression sickness, circadian dysrhythmias, drugs/medication, sleep disorders, weight, fatigue and stress (ICAO, 2014).

Campbell and Bagshaw (2002) proposed that better understanding of human biological limitations (anatomy and physiology) and capabilities reduces human error. This most certainly helps to improve aviation safety. Martins *et al.* (2014) and Muecklich (2023) noted that accident prevention and detection agencies records reported that close to 80% of the accidents occurring in air are caused by human error. They all implicated the human as the guilty component. After the reporting of an incident or accident, in most cases, a pilot was pointed at as a guilty person even without concrete evidence. Currently, black box readings continue to show that the human is still responsible for approximately seventy to eighty percent of aviation accidents (FAA, 2010).

In the aviation industry, human factors have gained importance as it is accepted that they are the cause of many accident occurrences. The study of human factors is a multidisciplinary field of study encompassing engineering, statistics, psychology, design, occupational sciences and anthropometry. It involves understanding human behavior and applying it to aviation design, technology and supporting people in aviation. Human factors is a multidisciplinary course that is difficult and requires a stable study environment as identifying specific events or situations and their impact on people is easier said than done. Research in human factors in various aviation sectors such as maintenance has an intention of recognizing and correcting the various issues touching human performance and limitation.

Commercial aviation safety has greatly improved over the centuries. Large airline accident rates have greatly reduced along all dimensions making it the safest means of transport. However, it is worth noting that this safety is not the same across all geographical sectors of commercial aviation (ICAO, 2014). As a result of human error, about 20 years ago, the European Aviation Safety Agency (EASA) mandated studying human factors as a perquisite for licensing all pilots (e.g. gliders, private pilot licenses (PPL), Airline Transport Pilot License (ATPL), commercial pilot license (CPL) for airplanes, helicopters and instrument flight) (ICAO, 2014).

The UK through its Civil Aviation Authority introduced mandatory Human Performance and Limitations examination in1992. This was to apply for all professional license applicants in the region (Campbell and Bagshaw, 2002). Later, other fields of aviation also identified the need for Human Factors and adopted it. There is need for continuous study of human factors in aviation engineering if the aircraft is to be well-kept and inspected with proper maintenance systems that are important for public safety and air transportation system (FAA, 1993).

The subject of Human Performance and Biological Limitations is taught in classroom or self-study, quite complex to understand and always written by medical experts yet it is for scientists. The aviation crews usually feel like it is far from their experience and training skills. It is heavy with loads of subject matter and always applicable during crisis circumstances like airplane unease. The subject is designed with unfamiliar medical, biological and psychological content, and its assessment is exceedingly complex with the use of multiple choice questions (FAA, 1993).

However, the industry has registered little or no improvement for the previous era much as safety levels in civil aviation have greatly been unpredictable. Some authors have even suggested current accident rate are lower than what is reported (Shampell *et al.*, 2007). More importantly, Phillips (1994) stated that approximately 75% of these accidents are due to pilot error or human error. Hence the need for a study to identify and classify human factor accidents and incidents as well as aeromedical factors in Eastern Africa.

1.2 Statement of the problem

Developing countries, inclusive of the ones in Eastern Africa seem to have a much poorer safety record as observed by ICAO (2014). Despite the fact that the aviation crews in these countries are trained with the aim of minimizing aviation accidents, the reality is that aviation accidents have continued to occur. Although improvement has been realized in commercial aviation accident rates in the last decade, many authors worldwide have specialized and documented information about different accidents and incidents bending them on human error which is related to biological limitations which in turn affect performance (Muecklich, 2023). There was a further observation that the data was unreliable and unclear about the safety impacts of aeromedical factors to aviation accidents (Hardy, 1997). Aeromedical factors are crucial in the collision chain and often go undetected after flying or falling. In this field, most accidents are not thoroughly investigated or fully documented due to aerospace medicine's inability to detect at postmortem, leading to disruption in medical practice for an event or condition (for example stress, fatigue, hypoxia, spatial disorientation) (Hardy, 1997).

Aeromedical risk assessment tools are very important in aviation but they no longer serve their optimum purpose due to the continuously evolving industry and aviation environment (Hardy, 1997). There is need for practical methodologies that must be investigated and used for determining dynamic aircrew cognitive and human physiological/ biological preflight function. Dynamic assessment processes need to assess effects of aeromedical hazards and their effects on performance with the need for risk assessment paradigms informed and guided by in-flight monitoring as well as preflight evaluations (Steinkraus *et al.,* 2012). A need for identification of significant human factor events causing the regional aircraft accidents and justification of the directions of aviation biology can give a direction for their prevention. This study set out to examine human factors in aviation accidents and incidents in the Eastern Africa region. It specifically aimed at establishing and modeling previous and existing biological risks as well as designing certain interventions for aeromedical risk assessment tools and investigating practical methodologies for determining the crew's preflight and inflight function so as to improve training and flight safety.

1.3 Objectives

1.3.1 General objective

To investigate the human factor risks in Eastern Africa region aviation operations.

1.3.2 Specific objectives

1. To identify and classify previous (2000-2017) and current (2019-2020) human factors risks in Eastern Africa Aviation Operations using HFACs analysis from Kenya and Uganda.

2. To examine aeromedical risks in the region's aviation operations in Kenya and Uganda from 2019-2020.
3. To design possible interventions to address selected emerging human factors risks.

1.4 Research Questions

1. What are the previous and current human factors risks in Eastern Africa Aviation Operations according to the region's accident and incident reports?
2. What are the aeromedical risks in the region's aviation operations?

3. What interventions can be designed to detect selected emerging human factors risks?

1.5 Justification

Aviation accidents occur for several reasons, one of the commonest in the recent years being human factors rather than maintenance and technical errors. After identifying emerging human factor risks, they need to be characterized, through modeling the elements of exposure and the outcome consequences, handling them through prioritizing the important risks, making the necessary recommendations and latter improvements. These steps are very important in determining the contributing factors to an accident (Oster, 2013).

1.6 Significance

Gaining new insights from human factors accident data is crucial for developing effective strategies to enhance flight safety. By comprehending these concepts, they can be applied in aircraft design, aviation training, management policies, and operating procedures, which will help individuals to perform at their best, promote safety, and reduce human losses.

Aviation safety is practically improved by understanding why accidents occur and when there is the greatest chance of them to happen. This information can be used to identifying the respective methods utilized to improve safety. Notably, in order to improve safety, the causes of the accident have to be identified and prevented at the source. A lot of work is put into investigation of major aviation accidents, in the specific regions of the world. Aviation safety has registered great improvement due to investigations of accidents and incidents of similar causes. Conclusions from one particular event can greatly inform other similar accidents in the future. This study therefore identified and classified broad causes of accidents (from corner to corner) in the Kenyan and Ugandan aviation industry.

1.7 Scope of study

1.7.1 Geographical scope

The study was carried out in two Eastern Africa countries: Uganda and Kenya which are most prone to human factor hazards among the eight countries in the region.

1.7.2 Content scope

This study used HFACs analysis to identify previous and analyze current human factors risk in Eastern Africa aviation operations between 2000-2017 and 2019-2020, with the aim of improving the research pedigree of human hazards in the region. It also examined current aeromedical risks in aviation operations in the region from 2019-2020 and created a tool to measure response as much as possible to detect human aeromedical causes.

1.7.3 Time scope

The study reviewed and analyzed accident and incident final investigation reports for Uganda and Kenya for the period between 2000- 2017 for the first part of objective one. The data for the second part of objective one and the other two objectives was collected from 2019- 2020.

1.8 Limitation of study

Some of the challenges were; due to COVID 19 there was no face to face interaction with the participants. There was also a lack of highly detailed information about the accidents and incidents in the target countries because preliminary accident investigation reports were more available than final investigation reports. One of the countries (Uganda) did not have publicized final accident and incident investigation reports on the responsible ministry (Works and Transport) website.

CHAPTER TWO: LITERATURE REVIEW

2.1 The aviation system

Aviation systems consist of smaller subsystems that include ground operations, aircraft operations, aircraft maintenance, and air traffic control. Each subsystem fulfilling its specifics function to ensure efficiency and safety of operations carrying both passengers and cargo flights worldwide (Das, 2016; Rodrigues, 2021). It is worth noting that the number of cases, especially fatal cases, has decreased approximately over the last 60 years, from about 40 deaths per million in flight by 1959 to about 5.5 fatal accidents per million, about 0.14 fatal accidents in flight. However, these accidents continue to occur with new challenges always arising (Allianz, 2014; IATA, 2022). When investigating incidents and accidents in the aviation system, the major emphasis is put on operations subsystems as the key elements with a visible and central role. They are sometimes referred to as the primary subsystems, like the cockpit crew flying operating the aircraft or the air traffic control (ATC) controlling the airspace (Fraher, 2015; Jakˇsi´c, 2020; Karanikas, 2018). However, the secondary operational subsystems are also important in ensuring effectiveness and safety efficiency when operating flights. In this context most studies have focused on an analysis of both primary and secondary subsystems such as the cockpit crews who fly the aircraft or air traffic control (ATC) that are surrounding airspace and secondary subsystem such as Ground Operations (Figure 2.1).

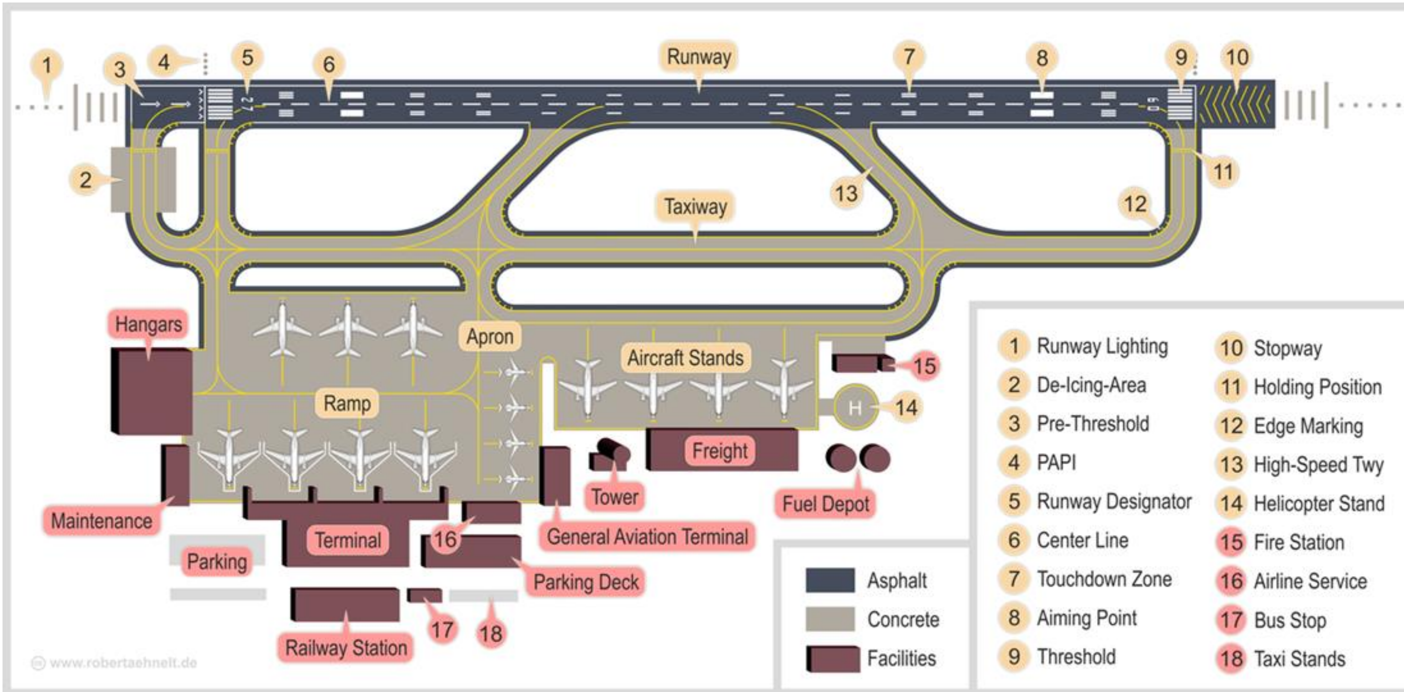


Figure 2.1 Standard layout of an airport (**Source:** Aehnelt, 2011)

The airport has an area where planes land: It is an open access area with at least one moving area, also known as a runway or helipad, where aircraft take off and land (Figure 2.1). Next to the landing area, there are buildings containing aviation materials, control towers and terminals for control and monitoring of aircraft. Larger airports may have furniture, taxi bridges, air traffic control centers, passenger areas; such as restaurants and resorts and emergency services. Airport operations are very difficult, passengers and flight management services are carried out with the best flight services. Therefore, in addition to being a large office, the airport is also an important place for tourism and various businesses. Airports are places where heavy machinery is used, but many safety measures and controls have been developed and implemented to reduce hazards. In addition, these airports have an impact on the local environment as a major source of noise, weather and other environmental impacts, making them key focus areas to those who benefit from the environmental impact of aviation. Airports are facilities that are sensitive to dangerous meteorological conditions, weather changes due to rising sea levels, as well as additional threats (ICAO, 1999).

2.2 Airport traffic pattern

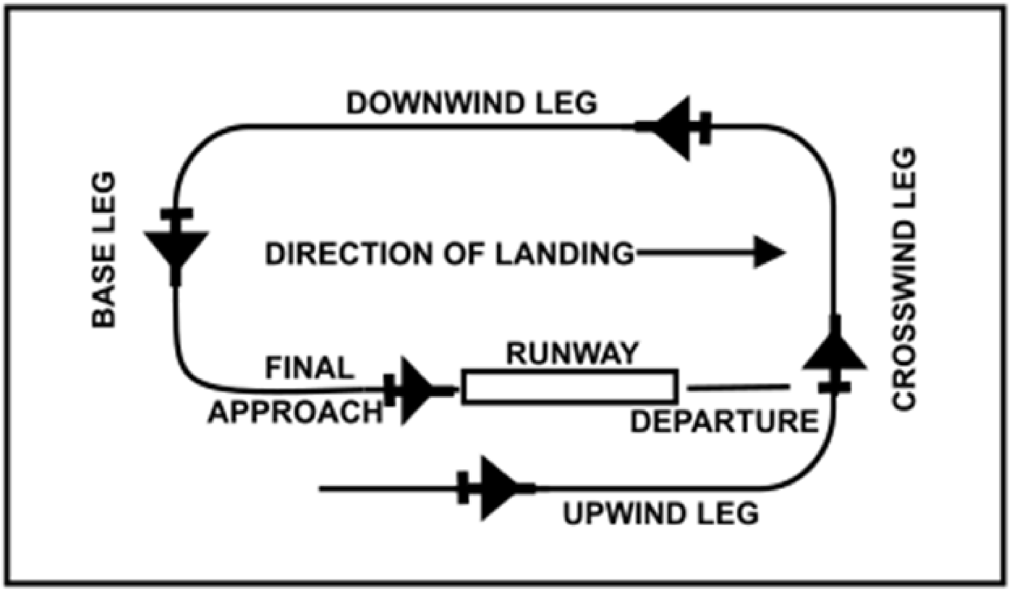


Figure 2.2 Airport traffic pattern (FAA, 2010)

A traffic pattern is used at all points of the airport to ensure flow of traffic for both departing and arriving air traffic. For example, if the aircraft is trying to land on runway 17 (about 170 degrees) from the north (360/0 degrees to 180 degrees), turn only 10 degrees to ensure the fastest landing and follow the glide path whenever possible. Each route is given a name (see Figure 2.2) and ATC tells crew how to join and exit the route. Traffic models operate at high altitudes, typically 800 or 1,000 feet (244 or 305 m) above ground level (AGL). The traffic pattern is left-hand, which means all pilots turn left. One of the main reasons for this is that pilots sit on the left side of the plane, and the left side improves the view of the airport and structures.

A contribution of both primary and secondary subsystems to the occurrence of incidents and accidents is less studied. Safety failures in aviation systems can cause widespread disturbances (Evler, 2021; NTSB, 2015; Wu, 2003).

Situational awareness is how cognitively present an individual is in a given situation or environment and the degree to which a person is aware of his or her environment and current activities. This kind or awareness is necessary for an individual to carry out operations at an airport as well as be able to stay safe. There is a possibility of loss of awareness of the situation due to lack of knowledge or unfamiliarity with traffic patterns. Each airport has specific traffic patterns (often called traffic lanes outside the United States). This aids the smooth flow of traffic for both departing and arriving aircraft. The need for performing this pattern in modern commercial aviation arises when there is a traffic queue. But landing queues are avoided by the SLOT-times. For example, if an aircraft approaches Runway 17 (approximately 170 degrees) from the north (360/0 degrees to 180 degrees), the aircraft only needs to turn 10 degrees and follow the glide path whenever possible to land as quickly as possible. Generally speaking, this model is a circle with five "legs" (two legs plus walking on one side and two legs plus three sides) forming a rectangle. Each route is given a name (Figure 2.2) and ATC tells pilots how to join and exit the route. Traffic models operate at high altitudes, typically 800 or 1000 feet (244 or 305 m) above ground level (AGL) Aehnelt, R. (2011).

Our commitment to a specific chore will divert us from other activities which are perceived to be less important. Edwards in 2013 noted that lack of situational awareness greatly affects our functionality and hence affects human performance (Martins, *et al.,* 2014). Latent factors in our environment such as noise, obstacles (hills, mountains, trees and buildings) can also be a source of distraction because they hinder successful ground operations. Planning ahead helps traffic flow because every crew knows what to expect and helps reduce ground collisions (FAA, 2010).

2.2.1 Theory of performance

The Theory of Performance (ToP) was developed and related to six major foundational concepts to form a framework that can be used to explain performance as well as performance improvements (Don, 2010). Since the development of a person's output defines a person's position on that journey. The current level of performance is generally determined by six factors: background, knowledge level, skill level, personality level, personal factors, and fixed assets. Our axioms focus on improving performance, combining skills and knowledge to create results (Elger, 2010).

2.3 Identifying and classifying previous and current Human Factors Risks in Eastern Africa Aviation Operations using HFACs analysis

2.3.1 History of human factors

Anthropometrics research related to man and flight begun in 1487, by Leonardo DaVinci. The famous picture of the Vitruvian Man, DaVinci's famous drawings, is evidence of his early work in anthropometry. At around this same time, the artist got curious about birds and started to study their flight. He noticed that a human was too heavy to fly and was able to simply use artificial wings attached to his arms to fly. Then DaVinci made a sketch of a device where a person would lie down on a plank and was able to control two large, membrane like wings with the use of hand levers, a pair of foot pedals, and a mechanized system of pulleys. Based on his work, anthropometry is now adopted in several fields and plays a key role in the fields like aviation instruction, maintenance, computer design, and ergonomics (Hussain, 2022).

In the 1900s, Orville and Wilbur Wright pioneered a lot of work on human performance and limitation and were finally the first to fly an aircraft. The duo designed the first set of usable aircrafts with controls modeled from a bird therefore beating many others who were still trying to work on the aircraft aerodynamic stability first (Hussain, 2022).

2.3.2 The Discipline of Human Factors

The ICAO defines, "The human factors as the science of humans in their living and working environment; how they relate with machines, certain procedures and the environment around them; as well as their relationships with other humans (ICAO, 1989). Aviation human factors include medical, personal and biological considerations necessary for safe aircraft and air traffic control operations" (ICAO, 1989; Lyssakova, 2019).

Although the percentages may vary, many would agree between 65% and 85% of accidents in aviation are as a result of error committed by the human (Shappell and Wiegmann, 1996). (Billings and Reynard, 1984; Gaur, 2005; Li, Baker, Grabowski, & Rebok, 2001; Shappell and Wiegmann, 2003; Wiegmann and Shappell, 2003), many of those studying aviation accidents have directly fixated on certain circumstantial factors as well as crew biological limitations, instead of the actual human errors causing the accidents. It must be acknowledged that everything from weather, lighting (day and night), and terrain contributes to these conditions over which the pilot has little control. Likewise, nothing much can be said about a person in terms of; gender, age, profession, flight hours as a determinant of pilot safety (Shampell *et al.*, 2007).

The main objective of aviation safety modules is to make the structures current, by including security and proficiency, and general safety of the human being. The human sciences usually study nature and structure of the individual, capacities and limits, and their behaviours both alone and in sets (Oxford, 2008). The term "human factors" has become widely used in the aviation industry with the realization that human error, rather than mechanical failure, is the cause of most aviation accidents and incidents. Human factors are a collection of information about human capabilities, biological limitations, characteristics, and their application to tools, machines, systems, tasks, performance, and the environment to ensure safety and efficiency (Martins *et al.,* 2014).

There is need to use information from psychology and physiology to understanding how humans make decisions and process information. Hence this makes human factors a multidisciplinary science. From these various fields that make up human factors comes an understanding of the means one can use for detecting and transmitting information known as sensory processes. Anthropometrics which involves the study movements and different measurements of the body - is essential when designing workplaces, the control layouts, and other characteristics in the cabin and flight deck. Scientists refer to biomechanics and anthropometry when carrying out ergonomics related research. Biology especially chronobiology is increasingly important in understanding the nature of circadian rhythms including jet lag, sleep and their effects in at different time-zones and during night flights (Martins *et al.,* 2014).

2.3.3 Conceptual models of human factors

The Software, Hardware, Environment, Liveware (SHEL) concept with its name being from the short form letters, which were derived in 1972 by Edwards (ICAO 216-AN31). The interpretation suggests; the human is liveware, the fuselage is the hardware, software are the procedures, machine, and finally the environment. Liveware is at the center of the model and this is the person, who is the most important and the most adjustable piece of the structure. However, individuals are victims of many disparities in their actions as they suffer many biological restrictions, hence the cause of accidents (Hawkins, 1993).

Remember that the center of SHEL model there is the human/ liveware, represented by letter L. In aviation, this is the ATC, engineer, pilot, safety officer or any other individual relevant to aviation. L is the most flexible as well as the most valuable component in the SHEL model but it affected by biological limitation and variations in performance but these are generally predictable (Molloy and O'Boyle, 2005).

The Liveware– Liveware about the human to human interface; it is characterized by interpersonal communication as the most common element. Old school aviation used to focus on the character of individual crew when raising questions about performance. However, modern approaches look at the crew's teamwork, with a particular focus on its breakdown and its implication to safety. The Liveware–Liveware interface mainly deals with team coordination and cooperation, leadership, personality interactions, conflict resolution, status hierarchies, and continuity of information flow at work. The Liveware–Liveware interaction should work to emphasize the efficient information flow between agencies and individuals. Shortcomings at the L-L interface result in poor dissemination of important information or situations in which information becomes difficult to obtain (Molloy, and O'Boyle, 2005).

Molloy and O'Boyle (2005) indicated in their work that human factors include; risk orientation, personality, communication styles, physical characteristics, level of tolerance to stress, learning styles, knowledge, skills, and attitudes. There was a proposed shift to competency based training from time-based training; this was very relevant in aviation. Some processes were adopted to define competence areas and then map them onto the aviation core curriculum to ensure that individuals function safely and effectively in a diverse range of environments. Henriqson, (2010) emphasizes that the spiritual and physical health of crew on the aircraft is dictated by various factors which should enable the crew to develop normally and do their various activities successfully.

"Swiss Cheese Model" developed by Reason in (Appendix 2) illustrations different layers of defense which have been put in place to act as protective barriers against natural and man-made disasters. In this model failures are represented as holes which can align for an accident to occur. In this case an accident is a series of errors leading to a series of catastrophes. If the staged fences (cheese layers) are demolished or vulnerable with certain flaws, then accidents are likely to occur and this is called a latent failure (Martins *et al.,* 2014).

2.3.4 Approaches in analyzing human error

2.3.4.1 Dirty dozen

Human Factors Dirty Dozen (HF DD) model is used as a start point for identifying most preconditions for human error in aviation (Dupont, 1997). The same model does list the twelve dominant preconditions for human error in aviation operations as shown in Figure 2.3. The model is not holistic and neither is it a comprehensive list with all the precursors. Though the model is used to identify human error in aviation accidents while doing analysis in the field, it is also used in health care (Shampell *et al.,* 2007).

Figure 2.3 Human factors dirty dozen

2.3.4.2 Human Factors Analysis and Classification system (HFACs)

The Human Factors Analysis and Classification System (HFACS) provides a way to identify the antecedents of human error that cause aircraft crashes or accidents (Dönmez and Uslu 2018). The HFAC project was developed by Shappell and Wiegmann and relies heavily on James Reason's Swiss Cheese Model for risk management. It not only focuses on human error but also evaluates what is required in the human work environment. HFACS is used not only in aviation investigations and accidents, but also to find active and latent system faults in the maritime, railway and chemical industries (Shappell and Wiegmann, 2000). Research on human factors has led to the development of many human factors models. A good example of the use of the HFACs model was developed for the Ministry of Defense but has recently become popular in investigation of many accident causes (Shappell and Wiegmann, 2000). The Human Factors Analysis and Classification System (HFACS) is the most widely used standard for classifying human factors. Shappell and Wiegman came up with the HFACS model after the two examined more than 300 U.S. Navy aircraft crashes. The same model is followed by the Traditional Swiss Cheese model (Dönmez and Uslu, 2018).

HFACS is applied to human factors in air traffic management, maintenance, ground crew and cabin crew; it also focuses on crew behaviour. Reason (1990) uses a basic approach of the concept of active and latent failure and considers four levels of failure as: level 1; unsafe acts, level 2; preconditions for unsafe acts, level 3; unsafe supervision, and level 4; organizational influences (Wiegmann *et al*., 2005). Furthermore he divides these levels into many individual errors with multiple causal categories (Wiegmann *et al*., 2005). Unwanted behaviors are classified as errors or crimes/ violations (Reason, 1990). Mistakes often represent failures in psychological or advanced learning techniques and development that people must use to perform in the real world. This is not surprising because negative attitudes dominate much of the world's climate data (Shappell *et al.*, 2014).

Human error is undoubtedly considered the number one cause of aviation accidents and incidents. Up to 80% of aviation accident and accident investigations have identified human error as at least a contributing factor or at least a contributing factor (Muecklich, 2023). The human error management approach in aviation essentially expresses the characteristics of high risk factors that differ from management and training. This process aims to prevent accidents and problems in the system caused by human error, thus limiting risks and improving occupational safety and procedures (Muecklich, 2023). It is worth knowing that, like most cases in other fields, aviation accidents do not occur in isolation. Instead, as Heinrich's axioms of economic security (Heinrich, Peterson, and Roos, 1931; Wiegmann and Shappell, 2003) pointed out, they often arise due to long-term conditions that lead to crew misbehavior. Bird's (1974) "domino theory" and Reason's (1990) "Swiss cheese" model of human HFACS failure are contradictory theories adopted by many researchers in the field of human psychology. Chief among these is Reason (1990), who explains business and the probability of failure using a “Swiss cheese” model. Therefore, as Shappell *et al.*, (2014) noted, an analysis such as the current study is needed so that the findings can inform different sectors of the aviation industry. The significance of unsafe acts is also evident in medical error investigators which have used HFACS in intensive care units. Results show that causal factors like the ones in aviation and other sectors of health care areas for example investigations in biopharmaceutical manufacturing processes (Cintron, 2015). The sectors register skill-based failures (unsafe acts), together with planning and supervisory errors, most especially when numerous chores are carried out at a particular time. These dominate the findings by several other researchers (ElBardissi *et al*., 2007).

Other fields have also used HFACs to identify and classify accidents reports for example in the automotive industry, where the accidents in this field. In the automotive field, errors are usually related to unsafe conditions and violations (Reyes, 2015).

2.4 A Conceptual framework of the study

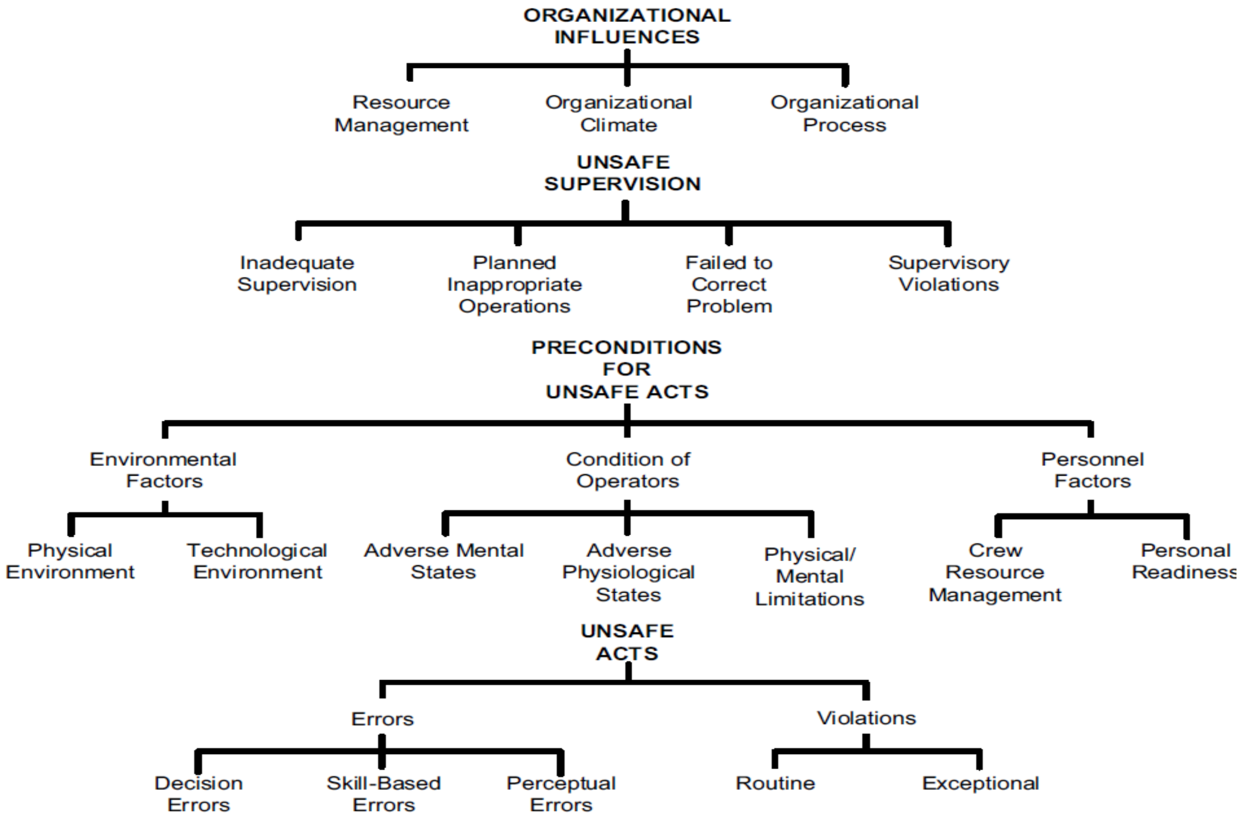


Figure 2.4: Conceptual HFACs Framework (Adopted from: Shampell *et. al.*, 2007)

Level 4; organizational influences, level 3; unsafe supervision, level 2; preconditions for unsafe acts and Level 1; unsafe acts. Organizational influences; the category with organizational climate gives a brief description of predominant environment/mission in a business, including the rules, organogram and beliefs/norms. Operational processes are official rules by which a mission in the enterprise is done including procedures, actions, and predictions (FAA, 2010). Resource management on the other hand looks at how individuals, financial, and tools or resources available are managed (Shampell *et al.*, 2007).

Unsafe supervision is an oversight in the running of workers as well as properties, which include teaching, drills, and functioning management. A prearranged unsuitable operation is a failure of administration to allocate work appropriately, as they have sessions like trouble shooting, staff roistering, and procedures. Failure to rectify a given challenge is a case in which the limitations of personale, tools, education, skills and additional well-being are thought to the administrative (FAA, 2010). Supervisory violations are the deliberate neglect of current regulations, orders, and regular working procedures by bosses throughout the course of supervision (Shampell *et al.*, 2007).

Preconditions for unsafe acts include a category of environmental technological factors encompassing a diversity of problems. These include the plan of gear and panels, display/boundary characteristics, checklists and automated systems (Shampell *et al.,* 2007). The physical environment includes the work environment (e.g., weather, altitude, terrain) and environmental factors (e.g., noise, heat, vibration, lighting, toxins). Psychiatric problems include serious mental illnesses and/or mental illnesses that impair functioning, such as mental fatigue, mood swings, and demotivation. Adverse physical conditions refer to severe physical or practical circumstances which hinder effective performance; these include sickness, drunkenness, and the use of drugs or narcotics, non-communicable or genetic diseases among others (Shampell *et al.*, 2007). Physical/mental restrictions include physical/mental incapacities which affect output; these include optical deficiency, malaise, cognitive incapacitation, general knowledge, and many mental health problems. Key people in personnel management include a team responsible for messages teamwork, and output collaboration. Self-discipline is the non-work activity that needs to be done to be effective at work, such as keeping track of employees' vacations, avoiding alcohol, and others.

Unsafe acts include making mistakes. Decision errors are “thinking” errors and represent deliberate, purposeful actions that are based on design (Shampell *et al*., 2007). Errors usually present as ill performed chores, inappropriate selections, or misinterpreted as well as misused information. Skill-based errors are skillful behaviours which happen with minute or no mindful thinking. These “doing” errors frequently appear as breakdown in visual scan patterns, inadvertent activation/ deactivation of switches, forgotten intentions, and omitted items in checklists. The manner or skill with which one flies is under errors. Perceptual errors occur if bodily sensation is ignored or misinterpreted, like when the pilot flies in darkness or at night, under bad weather, or in visually needy surroundings. When confronted with defective and partial information, crew stand a danger of miscalculating run way width, length or approach distances, as well as suffering different optical/vestibular illusions. Violations include routine violations which are also known as “bending the rules,” they tend to be characteristic in nature and are usually facilitated by a structure made of administration and organizational policies and rules that tolerate them. Exceptional violations are random withdrawals and disregard for rules/regulations and uncharacteristic of a person (Shampell *et al.,* 2007).

2.5 Examining aeromedical risks in the region's aviation operations

2.5.1 Aero medical factors

The human being is very important in any manned aircraft but can highly be influenced by the external environmental factors such as pressure, oxygen and chemicals. The human body is easily incapacitated by the previous factors, or can easily degrade through a variety of means. Aeromedical factors concern themselves with the body's conditions and evaluate external forces imposed upon it. Protecting yourself from these factors requires one to have knowledge of how the aviation environment affects the body (Caldwell *et al.,* 2009).

2.5.1.1 Fatigue and its effects in aviation

Pilot fatigue is a major problem in today's aviation industry, mainly due to irregular working hours, long working hours, disruption of circadian rhythm and sleep, resulting in deprivation in civil and military jobs. People who are tired of sleep think and act more slowly, make more mistakes, and have difficulty remembering than people who are well-rested. These negative effects can lead to aviation errors and accidents (Caldwell *et al.,* 2009). Uganda Airlines Flight 775, a Boeing 707-338C, registration 5X-UBC, crashed while attempting to land at Rome-Fiumicino Airport in Rome, Italy, on October 17, 1988. 33 of the 52 passengers were killed and lost their lives. The main cause of the accident was estimated to be psychological and bodily fatigue of the pilots (Ministry of Works and transport, Uganda 2018).

2.5.1.2 Body rhythm disturbance

Today's long flights often lead to circadian disruption patterns that cause disruptions in body physiology, affecting safety, performance and health. The effects of circadian problems not only affects long-distance trans-meridian flights; the performance of short-haul crew who fly regularly or at night, such as cargo companies and delivery companies, will decline due to circadian misalignment (CAE, 2022). It has influence on the circadian rhythms, which is a twenty four hour cycle in the biological, chemical, physical, functional and behavioural practices in the body. It controls everyday events, like waking, sleeping, eating, and body heat control (Nordqvist, 2017). Misalignments in these rhythms can cause jet lag, a collective term for physical imbalances or imbalances and refers to a lack of health after a long journey. Symptoms include sleep disturbances, disturbances in eating and elimination habits, fatigue, anxiety, irritability and depression. Evidence of slow reaction and decision-making times, lost or false memories of recent events, miscalculations, and a tendency to accept lower standards of performance is evident with body rhythm disturbances (Nordqvist, 2017).

2.5.1.3 Sleep and body rhythms disturbances

According to Caldwell, (2012) the normal adult requires around 8 hours of good quality sleep every single night and no amount of determination, competence, education, skill can prevent the loss in performance that can be attributed to the lack of sleep. Sleep refreshes the body and brain and is essential for mental processes and general organization (CAE, 2020). Sleep is also essential in restoring mental performance. Sleep disturbance and deprivation reduces attention span and alertness. Once this is confirmed, focus and alertness can be partially regained with increased effort (CAE, 2022). Ethiopian Airlines en route from Khartoum in Sudan to Addis Ababa on 15^{th} August 2022, a flight during which the captain and his co-pilot fell asleep.

2.5.1.4 Stress effects in aviation

Stress is a way that the human body responds to psychological and physical demand on it. The response to it will include release of adrenaline hormone into the circulatory system, to increase the metabolic rate so as to deliver excess or a good amount of Adenosine Triphosphate (ATP) to the muscular system (CAE, 2020). Heart speed, respiratory rate, blood sugar, perspiration and blood pressure will all rise when one is stressed. The word “stressor” describes a factor causing the person to be stressed. Stress can include; physiological (fatigue), physical (vibration or noise) and psychological stress such as personal problems as well as difficult work (Pilot’s handbook of Aeronautical knowledge 2008). Furgro Airborne aircraft crashed at Entebbe International Airport on 26th Sept 2007 and the report indicated pilot’s lapse of concentration before departure (Ministry of Works and Transport, Uganda 2018).

2.5.1.5 Hypoxia and hyperventilation effects in aviation

Hypoxia usually means "lack of oxygen". Without oxygen for a long time, all tissues in our body die; the most important thing is that enough oxygen goes to the brain because the brain is very inactive in the absence of oxygen (CAE, 2022). The brain needs to get enough oxygen because without it the individual makes mistakes while flying and suffers deteriorating mental health which can be life-threatening. Hypoxia is caused by a number of factors, including inadequate oxygen transport, inadequate oxygen supply, or the inability of body tissues to absorb oxygen. Some types of hypoxia include: congestive hypoxia, anoxic hypoxia, histotoxic hypoxia, and stagnant hypoxia (Oxford Aviation Academy, 2018).

On the other hand, hyperventilation is an unnecessary increased frequency of breathing which leads to an abnormal loss of carbon dioxide (CO_2) from blood and an increased depth of respiration. The condition of hyperventilation occurs more often to the crew than it is recognized. It is usually associated with complete incapacitation and it causes symptoms that can cause the uninformed crew to be alarmed. In some cases, the anxiety and increased breathing rate may make the problem worse. Hyperventilation may lead to the individual becoming unconscious because of the respiratory system overriding the mechanisms that can help it regain control of its breathing (CAE, 2022).

2.5.1.6 Spatial disorientation and illusions

Spatial disorientation refers to a lack of orientation in terms of attitude, position and movement of an airplane in space. There are 3 combined structures that our bodies use when working to gain movement plus orientation in the cosmos, these are:

• Vestibular system—where the innermost part of the ear ensures body position and balance.

• Somatosensory system—involves the muscular system, joints as well as nerve endings under the skin, working with the auditory system, to ascertain our situation based on sensation, sound as well as gravity.

• Visual system—uses the eyes, to make sense of one's position.

Contradicting information coming from these three systems leads to disorientation and illusions as was the case, on 13th Jan 2014 a C 182 Skylane 3 crashed at Lake Nakuru National Park due to the pilot's visibility being affected by sun glare on the wind shield (Ministry of Works and Transport, Kenya 2018). Another case was on 23rd October 2000 where an aircraft crashed near Entebbe International Airport and the possible reason for this accident was vertigo (Ministry of Works and Transport, Uganda 2023).

2.5.1.7 Carbon Monoxide (CO) Poisoning

Carbon monoxide (CO) is an odourless and colourless gas which is produced by the fuel combustion in engines. It can attach to haemoglobin at a rate of about 200 than oxygen. Carbon monoxide can also inhibit the oxygen carrying capacity of hemoglobin, a condition which can bring about hyperemic hypoxia. Furthermore, the human has a requirement of about 48 hours for proper disposure of CO. In severe incidences a human having poisoning due to CO inhalation may die (Oxford Aviation Academy, 2018).

2.5.1.8 Motion Sickness

Motion sickness also known as air sickness, is as a result of the human brain receiving contradictory signals about the body's' state. Crew members feel sick at the beginning of the flight but usually get over it throughout the rest of the course. The stress and anxiety you may experience at the beginning of flight training can increase the risk of illness. Symptoms or side effects may include nausea, dizziness, abdominal pain, pallor, vomiting, and sweating (Oxford, 2018).

Exposure to gravity can have the same effects as disease. Symptoms may be more bothersome with negative time Gz than with positive Gz in cases such as inversions, layer cycles, and some types of rotations. The organs are forced to ascend and blood is forced towards the head area, which affects hydrostatic change. Individuals may experience difficulty breathing, facial pain, and eyelids lifting, resulting in "red and weak" eyes. With negative pressure Gz, small blood vessels in the face and eyes will burst (CAE, 2022). Maximum tolerance is determined by the strength of each part of the body. The human body can withstand surprisingly short g-forces. Alcohol, heat, hypoglycemia, smoking, hypoxia, hyperventilation, hypoglycemia, stress, fatigue and obesity make the influence of gravity very painful (Oxford 2008).

2.5.1.9 Alcohol and its effects on flight crew

Alcohol is directly absorbed into the bloodstream from the stomach. After absorption, it goes to the brain where it affects alarm systems, also affects thinking and worrying. Effects of alcohol do increase as an individual climbs higher and this affects the brain's ability to take up oxygen. It has been suggested that when absorption is rapidly going on into the brain and the blood stream, these vascular organs, are so sensitive to changes of the blood composition. This reduction in oxygen concentration at a high altitude will also impair thinking.

The regulations state that12 hours is the safer minimum in the case that larger amounts of alcohol were consumed however, at least 8 hours should pass between the last alcoholic drink and flying (8 hours 'bottle to throttle') twelve hours or remarkably greater (Campbell and Bagshow, 2002). The World Health Organization (WHO) takes note of the fact that a person who takes caffeine or alcohol pre or post flight may worsen some physiological symptoms. Caffeine does disturb sleep patterns so one can always ensure that they drink water while flying. Consumption of alcohol will also disrupt one's sleep pattern, among other symptoms. Sometimes alcohol may induce sleep but its quality will be poor. Hangover effects due to alcohol can worsen travel fatigue and the effects of jet lag (Campbell and Bagshow, 2002).

A more accurate notion is that alcohol is removed from the blood at a rate of approximately 15 milligrams per 100 milliliters per hour. Drinking 1.5 liters of beer or three glasses of whiskey will put the blood/alcohol concentration at around 45-50mg/100ml, so it will take around 4 hours for the blood to return. The rate of absorption into the bloodstream varies depending on the type of beverage (mixed drinks are absorbed more quickly than pure alcohol), body weight, food intake, and individual metabolic rate. The most important of these is weight. Alcohol and flying don't go together; recent aviation research confirms that a blood/alcohol level of 40 mg/100 ml (half the legal driving limit) leads to an increase in driving errors even on small, easy-going aircraft. The blood alcohol limit for a sailor is 20 milligrams per 100 milliliters of blood. UK authorities have recommended that pilots avoid flying for at least 8 hours after consuming a small amount of alcohol, or longer if the amount of alcohol is greater. They added that pilots would be wise to avoid alcohol for at least 24 hours before flying. One of the probable causes of a C172SP crashed at Soroti airport on 21st May 2012 was that the pilot indicated that he had some alcohol a few hours before the incident (Ministry of Works and Transport, Uganda, 2018).

2.5.1.10 Gastral Intestinal infections

Gastral intestinal infections are common and they cause serious incapacitation in humans during flight. These infections may be caused by viruses or bacteria from water or food; sometimes they may be as result of consumption of spices, curry and alcohol which may irritate the gut. Gastro-enteritis is one of the diseases caused by viruses or bacteria is totally incapacitating during flight (CAE, 2022).

2.5.1.11 The effects of drugs and self-medication

Drugs are substances for example narcotics which are used for therapeutic purposes as a pharmaceutical or medical compound. The common side effects of drugs include depression, drowsiness, impaired judgment and decreased co-ordination. Side-effects of drugs may be minimal on the ground but may be harder to predict at higher altitude. However, crew members still taking medication or undergoing treatment are most likely unfit to fly, due to various physiologically related issues and side-effects (Campbell and Bagshow, 2002).

2.6 Designing possible interventions to address selected emerging human factors issues

2.6.1 Existing aeromedical tools

Case studies of U-2 and F-22 fleets did challenge many aeromedical experts; these studies brought to the lime light the need for better cognitive, physiological and in-flight aircrew monitoring (FOO, 2010). Current aerospace medicine risk assessment tools, although still appropriate, do not take into account many of the human risks present in aviation. The element of one's fitness to fly has some cognitive aspects which also need to be assessed. There is need for aviation scientists to investigate more dynamic and up to date methodologies that can be used to determine defects in crew physiological and cognitive function before flights and during the flight (Steinkraus *et al.*, 2012). Current aerospace medicine risk assessment tools, although still appropriate, do not take into account many of the human risks present in aviation (Liu, Nickens, Leon, and Boquet, 2013; Shappell *et al*., 2007; Vaughuen and Muschara, 2011).

In the face of these human performance challenges, aeromedical specialists (ASMs) must redefine "fit to fly." If the brain is the primary flight instrument, then cognitive function should be the primary fitness focus. Static "fit to fly" assessments based on single-point evaluations no longer suffice. Dynamic assessment processes are needed to examine the effects of risks such as spatial disorientation, workload, fatigue, and hypoxia on performance. Human and machine, working together via feedback loops within operational risk "envelopes," mark the next generation of aerospace advances, requiring better aeromedical risk assessment paradigms, informed and guided by in-flight monitoring as well as preflight evaluations and effects of automated systems (Steinkraus *et al.*, 2012).

It is quite clear that the current standard aeromedical risk assessment tools cannot adequately measure cognitive abilities or predict and measure dynamic cognitive capabilities of operations during the flight (Hardy, 1997). The flight physical medical examination is a relatively poor tool for predicting potential medical problems in the inter-physical period. Most aeromedical risks are detectable after death (spatial disorientation, stress, hypoxia, fatigue), complicating ASMs' ability to conclude the exact medical cause (Steinkraus *et al.*, 2012).

The U-2 and F-22 examples have reemphasized something that ASMs, have always known, that the best aeromedical assessment is functional—observing flyers performing duties in flight while tracking behavioural and physiologic parameters. Flight surgeons flying with their crews understand this concept. Aviation cannot put a flight surgeon on every mission, but perhaps it is time to put an analogue on board—a system that will give information that translates to better safety and performance (Steinkraus *et al*., 2012).

2.6.2 Aeromedical training transcending to knowledge

Student's learning styles and personality types studied across the education system are diverse, yet similar studies carried out on aviation students are few. A study conducted in the USA assessed the diversity of learning styles as well as personality types among pupils enrolled at a science degree program. A comparison of the personality type of the college students showed a significant over representation. When the diversity of education styles of traditional students was equated to the aeronautical students, results revealed a divergence of learners and their education styles (Fussell *et al.*, 2018).

2.6.3 Training and its relevance in aviation

Most organizations recognize training as an importance aspect in the development and growth of any company (Noe, 2002). Notably training is very important in human resource development (HRD) and the proper functioning of any company. (Rajeev *et al.*, 2009). Dessler (2005) defines development and training as the process which utilizes different methods to avail already existing and new employees with relevant skills needed for a job. This concept is similar to that used by many authors (Beardwell and Holden, 2003; Cascio, 1998; Cherrington, 1995; Ivancevich, 2003; Mondy and Noe, 2005; Torrington and Hall, 2005; Yong, 2003). Training is necessary if organizations need to expand, improve on their profits and development their capabilities (Cosh *et al.*, 1998). And this applies to aviation as well.

Other studies suggest that to overcome error in aviation some authors bend it to evaluation of training (Bramley and Kitson, 1994). In aviation, human error and its management have addressed the characteristics of various high-risk subsystems (and tied them directly to machinery) through technical procedures, trained screening, and appropriate management. The aim is to prevent injuries and accidents caused by human error, thereby controlling the risk and improving the safety of the working process (Muecklich, 2023; Haslinda and Mahyuddin, 2009). Hamid and others pointed out that in order to initiate a very effective training process, organizations should review the training process and ensure all training and development is a strategy-related system in the organization. Evaluation of training effectiveness must be carefully designed to increase the effectiveness of training (Hamid, 2002; WCES 2012).

Training and development is about good work: providing employees with the knowledge and skills necessary for good work (Noe & Schmitt, 1986) Cheng and Ho (2001). Since most organizations are unsure of what training contributes to the organization's development, they find it to be unnecessary and expensive. Yet with proper monitoring and evaluation they can establish the value of training (Bramley and Kitson, 1994; WCES 2012).

Recommendations to operators by International Air Transport Association (IATA 2015): Performance of power management training under various flight conditions and phases, including but not limited to engine failure, loss of thrust, and incorrect engine settings. Regular courses and simulator training are provided for pilots. In addition to the importance of compliance with regulations, when it comes to safety, there are standards that organizations must adhere to; including operating procedures, appropriate training and organizations must follow good security practice. Compliance with IOSA standards; involve and address monitoring of aircraft flight paths and training systems and support human intervention when necessary. Improved work management and job classification and prioritization. Ensuring operations are carried out in accordance with SOPs. Make sure pilots have appropriate communication and crew resource management (CRM) skills. Ensure training is completed within FSTD's Verified Scope of Training (IATA, 2015).

2.6.3.1 Training on situational awareness

A pilot's ability to prevent and overcome uncontrollable conditions is achieved by focusing on prior knowledge of the cause of such situations; development of the skills and discipline need to recognize stress early in the development or focus on stress recovery. Training that teaches awareness and prevention provides pilots with awareness of situations that can lead to undesirable accidents if not managed correctly. Therefore, the development of CRM training should focus on situational awareness, communication skills, effective flight monitoring (for interception and threat mitigation strategies), teamwork, division of labor and prioritization, decision making and error management (in the general context of SOPs) (IATA, 2015)

An example of loss of situational awareness results from misconfiguration of the airport environment (best location for the airport environment). The extended facilities on the airport are used primarily for air cargo. The airport usually has a landing area, which includes an open area accessible from the air that contains at least one working area, such as a runway or helipad, for the takeoff and landing of aircraft, and many include adjacent service buildings such as control towers as well as hangars and terminals for controlling and monitoring aircraft. Larger airports may include an airport terminal, taxiway, air traffic control centers, passenger facilities such as restaurants and lounges, and emergency services. In some countries, especially the United States, most airports have one or more permanent staff to assist with flight operations.

2.6.3.2 The importance of training evaluation

In reality, there are several other factors affecting training effectiveness in many companies (Haywood, 1992). It is well known that training is central to a company's success and growth and aims to provide employees with the knowledge and skills they need to do their jobs (Noe and Schmitt, 1986: Cheng and Ho, 2001).Development and training are a necessary expense for any company but most companies are unsure of the significance of training to the organizational output and development due to an overall lack of monitoring and evaluation in the same companies (Bramley and Kitson, 1994; WCES 2012).

CHAPTHER THREE: MATERIALS AND METHODS

3.1 Study area

The study was carried out in two selected countries in Eastern Africa namely; Uganda and Kenya.

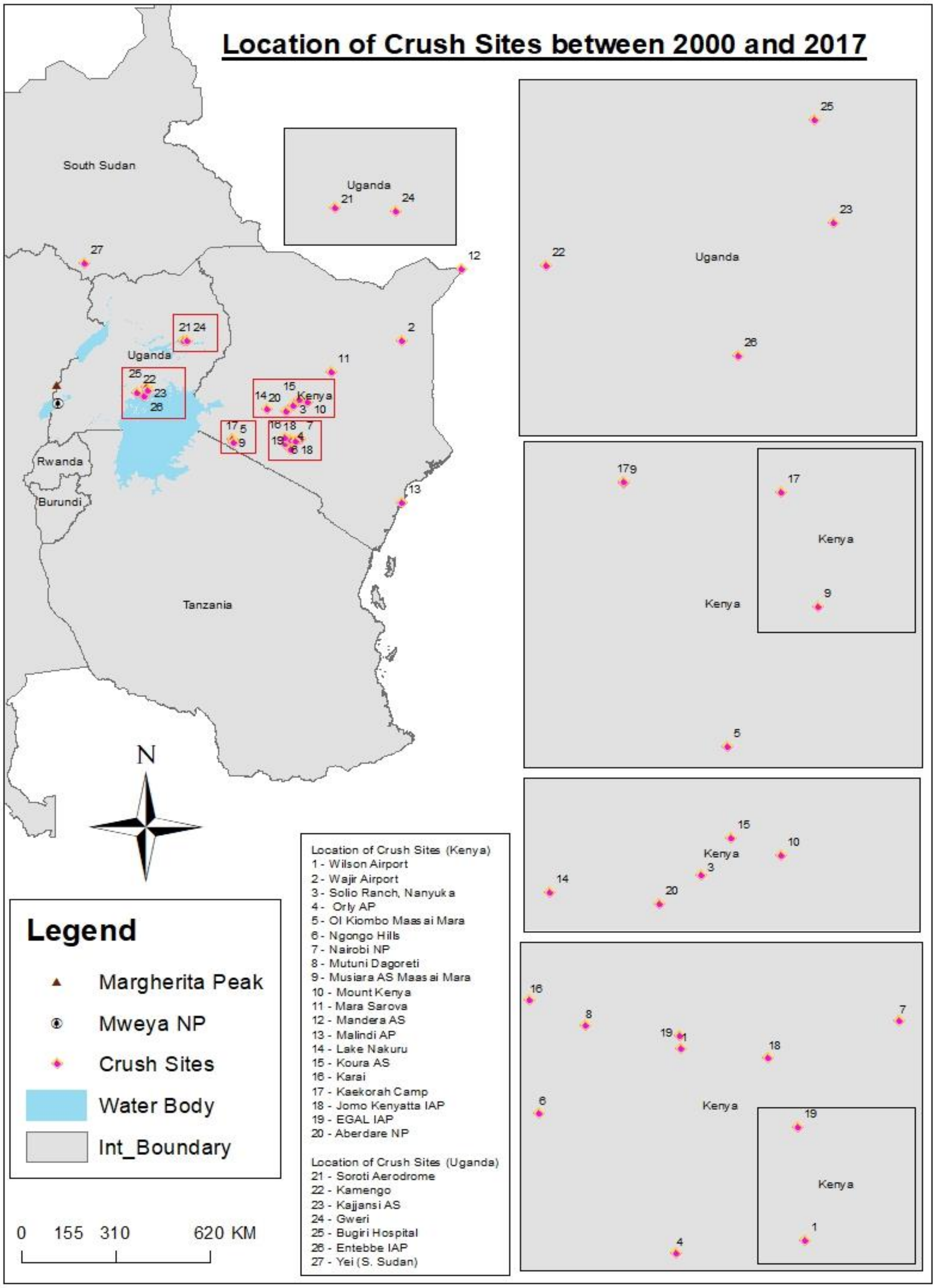


Figure 3.1: Map of crash sites in Kenya and Uganda

Source: Primary data July 2023

3.1.1 Geographical location

The study chose Kenya and Uganda since they are at the center of the Eastern Africa region and are the common access points to aircrafts en route or operating in the region. The two countries are also prone to environmental hazards due to the diversity of nature and land masses/ terrain.

3.1.1.1 Republic of Kenya

Kenya is geographically located in East Africa, straddling the equator, between latitudes 4º N and 4º S, and longitudes 34º E and 41º E; it is bordered to the east by Somalia and the Indian Ocean, north by Ethiopia and Sudan, on the west by Uganda and south by Tanzania. The country is 224,961 sq. miles in size (582,647 sq. km).

3.1.1.2 The Republic of Uganda

Uganda is geographically located in East Africa, between latitude 1º 30 ' and 4º N. Uganda is bordered to the east by Kenya, west by the Democratic Republic of Congo (former Zaire), north by Sudan, southwest by Rwanda and the south by Tanzania. Uganda covers a total area of about 243,411sq.km.

3.2 Research design

This study adopted a cross-sectional research design and used quantitative methods to collect data; perceptual information on people’s opinions was also collected by using the survey method. This design was selected because the data collected using this particular method gives an overview of responses representative of views for the whole population.

A case study design was employed for selection of regional airports to enable an in depth study of particular aerodrome settings (Appendix 6). Collection of data was quantitative in nature because the technique was helpful in mathematically establishing relationships and validity of the study variables.

3.3 Target population

The study population for a survey of current human factors in the region included licensed aviation stake holders operating in Kenya and Uganda. The target population was selected with inclusion of individuals possessing valid licenses as an operation requirement by ICAO and the respective country's Civil Aviation Authority (C.A.A).

3.3.1 Sampling Design

Sampling techniques included purposive sampling and random sampling to create a representative sample of licensed aviation stake holders (inclusion criteria) from the target population. The initial step involved a purposive selection of a total of 46 participants, operators, trainers and employers from the randomly selected 13 operating companies in Kenya and Uganda.

Hence a sample of 46 aviation employees and management personnel were selected through consultations made to the aero club management and approved by the Research Ethics Committee (REC). Participants were given questionnaires to answer closed and open -ended questions which were segmented for the capture of focused data. The questions that arose reflected many aspects of the human body and psychology in aviation-related human performance and limitations. The respondents included airport management, flight instructors, pilots, air traffic controllers (ATC), ground crew, maintenance, security and safety personnel. The criterion for selection was based on the rules of the International Civil Aviation Organization (ICAO) in Montreal, Canada (Samppell and Wiegmann, 2005).

3.4 Data Quality Control

The use of quality control was to ensure that the various instruments used in this particular study were the right ones for the selected purpose and that the data collected was reliable. A pre-test on 5 randomly selected target participants from the study population was used to validate the distress thermometer and the questionnaire (Mugenda and Mugenda, 2003).

3.4.1 Validity

Validity is the magnitude to which a survey tool measures what it is expected to measure (Amin, 2005). This study used the judgments of the survey study and some random members to examine the validity of the research instrument. This was done by determining the relationship of each item in the research instrument to the research objectives. Subjects were selected to rate specific items as either relevant or irrelevant to the target response. Validity was determined using the Content Validity Index (C.V.I). C.V.I equals the total number of items relevant to the assessment divided by the total number of items in the survey, as shown below.

$$CVI = \frac{\text{No. of items rated relevant}}{\text{Total no. of items}}$$

The instrument used for the study scored 0.80 for the CVI, which is exactly the recommended value by Waltz (2010).

3.4.2 Reliability

Reliability is always used as a measure of internal consistency also known as the reliability of a psychometric test score. In order to guarantee that the tools were reliable, a pre-test of each instrument was carried out. During pre-testing, a given number of individuals were selected from the study population with similarities compared with that from which the sample instrument research population was drawn (Borg and Gall, 2002). According to Sekaran (2010), a reliability of above 0.70 obtained on a substantial sample should be achieved in order for an instrument to be used. After performing the reliability test, the questionnaire scored 0.70 whereas the distress thermometer scored highly on the consistency or reliability of psychometric tests at 0.85which is recommended by Sekaran (2003).

3.5 Methods of data collection

Quantitative data is an aggregation technique which was used to collect data from a diverse group of participants. The research used document review guide and questionnaires tools (Appendix 5).

Structured written interviews were used to collect data from aviation instructors, flight instructors, pilots, air traffic controllers (ATC), ground crew, maintenance, security and safety personnel (Appendix 5). This was done to obtain information that was appropriate for gathering perception and understanding of stakeholders (Mubazi, 2008). In addition to written interviews, data from questionnaires was purposely used to triangulate the data.

3.5.1 Identification and classification of previous and current human factor risks in Eastern Africa Aviation Operations using HFACs analysis

3.5.1.1 Previous human factor risks

3.5.1.1.1 Inclusion and exclusion criteria

Accident and incident data was obtained from the National Aviation Accident Investigation website from Kenya and Uganda Ministry of Works and Transport in 2018. Reports in these files were verified against three factors; i) accident and incident reports between 2000 and 2017, ii) commercial air transport accidents which examined reports that had been included in 42 accidents and incidents reports summary (Table 4.1), and iii) final investigation reports while excluding preliminary investigation reports.

The strategy used in the current study employed three steps: First, it systematically analysed the Kenyan and Ugandan final accident investigation reports and identified what happened, where, how, and what human factor(s) contributed to it. The main ground operational areas in which those accidents or incidents occurred were defined and a template was developed for the identification, classification and quantification of data and information. Secondly, it identified the main human error preconditions for accidents and incidents using the Human Factors Analysis and Classification system (HFACs). Thirdly, a thematic analysis was offered to unveil main areas in which organizational, operational, procedural, or training improvements were necessary. In addition, reliability measures for the applied methods and conducted analyses were done. Intercoder reliability tests were applied to reduce subjectivity bias (Feng, 2014; Rasmussen, 1990).

The coding strategies (themes –codes) were agreed upon following reading, sorting, and re-reading the accident and incidents reports (Muecklich *et al*., 2023). The tests for homogeneity of the codes did not show significant differences between the coders at the 0.05 level. To further ensure reliability with a test-retest check, grading was repeated until level of acceptance was above 80%. In addition, reliability measures were done for the methods being used and then analysis of each single method was conducted. Reliability tests were carried out to reduce subjectivity bias. The data and information were coded into themes and categories relevant to HFACs four variables.

There are different approaches in analysing human error – most of which identify the contribution areas of aviation operations. HFACs analysis aided the structural organization and quantification of data and information with identifiable aviation operations.

Document review analysis which involved the selection of literature relevant and related to the study was done. Relevant information from accident investigation reports, journals and articles was also got. The documentary review literature chose information that was in line with the study objectives. Documents were scanned for necessary literature (secondary sources) to provide information that was relevant to the study (Das, 2009). Documentary evidence from 42 regional final accident and incident investigation reports was reviewed and subjected to HFACs analysis. Accident and incident data were obtained from the National Aviation Accident Investigation website and data from Kenya and Uganda engineering departments of 2018. Reports in these files were verified against three factors: The first was limited the to accident and incident reports between 2000 and 2017 while the second measure was only air transportation and the third were 42 final accident investigation reports (Table 4.1), (Yan and Histon, 2014). The level 1 of HFACs described the unsafe acts as they were committed by crew; they were then further separated into two groups which were violations and errors. The others were categorized as in the conceptual framework in section 2.4 (Lenné *et al.*, 2008).

3.5.1.2 Current human factors risks

A snap shot survey was adopted in the study to examine existing human factors at the respective selected airports in the region. The first step was a purposive selection of 46 participants, operators, trainers and employers from the randomly selected 13 operating companies in Kenya and Uganda. Participant selection was anonymous. Participants were selected by the aero club management and sample size approved by the Research Ethics Committee (REC). Human factors knowledge and skills of trained aviation personnel in the region was examined using questionnaires for the survey. Questionnaires varied somewhat in the characteristics of training acquired, as well as in the quality and usefulness of the scores generated after the course and during the survey (Rosenthal, 1976).

The questionnaire survey method was used to preserve the participant's privacy. It was also found to be quick and cheap. A self-administered structured questionnaire was formulated and distributed to the participants. The questionnaire tool (appendix 5) contained closed-ended and open-ended questions intended to collect quantitative data. The questionnaires were generated based on the research objectives and on the measurability of the dependent and independent variables. The closed and open ended questions were structured into sections for ease of capture of data. Each questionnaire had an informed consent form (appendix 4) that was administered to different members in each study group.

3.5.2 Examination of aeromedical risks in the region's aviation operations

Data was collected using the method described in section 3.5.1.2 and also a partly in this section. A snap shot survey was adopted in the study to examine existing aeromedical factors at airports and airstrips in the region. Human factors knowledge and skills of 46 trained aviation personnel on aeromedical factors commonly termed as human performance and limitation in aviation in the region were examined using both the closed and open ended questions in the questionnaire that was structured into sections for ease of capture of aeromedical risk data. Questionnaires (appendix 5) with an informed consent form (appendix 4) were administered to different members in the study group.

A purposive sample of 46 individuals from 13 operators, aero clubs and aviation schools were taken which included a sample of professional key informants (pilots, engineers, ATC, ground operators, safety and security operators). The key informants were subjected to written interviews to obtain further information through open ended questions. Questionnaires varied in the characteristics of trainings acquired, as well as in the quality and usefulness of the scores generated after the course and during the survey (Rosenthal, 1976). This tool contained research-focused themes aligned to the specific objectives so as to ask questions relevant to the study.

3.5.3 Designing possible interventions to address selected human factors risks

Interventions to address selected human factors risks was resolved by developing two types of tools to capture existing latent and active human factors risks in the selected countries in the region. Geographical Information Systems (GIS) were developed to collect data for latent human factors whereas the distress thermometer was used to capture the active human factors.

Geographical Information Systems (GIS) was used to obtain Global Positioning System (GPS) coordinates that located aerodromes and airports; the data was used to map them for ranking. Information from the GPS coordinates was converted into spatial data for mapping and profiling Ugandan and Kenyan airports and aerodromes. A total of 40 airports /aerodromes from both Uganda and Kenya were considered for this study. They were randomly selected basing on information from Civil Aviation Authority (CAA) in Kenya and Uganda as in appendix 6 and 7. Large and medium sized aerodromes were considered and their respective geographic coordinates were acquired for the both airports.

Microsoft Excel was then used to create Comma Separated Values (CSV) from which a shape file of point data was derived. ArcGIS (ArcMap 10.6.1) software was used to visualize, map and profile the airports. The other data layers used were acquired from Open Street Maps (OSM). The Digital Elevation Models (DEM) for both Uganda and Kenya were used to create the Elevation Profiles (EP) which were acquired at 30 Meters Resolution.

Overlay analysis was the form of Spatial analysis performed to come up with the two maps that depicted the location of the different airports, National Parks, forests, lakes and rivers, the elevation profiles and their influence on the airports (marked red, yellow or green).

Distress thermometer (Appendix 5) was used to collect information from 46 purposively sampled key informants that included pilots, engineers, ATC, ground operators, safety and security personnel.

3.6 Data analysis

3.6.1 Data analysis for identification and classification of previous and current human factors risks in Eastern Africa Aviation Operations using HFACs analysis

Investigation reports from 42 regional final accidents and incidents were reviewed for previous human factors and subjected to HFACs analysis. The data analysis was done in two parts; the first was analyzed using Pearson’s correlation in SigmaPlot program, where the relationships between “causal factors” of HFACs were examined in comparison with data from 17 countries worldwide (work done by Dönmez and Uslu 2018). The second part was analyzed using Mlogit model from STATA which predicted multinomial regression modeling to investigate associations between different factors.

3.6.2 Data analysis for examining aeromedical factors in the region's aviation operations

The data from 46 participant's questionnaires was entered in EXCEL and subjected to statistical package SigmaPlot 11.0 software to carry out analysis of binary variables which were done with correlation and regression, further analysis was done to investigate associations between different factors using Multiple Linear Model.

3.6.3 Data analysis for designing possible interventions to address selected human factors risks

Geographical Information Systems overlay analysis of spatial analysis was performed to create two maps that depicted the locations of the different airports, transportation networks, lakes and rivers, the elevation profiles and their influence on the airport human factors risks.

Selected participants were subjected to a distress thermometer: The coded data from the distress questionnaires (sample included in appendix 5) were entered in EXCEL and subjected to the analysis of binary variables with Pearson's correlation under the statistical package SigmaPlot, program. Further analysis was done to investigate associations between different factors using multinomial regression modeling.

3.7 Sources of information

Different accident and incident information was collected from relevant sources in the aviation industry and each study area was assessed for human factors related causes. Sources of information included the respective Government Ministries of Works and Transport libraries and personnel, NGOs, security forces, private and government operators, airport personnel and aviation students. Five individuals provided the relevant written interviews of aviation trainers and operations management.

3.8 Ethical considerations

Ethical considerations in this research related to the rules and ethics that guided the research. Specific ethical considerations in research included obtaining informed consent from all participants prior to participation so that they were not forced to participate and to maintain confidentiality while participating (Russell, 2005). All this information from the respondents was handled with confidentiality. The contacts, addresses, names and identity of all participants remained anonymous during and after the study.

3.8.1 Permission from authorities

Permission was obtained from the authorities before conducting the research. Ethical Approval Letter from Mengo Hospital Research Ethics Committee MH/2021-9 (Appendix 8) and clearance from Uganda National Council for Science and Technology (UNCST) NS251ES (Appendix 9) was obtained and copies were attached.

The informed consent forms were distributed to each and every participant and voluntary participation was encouraged. Participants were informed early enough about the intensions, purpose for collecting this information and how they would benefit. A written consent was filled by each participants, it was used to establish their willingness to participate voluntarily in this study.

3.8.2 Confidentiality

The study did maintain a high level of anonymity and confidentiality which was maintained all through the research process. Data including names and contacts of the participants were strictly confidential and private. The participants were identified by numbers to avoid accidental disclosure of their identities. The study endeavoured to balance professional integrity and respect for varying views and backgrounds of the participants.

CHAPTER FOUR: RESULTS

4.1 Identification and classification of previous and current human factors risks in Eastern Africa Aviation Operations using HFACs analysis

A comparison of the two country's accidents, incidents, fatalities and four (4) HFACs categories of air crew, ground crew, ATC and maintenance are shown below. Kenyan data is exclusive in all categories unlike the Ugandan data which has a lot of missing information due to lack of access to relevant information. The tables 4.1 and 4.2 below showed the selected accidents from document review.

4.1.1 Identification and classification of previous human factors risks in Eastern Africa Aviation Operations using HFACs analysis

4.1.1.1 Identification of previous human factors risks in Eastern Africa Aviation Operations

Table 4.1 Selected human factors accidents in Kenya (2000- 2017)

No	Registration Marks	Date	Location	Crew responsible	Accident/Incident	Fatalities
1	5Y LMB	1st August2009	Wilson Airport	Air crew/ Ground crew	Accident	1
2	5Y AUC	9th November 2006	Mandera AS	Air crew	Accident	0
3	5Y AZX	21st January 2005	Ngongo hills	Air crew	Accident	2
4	5Y BAT	9th April 2012	Wilson Airport	Air crew	Accident	0
5	5Y BCA	13th Jan 2014	Lake Nakuru	Air crew	Accident	0
6	5Y BGG	29th March 2010	Mutuni Dagoreti	Air crew	Accident	1
7	5Y BGP	5th March 2010	Solio Ranch, Nanyuka	Air crew	Accident	0
8	5Y BLA	28th March 2010	Wajir Airport	Air crew /ground crew	Incident	0
9	5Y BLK	12th July 2000	Mara Sarava Baloon lauching site	Ground crew/ maintenance	Accident	1
10	5Y BOP	8th September 2011	Musiara AS Masai Mara	Air crew/ Ground crew	Incident	0
11	5Y BPA	10th Feb 2006	Kaekorah camp Masai Mara	Air crew	Accident	2
12	5Y BXB	17th Feb 2015	Wilson AP	Air crew/ Ground crew	Accident	0
13	5Y BZK	26th April 2013	Nairobi National Park	Air crew	Incident	0
14	5Y BZQ	2nd April 2012	Orly AP	Air crew	Accident	0
15	5Y CCF	22nd March 2014	Pbadare NP	Air crew	Accident	0
16	5Y DPS	5th Feb 2006	Wilson AP	Air crew	Accident	2
17	5Y EKO	13th Sept 2010	EGAL International AP	maintenance	Incident	0
18	5Y HLI	17th Dec 2011	Kaptorkoki school	Air crew	Accident	0
19	5Y HVT	21st March 2014	Malindi AP	Air crew	Accident	0
20	5Y KNJ	29th Dec 2014	Karai	Ground crew	Incident	0
21	5Y LEO	31st Jan 2012	Wilson AP	Air crew/ Ground crew	Incident	0
22	5Y NAA	30th May 2013	Wilson AP	Air crew	Incident	0
23	5Y ONT	28th Nov 2012	Okiombo Masai Mara	Air crew	Accident	1
24	5Y SFE	10th June 2005	Lokichaggia AP	Air crew	Accident	0
25	5Y SIB	4th Jan 2015	Jomo Kenyata AP	Air crew/ATC	Incident	0
26	5Y TIM	3rd Sept 2012	Wilson AP	Air crew/ Ground crew	Accident	0
27	5Y TOR	19th Sept 2008	Mount Kenya	Air crew/ Ground crew	Accident	1
28	5Y VVQ	9th Nov 2009	Wilson AP	Air crew	Accident	1
29	5Y VVY	8th Jan 2013	Wilson AP	Air crew	Incident	0
30	F JSCZ	14th March 2016	Koura Air strip	Air crew	Accident	2
31	5Y BWL	9th Oct 2013	Nairobi NP	Air crew	Accident	2

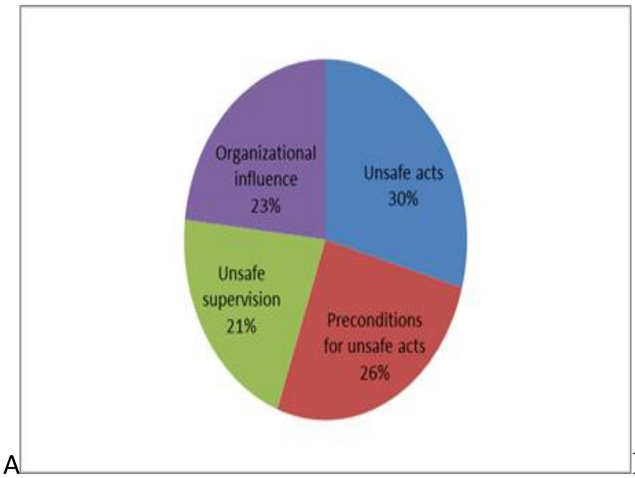
Table 4.1 above showed 31 selected human factors related accidents in Kenya obtained from 2000-2017 in the document review and included information on aircraft registration mark, day of accident or incident, location at which crash occurred, category of crew responsible, whether it was an accident or incident and number of people who died due to that particular occurrence.

Table 4.2 Selected human factors accidents in Uganda (2000- 2017)

No	Registration Mark	Date	Location	Crew responsibility	Accident/ Incident	Fatalities
1	5X VIC	23rd Oct 2015	Soroti aerodrome	Air crew	Accident	0
2	5X UAT	27th April 2013	Gweri	Air crew	Accident	0
3	5X SRI	21st May 2012	Soroti Aerodrome	Air crew	Accident	0
4	G IRL	28th June 2015	Entebbe Airport	Air crew	Accident	0
5	5X EIV	22nd June 2017	Yei S. Sudan	Air crew	Accident	0
6	ZS SSD	26th Sept 2007	Entebbe International AP	Air crew/ Ground crew	Accident	0
7	5X MAC	8th March 2010	Bugiri Hospital	Air crew	Accident	0
8	5X SRI	16th April	Soroti Aerodrome	Air crew	Accident	0
9	D EAGL	23rd Oct 2000	Entebbe I Airport	Air crew	Accident	0
10	5X LDR	23rd March 2017	Kajjansi Air strip	Air crew/ ground crew	Accident	1
11	5X WTA	31st Oct 2014	Kamengo Mpigi	Air crew	Accident	0

Table 4.2 above showed 11 selected human factors related accidents in Uganda obtained from 2000-2017 in the document review and it included information on the aircraft registration mark, day of accident or incident, location at which the crash occurred, category of crew responsible, whether it was an accident or incident and number of people who died due to that particular occurrence.

4.1.1.2 Classification of previous human factors risks in Eastern Africa Aviation Operations

A


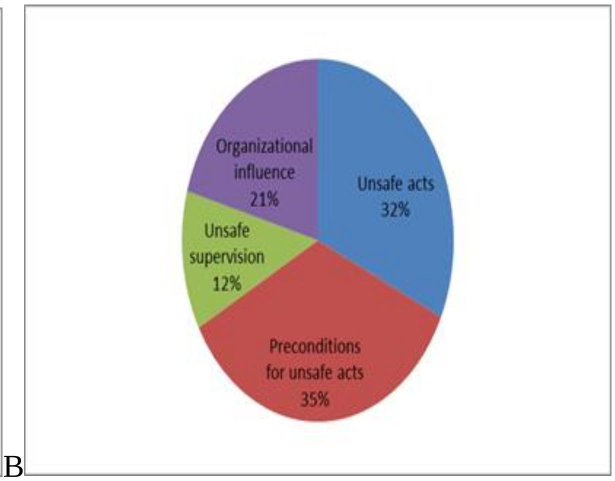
B


Figure 4.1 A and B Percentage of four main factors of HFACs in Kenya and Uganda respectively

Figures 4.1A and B above respectively showed that Kenya had unsafe acts at 30% while Uganda was at 32%, Preconditions for unsafe acts were at 26% for Kenya and 35% in Uganda.

Table 4.3 Summary of operational area related to the probable cause or major contributing factors for Kenya and Uganda

Stage of flight	Main findings	Number of A/I	Percentage %
Landing	Improper landing	11	28
	Weather	1	2.5
	Wildlife	1	2.5
	Belly landing	1	2.5
	Engine failure	1	2.5
	Hit an obstacle	1	2.5
Take off	Weather	1	2.5
	Improper planning	4	10
	Weight	2	5
	Wildlife	1	2.5
During flight	Glare	1	2.5
	Planning	2	5
	Stall	3	7.5
	Engine failure	4	10
	Disorientation	3	7.5
	Wildlife	1	2.5
Ground operations	Maintenance	2	5

Table 4.3 showed a summary of operational area which was related to the probable cause and or contributing factor. The stages of flight were grouped as landing, taking off, during flight and ground operations. Improper landing had the highest 28% (n=11), followed by improper planning at take off 10% (n=4) and engine failure during flight at10% (n=4).

4.1.1.2.1 Unsafe acts

Unsafe acts in the region are shown in Fig 4.1, 4.2 and 4.3. Table 4.4 had data that rated Kenya at 44%, Uganda at 50% were skill based errors, Kenya 45%, Uganda 25% were decision errors and Kenya 11%, Uganda 25% were perceptual errors.

Table 4.4 Errors in both Kenya and Uganda

	Kenya % (n)	**Uganda % (n)**
Decision errors		
Poorly executed procedures	37.5% (12)	0% (0)
Improper choices	37.5% (12)	50% (6)
Misinterpretation or misused information	25% (8)	0% (0)
Skill-based errors		
Break down of visual scan	0% (0)	0% (0)
Inadvertent activation/deactivation	25% (8)	0% (0)
Forgotten intentions	12.5% (4)	33.3%(4)
Omitted items on checklist	12.5% (4)	33.3%(4)
Manner or skill with which one flies	50% (10)	33.3%(4)
Perceptual errors		
Misjudging distance	50% (10)	50% (6)
Visual illusions	50% (10)	50% (6)
Vestibular illusion	0% (0)	0% (6)

Table 4.4 above showed, decision errors had the highest proportion at improper choices with Kenya at 37.5% and Uganda at 50%. When skill based errors were examined, the most common errors were the manner or skill with which one flies with 50% and 33.3% in Kenya and Uganda

respectively. While inadvertent activation/deactivation of controls was at 25% in Kenya and Uganda had none, on the other hand forgotten intensions and omitted items on the checklist had each 12.5% for Kenya and 33.3%. Uganda. Perceptual errors in Uganda and Kenya were at 50% for both misjudging distance and visual illusions. An examination of perceptual errors showed misjudged distance/altitude/airspeed factors and visual illusions were both at 50% in Kenya and Uganda.

4.1.1.2.2 Analysis of precondition for unsafe acts

Table 4.5 Preconditions for unsafe acts in both Kenya and Uganda

Preconditions for unsafe acts	Kenya % (n)	Uganda % (n)
Substandard conditions of operation		
Adverse mental states	11% (3)	14% (2)
Adverse physiological states	33% (10)	21% (3)
Physical/Mental limitations	51.9%(16)	35.7% (4)
Substandard practices of operation		
Crew resource management	3.7% (1)	14% (2)
Personal readiness	0% (0)	14% (2)

Table 4.5, above showed that preconditions for unsafe acts had physical/ mental limitations at 51.9% for Kenya and 35.7% for Uganda. This was followed by adverse physiological states with Kenya at 33% and Uganda at 21%. Adverse mental states followed with Kenya at 33% and Uganda 21%, least were Crew Resource Management (CRM) at 3.7% for Kenya, 14% for Uganda and personal readiness at 0% for Kenya and 14% for Uganda.

Table 4.6 Kenya data analysis for the various HFACs levels

	Correlation Value	P-Value
Level 4 x Level 4		
Resource management x Organizational Climate	0.381	0.0347
Level 4 x Level 2		
Resource Management x Adverse Mental state	0.381	0.0347
Level 3 x Level 2		
Supervisory violations x Physical and Mental states	0.411	0.0219
Failure to correct known problem x Crew Resource Management	0.558	0.00120
Level 3 x Level 1		
Failure to correct known problem x Forgotten intensions	0.558	0.00120
Failure to correct known problem x Misinterpretation/ misuse of information	0.358	0.0478
Inadequate Supervision x Misjudgment of distance	0.416	0.0200
Level 2 x Level 1		
Personal Readiness x Vestibular Illusion	1	0.0000002
Personal Readiness x Breakdown of Visual scan	1	0.0000002
Crew Resource Management x Forgotten Intensions x	1	0.0000002
Crew Resource Management x Misinterpretation/ misuse of information	0.695	0.00000455
Crew Resource Management x Poorly Executed Procedures	0.558	0.00120
Adverse Physiological state x Manner or skill of flying	0.390	0.0303
Level 1 x Level 1		
Routine Violation x Exceptional Violation	0.512	0.00343
Routine Violation x Omitted items in the check list	0.558	0.00120
Routine Violations x Inadvertent Activation	0.358	0.0478
Exceptional Violations x Improper choices	0.411	0.0220
Routine Violations x Improper Choices	0.358	0.0478
Breakdown of Visual scan x Exceptional Violations	1	0.0000002
Inadvertent Activation x Misjudgment of distance	0.695	0.00000455
Inadvertent Activation x Omitted items in the checklist	0.695	0.00000455
Misinterpretation/ misuse of information x Forgotten intentions	0.695	0.00000455
Improper Choices x Omitted items in the checklist	0.695	0.00000455
Poorly executed procedures x Forgotten intentions	0.466	0.00859
Poorly executed procedures x Misinterpretation/misuse of information	0.358	0.0478

The pair(s) of variables with positive correlation coefficients and P values below 0.050, tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables. Level 4; organizational influences, level 3; unsafe supervision, level 2; preconditions for unsafe acts and level 1; unsafe acts.

A comparison at different HFACs categories showed that Kenya had more human factors risks at unsafe acts at level 1 x level 1. This was followed by unsafe acts versus pre-conditions for unsafe acts at level 2 x level 1. The least number of risks were recorded at organizational influences at level 4 x level 4 (Table 4.6).

Table 4.7 Uganda data analysis for the various HFACs levels

	Correlation Value	p- value
Level 4 x Level 3		
Organizational Process x Inadequate Supervision	0.671	0.0201
Level 4 x Level 1		
Organizational Process x Manner or skill with which one flies	1	0.0000002
Organizational Climate x Routine violations	0.671	0.0201
Organizational Climate x Visual Illusions	0.671	0.0201
Level 3 x Level 2		
Supervisory Violations x Physical and Mental Limitations	0.671	0.0201
Level 3 x Level 1		
Failure to correct known problem x Vestibular Illusions	1	0.0000002
Failure to correct known problem x Breakdown of visual scan	1	0.0000002
Failure to correct known problem x Misinterpretation or misuse of information	1	0.0000002
Failure to correct known problem x Poorly executed procedures	1	0.0000002
Inadequate Supervision x Manner with which one flies	0.671	0.0209
Inadequate Supervision x Omitted items on checklist	0.671	0.0209
Level 2 x Level 1		
Personal Readiness x Omitted items on the checklist	0.671	0.0209
Personal Readiness x Inadvertent activation of switches	0.671	0.0209
Crew Resource Management x Misjudgment of Distance	0.671	0.0209
Crew Resource Management x Forgotten intentions	0.671	0.0209
Adverse Mental States x Misjudgment of Distance	0.671	0.0209
Adverse Mental States x Forgotten Intensions	0.671	0.0209
Level 1 x Level 1		
Visual Illusions x Routine Violations	1	0.0000002
Vestibular Illusions x Breakdown of Visual scan	1	0.0000002
Vestibular Illusions x Misinterpretation/ misuse of information	1	0.0000002
Vestibular Illusions x Poorly executed procedures	1	0.0000002
Misjudgment of Distance x Forgotten Intensions	1	0.0000002
Misjudgment of Distance x Improper Choices	0.671	0.0209
Improper Choices x Forgotten intensions	0.671	0.0209
Breakdown of Visual scan x Misinterpretation or misuse of information	1	0.0000002
Poorly Executed Procedures x Breakdown of Visual scan	1	0.0000002
Poorly Executed Procedures x Misinterpretation /misuse of information	1	0.0000002

The pair(s) of variables with positive correlation coefficients and P values below 0.050, tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables. Level 4; organizational influences, level 3; unsafe supervision, level 2; preconditions for unsafe acts and level 1; unsafe acts.

A comparison at different HFACs categories showed that Uganda had more human factors risks at unsafe acts level 1 x level 1 (Table 4.7). This was followed by unsafe acts versus pre-conditions for unsafe acts in Level1 x level 2 and unsafe acts versus unsafe supervision from level 1x level 3. The least number of risks were recorded at organizational influences with level 4 x level 4.

Table 4.8 Comparison of Kenya and Uganda data analysis for the various HFACs levels

	Correlation Value	p-Value	Correlation Value	p- Value
Level 3 x Level 2	**Kenya**	**Kenya**	**Uganda**	**Uganda**
Physical and Mental limitations x Supervisory violation	0.411	0.0219	0.671	0.0209
Level 3 x Level 1				
Misinterpretation/ misuse of information x Failure to correct known problem	0.368	0.0478	1	0.0000002
Level 2 x Level 1				
Forgotten Intensions x Crew Resource Management	1	0.0000002	0.671	0.0209
Level 1 x Level 1				
Breakdown of Visual scan x Vestibular Illusions	1	0.0000002	1	0.0000002
Poorly Executed procedures x Misinterpretation/misuse of information	0.358	0.0478	1	0.0000002

The pair(s) of variables with positive correlation coefficients and P values below 0.050, tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables. Level 4; organizational influences, level 3; unsafe supervision, level 2; preconditions for unsafe acts and Level 1; unsafe acts.

A comparison between Kenya and Uganda's HFACs correlation analysis showed that both countries shared two categories of unsafe acts of level 1x level 1, breakdown of visual scan x vestibular illusions (1; $p<0.001$) for both Kenya and Uganda, poorly executed procedures x misinterpretation/misuse of information Kenya (0.358; $p<0.001$), Uganda (1; $p<0.001$). The rest of the shared categories were unsafe acts versus pre-conditions for unsafe acts at level 2 x level 1, unsafe supervision versus pre-conditions for unsafe acts level 3 x level 1and unsafe supervision versus pre-conditions for unsafe acts at level 3 x level 2 (Table 4.8)

Table 4.9 Comparison of Kenya data analysis for the various HFACs with 17 countries worldwide

Level 3 x Level 2	Kenya Correlation Value	Kenya p- value	Worldwide Correlation Value	Worldwide p- value
Crew Resource Management x Failure to correct a known problem	0.558	0.0012	0.506	0.000

The pair(s) of variables with positive correlation coefficients and P values below 0.050 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables. Level 4; organizational influences, level 3; unsafe supervision, level 2; preconditions for unsafe acts and level 1; unsafe acts.

Table 4.10 Comparison of Uganda data analysis for the various HFACs with 17 countries worldwide

Level 4 x Level 3	Uganda Correlation Value	Uganda p- value	Worldwide Correlation Value	Worldwide p- value
Organizational Process x Inadequate Supervision	0.671	0.0209	0.654	0.000
Adverse Mental States x Skill Based Errors	0.671	0.0209	0.307	0.009

The pair(s) of variables with positive correlation coefficients and P values below 0.050 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables. Level 4; organizational influences, level 3; unsafe supervision, level 2; preconditions for unsafe acts and level 1; unsafe acts.

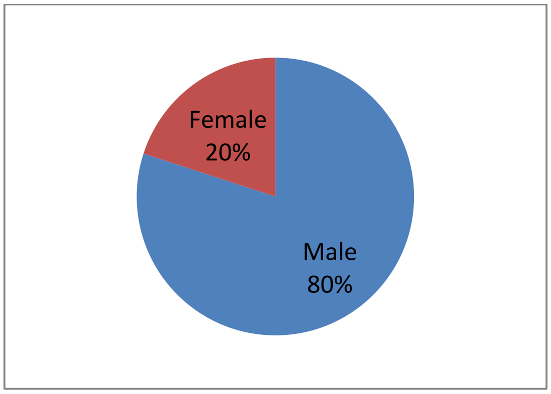
The above comparison in table 4.9 showed that Kenya shared HFACs risks at the level of pre-conditions for unsafe acts versus unsafe supervision level 2 x level 3 with 17 countries worldwide. While in table 4.10 Uganda shared HFACs risks at unsafe supervision versus organizational influences with 17 countries worldwide (Dönmez and Uslu 2018).

Table 4.11 MLOGIT model analysis of results for previous human factors risks in Kenya

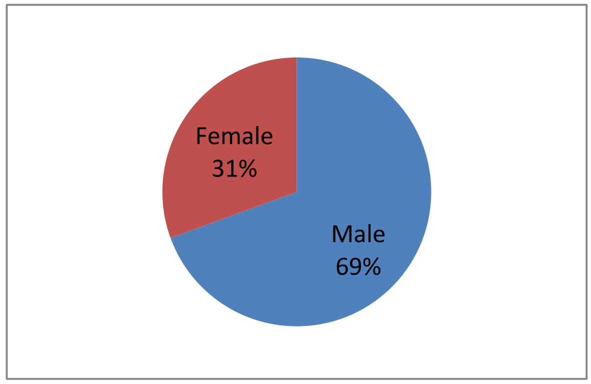
	Frequency n (%)	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Physical and Mental limitations	14 (45)	0.087 (0.009 - 0.818)	0.033	0.594 (0.003 - 99.272)	0.842
Supervisory violation	13(42)	0.104 (0.011 - 0.980)	0.048	$6.53X10^{-31}$ ($1.32X10^{-34}$ - $3.23X10^{-27}$)	<0.001
Improper choices	2(6)	2.625 (0.146 - 47.182)	0.513	$3.84X10^{-8}$	
Misinterpretation/ misuse of information	2(6)	2.625 (0.146 - 47.182)	0.513	$3.62X10^{8}$	
Manner or flying skill	4(13)	0.792 (0.711 - 8.807)	0.849	$1.85X10^{30}$ ($5.01X10^{27}$ - $6.85X10^{32}$)	<0.001
Routine violations	3(10)	6.000 (0.469 - 76.713)	0.168	$8.11X10^{15}$	
Exceptional violation	9(29)	1.333 (0.250 - 7.109)	0.736	$7.45X10^{29}$ ($4.40X10^{27}$ - $1.26X10^{32}$)	<0.001
Adverse Physiological state	9(29)	0.219 (0.230 - 2.082)	0.186	0.124 (0.003 - 4.948)	0.267
Inadequate supervision	5(16)	5.000 (0.671 - 37.256)	0.116	$3.36X10^{30}$	
Failure to correct known problem	3(10)	1.250 (0.100 - 15.796)	0.863	$7.63X10^{7}$	
Resource Management	10(32)	0.500(0.0830 - 3.011)	0.449	1.269(0.225 - 71.493)	0.908
Organizational Process	11(35)	1.714 (0.349 - 8.421)	0.507	$124X10^{31}$ ($5.39X10^{28}$ - $2.87X10^{33}$)	<0.001

Mlogit model using STATA showed that 12 out of 24 factors were significant with a validated of 70%. Out of the12 factors shown in table 4.11, it was only five which had significant Odds Ratios (OR) with relatively high impact. These included supervisory violations with ($6.53X10^{-31}$; p<0.001), exceptional violation ($7.45X10^{29}$; p<0.001), manner or flying skill ($85X10^{30}$; p<0.001) and organizational process ($124X10^{31}$. p<0.001), while the 30% were due to the intervening variables which were knowledge and skill background, personality and psychology. Among the significant factors, organizational processes showed the highest OR followed by the manner or flying skill, exceptional violations and supervisory violation showed the least OR (Impact).

4.1.2 Current human factors risks in the region's aviation operations



A



B

Figure 4.2 A and B gender comparison of participants from Kenya and Uganda

The above figures 4.2 showed that female participants were less than the males for both Kenya and Uganda.

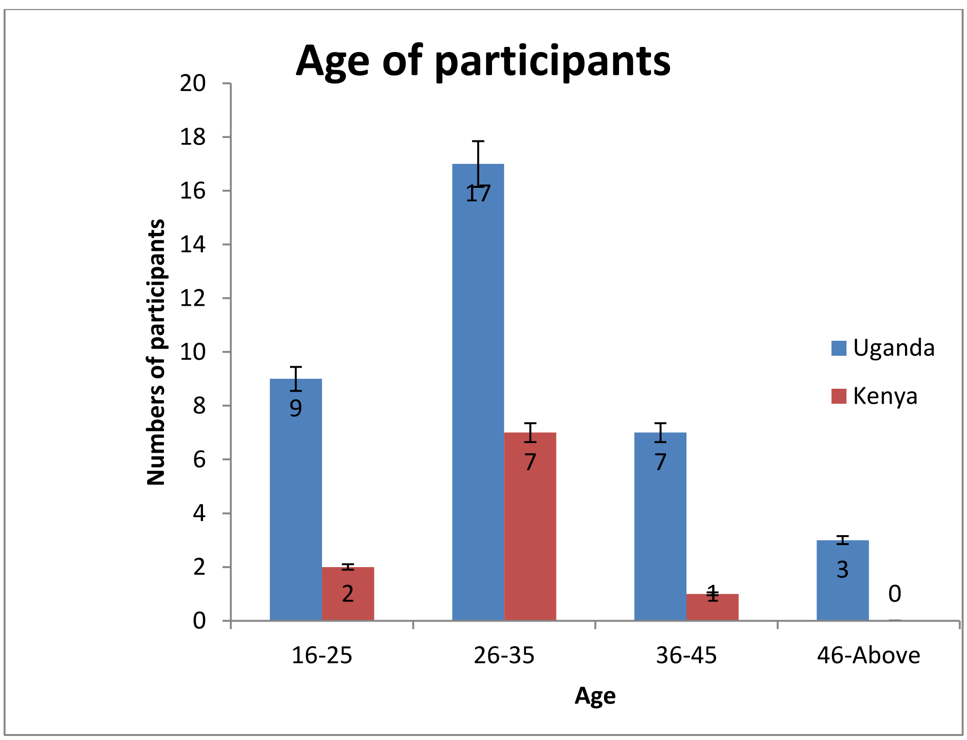


Figure 4.3 Age group comparisons of participants from Kenya and Uganda

Figure 4.3 above showed that Uganda had 47% of its participants between the ages of 26-35 while Kenya had 70% of its participants also between 26-35 years of age. It is worth noting that Uganda had 8% of its participants above the age of 46.

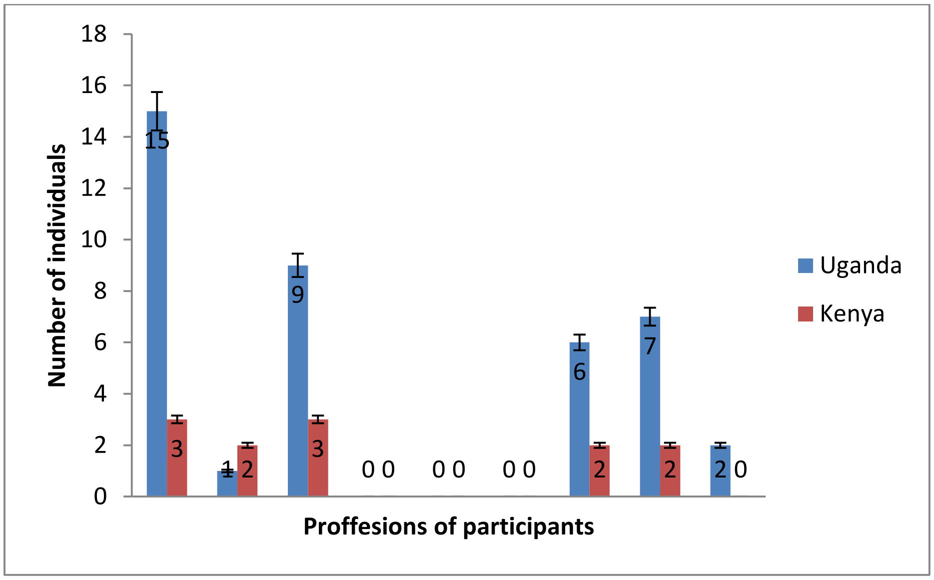


Figure 4.4 Different professions of participants from Kenya and Uganda

The above figure 4.4 showed that the total numbers of participants from both Kenya and Uganda were 39% engineers, 26% pilots, 25% members of management, 22% flight operators, 6% ATC and 4% safety members. The largest numbers of participants from Kenya were pilots and engineers followed by ATC, flight operators and management. Uganda had the participants were engineers, followed by pilots, management and lastly flight operators. The rationale for choosing 46 participants, 36 from Uganda and 10 from Kenya was due to the classification of participants by nationality. Most of the crews identified in the Kenyan aviation operations were Ugandans. A consensus was reached by the decision made through the aero club management and the research ethics committee to classify the participants by their counties of origin, unless they were expatriates. It was also noted that several of the participant could be captured more than once in both countries, a consensus was reached by the same authorities to consider each individual only once no matter their level of mobility.

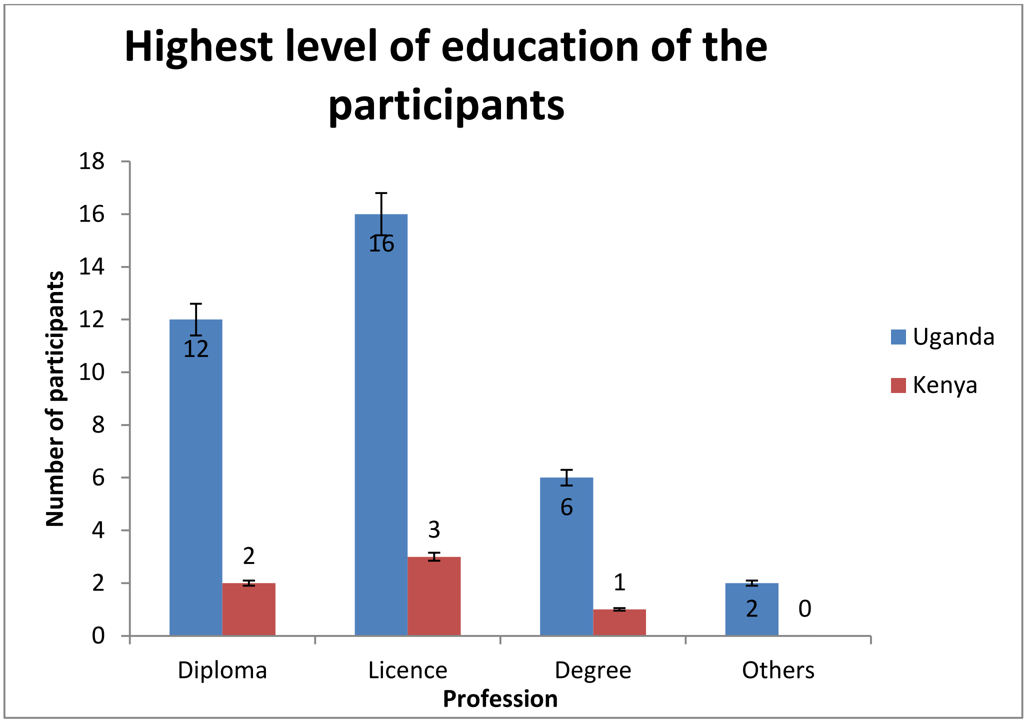


Figure 4.5 Level of education of participants from Kenya and Uganda

The highest level of education for participants from Kenya and Uganda was mainly license level with Kenya and Uganda at 30% and 44% respectively. This was followed by diploma holders with Kenya and Uganda at 20% and 19% respectively, then degree holders with Kenya and Uganda at 10% and 16% and lastly with other qualifications at Kenya 0% and Uganda 5%. However, the level of education in Uganda was higher than that of Kenya (Fig. 4.5).

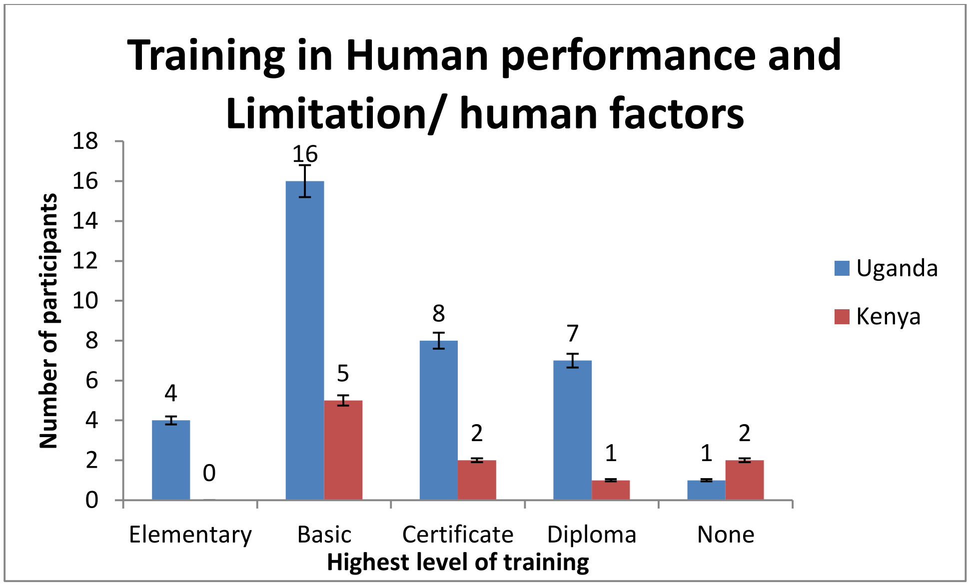


Figure 4.6 Level of training in Human performance and limitations of participants from Kenya and Uganda

The highest level of training in human performance and limitations for participants was mainly at basic with Kenya 30% and Uganda 44%. This was followed by certificate holders Kenya 20% and Uganda 22%, diploma holders with Kenya 10% and Uganda 19%, elementary training with Kenya 0% and Uganda 11% and lastly those with no qualifications Kenya 10% and Uganda 3%. However, Uganda had the highest level of training in human performance and limitations compared to Kenya in all categories.

Table 4.12 Combination of data analysis for skills required in the job for Kenya and Uganda participants

	Correlation Value	p- value
Operations Monitoring x Public Safety	0.562	0.00003
Operations Monitoring x Design	0.317	0.025
Quality Control x Public safety	0.312	0.03
Quality Control x Trouble shooting	0.550	0.0000596
Trouble shooting x Public safety	0.394	0.00582
Trouble shooting x Telecommunication	0.609	0.000000
Public safety x Design	0.454	0.00127
Public safety x Telecommunication	0.313	0.0344

Spearman Rank Order Correlation Tuesday, February 18, 2020, 12:15:01 PM

Table 4.12 above showed significant correlations (P < 0.05), between different skills required for the job among participants from both countries.

Data Analysis: Multiple Linear model

N = 46

R = 0.704 Rsqr = 0.496 Adj Rsqr = 0.352

R squared of 0.496 showed a moderate chance that the variations between quality control analysis and trouble shooting skills could be used to predict different skills required for the job.

NB: Only one observations was missing

Table 4.13 Multiple Linear Model data analysis for skills required for the job versus various independent variables

Variable	P value
Operations monitoring	0.254
Quality Control analysis	0.023
Trouble shooting	0.002
Public safety and security	0.703
Design	0.812
Telecommunication	0.364
Internship exposure	0.234
Subject to aeromedical assessment	0.951
Problem solving	0.175
Gender	0.406

Friday, June 16, 2023, 11:51:25 AM

Quality control analysis **(** Rsqr = 0.496; P= 0.023) and Troubleshooting abilities **(** Rsqr = 0.496; P= 0.02), appeared to account for the ability to predict skills required for the job (P < 0.05). The variations between different skills showed moderate relationship to the variables being compared with R squared equal to 0.496.

Further multiple linear model

R = 0.587   Rsqr = 0.345 Adj Rsqr = 0.314

R squared of 0.345 showed a moderate chance that the variations between quality control analysis and trouble shooting skills were be used predict different skills required for the job.

Table 4.14 Multiple Linear Model data analysis for skills required for the job versus various two independent variables of quality control analysis and troubleshooting

Variable	P value
Quality control analysis	0.001
Trouble shooting	<0.001

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The dependent variable *skills required for the job* were used to predict from a linear combination of the independent variables of q*uality control analysis* and *troubleshooting* (P < 0.05).

4.2 Aeromedical risks in the region's aviation operations

The information in table 4.15 below was obtained using a questionnaire for survey of 46 participants. The particular questions that the participants had to answer are in appendix 5, section c.

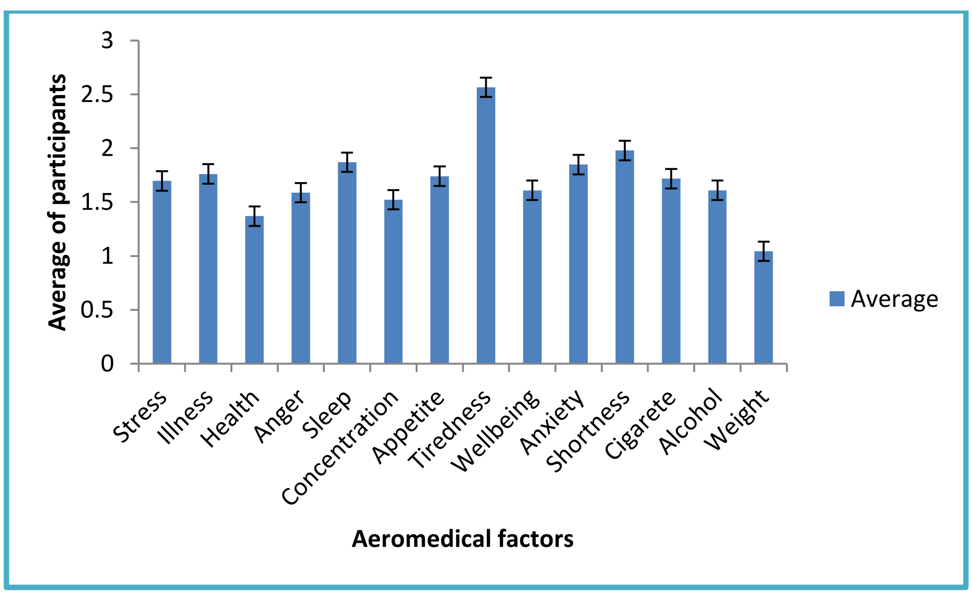
Table 4.15 Combination of aeromedical factors data analysis for Kenya and Uganda

The information in table 4.15 below was generated from information after quantifying responses of the 46 aviation personale using questionnaires in appendix 5 Section C.

	Correlation Value	p- value
Problem solving x Stress	0.537	0.0000946
Problem solving x General Health	0.276	0.0574
Problem solving x Concentration	0.517	0.000264
Copping with stress x General Health	0.376	0.00086
Copping with stress x Sleep disorders	0.320	0.0306
Copping with stress x Concentration	0.509	0.0003
Concerns about illness x General Health	0.414	0.00298
General Health x Sleep disorders	0.513	0.0003
General Health x Concentration	0.589	0.0000184
General Health x Appetite for food	0.447	0.00195
Sleep disorders x Concentration	0.459	0.00143
Sleep disorders x Appetite for food	0.318	0.031
Concentration x Appetite for food	0.435	0.00270
Appetite for food x well being	0.467	0.00115
Anxiety x weight gain	0.487	0.000659

Spearman Rank Order Correlation Tuesday, February 18, 2020, 12:43:34 PM

The table above closely analysed the significant correlations ($P < 0.05$) between different aeromedical factors among the participants from both countries of Kenya and Uganda. It showed a binary comparison of significant aeromedical factors in relation to each other.



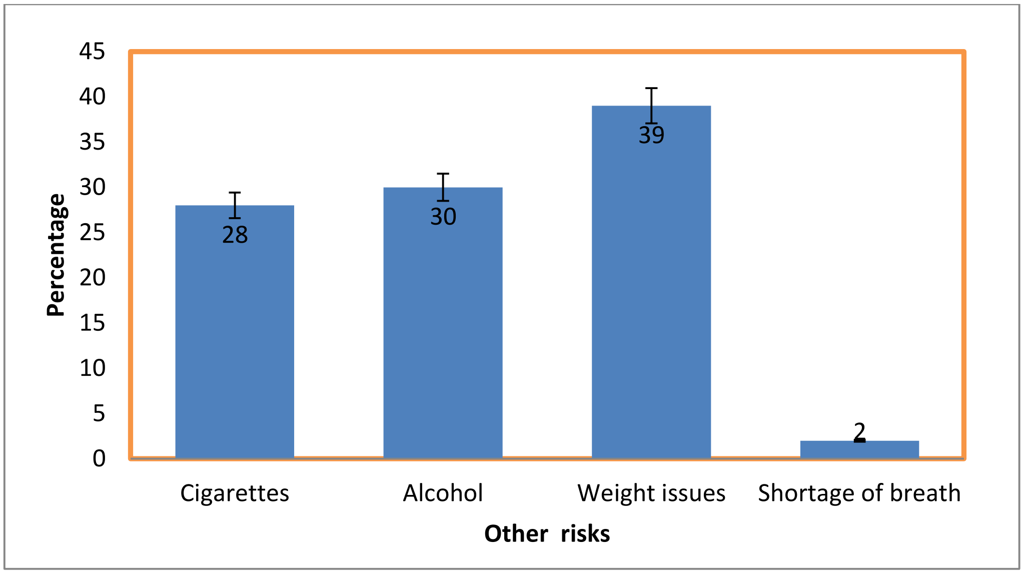


Figure 4.7 Summary of other significant aeromedical factors for participants from Kenya and Uganda

The figure 4.7 above showed a summary of other aeromedical factors that were captured by the study finding in addition to other factors in Table 4.15.

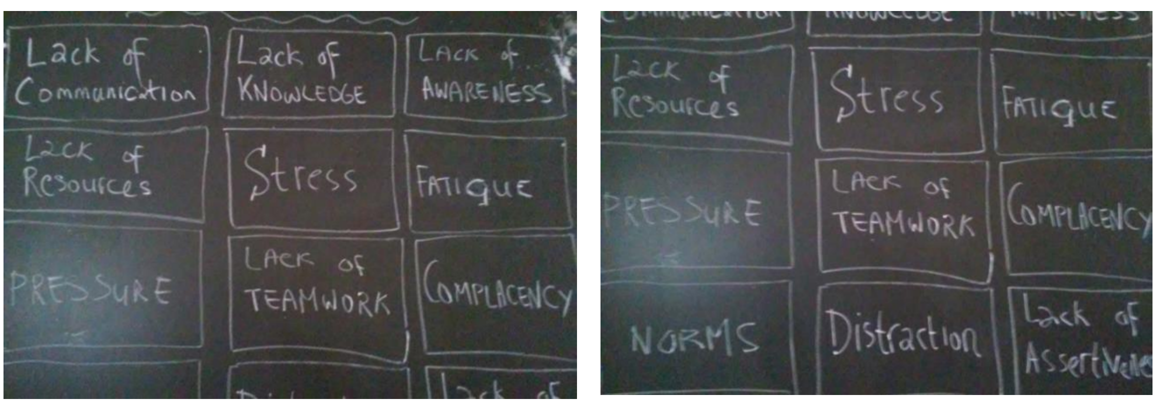


Figure 4.8 Photographic summary of the dirty dozen aeromedical factors from participants in an aviation training organization listed during a learning session

Figure 4.8 above showed the Human Factors Dirty Dozen (HF DD) which participants in an aviation training organization listed during a learning session was a model used before HFACs to identify preconditions for human error in aviation incidents and accidents.

Table 4.16 Data analysis for aeromedical factors

N = 46
R = 0.939 Rsqr = 0.881 Adj Rsqr = 0.827

R squared of 0.881 showed a strong chance that the different aeromedical factors sleep, high anxiety levels, cigarette smoking and shortness of breath were used to predict problem solving.

Variable	**P- Value**
Coping with work	0.198
Concerns	0.510
General Health	0.077
Anger management	0.573
Sleep	0.005
Concentration	0.564
Appetite	0.378
Tiredness	0.494
Well being	0.256
High levels of anxiety	0.021
Shortness of breath	0.011
Cigarette smoker	<0.001
Alcohol user	0.759
Weight gain issues	0.578

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The dependent variable problem solving were predicted from a linear combination of the independent variables, they were statistically significant at sleep (P=0.005), high levels of anxiety (P=0.021), shortness of breath (P=0.011) and cigarette smoking (P<0.001).

4.3 Designing possible interventions to address selected human factors risks

4.3.1 Aerodrome ranking in terms of human factors risks

The rankings below for figures 4.9 and 4.10 showed that different airports/ aerodromes rated by participants in terms of human factors risks were, red which was ranked as the one with the worst human factors risks, followed by yellow with the moderate and green with the least human factors risks.

Red: Wilson, Kasese, Kisoro, Kidepo, Moyo, Kaabong, Masindi, Mweya, Kakuma, Marsabit.

Yellow: Mbarara, Jomo Kenyatta, Kihihi, Kotido, Kalongo, Lira, Arua, Moroto, Kabong, Malindi, Magadi, Amudati, Lodwar, Mombasa.

Green: Entebbe, Kajjansi, Arua, Soroti, Gulu.

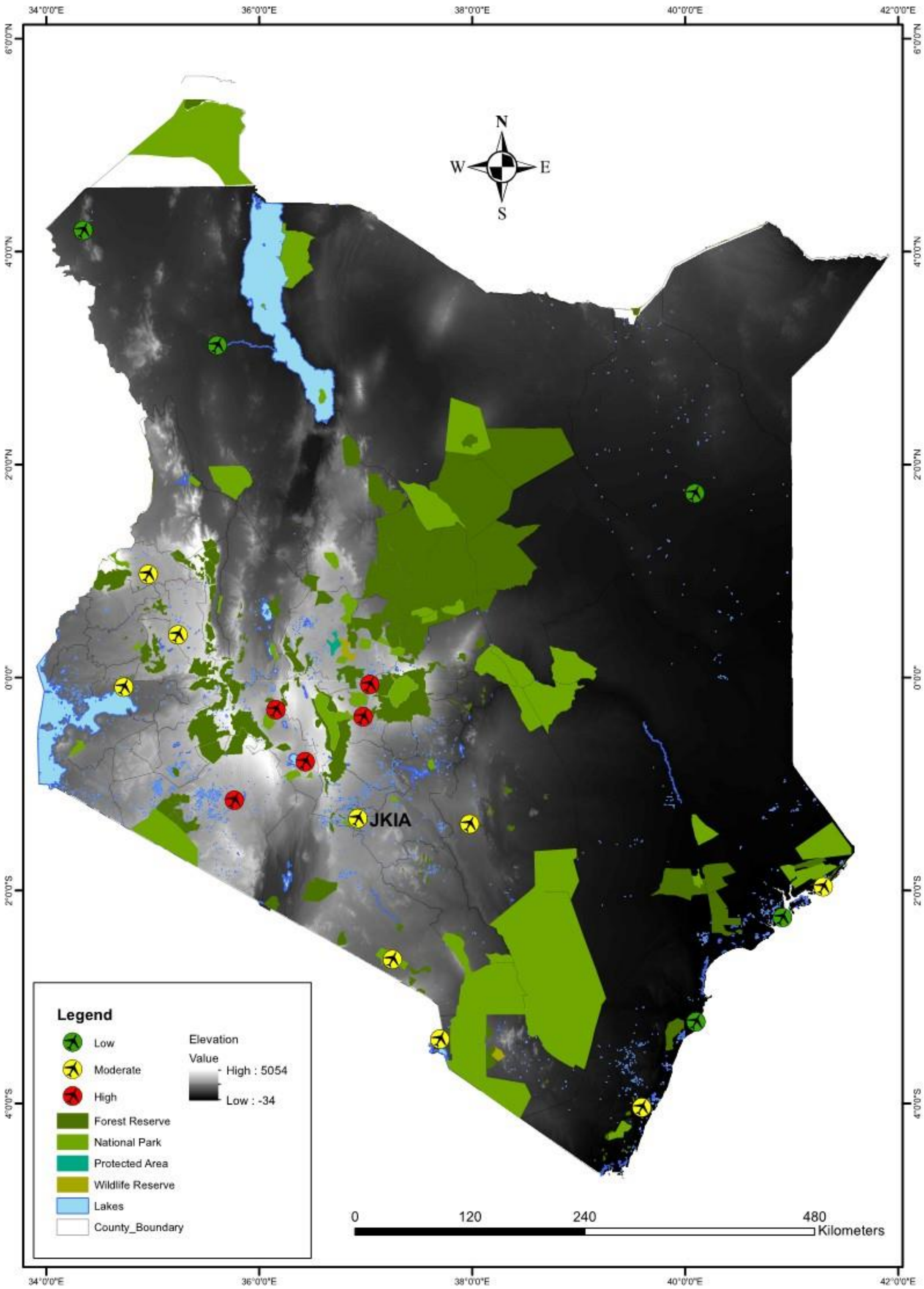

Figure 4.9 Map of airports and aerodromes with high human factors risks in Kenya (Source: Primary data Jan 2023)

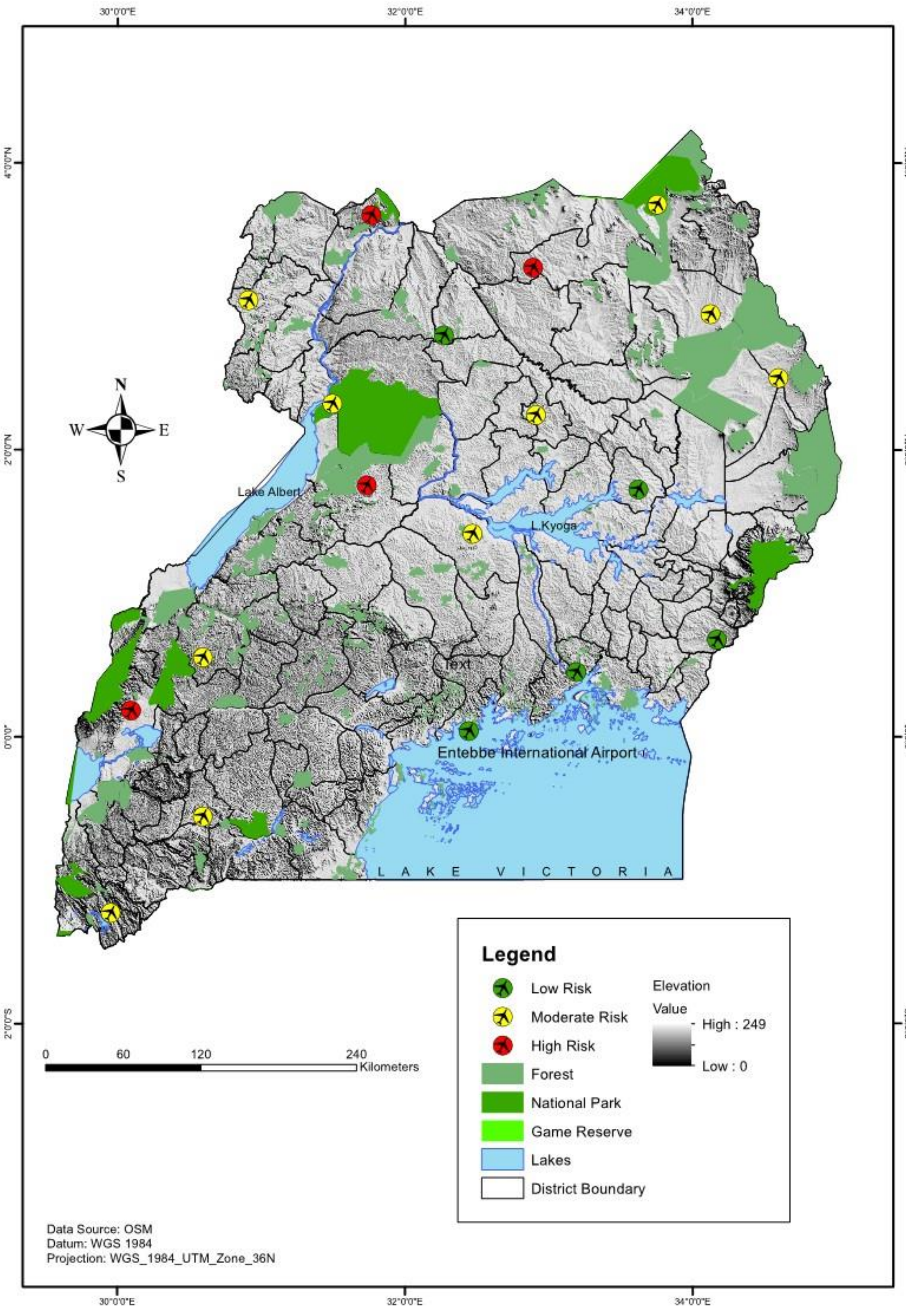

Figure 4.10 Map of airports and aerodromes with high human factors risks in Uganda (Source: Primary data Jan 2023)

4.3.2 Different categories of problems faced by participants from Kenya and Uganda using the distress thermometer

This information in the next sections was gathered from quantification of information gathered using the distress thermometer in appendix 5.

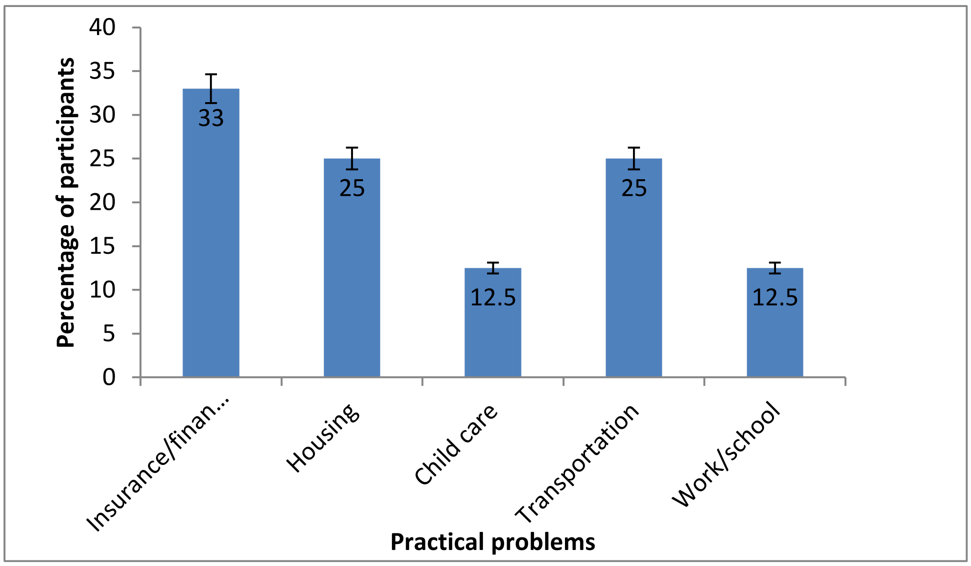

Figure 4.11 Practical problems faced by participants from Kenya and Uganda

The above figure 4.11 showed different practical problems caused by distress to participants from the two countries. Insurance/ finance 33 % ranked highest followed by housing 25%, transportation 25% and lastly each childcare and work/school 12.5%.

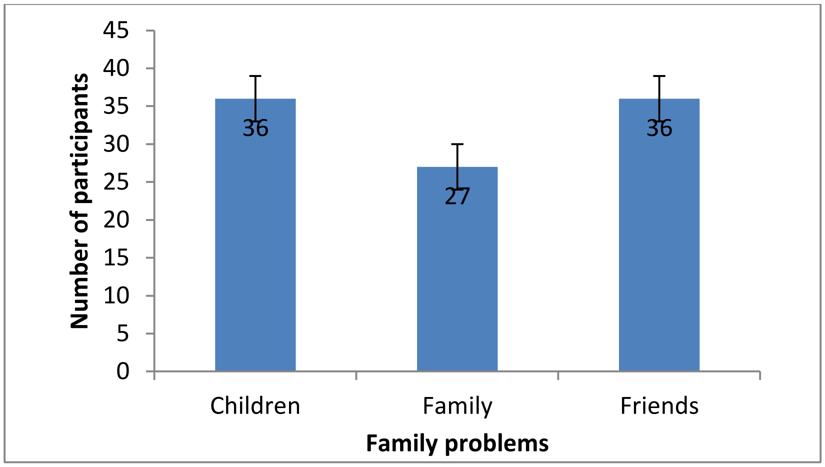

Figure 4.12 Family issues faced by participants from Kenya and Uganda

The above figure 4.12 showed different family problems which caused distress to participants from the two countries. Concerns about friends and children ranked highest both had 36% and a spouse ranked lowest 27%.

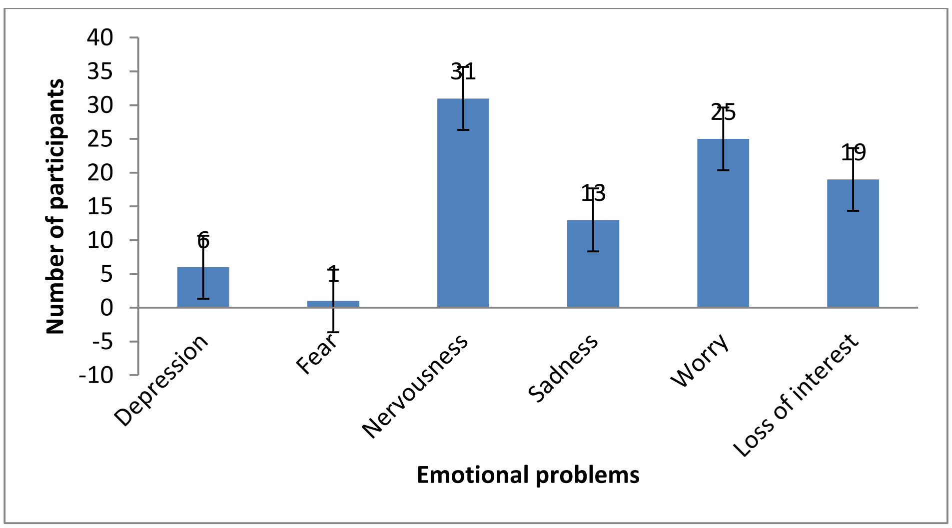

Figure 4.13 Emotional problems faced by participants from Kenya and Uganda

The above figure 4.13 showed different emotional problems which caused distress to 46 participants from the two countries. Concerns raised were mainly about nervousness which ranked highest with 67% participants, followed by worry with 54% and fear which was least at 2%.

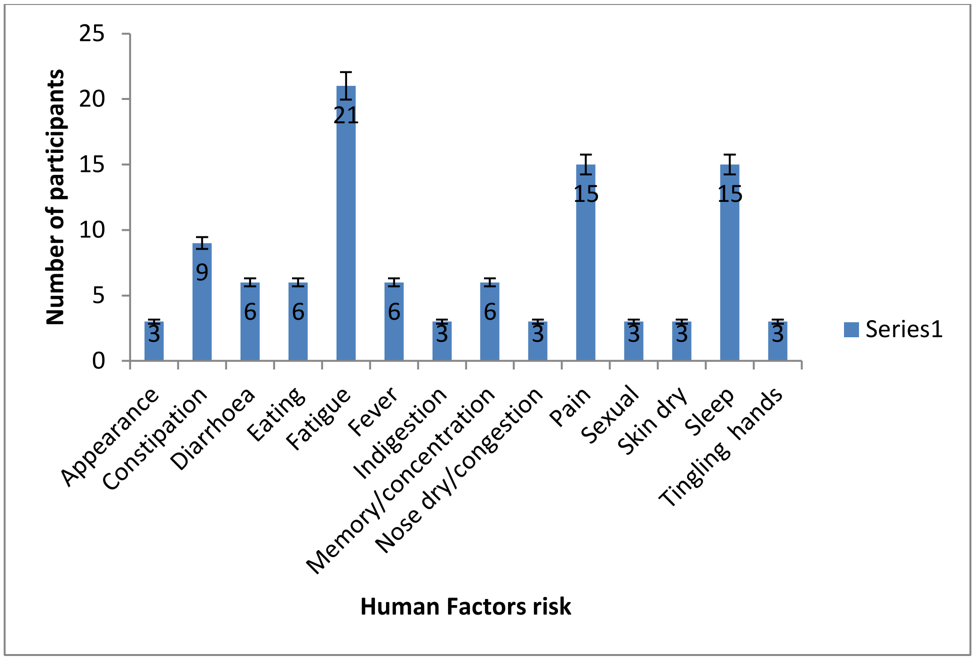

Figure 4.14 Physical problems faced by participants from Kenya and Uganda.

The above figure 4.14 showed different physical problems caused by distress to participants from the two countries. The major problems arising were mainly fatigue with 46% participants, pain 32% and sleep related problems 32%. Other problems worth noting were constipation 20%, diarrhoea 13%, eating disorders 13%, fever 13% and memory/ concentration 13%.

CHAPTER FIVE: DISCUSSION

5.1 Identification and classification of previous and current human factors risks in Eastern Africa aviation operations using HFACs analysis

5.1.1 Identification and classification of previous human factors risks using HFACs analysis

5.1.1.1 Unsafe acts

In general, Kenya had overall unsafe acts at 30% while Uganda had 32%. This is because in Eastern Africa region these unsafe acts are highly noted at landing phase with improper landing in 28% of the accidents and improper planning at takeoff in 10% of accidents (Table 4.3). This was exhibited by two unsafe acts; the first one was the manner or flying skill of the pilots which had an increased risk that an accident would occur as compared to an incident at Odds Ratio (OR) $85X10^{30}$; $P<0.001$. This implied a more likely chance that an accident would occur instead of an incident when the pilots' flying is unsatisfactory. The second unsafe act was the exceptional violations which had an increased risk of an accident as compared to an incident at Odds Ratio (OR) $7.45X10^{29}$;$P<0.001$. This implied $7.45X10^{29}$ more likely chance that an accident would occur instead of an incident when exceptional violation of certain procedures occurred. Apart from the analysis above, there were other factors likely to increase the chances of accident as compared to an incident and these included improper choices, misinterpretation/ misuse of information, routine violations, adverse physiological state, inadequate supervision, failure to correct known problem and resource management. However, these had no statistical significant influence in the MLogit model. Whenever the crew failed to recognize and implement rules, it led to an increase in airport accidents both at landing and takeoff phase as reflected in Table 4.3. As noted in the same table, the highest percentage of accidents at landing were due to improper landing which could be attributed to lack of skill as well as awareness of the airport traffic pattern.

Figure 4.4 showed a high level of unsafe acts in both countries. These findings also depicted a level of poor performance of tasks/teamwork, forgotten intentions and vestibular illusions in both countries. This was due to a lack of situational awareness by the respective crew. Reason (1990)'s findings were in addition human factors due to latent conditions which are inevitable flows within the system and will eventually result in error e.g. poor design, procedures or management (Reason, 1990). This could be as a result of certain active failures most frequently due to unsafe acts committed by the crew who are involved with the safety systems. This could also be a result of direct violation of systems or due to poor planning and inadequate training. Embarking on any task without a proper plan of how best to execute it will most likely end up in a blunder (Martins *et al.,* 2014).

Other authors do agree with the above information, for example Munene (2016) classified 55 out of 72 African civil accident investigation reports (Nigeria had 14, Kenya had 11 and South Africa had 13) between 2000- 2014 regardless of the country of origin and/or registration but operating in Africa. Findings showed a dominance of the pilot's unsafe acts which were observed at 56.4% (which is representative of 31 accidents) which indicates that unsafe acts are high in Africa and Eastern Africa. This is also in line with Shappell and Wiegmann (1997) who observed that, of all African aviation accidents, 76% were associated with human error.

The common occurrences of unsafe acts in other regions worldwide are also emphasized by Dönmez and Uslu (2018) who agreed that the inappropriate manner/ skill one uses to fly is evident in the inadvertent use of flight controls as 52% of all accidents they studied were attributed to unsafe acts - Level 1 in the accidents. This factor was followed by improper procedure, misjudged distance/altitude/airspeed, and spatial disorientation at 46%, 44% and 38%, respectively (Dönmez and Uslu 2018).

Accident records from different institutes (NTSB- National Transportation Safety Bureau, USA and CENIPA -Central Research and Prevention of Accidents, Brazil) showed that there are some difficulties in maintenance, operation and aircraft training, that do affect flight safety and creates gaps where by information is not being efficiently passed on to the different crew members (Rebelo and Soares, 2013). The professionals may not be aware of these circumstances relevant to the occurrence of incidents and accidents (Martins *et al.*, 2014).

Within the HFACS categorization, errors were expanded into basic types which include; skill-based, decision and perceptual errors as in Table 4.4.

5.1.1.1.1 Decision errors

In this study, decision errors for Kenya and Uganda were 45% and 25%, respectively. The decision errors had the highest proportion with improper choices higher in Uganda than in Kenya, misjudged distance was next for both countries and visual illusions were the lowest. These are due to improper decision making and/or are occasionally procedures that are either inappropriate or misapplied for the particular circumstances often culminating into an accident. These are rule-based mistakes as referred to by Rasmussen (1982) occurring during complex tasks of the sorts. Aviation is highly structured, and consequently, much of crew work by following certain procedural in the process of decision-making. These procedures are to be performed at virtually all phases of the flight (Shappell and Wiegmann, 2000; 2001).

5.1.1.1.2 Skill based errors

When skill based errors were examined, findings showed that Uganda had higher skilled based errors than Kenya, the commonest of all errors was the manner with which one flies with Kenya higher than Uganda. Other factors with high rates were inadvertent activation/deactivation of controls with Kenya at 25%, Uganda 0%, forgotten intensions and omitted items on the checklist had same ratings of Kenya 12.5% and Uganda 33.3%.

The manner or skill with which one flies was a skill based error which was statistically significant in Table 4.11. This is because aircrafts operated under unsatisfactory conditions in the manner or flying skill of the pilots had an increased risk of an accident as compared to an incident at Odds Ratio (OR) $85X10^{30}$; $P<0.001$. The OR implies a more likely chance of $85X10^{30}$ that an accident will occur instead of an incident when the pilots' flying skill was unsatisfactory. In the Eastern Africa region, the unsatisfactory skill of flying showed that improper landing was the highest, followed by improper planning at takeoff and engine failure during flight (Table 4.3). This is because the manner or flying skill classified under skill-based errors was as a result of skill-based behaviour within aviation best described as "stick-and-rudder" and other basic flight skills that occured without significant conscious thought. Secondly, skill-based actions were particularly vulnerable due to failures of attention and/or memory amongst the crew. Attention failures were due to the breakdown in visual scan patterns, inadvertent activation of controls, and the disordering of steps in procedures. Just as noted by Shappell and Wiegmann

(2000), memory failures such as omitted items in a checklist, place losing, or forgotten intentions have adversely impacted the unsuspecting aircraft.

This is also in line with Munene (2016) whose work showed that of 55 analyzed African accidents including those in Kenyan, the Republic of South Africa and Nigeria between 2000-2014, skill-based errors were the highest, hence it became the foremost common category of human failure. For South Africa's 82% of errors in accidents were due skill based errors. The descriptions of those errors included; unsatisfactory techniques, aircrew errors, poor handling techniques and failure or neglect of the flying speed (Munene, 2016).

Misinterpretations and forgotten intentions were also observed in Table 4.3: These arise because of communication problems which included; lack of communication caused when someone forgets to deliver information to colleagues, or if a written message isn't well laid out. Poor communication can also can be made worse if someone doesn't make a message clear; fails to stress exactly what the receiver must know, consequently giving inappropriate information, or when a document is barely has a handwriting that is barely legible.

This is in line with findings by Lyssakov (2019) who noted that between 2012-2018, one of the common reasons for accidents was human factors, the least of which were: violations of flight rules, pilots training and maintenance operating, lack of necessary experience of the high-automated planes piloting, inadequate level of crew proficiency for manual piloting, spatial orientation loss by aircraft crews and entering into spatial position (Mathavara and Ramachandran, 2022). Worth noting is that insufficient training and responsibility of pilots-instructors and instructors-examiners pilots' over estimation of their skills and capabilities, loss of control in flight, unwarranted maneuvers at the altitudes and with speeds below specified minima followed by rolls and pitch attitudes exceeding aircraft operating limitations, leading to aircraft stall, poor knowledge of flight area/route, neglecting/ignorance of meteorological conditions, flight operations conducted in condition of alcohol intoxication and other circumstances (Lyssakov, 2019).

5.1.1.1.3 Perceptual errors

Perceptual errors were higher in Uganda at 25%, than Kenya at 11%.However, perceptual errors did not get enough attention like the decision and skill-based errors which had dominated most accident databases and had therefore been included in most error frameworks. When perceptual errors were examined, they manifested as altitude/airspeed misjudgment, misjudged distance factors and visual illusions with both Kenya and Uganda at 50%. Perceptual errors occurred when sensory input was degraded or as is often the case when flying at night, in bad weather, or in other visually impoverished conditions. This is in line with a study which established that under unusual circumstances or inadequate information, the aircrew can run into the risk of misjudging landing and takeoff distances, altitude, decent rates, as well as responding incorrectly to a variety of visual/vestibular illusions (Shappell and Wiegmann, 2000; 2001).

In summary, a close look at the overall HFACS analysis in previous studies showed that, just like before, the highest in frequency are skill-based errors by almost 3 to 1 in margin (Shappell *et al.*, 2014), followed by decision errors, and lastly are perceptual errors (Shappell and Wiegmann, 1996).

5.1.1.1.4 Violations

The study revealed that the most frequent types of violations were exceptional violations with Kenya at 77% and Uganda at 81% while routine violations were lower with Kenya having 23% and Uganda 19%. Aircrafts operated under conditions of high levels of exceptional violations had an increased risk of an accident as compared to an incident at Odds Ratio (OR) $7.45X10^{29}$;$P<0.001$. This implied $7.45X10^{29}$ more likely chance that an accident occurred instead of an incident when exceptional violation of certain procedures was exhibited. This is a result of unconscious decisions to violate or an instinctive reaction to the situation. This is in agreement with Reason (1990) who stated that exceptional violations in contrast appear as isolated departures from authority, neither necessarily characteristic of an individual's behaviour nor condoned by management. For example, an isolated instance of driving 105 mph in a 55 mph zone is considered an exceptional violation. Likewise, flying under a bridge or engaging in other particularly dangerous and prohibited maneuvers would constitute an exceptional violation. However, it is important to note that while most exceptional violations are indefensible, they are not considered exceptional because of their extreme nature but rather because they are neither typical of the individual nor condoned by authority. Wiegmann *et al.* (2014) unfortunately observed that the unexpected nature of exceptional violations makes them particularly difficult to predict and problematic for organizations to manage. When violations are associated with General Aviation (GA) accidents, they are much more likely to result in a fatality than if a violation is not committed.

Violations were also reported during incidents of confusion, as Munene (2016) stated that during adverse weather conditions, the crew members in various accidents in Africa were not coordinating their duties during the particular flight. They easily became distracted from their responsibilities, or became indecisive when there was need for agreement on how to continue operating the aircraft (Yan *et al.*, 2014).

5.1.1.2 Preconditions for unsafe acts

In Table 4.4, physical/ mental limitations, adverse physiological states, adverse mental states, crew resource management (CRM) and personal readiness were all higher for Kenya and as compared to Uganda. Generally speaking among the preconditions for unsafe acts, physical environmental problems, which included the weather, adverse mental state like distraction, poor ATC services and lack of situational awareness as internal and external mental and psychological states affected the level of human performance. Weather and wildlife effects were evident in Table 4.3 with weather as the cause of accidents at landing phase (2.5%) whereas wildlife related accidents at landing phase, takeoff and during flight at 2.5%. Weather related events are mostly related to the occurrence or risk of a loss of control because of the effects of significant in flight icing or in flight turbulence. The turbulence case can involve en route or low level flight, the latter especially in respect of approach and landing. The impact of wildlife strike has been experienced to cause cracked or broken windshield and consequently, depressurization and possibly pilot injury or even engine failure due to ingestion, resulting in aborted take-off or emergency landing. This is also supported by Munene (2016) who proposed that preconditions for the unsafe acts were due to the physical environment at 36.4% and attributed them to crew resource management (CRM) in particular. These were then followed by environment failures, such as adverse physiological states, the adverse mental states and personal readiness categories.

The other preconditions for unsafe acts were the physical and mental limitations categories which were high in this study with Kenya at 51.9% and Uganda at 35.7%. Physical/mental limitations are permanent disabilities that may adversely impact performance, such as poor vision, lack of physical strength, mental aptitude, general knowledge, and a variety of other chronic mental illnesses. Personnel factors in crew resource management include a variety of communication, coordination, and teamwork issues that impact performance.

Contrary, Munene (2016) had few of the physical and mental limitations and they were observed and analyzed in only 10.9% of the selected accidents that were studied. Munene (2016) further stated that during adverse weather conditions, the crew members in various accidents in Africa were not coordinating their duties during the particular flight. They easily become distracted from their responsibilities, or became indecisive when there was need for agreement on how to continue operating the aircraft (Yan *et al.,* 2014). Dönmez and Uslu 2018 also noted that the preconditions of unsafe acts are present in most accident occurrences and they emphasized the importance of communication in aviation accidents. Unlike their study, in the Eastern Africa region Crew Resource Management was at Kenya 3.7% and Uganda at 14% and was not statistically significant unlike being the most influential factor in the accidents for 17 countries worldwide and was observed with 68% as the crew failed to communicate/coordinate.

5.1.1.3 Unsafe supervision

Unsafe supervision was observed with Kenya at 61% and Uganda at 40%. Supervisory violation was highest in Uganda with 60% unlike Kenya was 2%. Notably, the failure to correct a certain known problem was occurring in Kenya at 37% and in Uganda at 0%. Aircrafts operated under conditions of high levels of supervisory violations had an increased risk of an accident as compared to an incident at Odds Ratio (OR) $6.53X10^{-31}$; P<0.001. This implied that a $6.53X10^{-31}$ less likely chance that an accident will occur instead of an incident when supervisors violated certain procedures through deliberate neglect of existing instructions, rules, regulations or standard operating procedures by supervisors during the course of their duties. This is in line with Reason (1990) who stated that violations might be independent of the supervisor's input and contrary to Munene (2016) who showed that the levels of unsafe supervision and planned inappropriate operations were at 7.3% while inadequate supervision were at 3.6%; the most observed categories in human factors.

5.1.1.4 Organizational influences

As indicated information on resource/ acquisition management was rated at 43% and 50% for Kenya and Uganda, respectively, the contribution of organizational process was rated at 48% for Kenya and 13% for Uganda whereas organizational climate factor was relatively high in Uganda at 37% as compared to Kenya at only 9%. Using the Mlogit model, organizational process had an increased risk of an accident as compared to an incident at OR (95%) $124X10^{31}$, $P<0.001$, implying a $124X10^{31}$ likely chance that an accident will occur instead of an incident when official processes like the vision of an organization and how it is enforced in form of procedures, operations and oversight as well other duties is unsatisfactory. Additionally, some organizations fail to provide the necessary resources for the crew to land at an airstrip which has game parks or wildlife. Table 4.3 shows that wildlife had significant effects on aircrafts at landing and takeoff. This is because of a lack of safety culture and vulnerable organizational process management highly influenced by the organization and management of enterprises. This is in line with Munene (2016) who noted that organization processes are the most observed failures for organization influences at 9.1% and were followed by resource management and organizational climate respectively. These organizations failures were due to lack of adequate crew training in the storage, handling and delivery of fuel, which resulted in either incorrect fueling or fuel starvation of the flight.

It is worth noting that accident and incident reports in Uganda, are not readily available to the public and that Uganda started emphasizing investigations after 2015 ICAO regulations. This affected the data analysis for previous human factors in Uganda since they could not be modeled through the MLogit analysis. One of the Ugandan operators expressed the concern bellow;

"Aircraft accident and incident investigation reports contradict private reports and they (Ministry of Works final investigation reports) are not available to the respective operators".

5.1.2 Current human factors risks in the region's aviation operations

The results in Table 4.6 show that there was a direct correlation between public safety, operations monitoring, quality control, trouble shooting, design and telecommunications and public safety. Using the multiple linear model in Table 4.13 showed that quality control analysis P= 0.023 and troubleshooting abilities P= 0.02 had significant regression value, R = 0.704, R = 0.496, R^2 = 0.352 (Table 4.8 and 4.7). The factors appeared to be relevant in the prediction of skills required for the job and this pointed directly to automation and training. This is due to automation and training on automated systems being one of the complex systems in aviation because every aircraft has its unique automated system that each crew member requires to be trained in. This is supported by a study which revealed that with the inclusion of automated systems on artifacts to assist the pilot in command with the control of the aircraft, automation does provide a countless load of information to be processed in the shortest time (FAA, 2010). When considering the rapidness by which these changes occur, an approach that covers each human being as an individual is strongly recommended. This approach could include their thoughts in relation to all these artifacts and other workers who share that workspace (FAA, 2010). This is in agreement with Dekker (2003) who noted that the complexity of automated systems causes them to interface and always promote different philosophies and procedures to implement on the different types of aircrafts. This also affects the different series of aircrafts including those from even the same manufacturer. Inadequate training creates a difficulty for the crew to understand appropriate procedures. Accident investigations have on various occasions realized that it would better to include psychological stages, in the crew training, so as to give them an opportunity to identify possible "psychological breakdowns" as well as have an idea of self-knowledge. This enables the human biological machine to detect the presence of danger during the flight. More scientific and humane support rendered to the crew and anyone else involved in aerial duties would minimize the factors causing accidents and incidents. Accident investigators have in all concluded that ideally crew training should have a psychological element (Dekker, 2003).

It is highly emphasized that human cognition is recognized as the various mental processes which include thinking. The study of mental processes is multidisciplinary and has various area of interest which includes psychobiology, anthropology, artificial intelligence, cognitive psychology, philosophy and linguistics, all of which provide a better means to understand people's perception, remembering, learning, and finally thinking, which lead to a much broader understanding of how humans behave. Cognition cannot be isolated but is composed of various components, which include artificial intelligence, human intelligence, problem solving, reasoning, memory, creativity, consciousness, mental imagery, attention, perception, language, decision making, cognitive changes which occur throughout life and many other aspects of thought (FAA, 2010).

Furthermore, the effects of automation on the performance of humans is one of the myths “as the investment in automation is increasing, there is less being invested in skilling the human”. Facts from different researchers and different experiments show that automation creates new knowledge demand and a need for greater human skills (FAA 2010). Investigations showed that many companies have problems relating to the complexity and nature of automated aircrafts. This creates a need for additional knowledge for the crew on automated systems and how to operate them. Automation affects the crew psychologically since it creates complexities that require the crew to develop mental models about simplifying these complex systems as well as detecting any errors in them. This is particularly true when it comes to logical transition from manual to automatic operation (FAA 2010). Whereas the training process teaches the crew how to handle automated systems while in their good working conditions, it does not train them how to manage failing automated systems. It is expected that the crew will eventually figure it out. This very serious assumption has been proven in various aviation investigation reports that registered the pilots not knowing what to do, after some computers decisions taken, during emergency situations that did not go as planned (NTSB, 2011). Apart from misuse of automation, it is also worth noting that accidents also do occur due to poor design and a lack of information transfer from the surrounding environment which then leads to crew error. The errors in information transfer can be due to faulty equipment, faulty instruments, wrong sounds, signs and differing messages (Martins *et al.*, 2014). Martins *et al.,* (2014) argues that the humans vary biologically and so do they in aviation, this is one of the reasons why we have human error. There is serious aircraft damage and loss of life as a result of error. An example can be the crew’s inability to read instruments correctly; they can be subject to misunderstanding, deficiency and poor monitoring of the various instruments and inability to read instrument displays. This conduct can be due to poor instrument training that is ambiguous and wrong, stress and fatigue, and lack of motivation which can generate control failures (format, activation and scope). It is also worth noting that there is a great requirement of human effort in managing and executing actions when interfacing and monitoring automation. There should be a high level of accuracy in the command and application of permanent mental model consistent with the use of innovations in automation; this makes the process of operating automation vulnerable to error in most situations involving a human being (Martins *et al.,* 2014).

Reason (1990) noted that accidents will not just occur but have a series of predetermined causes that may take days, or even weeks and years to evolve. However, if poor attention span or negligence causes a crash, then investigators should beware of the chain of different interactions between the crew and the aviation system that created the optimum conditions for an accident to happen. Human variability combined with system failures are major causes of human error which causes accidents and incidents. Another study found out that an evaluation of crew qualifications, performance errors, crew training and following procedures, regulations and operations, allows one to know errors and their various components. The errors of the crew are easily identified, and it's well-known that a lot of these errors will be predictable and are caused by one or more human factors, associated procedures, policies and training for the duty. The foremost difficult task is identifying errors and creating a corrective action before a dangerous situation occurs. The FAA team, addressing human factors (Dekker, 2003), identified the requirement for aviation to enhance the aircraft manufacturers and various aviation companies' ability to detect and eliminate the features on an aircraft that may create errors. However, current regulations and rules of approval have not included an in depth evaluation of the deck so as to scale down crew errors and performance limitations (Martins *et al.,* 2014). Experience generating complacency was also noted in the study region as another major issue that arises when under load leads to a lack of drive to perform. This could be true as expressed by one of the operators;

"Sometimes experience gets in the way leading to complacency"

5.1.2.1 Evaluation of training

The Figure 4.8 shows a photographic summary of aeromedical factors which participants from a training organization listed during a learning session (dirty dozen). The students listed the components of the dirty dozen based on the vast automation systems they related with which could make them lack knowledge of the systems, assertiveness, necessary resources and teamwork, make them stressed, fatigued and have issues with communication as well as distract them. Wiegmann *et al.* (2014), further states that even more alarming yet not always looked into by investigators is the manner or technique with which one flies the aircraft. Even with all the best training, experience and education, the background of each pilot is different from the other looking at how they control their aircraft. The flying techniques are also an expression of one's personality and are a factor of innate ability and aptitude (U.S. Department of commerce, 2003). Of at most importance, are the techniques which do interfere with the flight safety or may exacerbate seemingly minor emergencies experienced in the air (Wiegmann *et al.,* 2014).

5.2 Examination of aeromedical risks in the region's aviation operations

Table 4.15 shows data obtained about outstanding aeromedical factors, which included stress, sleep, appetite, weight, concentration, alcohol, smoking, anxiety and age. The dependent variable problem solving could be predicted from a linear combination of the independent variables in

Table 4.16: R = 0.939, R^2 = 0.881, adjusted R^2 = 0.827; sleep (P=0.005), high levels of anxiety (P=0.021), shortness of breath (P=0.011) and cigarette smoking (P<0.001). This implied that sleep, anxiety levels, shortness of breath and cigarette smoking affected the individual's skills and in turn affected performance as discussed in details below.

5.2.1 Aeromedical human factors identified as risks in the region

5.2.1.1 Sleep and its effects on aviation crew

Sleep affected performance because the model predicted its significance at R^2 = 0.881, P=0.005 which signifies a high relationship between study variables. This is in agreement with findings in table 4.15 where sleep had a moderate correlation with concentration at a value of 0.459 at a p-value of 0.00143. Lack of sleep is a major contributor to fatigue which, in turn, can profoundly influence flight safety. Insufficient sleep can lead to poor concentration, increased irritability and lethargy. This is supported by work from another author who revealed that people working long hours, (particularly unsociable hours) have increased likelihood that they'll error (CAE, 2022). Adults require 8 hours sleep to function properly and because the good rule of thumb states; for each hour of prime quality sleep, it's good for 2 hours of activity (CAE, 2022). Wickens *et al.* (2004) looked at sleep disruption to occur when a person receives fewer than 8 hours of sleep within the night. There is an effect on cognitive abilities if a person has sleep disturbances (Baranski *et al.,* 2011). One of the prime regulators for sleep is temperature which controls the internal clock, or body clock and regulates the circadian rhythm. There is a direct relationship between body core temperature and the sleep cycle since at the time of the lowest body temperature, it is hard to stay awake. Generally, people feel sleepy when their body temperature is falling and most awake when their body temperature is rising. This relationship explains why individuals have difficulty with getting quality sleep for the next few days after crossing through different time zones. When this happens, it is a symptom of a phenomenon known as jet lag. The best mental performance is at 10.00 hr. and best physical performance is at 17.00 hr. acclimatized local time. Similarly, the window of circadian low is 02.00- 05.00 hr. and this is the time period for worst performance and vigilance (CAE 2022).

5.2.1.2 Fatigue and its effects on aviation crew

Fatigue affected performance because the model predicted its significance as anxiety (P=0.021) and shortness of breath (P=0.011) and R^2= 0.881, which signifies a high relationship between study variables. Pilot fatigue is a concern because it can affect flight safety, efficiency, productivity and personal health. Fatigue is recognized as one of the major factors that can impair human performance and has been cited as a cause of accidents and incidents in the transport industry (FAA, 2012). It is revealed that fatigued people are advised not to undertake any form of critical task in order to minimize the chances of error (CAE 2022). Possible causes of fatigue include sleep loss, extended time awake, circadian phase irregularities and work load.

The description in 1953 by Charles Lindbergh of his historic solo transoceanic flight of 33.5 h in 1927 illustrates the destructive effects of fatigue in aviation (Lindbergh, 1953). The work was the first of its kind to identify fatigue as a risk factor in aviation accidents. Another special recognition was in 1938 where the Civil Aeronautics Act addressed the issue of aircrew duty hours and flight times (Mathavara and Ramachandran, 2022). However, throughout the years, fatigue remained an important risk factor for aircraft incidents and accidents both in civil and military aviation (Mathavara and Ramachandran, 2022).

Much as execution of work related duties at night may be strategically necessary, this will most certainly lead to irregular sleep during placement, which will cause fatigue. This is problematic most especially at the end of any flying mission, especially at the landing phase which is recognized as a risky time for the occurrence of aviation accidents (European Union Aviation Safety Agency (EASA), 2020; Yara, 2022). In the context of aviation, mental fatigue and sleepiness have been mentioned as the most important form of fatigue (Williamson *et al.,* 2011; Wingelaar *et al.,* 2021). A recent review stressed the importance of distinguishing between sleepiness (i.e., drowsiness) and mental fatigue, emphasizing the differences in their causes and psychological and physical responses, while acknowledging that they interactively contribute to reduced performance and vigilance (Hu and Lodewijks, 2020). Sleepiness is mainly caused by circadian rhythm disruptions, sleep loss and time awake, whereas mental fatigue is mainly caused by time-on-task and cognitive workload (Balkin and Wesensten, 2011). Similar to civil air operations, fatigue plays a major role in military aviation accidents. Fatigue was reported to be a causative factor in 12% of the US Navy's Class A (most severe) accidents and in 25% of the US Air Force's (USAF) night tactical fighter Class A accidents (Ramsey and McGlohn, 1997). A recent review of nearly 15 years of USAF mishap reports showed that approximately 4% of all mishaps were fatigue related, resulting in 32 fatalities and costing >$2 billion (Gaines *et al.*, 2020). Interestingly, the percentage of fatigue-related class A mishaps was significantly higher at 24%, which is comparable to the 23% found in civil aviation (Marcus and Rosekind, 2017; Gaines *et. al.,* 2020). The amount of sleep during the previous 24 h was shown to be an independent predictor of threat and error management. Also, limited sleep, defined as <5 h, during the previous 24 h was associated with confusion (Drury *et al.,* 2012). Sleep loss may be acute (not sleeping at all for an extended period of time, also known as sleep deprivation) or chronic "trimming" of sleep at night by 1 or 2 h, also known as sleep restriction (Goel *et al.*, 2013; International Civil Aviation Organization ICAO, 2020). Research has shown that the effects of sleep restriction accumulate, leading to a progressive reduction in performance, which intensified as sleep restriction per night increased (Samel *et al.*, 2004; International Civil Aviation Organization (ICAO), 2020). In addition to reductions in hours slept, the quality of sleep may also be disturbed. For example, sleep at layovers may be complicated by transient factors such as unfamiliar or uncomfortable sleep environments, circadian disruptions, or situational stress (Caldwell, 1997; Yara *et al.*, 2021).

Biological effects of fatigue include impaired alertness; where sleepiness and unintentionally falling asleep are possibly the two effects which are described most often by pilots when asked about their experience with fatigue in-flight (Yara *et al.*, 2021). Fatigued individuals may initially become less alert and may subsequently start to feel sleepy or drowsy. If these individuals do not get the rest period they need, the feeling of sleepiness may become overwhelming, resulting in the so-called micro-sleeps, defined as brief uncontrollable periods of sleep (ICAO, 2020). This feeling of sleepiness decreases a pilot's alertness, in ultimo resulting in unintentional (micro) sleeps, which leads to performance decrements (International Civil Aviation Organization (ICAO), 2020). Secondly, is decreased performance as shown by some studies, that just 2 h of sleep loss leads to performance decreases equal to those observed after consuming two to three bottles of liquor (Roehrs *et al.*, 2003). Impairment of cognitive functioning is particularly noticeable when measuring executive functioning, sustained attention and long-term memory (Lowe *et al.*, 2017). Despite not being included in the ICAO definition, research has shown that fatigue may cause long-term health effects (FAA, 2010). Although these effects may have a limited influence on the performance of a fatigued pilot, they may lead to long-term reductions in performance (Yara *et al.*, 2021).

Fatigue has been shown to reduce working ability in general and may be associated with feelings of depression or anxiety (O'Hagan *et al.*, 2016; Pasha and Stokes, 2018; Pellegrino and Marqueze, 2019). Moreover, severely fatigued pilots had higher rates of excessive daytime sleepiness, depression and obstructive sleep apnea as compared to non-fatigued pilots (O'Hagan *et al.*, 2018). Levels of cardiovascular strain were found to be higher on day 4 than on day 1 of a work period, consistent with the hypothesis that fatigue and work periods increase cardiac strain among aircrew (Goffeng *et al.*, 2019). These long-term detrimental effects of circadian rhythm disruption and fatigue have also been observed in other occupational areas. For example, poor sleep hygiene in the military has been associated with cardiovascular disease, substance abuse and mood disorders (Good *et al*., 2020).

One of the key management informants noted that;

"All flying involves some level of stress and fatigue"

In the past, fatigue has been identified in several situations as the probable cause of 21–23% of main aviation accidents (Yara, 2022). In 2020, the European Aviation Safety Agency (EASA) identified "state of wellbeing and fitness for duties" as top safety issue for large airplanes (European Union Aviation Safety Agency EASA, 2020).

The amount of time one spends on a task is likely to cause fatigue especially for longer tasks (Van Dongen, Belenky and Krueger, 2011; Isaac and Ruitenberg, 1999). Gilbertova and Gilvicky (1967) reported that the effects of fatigue are made worse by monotonous tasks (reported as loss of interest in Figure 4.13), but the opposite is expected when one is doing performing a novel task or a demanding task. The increasing number of accidents and incidents bent to fatigue is quit alarming (Dorrian *et al.*, 2007). It is good to note that the association between fatigue and its effect on performance is a complex one. This is to say that fatigue (reported as loss of interest in Figure 4.13) will indirectly affect one's performance with a moderate relationship which is also determined by other factors including the strains of a task, level of motivation as well as the amount of effort needed for the selection strategy. Martins *et al.* (2014) noted that emotional fatigue (reported in Figure 4.13) among crew members is stress caused by the reduction of number of individuals at various section for example reduction in the number cockpit crew to just two pilots from three. Large aircrafts which are heavy machines with four engines and about six hundred passengers are too complex to be handled by only two pilots. If all the flight operation and emergencies are handled by only two pilots, this is risky because of the constant need to do monitoring and re-checks. Where the operations are so complex, monitoring is best done by a crew of three in the cockpit. Clearly, the FAA (2010) notes that unlike other types of aircrafts, only DC9-30 and the MD11 series can comfortably have the two flight crew on board.

In human factors, the attention span of any human is greatly affected by fatigue. Stern *et al.* (1994) noticed that as fatigue increased in their study subjects, they exhibited changes in their gaze control which meant that the subject had a breakdown.

Aviation is data poor relative to the safety implications of variables such as fatigue, spatial disorientation, or mild hypoxia. These may be important in accident chains, but are generally not detectable post flight or post-crash (Steinkraus *et al.,* 2012). So given a human "black-box" and associated systemic changes, potential positive outcomes include fatigue management using dynamic cognitive/physiologic monitoring protocols, automated G-tolerance or hypoxia algorithms, and post-event analysis (Steinkraus *et al.,* 2012).

5.2.1.3 Stress and its effects on aviation crew

Stress affected other human factors and performance too in Table 4.15 which showed that stress has a weak positive correlation with sleep at a value of 0.320 and p-value 0.0306. Stress and problem solving had a moderate positive correlation with problem solving with a value 0.537 and a p-value 0.0000946. Stress was both domestic and work related. Since it is hard to separate our work and home life, the two will inevitably affect each other. If someone appears to be suffering from stress, it is wise not to give them a complex or critical task (overload will exacerbate stress) as it will increase likelihood of error. In aviation, stress is a relevant topic because of its impact on human performance. Stress, mental workload, fatigue, distraction, and situational unawareness can be the cause of human errors, and produce a variety of scenarios, from small inefficiencies to great disasters.

According to Congeton *et al.* (1997), stress is defined as a psychological and physical state of tension and is a result of perceived or actual conflict between demands from one's environment and the available resources at the moment to meet the demands (Desaulnires, 1997; Mathews 2002). It is well known that team work can reduce and eliminate stress which is affecting human performance. However, Glasser *et al.* (1999) argues from his study that the relationship between stress and teamwork is weak. Serfaty *et al.* (1993) and Martins *et al.* (2014) noted that there is a requirement for close attention to the interface bringing the machine and the human together to ensure that they work well together. Any ergonomic project should aim at recognizing and designing ways for the human to properly monitor tasks and therefore not fail when it comes to the team monitoring any particular tasks. Humans are not like a computer which is properly designed machine that performs well in monitoring tasks. An emotional and cognitive overload is created by the continuous monitoring work since there is an increase in the amount of information. In general Martins *et al.* (2014) noted some stress causing factors that are important during the cognitive activity of the crew include sleep, sleep disorders, body rhythms, rest, fatigue, and the circadian rhythms, acceleration due to gravity and the G-forces, as well as physiological demands when individuals are at a high-altitude, visual and false illusions of climbing and nighttime take-offs. There are other demands mainly physiological ones placed on the human in aviation. There is need for individual studies to be done for every specific type of work place and aircraft, so as to lessen the rising occurrences of stress related incidents and accidents.

5.2.1.4 Other key aeromedical factors affecting aviation crew

Alcohol, smoking, age and weight are fully elaborated in relation to human factors as shown in Figure 4.7. Alcohol (ethyl alcohol or ethanol), regulations in aviation show that there is minimal or zero tolerance to alcohol consumption among aviation crew yet 30% of the participants consumed alcohol. It is not digested in the human body. It is absorbed directly from the stomach (20%) and intestines (80%) into the bloodstream. From there, it is carried to every portion of the body. The liver is responsible for eliminating the alcohol and does this by changing the alcohol into water and carbon dioxide. Drunkenness occurs when the individual drinks alcohol faster than the liver can dispose it off. Alcohol is broken down by the body at a rate of approximately one unit per hour, though there are many individual differences (1 unit is approximately half a pint of beer or an imperial glass of wine or spirits). Alcohol decreases the ability of the brain to make use of oxygen. This adverse effect can be magnified as a result of simultaneous exposure to altitude, characterized by a decreased partial pressure of oxygen. Visual symptoms include eye muscle imbalance, which leads to double vision and difficulty focusing (CAE, 2020).

The graph in Figure 4.7 showed that cigarette smoking was evident in 28% of the participants. This is a concern as it can be responsible for hypermic hypoxia which is an occurrence when blood is unable to absorb and move an adequate amount of oxygen to the body cells that need it. This results in deficiency of oxygen in the blood. Hypemic means “not enough blood. CO poisoning; tobacco smoke alone can cause CO poisoning, a smoker taking a cigarette at sea level can cause the CO concentration in the blood to rise and results in the physiological effects equivalent to flying at 8,000 feet (CAE, 2020). Besides hypoxia, tobacco smoking can cause physiological debilitation and disease that can medically be prohibiting for aviation crew. The effects of CO poisoning may include; dizziness, blurred vision, headache, drowsiness, and/or loss of muscle power. The direct curative actions will include; opening fresh air vents, turning off the heater and windows, and using supplemental oxygen (Oxford Aviation Academy, 2008).

5.2.1.5 Situational awareness and its relevance to aeromedical factors

All the factors mentioned above; sleep, fatigue (anxiety and shortness of breath), stress, alcohol, age and smoking in turn affect situation awareness. This observation is supported by some authors like Shappell *et al.* (2007), whose studies showed that different demographics and situational factors are the underlying causes of accidents related to human error. Notably age, one’s occupation, flight experience and the gender are also relevant in this case (Wiegmann, *et al*., 2014).

Aviation crews need to have a realistic idea of what is going on around them. In aviation, the realistic idea is known as situational awareness, and it is key for flight safety. Orientation is the ability of one to have control over their position in space and this can be achieved by the blend of information from two sense organs; the eye (vision), the ear (“balance and the seat of pants”).

Physical knowledge of the outside world is gained through different sense organs. These organs supply information to five human senses which are; taste, hearing, touch, smell and sight, where information from the eye provides 70% -80% of the aviator's necessary information (CAE 2022). Located within the muscles, tendons and skin are pressure sensitive and stretch sensitive cells. Data from these cells combines with other sensory information to provide people with perception of their relative position and movement. Together with vision, these complement each other (CAE 2022). Notably, the eye as the sense relied on most has biological limitations which lead it to deliver information with errors. These limitations include a blind spot, binocular vision (two eyes with different perception of the same image), effects of glare, flickering lights effect, difference in depth perception, defects in visual acuity, colour blindness, optical illusions, scanning effect, adaptation to light and eye defects. It is also important to note that a great deal of work has been done to inform air crew about the dangers of spatial disorientation and visual illusions (CAE 2022).

The biological limitation in the eye can be further discussed. Binocular vision occurs since a human has two eyes function together simultaneously. When you observe one image, each of the two eyes sees it from a different angle and its relationship to the background will be different. This makes the eye subject to illusions and a loss of situational awareness in case of any misinterpretation. The blind spot occurs in both eyes and this is as a result of the fact that there is no place for rods or cones on the area of the retina where the nerves bundle together to form the big optic nerve. Any image that falls on this area will therefore not be seen. The effects of the blind spot is very important with traffic monitoring of incoming air traffic. Visual acuity is the clarity and sharpness with which the eye sees images; perfect visual acuity means that the eye can see an image clearly without distortion, no matter how far the object is. But this varies among individuals and depends upon whether the person is fatigued, suffering from hypoxia or under the influence of alcohol or drugs. Glare occurs if one is flying at high altitudes especially above cloud layers or flying into a rising or setting sun, the crew are exposed to light of very high intensity, possibly coming from all angles. The problem with glare is that it affects visual acuity and adaptation from the bright aircraft exterior to the cockpit instruments. Depth perception by the eye is also subject to limitations since it feeds signals to the brain to help judge distance. Information including size, distances, texture (there is an illusion that the more texture on an object the nearer it is) are subject to misinterpretation or variations as per each individual (Oxford Aviation Academy, 2008).

Colour vision is detected by the central region of the fovea in the retina by cone cell receptors which are active only in fairly bright light. The perception of different colours highly affects aviation operations. The average human eye can distinguish over one hundred hues (single wavelength colours) and one thousand shades. The dilemma is that there are some eyes which cannot distinguish any colours at all even in bright light. Males are subject to colour blindness with about 1 in 12 caucasian males having some kind of colour blindness). This is also affected by gender, being that in humans, females seem to differentiate colours better. Defective colour vision shows up as trouble differentiating red from green. This will become a problem when one encounters white, red and green colours of navigation lights during poor visibility. Adaptation of the eyes to darkness takes the eye some minutes to adjust. The light absorption rate depends on the brightness and contrast between the light formerly experienced and the amount of darkness in the new environment. Flicker vertigo is also brought about by flashing lights such as a strobe light or sunlight reflecting off rotating propeller blades (Oxford Aviation Academy, 2008).

Visual illusions; autokinesis refers the illusion of self-motion that do occur usually in the night as one continuously stares at a point light against a very dark background. The light does appear to move and one loses orientation in space if it is used as a single reference point (CAE, 2022).

The ear is also equally important in ensuring situational awareness because it performs two major functions; one being the reception of sound and another being balance. Occupational risks associated with noise at the work place are due to the fact that aircrafts and airports are very noisy environments where noise levels from can exceed 110 decibels to 120 decibels. Undesirable sound, especially very loud sound can be regarded as noise, because it can be mentally fatiguing because it has effects on one's ear and it can affect the whole body, especially if vibrations are associated with it. Noise does interrupt communication and will affect one's concentration and extreme noise damages the ear. Conductive hearing loss is a problem with conduction of sound through a blocked outer canal (ear wax), fluid or pressure problems in the middle ear such as barotrauma caused by a cold or Covid 19. Vestibular illusions which can cause one to loose situational awareness include; the leans which occur as an illusion of an aircraft being banked when infact the wings are straight and level. Vertigo is generally experienced as a feeling of rotation when infact there is no rotation or vice versa caused by disease, acceleration and sudden pressure changes. Other examples of vertigo include pressure vertigo which is as a result of effects on the apparatus responsible for balance as a result of blocked eustachian tubes which leads to failure of the eardrums to balance pressure (CAE, 2020).

The leans result when a banked attitude, to the left for example, may be entered too slowly to set in motion the fluid in the "roll" semicircular tubes, this gives an illusion of the aircraft being banked when in fact the wings are straight and level. Vestibular and "seat of pants" illusions include: Graveyard Spiral; as in other illusions, a pilot in a prolonged coordinated, constant-rate turn, will have the illusion of not turning. During the recovery to level flight, the pilot will experience the sensation of turning in the opposite direction (CAE, 2022). A disoriented pilot may return the aircraft to its original turn. Since an aircraft tends to lose altitude in turns unless the pilot compensates for the loss in lift and the pilot needs to notice a loss of altitude and correct it. The absence of any sensation of turning creates the illusion of being in a level descent. The pilot may pull back on the controls in an attempt to climb or stop the descent. This action tightens the spiral and increases the loss of altitude; this illusion is referred to as a graveyard spiral. At some point, this could lead to a loss of aircraft control. Somatogravic illusion; occurs during rapid acceleration, such as experienced during takeoff, this stimulates the otolith organs in the same way as tilting the head backwards. This action creates the somatogravic illusion of being in a nose-up attitude, especially in situations without good visual references. The disoriented pilot may push the aircraft into a nose-low or dive attitude (CAE, 2020). A rapid deceleration by quick reduction of the throttle(s) can have the opposite effect, with the disoriented pilot pulling the aircraft into a nose-up or stall attitude. Inversion Illusion; an abrupt change from climb to straight-and-level flight can stimulate the otolith organs enough to create the illusion of tumbling backwards, or inversion illusion. The disoriented pilot may push the aircraft abruptly into a nose-low attitude, possibly intensifying this illusion. Elevator illusion occurs during an abrupt upward vertical acceleration, this can occur in an updraft; this stimulates the otolith organs to create the illusion of being in a climb. The disoriented pilot may push the aircraft into a nose-low attitude. An abrupt downward vertical acceleration, usually in a downdraft, has the opposite effect, with the disoriented pilot pulling the aircraft into a nose-up attitude. Coriolis illusion is caused by shifting the semicircular canals out of their normal plane of rotation. It is a common occurrence when crews do not hold the head in normal position during flight. Rolling into and out of a turn _ the same situation applies to changes in pitch and in yaw using the semicircular canals relative to those axes. Motion sickness also known as airsickness is caused by a balance mechanism of the inner ear being continuously stimulated by acceleration. As a result of spins, steep turns among others. It is caused a mismatch of the balance signals from the visual signals from the eye and the ear CAE (2020).

Martins *et al.* (2014) stipulated that there is a growing hidden problem in the aviation industry where by emotional disorders are increasing in this field. The other issue is with the unexpected automation surprises which reflect misinformation of users or complete misunderstanding of knowledge laid right down to the users. It also heightens their limitations and inability to beat new situations which weren't foreseen by aircraft manufacturers and designers. This information that is subject to misunderstanding due to a lack of situational awareness is speed, altitude and positioning of one's aircraft operations of the hydraulic power systems (Sternberg, 2000). If there is a controversy, the man-machine interaction and communication increases as several lights are turned on and also the warning sounds increase. The interaction between man and machine can cause perception to diminish because the information to be processed by the crew increases. Since all the knowledge should be processed by one brain at the particular time so it can decide the subsequent action within a limited span of time. Yet as a part of the human's biological limitation, there's a limit to the amount of knowledge the brain can house. It will then result in an unusual situation, where by while the mind is working normally, an outsized volume of incoming data creates an overload, resulting in mistakes and failures considering that the person is a biological machine.

Endsley and Rodgers (1996) concluded that a lack of situational awareness may disturb attention mainly if attention is drawn away from certain important environmental information, hence situational awareness may fail to be maintained. A reduction in situational awareness will lead to a decline in human performance. Most known human factors including the physiological and psychological factors impact situational awareness and then affect human performance. A relationship between stress and workload was relevant to workload and situational awareness. Martins *et al.* (2014) stated that the lack of perception, flaws in the emergency decision-making situations and all associated elements will make a given situation easy to handle in short space of time or lead to a loss of situational awareness. Communication also prominently affects the level of situational awareness. Koester (2003) revealed that especially under critical situations, the channels of communication and the types increased but the general communication dropped.

Yan *et al.* (2014) noted that it is so strange but "active failure" resulting from the unsafe acts is very common as compared to "latent failures" which are common in the organizational and supervisory environment, mostly because these unsafe acts are very common in performance. The contributing factors to failure are due to incorrect use of equipment/controls and the failure to follow the Standard Operating Procedures (SOP).

5.3 Designing possible interventions that can be designed to address selected human factors issues

5.3.1 Human factors ranking of aerodromes in Kenya and Uganda

The aerodromes ranked red (Figure 4.9 and 4.10) were selected as unfavorable and stressing in terms of human performance and limitation. Participants noted that these places (in terms of environment terrain, weather and wildlife) would put them at maximum stress when in use mainly during landing and taking off. The map of aircraft crashes in the study area has certain locations marked out mainly in Kenya being captured again by the maps in Figure 4.9 and 4.10. Wilson airport and the surrounding areas were marked red because they recorded latent human factors risks and this was because of the mountainous terrain around the flight path which brings about foehn winds which are due to orographic cloud formation on the lee side of the mountain range, fog and low stratus clouds, mist, early morning frost and a national park in the vicinity which brings about wildlife interference.

National parks (areas of Kasese/Rwenzori mountains National Park, Queen Elizaneth NP, Kibaale, Murchsion falls NP, Bwindi impenetrable forest) experience wildlife interference in form of birds and animals crossing the runways, forming weather and forested area responsible for large numbers of wildlife and weather formation. This is also evident in Table 4.3 where wildlife and weather related accidents are noted at landing and takeoff in both countries. For example the crash of Cessna 208B 5X GBR Grand Caravan in Mweya while landing (descent or approach) on 31st Dec, 2022 at 1315 LT. Another example is the crash of a Cessna 208B ZS ADL Grand Caravan on Mt. Margherita, Rwenzori mountains killed 3 on 28th August 2006. Poor weather conditions among other factors led to controlled flight into terrain after the crew failed to follow prescribed route and executed a direct route over the mountain at an unsafe altitude in poor visibility due to weather.

Shappell (2007) showed that a majority of accidents have underlying factors which were pinned on the aircrew and environmental effects. A comparison was made between HFACS causal categories and old-fashioned situational variables such as optical conditions, injury brutality, and regional differences. This is also in line with International Air Transport Association IATA (2015) which noted that environmental threats were identified in a significant proportion of all loss of control accidents and therefore a strong link can be drawn between environmental factors and fatal accidents. These contributing factors include latent conditions in the system, external threats to the flight crew, errors in the handling of those threats, and undesired aircraft states resulting from deficiencies in managing threats and errors. Events outside the influence of the flight crew, which have the potential to reduce the safety margins of a flight, are considered threats. These require flight crew attention and making timely and correct decisions to ensure the continued safety of the flight. In the environmental and airline threats contributing factors, adverse meteorological conditions, wind shear and aircraft malfunction were cited as common factors (IATA, 2015). To avoid loss of control accidents, it is recommended that pilots receive appropriate training for both malfunction recognition and proper response to it; hence, operators should provide enhanced and more realistic training for the appropriate pilot reactions to engine malfunctions. Adequate classroom and simulator training should be provided to pilots to increase their skills, discipline and knowledge academically as well as to help pilots develop the ability to manage the aircraft state through the correct implementation of skill-based behavior (International Air Transport Association IATA, 2015).

Another important element of continued reduction in the number of loss of control accidents is the collection and sharing of flight data to identify hazards ahead of time and mitigate the risks that can lead to an accident. The use of Flight Data Monitoring (FDM) is essential as it identifies potential hazards in flight operations and provides accurate quantitative data. FDM is also the best-known indicator of UAS like operation outside aircraft limitations. It is also essential as it strongly contributes to improve flight safety and increase operational benefits, and while it may not be required on all aircraft, it is strongly recommended as part of an overall SMS program (ICAO, 1999).

Moderate stress was experienced at aerodromes marked yellow and these were observed to be less stressful for crew to operate around as compared to those marked red. One of the airports marked orange was Jomo Kenyatta International Airport (JKIA). Jomo Kenyatta International Airport (JKIA) in Kenya ; is prone to visibility issues due to being located in a place which has slightly low temperatures and experiences fog, the terrain around the airport also has varying land masses around it which affect the approach and take off for those using the airport.

Minimum stress was at the aerodromes marked green due to the little stress the crew expressed when operating at these airports. An example is Entebbe International Airport which was ranked green due to the ease with which the crew found when operating at this airport. This is also due to the fact that a complex system of aircraft support services, passenger services, and aircraft control services have been put in place to ease operations in addition to the strict regulation by CAA. But despite all this, the airport still presented some constraints to the crew as mentioned.

Entebbe airport in Uganda is prone to low flying and migratory birds which strike engines and cause fires or engine failure, lake fly flocks in swarms of large groups which affect visibility for aircrafts departing or landing, illusions (most commonly empty field myopia, "black hole approach, RWY 17" due to the presence of Lake Victoria right next to the airport) and weather (lightening & thunder 04:00-08:00 hours which affect visibility). An example is the crash of a Cessna F406 ZS SSD Caravan II in Entebbe which killed 2 on September 26th 2007 shortly after takeoff from Entebbe International Airport. A crash of a Boeing 707 3K1C 9G IRL off from Entebbe Airport on 19th March 2005 on approach runway 17 in a 8 Km visibility, the captain decided to initiate a go around procedure, a few minutes later while on the second attempt to land on runway 35, the crew encountered local patches of fog and the aircraft crashed in Lake Victoria. On Jan 8th 2005 at 1300LT, the crash on an Antonov AN 12 near Entebbe killed 6;

findings showed that the operator did not have an AOC or any license to fly, poor flight planning as well as poor loading, in addition to lack of crew training or licensing among other reasons. On 30th April 2000, the crash of a Douglas DC 10 30F N800WR DAS Air in Entebbe after landing on runway 17, the aircraft was unable to stop within the reaming distance (runway 17/35 is 12,000 feet long) overran and plugged in the lake Victoria (Ministry of Works and Transport, Uganda, 2023).

Federal Aviation Authority (FAA) (2010) emphasizes that smoothly operating airports is extremely complicated but quite possible, with a complex system of aircraft support services, passenger services, and aircraft control services contained within the operation. Thus, airports can be major employers, as well as important hubs for tourism and other kinds of transit because they are sites of operation for heavy machinery, a number of regulations and safety measures have been implemented in airports, in order to reduce hazards. Additionally, airports have major local environmental impacts, as both large sources of air pollution, noise pollution and other environmental impacts, making them sites that acutely experience the environmental effects of aviation. Airports are also having infrastructure which are vulnerable to extreme weather, climate change caused sea level rise and other disasters (FAA, 2010).

5.3.2 Discussion of findings from the distress thermometer

Findings from the distress thermometer in Figure 4.11 showed different practical problems causing distress to participants from the two countries. Of these, insurance/ finances ranked highest followed by housing and transportation and lastly childcare and work/school. Figure 4.12 showed different family issues causing distress to participants from the two countries. Concerns about friends and children ranked highest and a spouse ranked lowest. Figure 4.13 showed different emotional issues causing distress to participants from the two countries. Concerns raised were mainly about nervousness which ranked highest followed by worry and loss of interest which was least. The Figure 4.14 showed different physical problems causing distress to participants from the two countries. The major problems were mainly fatigue, pain and sleep related issues. Other issues worth noting are constipation, diarrhoea, eating disorders, fever and memory/ concentration. Notably, in aviation life, the causes of stress (stressors) are daily event which one cannot distance him/her from. These could be major life events, such as a death in the family or a new job; ongoing aggravations, such as a chronic illness or an inflexible work schedule; or the annoyances of daily life, such as traffic jams or — to crew members — exposure to aircraft engine noise and vibration during flight.

The Figure 4.13 reflects elements in social psychology, in particular, demotivation due to nervousness, loss of interest and worry. This is in agreement with a discussion by Reason (1990) _in Human Factors who observed that social psychology is one of the factors affecting performance; demotivation is due to monotonous chores hence loss of interest. Demotivation in individuals happens and is affected by multiple factors; i) Task being undertaken (chore is monotonous or individual sees little value in the task) ii). Environment affects motivation.

Among the factors that affected performance were health and fitness, work and domestic related stress, deadlines and time pressure, fatigue, sleep, pain and nervousness (which may be as a result of lack of Situational awareness).

5.3.2.1 Pain among aviation crew members

In Figure 4.14, the major problems arising are mainly fatigue, pain and sleep related issues. Pain was a major issue among the participants, in maintenance pain is due to the nature of work;

engineers have to carry or pull around heavy load which causes muscle and back pain. Backache is much more common among aircrews that sit for long hours, have little exercise and are overweight or obese. Among the air crew, pain is experienced due to the biological limitations occurring when a human is operating off the surface of the earth. Firstly, the air crew is prone to dehydration when flying because the air in airplanes is very dry. This can cause muscles and joints to ache. Secondly, the change in air pressure when flying can also cause our muscles and joints to ache.

Pain can be due to barotrauma, decompression, hypoxia and acceleration due to gravity (Gz). Pain is an aeromedical factor from the distress thermometer. In aviation, pain can be encountered as a result of several factors. Barotrauma follows "Boyle's law which states that: "Provided the temperature is constant the volume of gas is inversely proportional to its pressure".. Barotrauma is pain caused by the expansion and contraction, due to outside pressure changes, of air trapped in the cavities of the body, notably within the intestines, middle ear, sinuses or teeth (Otic and Gastro-Intestinal Tract Barotrauma, Aerodontalgia). Barotrauma can cause discomfort or extreme pain sufficient to interfere with the pilot's ability to operate the aircraft (CAE, 2022).

Otic (middle ear) barotrauma; pressure is normally equalised across the eardrum by the eustachian tube leading from the middle ear to the back of the mouth/nose. There is seldom any problem in the climb when air passes from the middle ear to atmosphere, most problems occur in the descent when air is attempting to return to the middle ear. The end of the eustachian tube acts as a flap valve which allows air to escape with relative ease (required in the ascent) but can restrict air entering the middle ear (required in the descent). With a reduced pressure in the middle ear, the increasing pressure outside will cause a distortion of the ear drum and sometimes causing extreme pain. The severity of otic barotrauma depends upon the rate of climb or descent.

It occurs mainly at lower levels where pressure changes are the greatest (CAE, 2022). The problem is increased if the person has a cold or any other condition which causes the mucous membrane lining the eustachian tube to become inflamed and swell. One or both ears can be affected and will cause; pain (gradual or sudden), which can radiate to the temples, temporary deafness, pressure vertigo, tinnitus (a ringing in the ears), rupture and bleeding of the ear drum in extreme cases which may cause deafness in the extreme cases.

It is most important that pilots ensure that, having suffered from otic barotrauma, they are in a perfect state of health before returning to flying. If the resumption of flying takes place prior to a complete recovery, it can lead to further damage to the system which may result in a chronic state and the risk of infection. When "Clearing the Ears", care must be used when blowing down a held nose with the mouth closed (valsalva manoeuvre). A violent usage of this method may cause pressure vertigo. Less severe methods include; the frenzel manoeuvre (similar to stifling a sneeze), swallowing with the nose held, yawning, moving the lower jaw from side to side (Oxford Aviation Academy, 2008). These methods could only be used for equalizing pressure in the middle ear during the descent. Should all these methods fail, a landing should be made as soon as is practically possible and medical assistance sought from an Aviation Medical Specialist (Oxford Aviation Academy, 2008)..

Sinus Barotrauma: Sinuses are cavities within the skull which are air-filled and their function is to make the skull lighter and the voice resonant. They are situated above the eyes, in the cheeks and at the back of the nose and are connected to the nasal cavity by narrow ducts. These tiny ducts can become swollen or obstructed allowing air to become trapped within the sinuses. As with the ears, the sinuses can vent air more easily in the ascent than they allow gas to re-enter in the descent. Thus, the painful results normally occur in the descent if the sinuses are affected by a cold or influenza. The pain, which normally starts around the eyes spreading to the temples, can be so severe as to render the pilot quite incapable of maintaining control of the aircraft. Fainting due to such pain is not unknown. Associated with the pain is a watering of the eyes making vision difficult and, in addition, bleeding from the nose may occur. The immediate treatment is to return to the altitude where the pain first became apparent. The flight should then be terminated with a return to ground level at as slow a rate as possible. Note: Unlike otic barotrauma, the pain suffered due to sinus barotrauma may be equally as acute in the climb or the descent (CAE, 2022).

Barotrauma of the teeth (aerodontalgia): Healthy teeth do not contain air but gas pockets can form in old or poor fillings or abscesses. Aerodontalgia is most common in the ascent as the gas expands, perhaps pressing on a nerve, and can cause severe tooth pain. Good dental care and hygiene can prevent any problem (CAE, 2022).

Gastro-intestinal Barotrauma: The gastro-intestinal tract is, in effect a tube from the mouth to the anus. Air can be swallowed along with food and the digestive processes produce gas. Gas collecting in the stomach can easily escape through the mouth whereas at the other end of the system, gas in the large intestine, mostly caused by the action of bacteria, can readily be vented to the outside (known as "passing flatus"). The main problem is gas in the small intestine. It has no easy exit from the system at either end and will expand causing discomfort and sometimes pain sufficiently severe to cause fainting. Very occasionally, the wall of the intestine may tear. There is no easy way to relieve the symptoms during flight except by descending but the effects may be greatly reduced by avoiding foods which are high gas producers (raw apples, cabbage, cauliflower, celery, cucumber, beer, beans, any highly spiced foods such as curries) before flight, eating slowly and not rushing meals, especially just before flight, eating smaller portions (less swallowed air), not using chewing gum (less swallowed air) (CAE, 2022).

Lungs: The lungs contain a large volume of gas but there is easy communication to the outside air, so that pressure changes are rapidly dealt with. The only potential risk is from a very rapid decompression but, provided the individual breathes out during this stage, lung damage is extremely rare. It is worth noting that air trapped within plaster casts will expand and can cause acute distress to the wearer. If in doubt, passengers' casts should be split prior to take-off especially if the flight is to be lengthy (CAE, 2022).

Hypoxic hypoxia is a term for the effects of a shortage of oxygen in the body. This could result from a number of reasons such as extreme anaemia, asthma and meningitis. But the most important reason, as far as pilots are concerned, is altitude. Haemoglobin at sea level is approximately 97.5% saturated with oxygen. At 10,000 ft. this falls to 87% and thereafter falls off rapidly so that, at 20,000ft, the haemoglobin is only 65% saturated with oxygen. The symptoms of hypoxia may develop slowly at lower levels or very rapidly at high altitudes (CAE, 2022).

Hyperventilation can be defined as lung ventilation in excess of the body's needs and denotes an over-riding of the normal automatic control of breathing by the brain. Simply, hyperventilation is over-breathing. That is breathing in excess of the ventilation required to remove carbon dioxide. Over-breathing induces a reduction in the carbon dioxide and thus decreases the carbonic acid balance of the blood. This disturbance of the acid balance has a number of effects, the major one being that haemoglobin giving up its oxygen readily only in an acid medium. Hypoxia does cause hyperventilation but it is far from the only cause. Anxiety, motion sickness, shock, vibration, heat, high G-forces, pressure breathing can all bring on the symptoms of hyperventilation. A high standard of training breeds confidence and decreases the chances of confronting unusual and stressful situations and is, without doubt, the best means of preventing hyperventilation in aircrew (Oxford Aviation Academy, 2008).

Cabin decompression: Loss of cabin pressurization can occur in flight. The rate of loss may be slow, with the crew recognizing the problem and making appropriate height reductions before the passengers are aware of anything amiss. Very occasionally, there is rapid decompression perhaps due to the loss of a window or door, or a failure in the fuselage. Oxygen can be supplied to all occupants but for only a limited period an anxious passenger boarding an aircraft must be closely watched since hyperventilation may take place even whilst still on the ground (CAE, 2022).

Decompression sickness (DCS): As one of the gases making up the major part of the air - nitrogen - is dissolved in the blood to a small extent but plays no part in the normal bodily processes. It may however cause severe problems if the nitrogen should come out of solution as small bubbles. It can be likened to the bubble formation in fizzy drinks when the top of the bottle is opened and the pressure is allowed to drop. If this occurs in the human body, and nitrogen bubbles are formed in the blood, the process leads directly to DCS (CAE, 2022). Body exposure to reduced pressure can lead to DCS since the body is normally saturated with nitrogen. When ambient pressure is abruptly reduced, some of this nitrogen comes out of solution as bubbles. Any ascent to altitudes over 25,000ft is normally associated with DCS, however, it is more likely at the higher and longer the exposure to altitudes above 18,000 ft. It is unlikely to occur below 14,000 ft. ultimately, the individual may collapse and in rare cases, DCS may occur or persist after descent and go on to cause death. Hypoxia and cold increase the risk as does age and excess body mass/obesity. The primary symptoms are bubbles in the joints (shoulders, elbows, wrists, knees and ankles) causing rheumatic-like pains called the bends. In aviation, the shoulder, wrist, knee and ankles are most commonly affected. Movement or rubbing the affected parts only aggravates the pain but descent usually resolves the problem (CAE, 2022). Under the skin the released nitrogen bubbles cause the creeps, where the sufferer feels like a small compact colony of ants are crawling over the body or just under the skin. In the respiratory, system this is known as the chokes. Nitrogen bubbles may get caught in the in the capillaries of the lungs blocking the pulmonary blood flow. This leads to serious shortness of breath accompanied by a burning, gnawing and sometimes piercing pain. The bubbles affect the blood supply to the brain and the nervous system this effect is known as the staggers. The sufferer will lose some mental functions and control of movement. In extreme cases, chronic paralysis or even permanent mental disturbances may result. The secondary symptom is post descent collapse. This may occur up to four hours after the primary symptoms when nitrogen bubbles have combined and therefore not gone back into solution and have reached the heart. The DCS can be avoided by pre-oxygenation before exposure to high altitudes, thus reducing the body store of nitrogen as much as possible (Oxford Aviation Academy, 2008).

G forces; the human body has adapted to live under the force of gravity on the earth (the pull of the earth’s gravity giving the body weight). Acceleration in an aircraft can subject the body to forces much greater than this. For convenience, the forces are measured as multiples of our 1g terrestrial environment. Acceleration in the fore and aft (the horizontal) plane is referred to as Gx, whereas acceleration in the lateral plane (side to side) is known as Gy. However, the usual G force encountered in aviation is that in the vertical plane which is termed as Gz. Effects of positive g force on the human body in long-term positive acceleration, the changes in g force are perceived as: An increase in body weight so that limbs become harder to move, the head becomes heavy (2G and above). Mobility is impaired, for example, if the head is lowered it may be impossible to raise it again. At 2.5G, it is impossible to rise from the sitting position. Internal organs are displaced downwards from their normal positions and the lower facial area feels "pulled down" at 3-4G and above. Blood pressure in the legs and lower body is greater than that at the heart. As the positive g forces increase so the hydrostatic variation increases (CAE, 2022). The result is a pooling of blood in the lower body with a reduced venous return to the heart. There is a consequent reduction of blood pressure in the head and blood supply to the brain, heart and eyes with an increased blood pressure at the feet. The photosensitive cells of the eyes (rods and cones) need a disproportionate amount of oxygen from the blood. Positive g forces reduce the amount of oxygen available, thus causing a 'greying out' (3-4G) as vision is affected. It also induces a tunneling of vision as the eye cells at the edge of the retina, being furthest from the blood supply, suffer first. Eventually, (above 5G) the individual will lose consciousness "black-out" - now more commonly referred to as G-LOC. The effects of blacking-out disappear almost as soon as the g level is reduced although the individual will be confused for a few seconds and may have difficulty in focusing his/her eyes (Oxford Aviation Academy, 2008). Inspiration difficulties are due to the lowering of the diaphragm (4-5G) while loss of sensory functions and cramping of the calf muscles occurs above about 8G. At very high G forces, hemorrhages can occur in legs and feet. At extreme G forces, fracture of the vertebrae and death will occur due to lack of venous return to the heart (CAE, 2022).

5.3.2.2 Other factors captured by the distress thermometer

5.3.2.2.1 Weight concerns among the participants

Obesity tends to be genetic and is in tern an excess of fatty tissue in the body. An individual who is obese is susceptible to heart attack, hypertension (high blood pressure) with the higher risk of a stroke, hypoxia at lower altitudes than normal, general circulation problems, gout (painful inflammation of the joints due to an excess of uric acid), osteoarthritis (wear and tear on the joints), diabetes, G forces, problems with joints and limbs due to weight, decompression sickness (DCS), heavy sweating, chest infections, varicose veins and reduced life expectancy.

Losing weight, if an individual is overweight or obese there are obvious advantages in losing weight. There is no magic formula or secret dietary method to reduce weight. Any food taken in has to be balanced by the energy output. Any excess is stored in the body as fat. The only practical way to lose weight is to eat less from a balanced diet containing the right mix of carbohydrates, protein and fat. The use of "crash diets" must be avoided. They are normally ineffective in the long term and may cause dangerous physical and emotional symptoms. The overall objective must be to introduce new habits of eating, with a change in frequency, size and content of meals. On no account should appetite-suppressants be taken unless under the direct supervision of an Aviation Medical Specialist AMS (CAE, 2022). .

Body exercises promotes both mental and physical fitness and a sense of well-being but the amount of exercise required to burn off excess weight is so high that it is not a practical solution to obesity. Those who do take regular exercise can cope with fatigue much better and their resistance to stress is improved. As pilots are required to sit for long periods of time, regular exercise is of particular importance. To be effective in reducing coronary artery disease, exercise must be regular and sufficient to raise the resting pulse rate by 100% for at least 20 minutes, three times a week. Playing squash or tennis, swimming, jogging and cycling provide good exercise. Playing around of golf or walking the dog may be pleasant but provide insufficient exercise to benefit the individual physically (Oxford Aviation Academy, 2008).

5.3.2.2.2 Nervousness among participants

One of the key informants in aviation training noted that;

"Operators should note that the crew is worried and nervous. They are not involved in organizational planning and briefing is insufficient. Training, knowledge and skills on required machines are lacking. Poor decision making, lack of motivation, poor crew resource management and lack of periodic checks are also a problem. So refresher training in key aeronautical areas is highly recommended"

This was also one of the biological elements captured by the distress thermometer; it is highly affected by nutrition and food hygiene. Healthy diets most especially a balanced diet is the foundation of good health. A high-carbohydrate/fiber and low-fat diet can reduce the risk of coronary heart disease, stroke, diabetes and certain forms of cancer. Sources of carbohydrates include grains, vegetables, nuts, potatoes and fruits and should make up more than 50% of the calories consumed. The rest should come from lean meats and poultry, fish and low-fat dairy products. Never miss breakfast - it is the most important meal of the day. Medical authorities state that breakfast should supply about 25% of the daily calorie intake. Never wait until you get on board the aircraft to eat. Not eating regular meals or fasting can result in low blood sugar (Hypoglycemia) (below about 50 mg per 100 ml of blood). Its symptoms are: headache, stomach pains, lack of energy, nervousness, shaking, sleepiness, lack of concentration and fainting. Hypoglycemia can be relieved in the short term by eating a snack (CAE, 2022)

5.3.2.2.3 Tropical diseases and medical hazards

Aircrews are responsible for arranging their own vaccinations against the communicable diseases. If travelling for the first time to areas where these may be found, a medical brief should be arranged prior to travel (CAE, 2022). It is also notable that the side effects of vaccination can last weeks before resolution.

Approximately two thirds of the cabin air in modern airliners is re-circulated which can in itself cause health problems such as legionnaires disease and be associated with the spread of other infections/ diseases. Malaria is still considered as one of the world's biggest killers. It is responsible for the death of about 1 million infants and children every year in Africa. The symptoms include recurrent cyclic fever, uncontrolled shivering and delirium and must be treated in hospital (Oxford Aviation Academy, 2008).

In summary, the distress thermometer is a viable tool that can be further modified to detect current and existing aeromedical risks. It does a pre-flight and on ground assessment of the current state of the crew before they embark on a task. This is similar to Steinkraus *et al*., 2012 suggestion in the F-22 and U-2 examples which reemphasized that, the best aeromedical assessment is functional—observing flyers performing duties in flight while tracking behavioral and physiologic parameters. Flight surgeons flying with their crews understand this concept. It is noted that the aviation system cannot put a flight surgeon on every mission, but perhaps it is time to put an analogue on board—a system that will give information that translates to better safety and performance. In short, human factor (human factors) obviously impacts on aviation safety, covering medical, psychological, ergonomic, educational aspects of the professional environment. Aviation psychology, for its part, among the other sciences of human factor is aimed at development of practical recommendations, including prevention of aircraft accidents (Lyssakova, 2019).

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The first objective identified and classified documented human factors related accidents and incidents in Eastern Africa Aviation Operations using HFACs analysis. Findings showed that the region's operations have unsafe acts as the highest category. Pre-conditions for unsafe acts followed closely after the unsafe acts. The commonest unsafe acts were exceptional violations and skill based errors (manner or skill with which one flies). Examining existing human factors risks in the region's aviation operations showed quality control analysis and troubleshooting abilities, did account for the ability to predict skills required for the job.

Objective two examined aeromedical risks in the region's aviation operations and finding showed that the aeromedical factors affecting performance included; sleep, high levels of anxiety, shortness of breath and cigarette smoking.

The objective 3 designed a GIS tool which was able to capture latent human factors risks as the study revealed selected factors leading up to a LOC accident triggered by external environmental factors, predominantly meteorological and terrain. Human performance deficiencies frequently compounded the initial upset and precluded an effective recovery until it was too late; automation and flight mode confusion, distraction, startle effect and loss of situational awareness. While the distress thermometer was able to capture active risks which included time pressure and deadline, pain, sleep, fatigue, worry and nervousness. Problem solving could be predicted from a linear combination of the independent variables: sleep, high levels of anxiety, shortness of breath and cigarette smoking.

6 .2 RECOMMENDATIONS

6.2.1 Recommendations for further research

Further research is needed to address gaps in the records and literature of the region with the need to understand the interactions of various human factors and combining the effects of these interactions on human performance, limitations and error.

Accident and incident reports in Uganda, be made readily available to the public on the Ministry of Works website like is the case for Kenya and Rwanda.

Aviation training should give scientists a chance to carry out studies in occupational medicine and physiology, so as to enrich the relevant literature that is currently scarce, an indicator of the need for more work in this direction.

6.2.2 Recommendations to policy makers and aviation operators

The GIS tool and distress thermometer are viable tools that can be further modified to detect latent and active human factors risks. They can be used for pre-flight and on ground to assess the current state of the environment and the crew before one embarks on a task.

Training and its evaluation should be progressively reemphasized by the respective authorities to increase individual’s skills and further reduce the emerging unsafe acts.

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Classifying Emerging Human Factors Risks in Eastern Africa Aviation Operations using HFACS analysis

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Abstract

Aviation safety in the African region has continued to be a concern for the International Civil Aviation Organization (ICAO) and the industry as a whole. Accident statistics show Africa's accident rate at 5.3 per one million departures with 3% of the worldwide traffic distribution (ICAO, 2013). Human error has been suggested to account for 70–80% of all aviation accidents. The Human Factors Analysis and Classification System (HFACS) methodology was applied to accident reports from two Eastern African countries: Kenya and Uganda. In all, 42 finalized reports for accidents occurring between 2000 and 2017 were analyzed. In all unsafe acts predominated with Kenya 44%, Uganda 50%. Categorizing violations found exceptional violations were highest with Kenya at 77% and Uganda 81%. Pre-conditions for unsafe acts follow closely after the unsafe acts. A comparison between Kenya and Uganda's HFACs analysis shows that both countries share two significant categories of unsafe acts (Breakdown of Visual scan x Vestibular Illusions and Poorly Executed procedures x Misinterpretation/misuse of information) with positive correlation coefficients. The rest of the shared categories are unsafe acts versus pre-conditions for unsafe acts (Forgotten Intensions x Crew Resource Management), unsafe supervision versus pre-conditions for unsafe acts and unsafe supervision versus pre-conditions for unsafe acts. The results were consistent with previous industry observations: Over 70% of aviation accidents in Africa have human factor causes. Adverse weather was seen to be a common secondary casual factor. Changes in flight training and risk management methods may alleviate the high number of accidents in Africa.

Keywords: Aviation, Aviation accidents, Eastern Africa, Human Factors, HFACs

INTRODUCTION

Many authors have done research and written reports about different accidents and incidents worldwide caused by human factors. In the Eastern Africa region, these human factors are not elaborately investigated and documented partly because common aeromedical conditions are not detectable at autopsy (hypoxia, spatial disorientation, fatigue, stress), complicating ability to indict medical causation. The persistent conclusion that developing countries have much poorer safety records has been the case in aviation safety research and continues to be so (ICAO, 2014). The Swiss cheese model stipulates that accident investigators must analyze all aspects of the system to fully understand the causes of accidents and improve safety. For example, if you go backwards from the moment of the accident, unsafe acts of cockpit crew will be the first level to be examined. Reason's model directs accident investigators to find hidden errors, from this point of view the model mentions additional levels of errors that could lead to an accident.

Human factors work has been done elsewhere but not in the Eastern Africa region. It is important to identifying emerging risk factors, characterize these risks through modeling exposure and consequences, prioritize the risk and make recommendations with regard to necessary improvements (GAO, 2012, Oster, 2013). That understanding is then translated into design, training, policies, or procedures to help humans perform better, and design airplanes and support products that help humans to perform to the best of their capabilities while compensating for their natural limitations.

METHODOLOGY

Document review analysis which involved the relevant information from final accident and incident investigation reports was done. A documentary review checklist consisting of all documentation about aviation final accidents and incidents investigation reports from Kenya and Uganda was examined and reviewed for selection of human factors related causes. The selected reports included those for aircrafts registered within Eastern Africa (Figure 1) and beyond but having accident or incidents occurring within Kenya and Uganda between 2000- 2017. Accidents and incidents involving human errors were then categorized by 4 types of personnel (ground crew, Air Traffic Controllers (ATC), maintenance and aircrew) who had direct or indirect influence on the occurrences. The contributing factors of the occurrences were coded into of Human Factors Analysis classification system (HFACS) categories based on the probable causes in each report. These HFACs levels are as follows; level 1 - unsafe acts, level 2 - preconditions for unsafe acts, level 3 - unsafe supervision, level 4 - organizational influences (Shappell & Wiegmann, 2003). The coding started from higher levels of failure to sub-categories, mapping each causal factor mentioned in the report to the HFACS categories (Yan & Histon, 2014). The analysis of the data consisted of two parts. In the first part, the data which was obtained after coding was explained in detail, with graphics and tables. The second part of analysis, was to transfer the data to SigmaPlot program and establish the nature of relationship between "Causal Factors" of HFACS which were examined. As a result, the relationship between operations and organizations in aircraft accidents was examined and visualized.

RESULTS

Table 2 below indicated the target group categories of HFACS in Kenya nd Uganda.

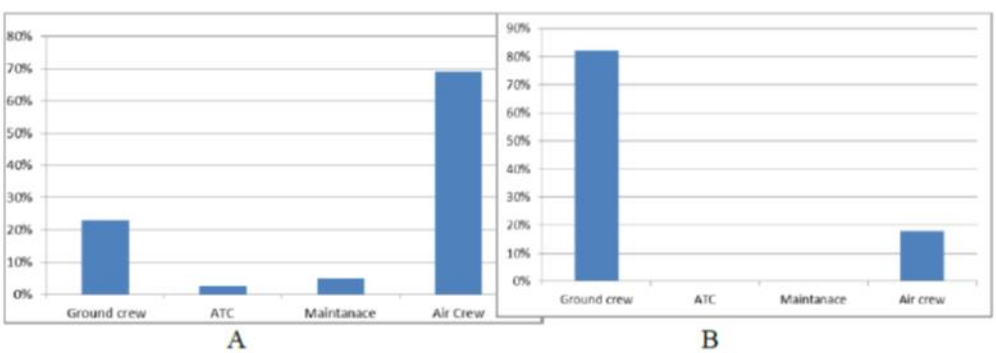


Figure 2: The four main target group categories of HFACS in A Kenya and B Uganda

causal and contributory factors. In line with Shappell and Wiegmann's (1997) observation, 76% of African aviation accidents were related to human factors (Munene 2016). His findings show of the 55 accidents analyzed in Kenya, Nigeria and South Africa (2000- 2014) unsafe acts of the pilot operators were observed, 56.4% (31) of them exhibited skill-based errors, making it the most common category of human factor failure. The similar findings in the current study show Kenya 44% and Uganda 50% on skilled based error. These errors were observed in a majority of South Africa's accidents (82%), an indicator of its prevalence in Africa's accidents.

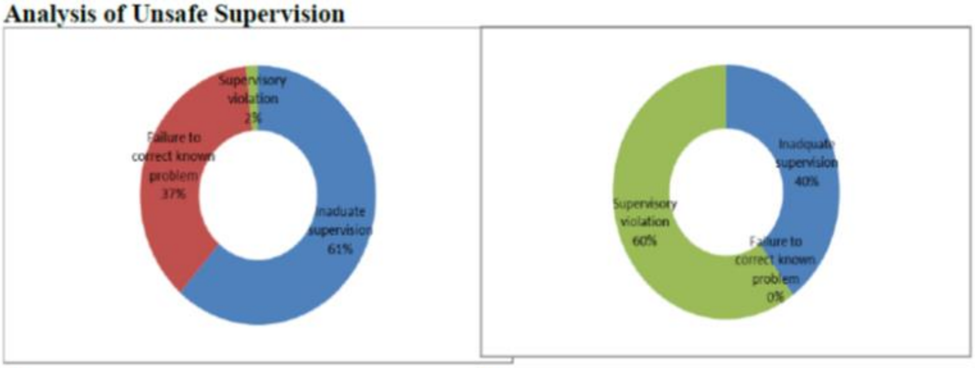
Analysis of precondition for unsafe Acts

Table 2: Preconditions for unsafe acts in both Kenya and Uganda

Preconditions for unsafe acts	Kenya (%)	Uganda (%)
Substandard conditions of operation		
Adverse mental states	11%	14%
Adverse physiological states	33%	21%
Physical/Mental limitations	51.9%	35.7%
Substandard practices of operation		
Crew resource management	3.7%	14%
Personal readiness	0%	14%

The table 2, shows preconditions for unsafe acts has physical/ mental limitations at 51.9% for Kenya and 35.7% for Uganda. This is followed by adverse physiological states with Kenya at 33% and Uganda at 21%. Adverse mental states follow with Kenya at 33% and Uganda 21%, least were Crew Resource Management (CRM) and personal readiness respectively.

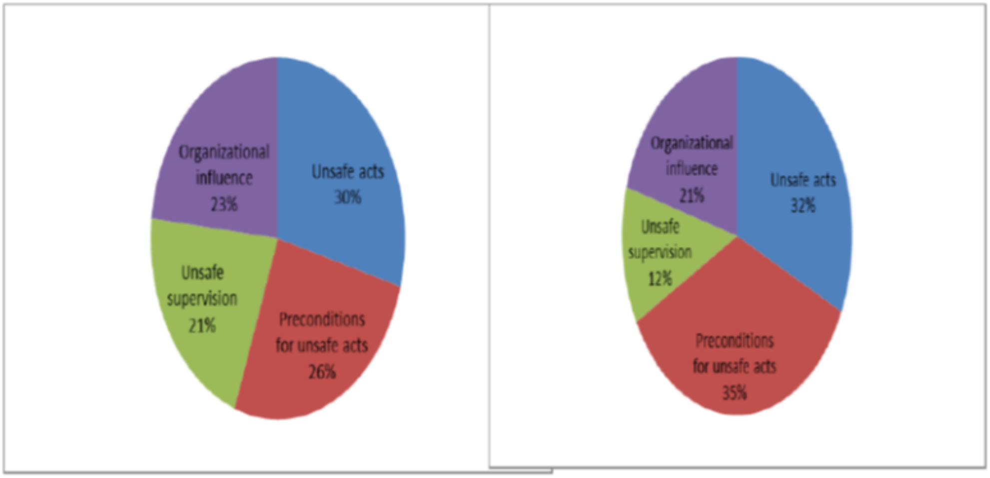
Analysis of Unsafe Supervision



A B

Figure 6: Percentage of unsafe supervision for A. Kenya and B. Uganda

The figure 7 below shows organizational influences with resource/ acquisition management for Kenya at 43% and Uganda at 50%, the contribution of organizational process in Kenya at 48% and Uganda at 13%. Organizational climate factor is relatively high in Uganda at 37% as compared to Kenya at only 9%.

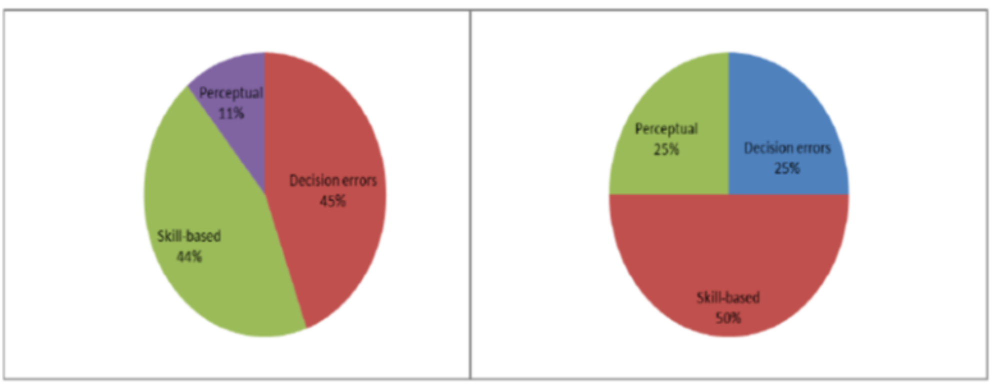


A B

Figure 3: The ratio of four main factors of HFACS affecting each other in A. Kenya and B. Uganda

Unsafe acts analysis

These were examined in the two categories: Errors and violations. As a result of analysis and coding the ratio of unsafe acts is given Figure 3 bellow.



A B

Figure 4: Percentage of errors for A. Kenya and B. Uganda

Table 1: Errors in both Kenya and Uganda

Decision errors	Kenya (%)	Uganda (%)
Poorly executed procedures	37.5%	0%
Improper choices	37.5%	50%
Misinterpretation or misused information	25%	0%
Skill-based errors		
Break down of visual scan	0%	0%
Inadvertent activation/deactivation	25%	0%
Forgotten intentions	12.5%	33.3%
Omitted items on checklist	12.5%	33.3%
Manner or skill with which one flies	50%	33.3%
Perceptual error		
Misjudging distance	50%	50%
Visual illusions	50%	50%
Vestibular illusion	0%	0%

The table 1 above shows, the highest proportion of decision errors was the improper choices with Kenya at 37.5% and Uganda at 50%. Poorly executed procedures were next with Kenya at 37.5% and lastly misinterpretation/ misuse of information at 25%. (Note that percentages will not add up to 100% because each accident typically associated with multiple causal factors across several causal categories).

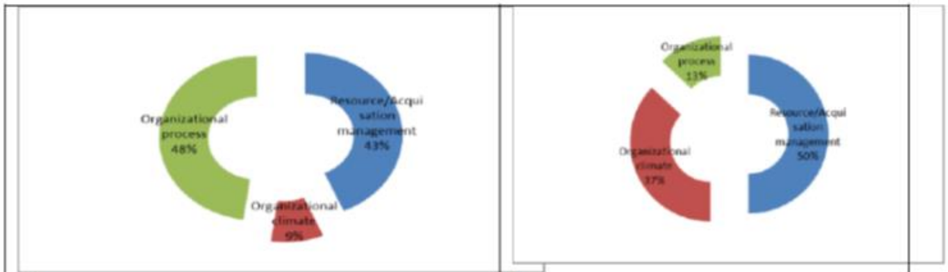
When skill-based errors were examined, the commonest of all decision errors was the manner with which one flies with Kenya at 50% and Uganda at 33.3%. Other factors with high rates were inadvertent activation/deactivation of controls with Kenya at 25%, forgotten intensions and omitted items on the checklist had same ratings of Kenya 12.5% and Uganda 33.3%. When the perceptual errors were examined, misjudged distance/altitude/airspeed factors and visual illusions were both seen at Kenya 50% and Uganda at 50%.

A B

Figure 5 shows percentage of violations for A. Kenya and B. Uganda

The figure 5 shows the most frequent types of violation were exceptional violations with Kenya at 77% and Uganda 81%. Routine violations were lower with Kenya 23%and Uganda 19%. This tallies with Munene 2016 who classified a total of 55 of the 72 civil accident investigation reports involving aircraft occurring within Africa irrespective of ownership or country of registration were selected for analysis. The numbers per country were as follows: Kenya, 11 of 14; Nigeria, 10 of 13; and South Africa, 34 of 45. These reports were considered to have one or more human factors as

Analysis of organizational influences



A | B.

Figure 7: Percentage of organizational influence for A. Kenya and B. Uganda

Relationship analysis

Table 3: Kenyan data analysis for the various HFACs levels

	Correlation Value	p-Value
Level 4 x Level 4		
Resource management x Organizational Climate	0.381	0.0347
Level 4 x Level 2		
Adverse Mental state x Resource Management	0.381	0.0347
Level 3 x Level 2		
Physical and Mental states x Supervisory violations	0.411	0.0219
Crew Resource Man agent x Failure to correct known problem	0.558	0.00120
Level 3 x Level 1		
Forgotten intensions x Failure to correct known problem	0.558	0.00120
Misinterpretation/ misuse of information x Failure to correct known problem	0.358	0.0478
Misjudgment of distance x Inadequate Supervision	0.416	0.0200
Level 1 x Level 2		
Vestibular Illusion x Personal Readiness	1	0.0000002
Breakdown of Visual scan x Personal Readiness	1	0.0000002
Forgotten Intensions x Crew Resource Management	1	0.0000002
Misinterpretation/ misuse of information x Crew Resource Management	0.695	0.00000455
Poorly Executed Procedures x Crew Resource Management	0.558	0.00120
Manner or skill of flying x Adverse Physiological state	0.390	0.0303
Level 1 x Level 1		
Routine Violation x Exceptional Violation	0.512	0.00343
Omitted items in the check list x Routine Violation	0.558	0.00120
Inadvertent Activation X Routine Violations	0.358	0.0478
Improper choices x Exceptional Violations	0.411	0.0220
Improper Choices x Routine Violations	0.358	0.0478
Breakdown of Visual scan x Exceptional Violations	1	0.0000002
Inadvertent Activation x Misjudgment of distance	0.695	0.00000455
Inadvertent Activation x Omitted items in the checklist	0.695	0.00000455
Misinterpretation/ misuse of information x Forgotten intentions	0.695	0.00000455
Improper Choices x Omitted items in the checklist	0.695	0.00000455
Poorly executed procedures x Forgotten intentions	0.466	0.00859
Poorly executed procedures x Misinterpretation/misuse of information	0.358	0.0478

The pair(s) of variables with positive correlation coefficients and P values below 0.050 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, *one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables.*

A comparison at different HFACs categories shows that Kenya has more human factors risks at unsafe acts level1 x level1 with 12 categories having significant positive correlation coefficients and $p < 0.05$. This is followed by unsafe acts versus pre-conditions for unsafe acts Level1 x level2 which has 6 categories. The least number of risks are recorded at organizational influences level4 x level4 with only one significant category.

Table 4: Ugandan data analysis for the various HFACs levels

	Correlation Value	p- value
Level 4 x Level 3		
Inadequate Supervision x Organizational Process	0.671	0.0201
Level 4 x Level 1		
Manner or skill with which one flies x Organizational Process	1	0.0000002
Routine violations x Organizational Climate	0.671	0.0201
Visual Illusions x Organizational Climate	0.671	0.0201
Level 3 x Level 2		
Physical and Mental Limitations x Supervisory Violations	0.671	0.0201
Level 3 x Level 1		
Vestibular Illusions x Failure to correct known problem	1	0.0000002
Breakdown of visual scan x Failure to correct known problem	1	0.0000002
Misinterpretation or misuse of information x Failure to correct known problem	1	0.0000002
Poorly executed procedures x Failure to correct known problem	1	0.0000002
Manner with which one flies x Inadequate Supervision	0.671	0.0209
Omitted items on checklist x Inadequate Supervision	0.671	0.0209
Level 2 x Level 1		
Omitted items on the checklist x Personal Readiness	0.671	0.0209
Inadvertent activation of switches x Personal Readiness	0.671	0.0209
Misjudgment of Distance x Crew Resource Management	0.671	0.0209
Forgotten intentions x Crew Resource Management	0.671	0.0209
Misjudgment of Distance x Adverse Mental States	0.671	0.0209
Forgotten Intensions x Adverse Mental States	0.671	0.0209
Level 1 x Level 1		
Visual Illusions x Routine Violations	1	0.0000002
Breakdown of Visual scan x Vestibular Illusions	1	0.0000002
Misinterpretation/ misuse of information x Vestibular Illusions	1	0.0000002
Poorly executed procedures x Vestibular Illusions	1	0.0000002
Forgotten Intensions x Misjudgment of Distance	1	0.0000002
Improper Choices x Misjudgment of Distance	0.671	0.0209
Improper Choices x Forgotten intensions	0.671	0.0209
Misinterpretation or misuse of information x Breakdown of Visual scan	1	0.0000002
Poorly Executed Procedures x Breakdown of Visual scan	1	0.0000002
Poorly Executed Procedures x Misinterpretation /misuse of information	1	0.0000002

The pair(s) of variables with positive correlation coefficients and P values below 0.050 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables.

A comparison at different HFACs categories shows that Uganda has more human factors risks at unsafe acts level 1 x level 1with 10 categories having significant correlation coefficients with $p < 0.05$. This is followed by unsafe acts versus preconditions for unsafe acts Level 1 x level 2 with 6 categories of correlating factors at $p < 0.05$ and unsafe acts versus unsafe supervision level 1x level 3 with 6. The least number of risks are recorded at organizational influences level 4 x level 3 with only 1 significant correlation.

Table 5: Comparison of Kenya and Uganda data analysis for the various HFACs levels

	Value	p-Value	Value	p- Value
Level 3 x Level 2	Kenya	Kenya	Uganda	Uganda
Physical and Mental limitations x Supervisory violation	0.411	0.0219	0.671	0.0209
Level 3 x Level 1				
Misinterpretation/ misuse of information x Failure to correct known problem	0.368	0.0478	1	0.0000002
Level 2 x Level 1				
Forgotten Intensions x Crew Resource Management	1	0.0000002	0.671	0.0209
Level 1 x Level 1				
Breakdown of Visual scan x Vestibular Illusions	1	0.0000002	1	0.0000002
Poorly Executed procedures x Misinterpretation/misuse of information	0.358	0.0478	1	0.0000002

The pair(s) of variables with positive correlation coefficients and P values below 0.050 tend to increase together. For the pairs with negative correlation coefficients and P values below 0.050, one variable tends to decrease while the other increases. For pairs with P values greater than 0.050, there is no significant relationship between the two variables.

A comparison between Kenya and Uganda's HFACs analysis shows that both countries share two significant categories of unsafe acts level 1- level 1 with positive correlation coefficients and $p < 0.05$. The rest of the shared categories are unsafe acts versus pre-conditions for unsafe acts level 2 x level 1, unsafe supervision versus pre-conditions for unsafe acts level 3 x level 1and unsafe supervision versus pre-conditions for unsafe acts level 3 x level 2.

Table 6: Comparison of Kenya data analysis for the various HFACs with 17 countries worldwide Dönmez, K., Uslu, S. (2018)

	Kenya	Kenya	Worldwide	Worldwide
Level 3 x Level 2	Value	p- value	Value	p- value
Crew Resource Management x Failure to correct a known problem	0.558	0.0012	0.506	0.000

Table 7. Comparison of Uganda data analysis for the various HFACs with 17 countries worldwide Dönmez, K., Uslu, S. (2018)

	Uganda	Uganda	Worldwide	Worldwide
Level 4 x Level 3	Value	p- value	Value	p- value
Organizational Process x Inadequate Supervision	0.671	0.0209	0.654	0.000
Adverse Mental States x Skill Based Errors	0.671	0.0209	0.307	0.009

The above comparison in table 7 shows that Kenya shares significant HFACs risks at the level of pre-conditions for unsafe acts versus unsafe supervision level 2 x level 3. While Uganda shares significant HFACs risks at unsafe supervision versus organizational influences with 17 countries worldwide.

DISCUSSION

Unsafe Acts: These were examined in the two categories: Errors and violations. Table 3, 4 and 5 depicts a level of poor performance of tasks/teamwork, forgotten intentions and vestibular illusions in both countries. Based on Prof James Reason's findings in Human Factors a high level of unsafe acts in both countries is due to: Latent conditions which are inevitable flows in the system that will eventually lead to error e.g. poor design, procedures or management. Or due to active failures which are frequently caused by unsafe actions by people involved in the safety system. This is due to a lack of situational awareness by the respective crew. Situational awareness relates to how aware the individual is of their surroundings and the task unfolding in real time. Our heightened level of concentration on a particular task may divert attention away from other seemingly less important areas or tasks. This could be due to direct violation of systems or due to insufficient training and poor planning. This is further justified by Munene (2016) who observed violations at 36% of Kenya's accidents with instances where the pilots did not follow company procedures or policies for operations, exceeded the aircraft manufacturer's demonstrated performance capability, or failed to prepare adequately for the flight they performed.

Edwards (2013) notes that most human factors impact situational awareness and may then affect human performance. Endsley and Rodgers (1996) concluded that attention distribution strategies may sometimes lead to reduction in situational awareness. If attention is not directed to certain key information in the environment, situational awareness cannot be maintained. Subsequently the reduction in situational awareness is likely to lead to a decline in human performance. Most human factors impact situational awareness and may then affect human performance. The relationship between workload and stress may also be relevant to the interaction of situational awareness and workload. Martins, *et. al.,* (2014) states that the flaws in the commitment of decision-making in emergency situations and the lack of perception related to all elements associated with a given situation in a short space of time indicate, often lead to lack of situational awareness. Martins, *et. al.,* (2014) further stipulates that this scenario contributes to emotional disorders and a growing hidden problem in the aeronautical field. He also states that the unexpected automation surprises reflect a complete misunderstanding or even the misinformation of the users. It also reveals their inability and limitations to overcome these new situations that were not foreseen by the aircraft designers.

Misinterpretations and forgotten intentions are depicted in Table 3 and 4: These arise due to communication problems which include; lack of communication brought about when a person forgets to pass on pertinent information to colleagues, or when a written message is mislaid. Poor communication is typified by a person who does not make the message clear; does not emphasize what the receiver needs to know and consequently receives inappropriate information, or a written report is barely legible handwriting. Sternberg (2000) further states that the mind of the pilot is influenced by cognition and communication components during flight, especially if we observe all information processed and are very critical considering that one is constantly getting this information through their instruments. There is information about altitude, speed and position of one's aircraft and the operation of its hydraulic power systems. If any problem occurs, several lights will light up and warning sounds emerge increasing the volume and type of man-machine communication which can diminish the perception of detail in information that must be processed and administered by the pilot. All this information must be processed by one's brain at the same time as it decides the necessary action in a context of very limited time. There is a limit of information that the brain can deal with which is part of natural human limitation. It can lead to the unusual situation in which, although the mind is operating normally, the volume of data makes it operate in overload, which may lead to failures and mistakes if we consider this man as a biological machine. Communication is a prominent factor that impacts situational awareness. Koester (2003) investigated situational awareness and results showed that at potentially critical situations, relevant communication types increased and general communication dropped.

Precondition for Unsafe Acts: While unsafe acts can lead to the largest single cause of aircraft accidents, the analysis of the preconditions for unsafe acts is just as important. These preconditions could be due to direct violation of systems or due to insufficient training and poor planning for example starting a task without planning how best to do it almost certainly leads to an error. It is important to note that pre-conditions for unsafe acts always follow closely after the unsafe acts.

Analysis of Unsafe Supervision also has contribution to the cause of aircraft accidents and incidents in the study region, this can be attributed to the cockpit crew controlling the aircraft. However, there may be errors and violations made by the managers and supervisors, behind the causes of aircraft accidents.

Organizational influences are the last of the HFACS levels and it shows us how the top-level organization or management has an impact on aircraft accidents. These reports were considered to have one or more human factors as causal and contributory factors.

CONCLUSSION AND RECOMMENDATIONS

Unsafe acts followed by preconditions for unsafe acts still dominate in the study region. This research sought to identify the contributory human factors to the selected accidents. The selection of the two countries' accident and incident data aimed to capture the diversity of Eastern Africa aviation human factors risks. The limited number and access to accident reports for Uganda shows a need for African countries to follow other countries' lead in having a robust aviation safety organization that investigates and documents for their accidents. The low number of accident reports from Uganda is a limitation for the study and therefore is considered an initial step in understanding human factors as contributors to accidents in Africa. A larger dataset and multiple coders should be used in future research. Accident and incident reports in Uganda, be made readily available to the public on the Ministry of Works website like is the case for Kenya.

BIODATA

Florence Nassimbwa (MSc. Molecular Biology) is a Biologist (Lecturer) and an instructor (FOO) at DAS Aviation School, Entebbe and a PhD candidate in Biological sciences at Kyambogo University. I have knowledge and experience in Biological sciences and in Aviation Human Performance and Limitations (Human Factors).

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Existing Human factors Risks in Eastern Africa Aviation Operation: Focus on skill Risks and Aeromedical factors. A Cross-sectional Study.

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Abstract

Background:

Aviation safety in the Africa region has continued to be a concern for the International Civil Aviation Organization (ICAO) and the industry as a whole. ICAO's 2012 accident statistics show that Africa had an accident rate of 5.3 per one million departures with 3% of the worldwide traffic distribution. A study set out to examine the existing human factors risks in the region's aviation operation with a particular focus on skill and aeromedical risks exist in the Eastern African region.

Methodology:

A cross-sectional study research design was used with quantitative methods of data collection applied; perceptual information was collected by the use of a survey.

Results:

Four categories of variables investigated skills required for the job and had a positive moderately strong correlation with values between 0.4-0.6 and were statistically significant with $p < 0.05$. Another four had a weak positive correlation which is less than 0.4. Eleven out of fifteen categories of the aeromedical variables had a positive moderately strong correlation with values between 0.4-0.6. Four had a weak positive correlation which was less than 0.4. Results did show current skill-related risks in public safety, operations monitoring, quality control, troubleshooting, design and telecommunications, and public safety. Most of the above skills had a direct correlation with each other.

Conclusions:

Aeromedical factors affecting performance included fitness and health, stress, time pressure, and deadlines, sleep-related issues, fatigue, cigarette smoking, alcohol, pain, and nervousness.

Recommendations:

There is a need for redefining human factors risks in Eastern Africa and incorporating them in the curriculum at all levels to ensure that individuals are capable of functioning effectively and safely in a range of situations and environments continuous as well as aeromedical assessment should be designed to fully capture the existing skill related and aeromedical risks in the region and improve the region's safety record.

Keywords: Aeromedical factors, Eastern Africa, Human factors, Human Performance and Limitations, Skills Background, Date Submitted: 2022-09-02 Date Accepted: 2022-09-22

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1. Background

Aviation, safety performance has not been evenly distributed across all segments of commercial aviation, nor among all countries and regions

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of the world. (International Civil Aviation Organization [ICAO], 2014) African aviation safety is a continuous concern to ICAO and the aviation industry, with a 3% accident rate at 5,300,000 departures per million (ICAO 2013). (Munene, 2016).

Unfortunately, reliable fatality rates for many aviation operators worldwide are not readily available and this makes safety improvements in these regions quite hard. (ICAO, 2014).

Accidents are occurring for various reasons and human error is cited as the cause of over 70% of these accidents. Understanding human psychology and physiology helps us to put in context how an understanding of human limitations and capabilities contributes to the improvement of flight safety through the reduction of human error (Badshaw, 2001). Martins, *et. al.*, (2014) note that most accident investigations conclude that human is guilty at a rate as high as 80%. Usually, when an accident or incident occurs, the pilot is pinpointed as the guilty party even before the establishment of facts and thorough investigations are done. The readings of the Black Boxes show that 70% to 80% of accidents are due to human error or as a result of failures related to human factors. (FAA, 2010).

Human factors is a popular term in the commercial aviation industry since it is now known that error is the cause of many aviation accidents and incidents and not mechanical failure. Human factors cover the understanding of human limitations and capability, this understanding is later applied in the deployment and design of systems and services It is multidisciplinary and attains information and conclusions by working with the fields of industrial design, operations research, engineering, psychology, statistics, operations research and anthropometry. The various disciplines in human factors include Computer Science, Cognitive Science, Experimental Psychology, Clinical Psychology, Organizational Psychology, Educational Psychology, Anthropometrics, Medical Science, Safety Engineering, and Industrial Engineering. The study of human factors is complex and does not solve errors immediately or cause an instant change in a given situation.

The classic term, "pilot error" or "human error", is attributed to accidents or incidents over 75% of the time (Phillips, 1994). This needs to be put in context with regards to developing countries that have much poorer safety records as compared to others and so there is a need to determine the existing human factors risks in Eastern Africa region.

The Eastern African region is a substandard performer in aviation safety. In the region existing human factors risks are not elaborately investigated and documented partly because common aeromedical conditions are not detectable at autopsy (hypoxia, spatial disorientation, fatigue, stress), complicating the ability to indict medical causation. There are relatively poor records about the safety implications of aeromedical variables such as distress, fatigue, spatial disorientation, or mild hypoxia. No dynamic assessment processes have been done to assess the effects of hazards such as distress, hypoxia, fatigue, workload, and spatial disorientation on performance. Dynamic processes are important in accident chains but are generally not detectable post-flight or post-crash. Furthermore, aerospace medicine assessment tools are very necessary for aviation but they are not evolving with the aerospace environment. Shortcomings with these tools are at the pre-flight selection and retention level and in-flight retention, selection, performance, and enhancement level. Hence the need for a study of the existing human factors risks in the region's aviation operations including existing skills-based human factors risks and aeromedical risks in the region.

Much as there are different reasons why aircraft accidents occur, studies reveal that most of these causes are related to human factors and not technical failures. Enormous resources and efforts are needed when undertaking accident and incident investigations. This is not a total loss because the information gained from such investigation work is greatly improving aviation safety by reducing causes of similar accidents and incidents in the future. Safety is improved through investigating each accident independently, then learning from it and ensuring that similar accidents do not occur. Looking at the causes of accidents in a broad sense and comparing them across regions and countries over time gives great gain to the aviation industry (Oster, 2013). The purpose of this study was to identify existing human factors risks in the East African region, characterizing these risks through modeling exposure and consequences, prioritizing the risks, and making recommendations about necessary improvements and what factors contributed to the accident is very important. (GAO, 2012, Oster, 2013). Information from such studies is used to inform the designing of aircraft, structuring of aviation training, and the making of policies and procedures which help humans perform better, perform with better capabilities while lowering the natural limitations, in turn, it will help in making key decisions that will improve safety in the study region. Understanding when accidents are most likely to occur helps target approaches to improve safety, but to reduce accidents it is also necessary to try to determine why they occur.

2. Methodology

Study design:

A cross-sectional study research design was used where quantitative methods of data collection were applied; perceptual information was collected by the use of a survey.

Setting:

The study countries: Kenya and Uganda were selected based on their central location in the Eastern Africa region.

Sample:

The first step involved a purposive selection of 43, operators with valid licenses, trainers, and employers from Kenya and Uganda for the period between 2018 and 2020. A purposive sampling procedure was used to draw a representative sample of aviation stakeholders. The target sample included Aviation Managers, Employers, Pilots, Student Pilots, Flight Instructors, Air Traffic Controllers (ATC), Ground Operators, Engineers, Safety officers, and Security.

Methods and tools:

Questionnaires; structured self-administered questionnaires with an informed consent form were administered to different members in each study group, who were key informants, supervisors, and employers. The questionnaire tool contained open-ended and closed-ended categories of questions intended to collect qualitative and quantitative data when filled in by respondents. The questionnaires used in this research were generated based on research objectives and the dimensions of the independent and dependent variables and structured into sections for ease of capture of data. The questions asked reflected on the different aspects of human physiology in Human Performance and Limitations related to daily operations, aviation incidents, and accidents.

Variables:

Knowledge, skills, and aeromedical factors of trained aviation personnel in the region were established using questionnaires and guiding question tools.

Bias:

Some of the ethical considerations in this research were; written consent of respondents was sought from each respondent before engagement; confidentiality was ensured when interacting with the respondents and disseminating information, and all information given by respondents was handled with confidentiality. Respondent anonymity – all addresses and contacts as well as names of respondents remained anonymous during and after the study.

Data analysis:

Involved coding the data and subjecting it to the statistical package SigmaPlot. Analysis of binary variables was done with correlation to investigate associations between different factors.

3. Results:

The above figure showed that both female participants from Kenya and Uganda were less than the males.

Uganda had most of its participants between the ages of 26- 35 while Kenya had most of its participants between 36- 45 years of age. It is

Figure 1: Gender comparison of participants from Kenya and Uganda

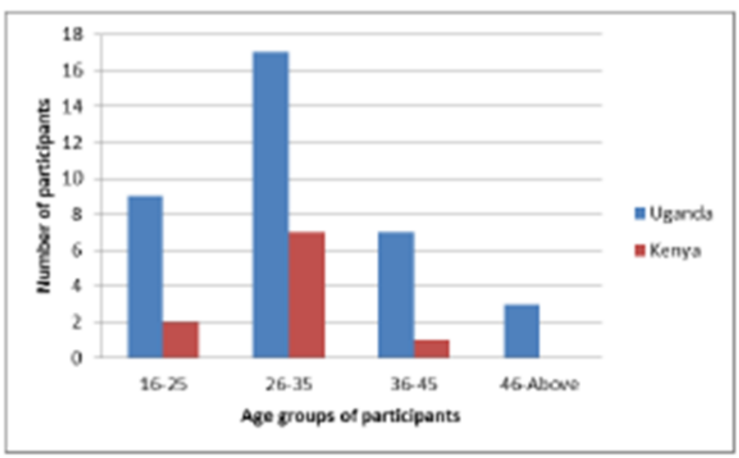

Figure 2: Comparison of age groups between participants from Kenya and Uganda

September 27, 2022

worth noting that Uganda had some participants above the age of 46.

Figure 3 showed that the largest number of participants from Kenya were pilots and engineers followed by ATC, flight operators, and management. In Uganda, a big percentage of participants were engineers, followed by pilots, managers, and lastly flight operators.

The highest level of education for participants from Kenya and Uganda was mainly at the license level. This was followed by diploma holders and lastly those with other qualifications like seminars and certificates.

Skill based risks

The highest level of human performance training for participants from Kenya and Uganda was mainly at a basic level. This was followed by certificate holders, diplomas, elementary, and lastly those with no qualifications.

The table 1 closely analyzed the correlation among different skills required for the job among the participants from both countries. Four categories of the variables had a positive moderately strong correlation with values between 0.4-0.6 and were significant with $p < 0.05$. Another four had a weak positive correlation which is less than 0.4 and was significant with $p < 0.05$.

Aeromedical risks

The table 2 closely analyzed the correlation between different aeromedical factors among the participants from both countries. Eleven out of fifteen categories of the above variables had a positive moderately strong correlation with values between 0.4-0.6 and were significant with $p < 0.05$. Another four had a weak positive correlation which was less than 0.4 and was significant with $p < 0.05$.

This shows that 38 out of the 43 participants had issues with their weight, 30 out of 43 consumed alcohol 27 of the participants were cigarette smokers and only 3 had shortness of breath.

4. Discussion:

The results in table 1 showed that there was a direct correlation between public safety, operations monitoring, quality control, troubleshooting, design and telecommunications, and public safety with design and telecommunication. Keeping in mind that Shappell et. al., 2007 realised that much as situational and demographic variables are physical and easier to study, it is not the case with the human error where it is not easy to ascertain methods of investigation that are acceptable and easy to understand.

Martin, et. al., 2014 argues that the human component varies in aviation and this is a possible reason for human error. A system failure due to human variability has been observed as a source of error causing accidents and incidents (Reason, 1990). The high level of misunderstanding in aviation operations arises as a result of a lack of control when performing a task: due to poor motivation, stress and fatigue, failure to control the situation, inadequate training, and poor instructions (Martin, et. al., 2014).

Reason in 1990 wrote that accidents are not a one-day event but do occur days, weeks, or even years before the actual event. However, neglect and/or poor attention leading to a crash should reflect that there is a particular level of user and system interactions that created favourable conditions for the accident to occur.

CENIPA (Central Research and Prevention of Accidents, Brazil) and NTSB (National Transportation Safety Bureau, USA) suggests a list of difficulties in operation, the type of training aircraft, and its maintenance, as important to note in the training of crew worldwide. They further note that these affect the safety of the flight but unfortunately they are not emphasized during training. It is also worth noting that aviation trainers and professionals in aviation are not aware of the circumstances leading to accidents and incidents, sometimes as a result of a lack of experience (Martins, et. al., 2014).

Optimum performance in all these areas is directly related to training/ skill and level of experience. Levels of training, evaluation of training, and experience directly affect the skill.

An understanding of components that lead to errors can be reached by gagging performance errors, evaluating crew qualifications and train-

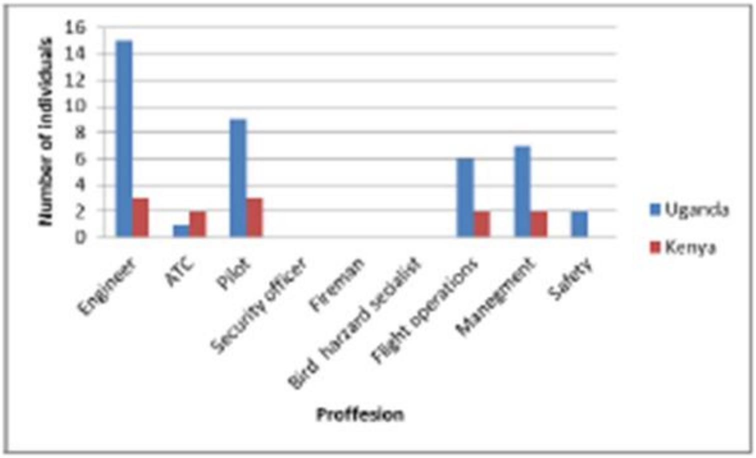

Figure 3: Different professions of participants from Kenya and Uganda

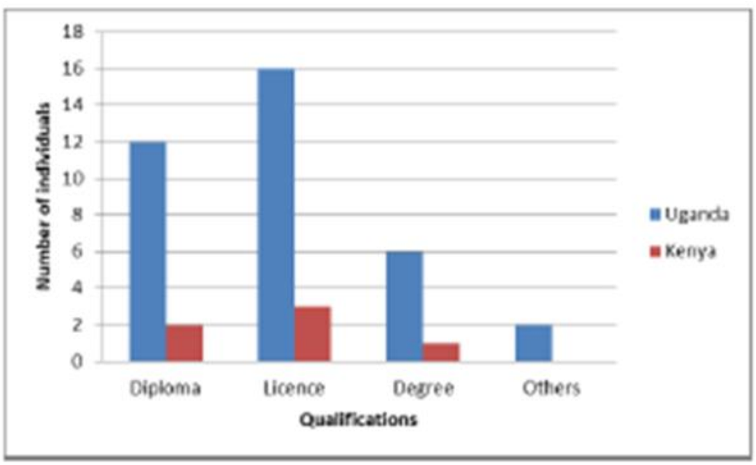

Figure 4: Level of education of participants from Kenyaand Uganda

Table 1: **Correlation of data on skills required for the job between Kenyan and Ugandan participants**

	Value	p- value
Operations Monitoring x Public Safety	0.562	0.00003
Operations Monitoring x Design	0.317	0.025
Quality Control x Public safety	0.312	0.03
Quality Control x Trouble shooting	0.550	0.0000596
Trouble shooting x Public safety	0.394	0.00582
Trouble shooting x Telecommunication	0.609	0.000000
Public safety x Design	0.454	0.00127
Public safety x Telecommunication	0.313	0.0344

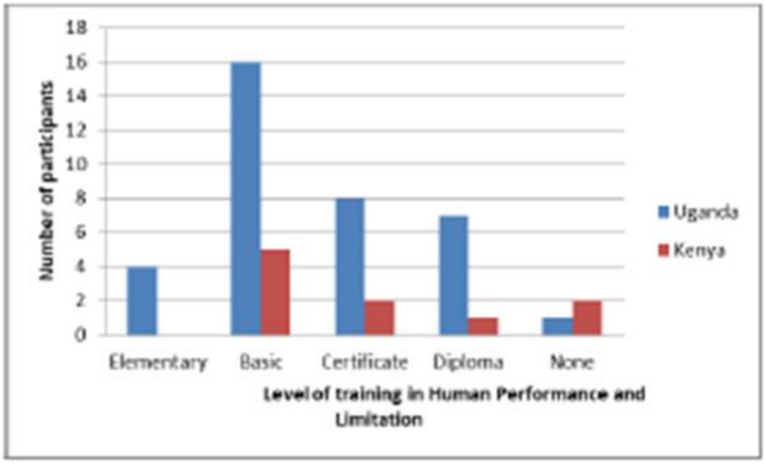

Figure 5: Level of Human performance and limitation training of participants from Kenya and Uganda

Table 2: **Correlation of data on Aeromedical factors for Kenyan and Ugandan participants**

	Value	p- value
Problem solving x Stress	0.537	0.0000946
Problem solving x General Health	0.276	0.0574
Problem solving x Concentration	0.517	0.000264
Copping with stress x General Health	0.376	0.00086
Copping with stress x Sleep disorders	0.320	0.0306
Copping with stress x Concentration	0.509	0.0003
Concerns about illness x General Health	0.414	0.00298
General Health x Sleep disorders	0.513	0.0003
General Health x Concentration	0.589	0.0000184
General Health x Appetite for food	0.447	0.00195
Sleep disorders x Concentration	0.459	0.00143
Sleep disorders x Appetite for food	0.318	0.031
Concentration x Appetite for food	0.435	0.00270
Appetite for food x well being	0.467	0.00115
Anxiety x weight gain	0.487	0.000659

ing, and examining standard operating procedures and regulations. Over and over again it has been observed that errors can be identified and predicted by crew members. Errors have multiple causal factors which relate to the level of training, operating procedures, regulatory policies, or the type of job. After all this, the difficult task is with identifying the corrective measures before a much more dangerous situation occurs. Different teams deal with human factors worldwide, these included The FAA team in the USA, (Dekker, 2003), they believe that by improving error detection and eliminating certain features on the aircraft, manufacturers can easily improve operation when they detect future causes of errors. Unfortunately aviation operations approvals and regulations today do not go through the tedious process of evaluating the project details from a flight deck to reduce the occurrence of pilot errors and other problems in performance problems

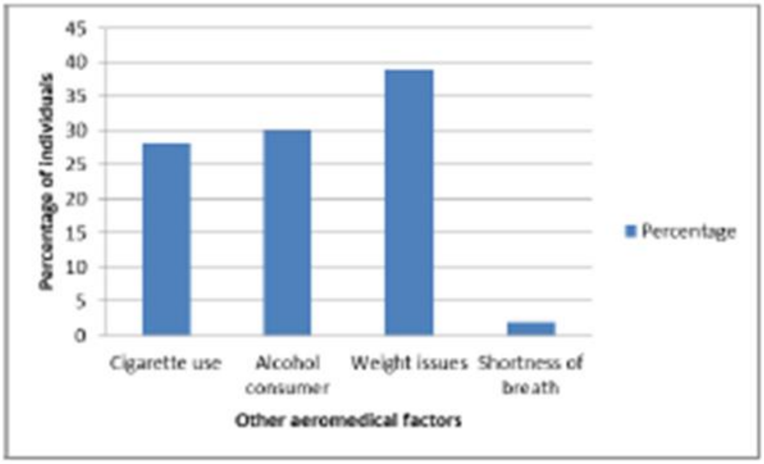

Figure 6: Other significant aeromedical factors forparticipants from both Kenya and Uganda

that lead to accidents (Martins et. al., 2014).

Haslinda and Mahyuddin (2009) training can be made more effective by developing systems that align training effectiveness with organization activities. They further suggest training evaluation should check effectiveness in behaviour, learning, reaction, and results in level (Hamid Khan, 2002). Effectiveness goes to the heart of what training and development are all about in an organization: giving employees the knowledge and skills they need to perform their jobs effectively (Noe and Schmitt, 2006) Cheng and Ho (2001). One of the cited reasons for considering training and development as an unnecessary and expensive expenditure is that most organizations are unsure of the contributions of training and development toward the organization's overall performance due to a lack of evaluation. (Bramley and Kitson, 1994) (WCES, 2012).

Giving the student or crew, the opportunity of self-knowledge, identifying possible "psychological breakdowns" that biological features can present and can endanger the safety of flight. It should be given, thus, more humane and scientific support to the crew and everyone else involved with the aerial activity, reducing factors that can cause incidents and accidents (Martins, et. al., 2014). The authors go on to write that and define human cognition as the mental processes that are involved in thinking and their use. Due to its multidisciplinary nature, it focuses on anthropology, psychobiology, cognitive psychology, philosophy, artificial intelligence, and linguistics. These fields are being employed in a better understanding of human perception, memory, and thinking, which leads to a much broader understanding of human behavior. Cognition is then considered a broad field, composed of mental imagery, attention, language, problem-solving, creativity, decision making, consciousness, cognitive changes during development throughout life, human intelligence perception, memory, reasoning, and artificial intelligence among others. Humane support during aerial activity and self-knowledge of the crew or the aviation trainee is very very important but allowing individuals to identify their own "psychological breakdowns" during flight is very dangerous (Martins, et. al., 2014).

Molloy and O'Boyle, (2005) further note that individual human factors are wide and shift from time to time based on training and competency which is relevant to the current situation. The authors support that defined areas of competence are necessary for developing a study curriculum for aviation efficiency and safety improvement. For example; complex automation changes the procedures for implementing certain activities in certain types of aircraft even if they are different models or series under the same manufacturer. Any loopholes in training or inadequate training will make it difficult for the crew to understand procedures. Accident investigations suggested that pilot training should include an evaluation of the biological machine, a psychological stage, which allows the trainee or crew to check their self-knowledge and identify "psychological breakdowns". This would give more humane support to the crew and trainee during aerial activity, and reduce accidents and incidents. Accident investigators recommend a psychological phase in the crew's training. (Dekker 2003). Another example of an area of competence that needs to be incorporated into the study region's aviation curriculum is automation, as it has a visible impact on human performance. The myth that there is less need for investing in human skill as automation increases stands to be investigated". Various experiments show that in humans there is a demand for new knowledge and greater skills created in response to better handling automation. FAA 2010 investigations, during automated flight platforms, showed that aviation companies are reporting problems in nature and the complexity of the flights. This is because automated systems require additional knowledge and training of the crew on how to work subsystems and automated methods differently. Studies also show mental models have to be created in response to modified system operations in the industry. This means that there is a shift from manual to automatic operations and it does affect the logical flow of information too. The normal training process does not teach the crew how to manage new situations in an automated environment but does teach them how to do so in normal situations only. This kind of situation is very serious and manifests in aviation investigation reports as the crew fails to know what to do in emergencies after computer decisions are taken. (NTSB, 2011).

showed that data obtained on outstanding aeromedical factors included stress, sleep, appetite, weight, concentration, alcohol, smoking, anxiety, and age. The findings by Reason's (1977 to 2001) on Human Factors proved that stress was both domestic and work-related. Since it is hard to separate our work and home life, the two will inevitably affect each other. Overloadingcan lead to stress. If someone appears to be suffering from stress, it is wise not to give them a complex or critical task as this will add to stress and increase the likelihood of error.

Stress affects performance among other human factors as in Table 2 stress has a weak positive correlation with sleep at a value of 0.320 and a p-value of 0.0306, stress and problem solving had a moderate positive correlation with problem-solving at a value of 0.537 and a p-value 0.0000946. In this context stress is the psycophysical problem leading to tension (Congeton *et. al.*, 1997) whether it is actual or perceived, it creates a situational imbalance between demands and resources available (Desaulnires, 1997: Mathews 2002). Teamwork may relieve and eliminate stress. However, Glasser *et. al.*, 1999 argue that the relationship between teamwork and stress is relatively weak. Serfaty *et. al.*, 1993 research results showed that efficient teams were able to maintain the same level of performance with one-third of the time available to make decisions.

Sleep; people working long hours, (particularly unsociable hours) have an increased likelihood that they will error. Adults require 8 hours of sleep to function properly and as the good rule of thumb states; every hour of high-quality sleep is good for two hours of activity Reason's work (1977 to 2001). Wickens, *et. al.*, (2004) describes sleep disruption as a night sleep of less than 7 hours. Another author also notes that cognitive abilities are affected by sleep disturbance. (Baranski, *et. al.*, 2011), this is in agreement with findings in table 2 where sleep had a moderate correlation with concentration at a correlation value of 0.459 at a p-value of 0.00143. Sleep issues arise after people have been working long hours, (particularly unsociable hours) and have an increased likelihood that they will error due to interruption of the circadian rhythm.

Fatigue (results from the distress thermometer are not shown); if someone appears visually tired, it is advised that they do not undertake any form of a critical task to minimize the chances of error. One of the key informants from the operator's management noted that; "All flying involves some level of stress and fatigue".

The time spent on task can also be a cause of fatigue (Van Dongen, Belenky, and Krueger, 2011: Isaac and Ruitenberg, 1999). Gilbertova and Gilvicky, (1967) noted that the level of attention decreased when performing monotonous tasks, but increased when performing a new or demanding. During many incidents and accidents, fatigue has been pinpointed (Dorrian *et. al.*, 2007). Some authors note that there is a complex relationship between fatigue and performance. As the two may not directly influence each other but may have other intervening influences such as demand in performing a task and motivation. Martins *et. al.*, 2014 note that emotional fatigue and stress among crew members can increase as a result of reducing cockpit crew members to only two individuals. An example is in large four-engine aircrafts carrying hundreds of passengers with only 2 cock pit crew members. All sensitive operations including emergency procedures, monitoring, and sensitive checks are carried out by the two individuals.

Stern, *et. al.*, (1994) also noted that fatigue also affects attention. Prof Reason's work (1977 to 2001) still notes that fatigue arises if someone appears visually tired, it is advised that they do not undertake any form of a critical task to minimize the chances of error. Furthermore, he also noted that low levels of physical fitness can lead to tasks not being carried out correctly especially if it requires physical exertion. Given a human "black-box" and associated systemic changes, potential positive outcomes include fatigue management using dynamic cognitive/physiologic monitoring protocols, automated G-tolerance or hypoxia algorithms, and post-event analysis. We are data poor relative to the safety implications of variables such as fatigue, spatial disorientation, or mild hypoxia. These may be important in accident chains, but are generally not detectable post-flight or post-crash (Steinkraus, *et. al.*, 2012).

Martins, *et. al.*, 2014 pinpoint the amount of rest and body rhythms, the number of sleep hours, and related sleep disorders, acceleration due to gravity and G forces, high altitude, night take-off illusions, and disorientation among others notes as predictable and very important reduction of human error but few studies have been carried out on them. arising from causes so predictable, yet so little studied. He further suggests that scenario-based studies should be done at individual workplaces and on specific aircraft.

Figure 6 shows that a high number of the participants smoked cigarettes. Tobacco smoking has harmful effects in just about every respect. In particular, on the respiratory system and cardiovascular systems, it reduces the ability to withstand G- forces and the effects of hypoxia and degrades night vision as well. Cigarette smoke contains carbon monoxide, a poisonous gas that renders haemoglobin unable to bind to oxygen. Figure 6 still shows that a high number of the participants consumed alcohol. Alcohol potentially damages the body directly, and immediately, and negatively affects human performance. It degrades the ability to perform tasks properly. It disrupts sleep patterns and loss of REM sleep, leading to fatigue, decreasing hypoxia threshold, creating a greater inability to cope with lack of oxygen at altitude, reduction in quality of vision, and diminishing balance among others (CAE ATPL 2020).

5. Conclusion

Analysis of existing human factors risks in the region's aviation operations showed that the current risks are in public safety, operations monitoring, quality control, troubleshooting, design and telecommunications, and public safety. Most of the above skills had a direct correlation with each other. Aeromedical factors affecting performance included fitness and health, stress, time pressure and deadlines, sleep, fatigue, cigarette smoking, alcohol, pain, and nervousness.

Recommendations:

Include a need for redefining human factors areas of competence in Eastern Africa and modifying the training curriculum with evidence-based changes to improve regional aviation performance and safety as recommended by Molloy, and O'Boyle, (2005). Secondly, an evaluation of regional aviation training and the need for aeromedical assessment tools that can fully capture the existing aeromedical risks in the region is necessary.

6. List of Abbreviations.

ASMs: Aeromedical specialists
AME: Aviation Medical Examiners
ATPL: Airline Transport Pilot License
CRM: Crew Resource Management
EASA: European Aviation Safety Agency
FAA: Federal Aviation Administration
HFACS: Human Factors Analysis and Classification System
HRD: Human Resource Development
ICAO: International Civil Aviation Organization
PPL: Private Pilot License
NTSB: National Transportation Safety Bureau
SMS: Safety Management System
CAA: Civil Aviation Authority
IATA: International Air Transport Association
SACAA: South African Civil Aviation Authority
KCAA: Kenya Civil Aviation Authority

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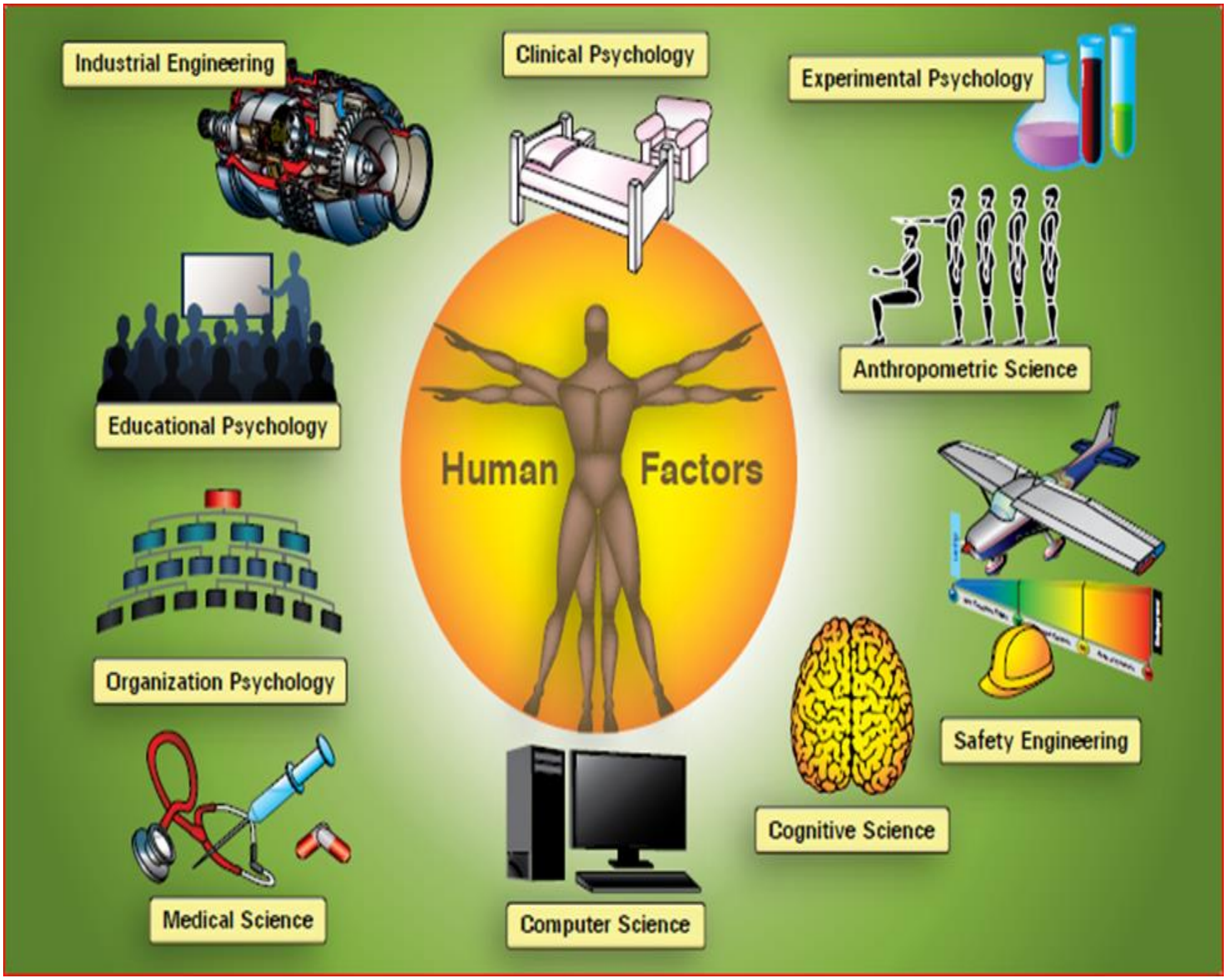
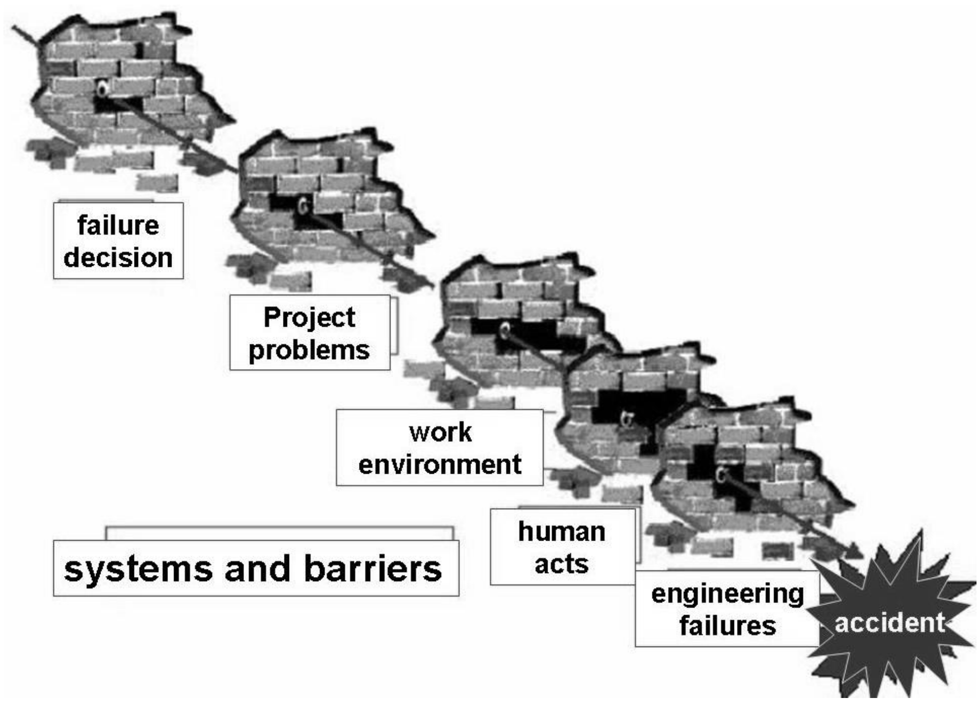
APPENDICES

Appendix 1 Human factor disciplines



Source: https://www.faasafety.gov (02/07/21)

Appendix 2 Reason's Swiss Cheese Model



Source Martins *et. al.*, 2014

Appendix 3 Risk management plan

RISK MANAGEMENT PLAN

Risk Management Plan for the Study Titled: "EMERGING HUMAN FACTORS RISKS IN EASTERN AFRICA AVIATION OPERATIONS"

The measures to be put in place by the study team include:

1. Hand washing/sanitization

Both the study staff and study participants will have to first wash or sanitize their hands before entering the study area. The sanitizers, water and soap will be availed at the study area entrance.

2. Measurement of the body temperature

The body temperature for study staff and study participants will be re-measured daily by one of the study staff using the non-contact infrared thermometer already available at the facility. Any person whose temperature will be above 37.5 degrees Celsius presenting with flue, cough difficulty in breathing will be restrained from participating in the study. The thermometer will be held 3 to 5cm away from the participant.

3. Use of Personal Protective Equipment

The study staff and study participants will put on medical face masks at all times covering the nose, mouth and chin. The research assistants will be encouraged to always wash their hands before and after putting the gloves. As well as follow the recommended steps of removing and disposing them off.

4. Maintaining social distancing

While at the waiting area and the study room where the consenting will take place, chairs will be placed at least 2 meters apart to maintain social distancing between the study interviewer and the study participant. Both the interviewer and the study participant will be required to keep on their face masks with the nose, mouth and chin completely covered through-out the entire consenting, examination and interviewing sessions.

5. Maintaining the working environment clean

The study room will be kept clean through mopping the floor on a daily basis plus sanitizing tables, chairs, door locks, filing cabins using alcohol solutions before and after working with each study participant. Constant supply of disinfectants will be ensured at the examination room and waiting area. Proper ventilation of the room will be ensured by keeping the windows and ventilators of the room wide open.

6. Safe waste management

Used disposable masks will be removed safely and disposed appropriately in infectious waste bins that will be provided by the study to avoid transmission of infections.

7. Implementation phase

A practical training session will be held with the study staff before re-starting any study recruitment activities.

Yours Sincerely,

……………………………….Name (Principal investigator)

Appendix 4 Informed consent form

KYAMBOGO UNIVERSITY DEPARTMENT OF BIOLOGICAL SCIENCE

KEY INFORMANT INFORMED CONSENT FORM

STUDY TITLE: EMERGING HUMAN FACTORS RISKS IN EASTERN AFRICA AVIATION OPERATIONS

1. Study Investigators

The Investigators in charge of this study are:

1.Nassimbwa Florence (PhD student)	Kyambogo University, Department of Biological Sciences, P. O. Box 1, Kampala	+256 78 2809949	nassimbwaflorence @gmail.com

2. Organizational Affiliation/ Collaboration and Sponsorship

This study is being conducted by Nassimbwa Florence in collaboration with Kyambogo University and sponsored by Nassimbwa Florence.

3. Background and rationale for the study

This research project is about: **"Emerging human factors risks in Eastern Africa aviation operations"** and is being conducted in two East African countries. This study does not involve experimentation.

4. Purpose of this research study

The purpose of this research study is to collect data that will help in improving aviation HPL (Human Performance and Limitation) training and working conditions in the aviation industry in Eastern Africa. Involvement of operators will help in the development of some practical human factors monitoring and awareness tools for the region. Gaining evidence based information on the current status of Human factors risks and giving recommendations will help to close the gaps in the regional aviation industry.

And you are being asked to participant in this research study because you are in the target group as an Engineer, ATC, Pilot, Security, Fireman, Bird hazard specialist, Operations, Management or Safety. This is a research study and not a provision of clinical care.

5. Length of Your Participation

Your participation in the study will last 30 minutes. You will be given a hard copy of a self-administered questionnaire and respond to oral questions during interviews. This will last only a few minutes.

6. Where the Study is being done and Number of People Participating

This study is being conducted at in Kenya and Uganda, and about 60 people are expected to take part.

7. Study Procedures

Before you take part in this research study, the study must be explained to you and you must be given the chance to ask questions. You must read and sign this informed consent form. A copy of this consent form will be archived for future reference. If you agree to take part in this study, the following will happen

You will attempt the questionnaire and where necessary answer a few questions during an interview.

8. What Will Happen When You Complete the Study:

When your participation in the study ends, you will no longer have access to the study but will readily access the study finding through seminar presentations and a published work.

9. Costs for Taking Part in this Study

There are no possible costs to be met by participants during the conduct of the study as far as the particular participants are concerned. The person who will meet the bill of paying for any arising costs is the Principle Investigator .

10. Compensation for Participation in the Study:

You will be compensated 20,000 Uganda shillings for participating in the study and for your time, meals & transport refund. Since the study involves some long term benefits for the participants as they air out their concerns in Human Factors.

11. Compensation for Injury

There is no anticipated risk of injury during the course of participation. Hence no fore seen cause for suffering permanent damage.

By signing this consent form, you will not waive any of your legal rights or release the parties involved in this study from liability for negligence.

12. Possible Risks or Discomforts while taking part in this study

The possible risks and discomforts that a participant might experience while in the study are time taken off to answer the questionnaire and giving additional information where necessary.

13. Possible Benefits to You for Taking Part in the Study

There may be no direct benefits to you for participating in this study. However, as a participant in this study you will gaining feedback from evidence based information on the current status of Human factors risks and recommendations that will help to close the gaps in the regional aviation industry will be available to you at the end of the study. However, you may or may not be expected to pay for these items.

14. About Participating in this Study

Your participation in this study is voluntary. You may stop participating in this study at any time without penalty. Your decision not to take part in this study or to stop your participation will not affect your access to services. If you decide to stop taking part in this study, you should notify the investigator. Alternatively, the investigator may stop your participation in this study at any time if he/she decides that it is in your best interest. He/she may also do this if you do not follow instructions.

15. Approval of the research study

This study has been approved by the Mengo Hospital Research Ethics Committee (MHREC) and the Uganda National Council for Science and Technology (UNCST).

16. Confidentiality of Study Records and Medical Records

Information collected for this study is confidential. All study records accessed by the team other than the PI will use anonymous ID codes. However, the study Sponsor, MHREC and UNCST will receive copies of the study records. MHREC and UNCST may have access to private information that identifies you by name. Any publication resulting from this study will use anonymized data.

17. Names of Contacts for Questions about the Study

If you have any questions about taking part in this study, or if you think you may have been injured because of the study, call the principle investigator: Nassimbwa Florence on +256 782 809949 or email at nassimbwaflorence@gmail.com. If you have any questions about your rights as a research participant, please call the Chair of MHREC, Prof Kawoya Grace M. on +256 772505189

18. Feedback on Study Findings and Progress of the Study

You will get feedback on the findings and progress of the study and any new information that affects the study or data that has clinical relevance to you (including incidental findings) will be made available to you and your health care providers.

19. Participant Consent Page

I certify that I have read or have had read to me this consent form, describing the procedures, benefits and risks of the study titled "**Emerging human factors risks in eastern Africa aviation operations**", or that the consent form has been read and explained to me, and that I understand it. I have been given an opportunity to ask questions about the study and these have been answered to my satisfaction. I agree to participate voluntarily.

____________________ ________________________________

Date Signature or mark of participant

____
Name of participant (print)

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this study have been explained to the above individual (s).

____________________	____________________________________
Date	Signature of person who obtained consent
	____________________________________
	Name of person who obtained consent

Appendix 5 Questionaires

PROJECT TITLE: EMERGING HUMAN FACTORS RISKS IN EASTERN AFRICA AVIATION OPERATIONS

AVIATION PERSONALE QUESTIONNAIRE (APPENDIX A) This protocol is to be applied to the gathering of information in relation to Research "**Emerging human factors risks in eastern Africa aviation operations**". You are kindly requested to fill the questionnaire, a tool to help the study collect data that will help in improving aviation HPL (Human Performance and Limitation) training and working conditions in the aviation industry in East Africa. Involvement of operators will help in the development of some practical human factors monitoring and awareness tools for the region. The study is by Nassimbwa Florence, A PhD student of Biological Science Kyambogo University. The information obtained is strictly for research purposes and will be treated with confidentiality.

SECTION A: DEMOGRAPHIC DATA INSTRUCTION: KINDLY PLACE A TICK (√) IN THE APPROPRIATE BOX THAT REPRESENTS THE CORRECT STATUS

1. Gender (a) Male ☐ (b) Female ☐

2. Age (a) 16- 25 ☐ (b) 26 – 35 ☐ (c) 36 – 45 ☐ (b) 46 – Above ☐

3. Kindly indicate your profession and highest level of education attained.

(a) Engineering ☐, ATC ☐, Pilot ☐, Security ☐, Fireman,☐ Bird hazard specialist ☐ ,Operations,☐ Management ☐ Safety ☐

(b) Diploma ☐ (c) License ☐ (d) Other Specify……………………………………………………………………………………………….

4. Kindly indicate the level of training in human performance and limitations?

(a) Elementary ☐ b) Basic ☐ (c) Certificate ☐ (d) Diploma ☐ (e) None ☐

5. Are you currently employed? Yes ☐ No ☐

6. What is your current level of employment?

Part time ☐ Full time ☐ Private ☐

7. Which sector do you belong? (a). Public ☐ (b). Private ☐

SECTION B: SKILLS REQUIRED FOR THE JOB

8. Do you have the skills required for your job? (Yes ☐ /No ☐). If the answer is NO, elaborate

………………………………………………………………………………………………………
……
…………….

9. If your answer is no, skip to section C. If yes, which ones do you have? (For the ones you have indicate YES for the ones you don't have indicate NO).

………………………………………………………………………………………………………
……..

SKILLS	Yes/No
1.Operation Monitoring - Watching gauges, dials, or other indicators to make sure a machine or aircraft is working properly	
2. Quality Control Analysis - Conducting tests and inspections of products, services, or processes to evaluate quality or performance	
3. Troubleshooting - Determining causes of operating errors and deciding what to do about it	
4. Public Safety and Security - Knowledge of relevant equipment, policies, procedures, and strategies to promote effective local, state, or national security operations for the protection of people, data, property, and institutions	
5. Design - Knowledge of design techniques, tools, and principles involved in production of precision technical plans, blueprints, drawings, and models	
6. Telecommunications - Knowledge of transmission especially RT, broadcasting, switching, control, and operation of telecommunications systems	

10. Have you ever been admitted for internship in an aviation institution? If yes, give the name of the company and date.

………………………………………………………………………………………………………
………………………………………………………………………………………………………
…………

11. Have you been subjected to any tools for evaluation of aeromedical factors at your work? If the answer is Yes elaborate.

………………………………………………………………………………………………………
………………………………………………………………………………………………………
………………………………………………………………………………………………………
………………

12. Mention airports/ airstrips within Kenya and Uganda where you experience major aeromedical factors occurrences, at a scale:

Red
(High)…………………………………………………………………………………………

Orange
(Moderate)…………………………………………………………………………………

Green
(Low)…………………………………………………………………………………………

Name of company
(Optional)……………………………………………………………………………..

Duration of work: from ……………………………….to
….……………………………………………

SECTION C: ESTABLISHING LEVELS OF DISTRESS AT WORK

In the past two weeks have you experienced the challenges bellow, please rate at a scale of

1. Good 2. Fair 3. Average 4. Poor 5. Very Poor

Component	1	2	3	4	5
13. Problem solving skills					
14. Coping with work stress concerns					
15. Concerns about the illness					
16. General health					
17. Anger management and the loss of control					
18. Sleep disruption at work					
19. Concentration on task at hand					
20. Appetite for food					
21. Tiredness at work,					
22. General wellbeing					

23. Do you experience high levels anxiety?
(Yes/No)…………………………………………………….

24. Do you experience episodes of shortness of breath?
(Yes/No)………………………………………..

25. Number of cigarettes smoked

On-the-job ………………………………. at-home smoking……………………………………………

26. Self-report of alcohol consumption and other drug use
……….

27. Recent weight change, from
……………………………..……..to…………………………………

28. Number and severity of occurrences (incidents or accidents);

Work-related, numbers………………………………Level of severity: High☐ Medium ☐ Low ☐

Non-work-related; numbers…………………………Level of severity: High☐ Medium ☐ Low ☐

24. Number of days per year lost from work in the recent one month………………………………..

Thank you for your participation in this study.

PROJECT TITLE: EMERGING HUMAN FACTORS RISKS IN EASTERN AFRICA AVIATION OPERATIONS

Appendix B: Supervisor Evaluation Questionnaire

This protocol is to be applied to the gathering of information in relation to the research on **"Emerging human factors risks in eastern Africa aviation operations".**

You are kindly requested to fill the questionnaire, a tool to help the study collect data that will help in improving aviation HPL (Human Performance and Limitation) training and working conditions in the aviation industry in East Africa. Involvement of operators will help in the development of some practical human factors monitoring and awareness tools for the region. The research is being conducted by Nassimbwa Florence, a PhD student from Kyambogo University, Uganda. The information obtained is strictly for research purposes and will be treated with confidentiality.

SECTION A: DEMOGRAPHIC DATA

INSTRUCTION: KINDLY PLACE A TICK (√) IN THE APPROPRIATE BOX THAT REPRESENTS THE CORRECT STATUS

1. Gender

(a) Male ☐ (b) Female ☐

Name of Organization/Company (Optional) ....

Nature of Organization/ Public/Private...

Type of Busines...

Job Title/ Designation (Optional)...

SECTION B: SOFT SKILLS

1. Using a scale of 1-5, indicate to what extent you feel that the job seekers you interact with possess the following soft skills. 1. Good 2. Fair 3. Average 4. Poor 5. Very Poor

SKILL	1	2	3	4	5
1. Communication Skills					
2. Problem Solving skills					
3. Teamwork					
4. Initiative					
5.Leadership					
6. Flexibility					
7. Creativity					
8. Willingness to Learn					

9. Attention to Detail					

SECTION C: TECHNICAL SKILLS

2. Skills required for effective performance at a scale of 1-5, indicate to what extent you feel that the supervisees you interact with possess these skills. 1. Good 2. Fair 3. Average 4. Poor 5. Very Poor

Name of Skill	1	2	3	4	5
1. Following Standard Operating Procedures					
2.Operation Monitoring					
3.Operation and Control					
4.Understanding of aeromedical factors					
5.Deal with stress effectively					
6.Deal with fatigue effectively					
7.Show complacency					
8. Mechanical work					
9. Visual Monitoring					
10.Quality Control Analysis					
11. Radio Telephoning					
12. Equipment Selection					
13.Troubleshooting					
14. Safety and emergency procedures					
15.Have the skills required for the job					

3. Do you have any comments, feedback or clarifications on information provided on the above questions?

....
....
....
....

4. Mention airfields/ airstrips within Kenya and Uganda where you experience major aeromedical factors occurrences, at a scale:

Red (High)……………………………………………………………………………………….

Orange (Moderate)………………………………………………………………………………

Green (Low)……………………………………………………………………………………...

Thank you for sharing your views. We very much appreciate your contribution.

PROJECT TITLE: EMERGING HUMAN FACTORS RISKS IN EASTERN AFRICA AVIATION OPERATIONS

Appendix C: Employer Evaluation Questionnaire

This protocol is to be applied to the gathering of information in relation to the research on **"Emerging human factors risks in Eastern Africa aviation operations".**

You are kindly requested to fill the questionnaire, a tool to help the study to collect data that will help in improving aviation HPL (Human Performance and Limitation) training and working conditions in the aviation industry in East Africa. Involvement of operators will help in the development of some practical human factors monitoring and awareness tools for the region. The research is being conducted by Nassimbwa Florence, a PhD student from Kyambogo University, Uganda. The information obtained is strictly for research purposes and will be treated with confidentiality.

SECTION A: DEMOGRAPHIC DATA

INSTRUCTION: KINDLY PLACE A TICK (√) IN THE APPROPRIATE BOX THAT REPRESENTS THE CORRECT STATUS

1. Gender

(a) Male ☐ (b) Female ☐

Name of Organization/Company (Optional)..

Nature of Organization/ Public/Private...

Type of Business...

Job Title/ Designation (Optional)..

SECTION B: SOFT SKILLS

1. Using a scale of 1-5, indicate to what extent you feel that the employees you interact with possess the following soft skills. 1. Good 2. Fair 3. Average 4. Poor 5. Very Poor

SKILL	1	2	3	4	5
1. Communication Skills					
2. Problem Solving					
3. Teamwork					
4. Initiative					
5.Leadership					
6. Flexibility					
7. Creativity					

8. Willingness to Learn					
9. Attention to Detail					

SECTION C: TECHNICAL SKILLS

2. Skills required for effective performance at a scale of 1-5, indicate to what extent you feel that the emloyees you interact with possess theses skills. 1. Good 2. Fair 3. Average 4. Poor 5. Very Poor

Name of Skill	1	2	3	4	5
1. Following Standard Operating Procedures					
2.Operation Monitoring					
3.Operation and Control					
4. Mechanical work					
5. Visual Monitoring skills					
6.Quality Control Analysis					
7. Radio Telephoning					
8. Equipment Selection					
9.Troubleshooting					
10. Safety and emergency procedures					
11.Have the skills required for the job					

3. Do you have any comments, feedback or clarifications on information provided on the above questions?

....
....
....
....

4. Mention airports/airstrips within Kenya and Uganda where you experience major aeromedical factor occurrences, at a scale:

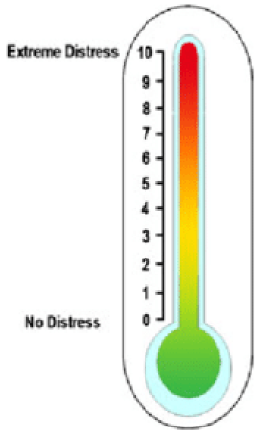
Red (High)…………………………………………………………………………………….

Orange (Moderate)……………………………………………………………………………

Green (Low)…………………………………………………………………………………..

Thank you for sharing your views. We very much appreciate your contribution

Distress thermometer

First please circle the number (0-10) that best describes how much distress you have been experiencing in the past week including today.	Second, please indicate if any of the following has been a problem for you in the past week including today. Be sure to check YES or NO for each.	
	YES NO <u>Practical Problems</u> □ □ Child Care □ □ Housing □ □ Insurance/financial □ □ Transportation □ □ Work/school <u>Family Problems</u> □ □ Dealing with children □ □ Dealing with partner □ □ Dealing with close Friend/relative <u>Emotional Problems</u> □ □ Depression □ □ Fears □ □ Nervousness □ □ Sadness □ □ Worry □ □ Loss of interest in usual activities □ □ <u>Spiritual/religious concerns</u>	YES NO <u>Physical Problems</u> □ □ Appearance □ □ Bathing/dressing □ □ Breathing □ □ Changes in urination □ □ Constipation □ □ Diarrhoea □ □ Eating □ □ Fatigue □ □ Feeling Swollen □ □ Fevers □ □ Getting around □ □ Indigestion □ □ Memory/concentration □ □ Mouth sores □ □ Nausea □ □ Nose dry/congested □ □ Pain □ □ Sexual □ □ Skin dry itchy □ □ Sleep □ □ Tingling in hands/feet <u>Other problems</u> ____________________ ____________________

https://www.google.com/search?client=firefox-b&biw=1366&bih=626&tbm=isch&q=distress+thermometer&chips=q:distress+thermometer,g_1:emotional:dv44oF2Hewc%3D&

Appendix 6 Airports and airstrips in Uganda

City served	Region	ICAO	IATA	Airport	Coordinates	Elev. (m)	Rwy. (m)
Adjumani	Northern	HUAJ		Adjumani Airport	03°20′21″N 31°45′53″E [2]	796 [2]	1,131 [2]
Arua	Northern	HUAR	RUA	**Arua Airport**	03°02′50″N 30°54′44″E	1,204 [3]	1,707 [3]
Bugungu	Western	HUGG		Bugungu Airstrip	02°12′10″N 31°33′16″E	753[4]	1540
Bundibugyo	Western	HUBU		Bundibugyo Airport	00°40′15″N 30°01′35″E	3100	965
Entebbe	Central	HUEN	EBB	**Entebbe International Airport**	00°02′33″N 32°26′37″E [5]	1,153 [5]	3,658 [5] 2,408
Fort Portal	Western	HUFP		Fort Portal Airport	00°42′32″N 30°14′53″E	1,530	850
Gulu	Northern	HUGU	ULU	**Gulu Airport**	02°48′20″N 32°16′18″E [6]	1,070 [6]	3,144 [6]
Jinja	Eastern	HUJI	JIN	Jinja Airport	00°27′11″N 33°11′34″E	1,175 [7]	1,800 [7]
Kabale	Western	HUKB		Kabale Airport	01°13′34″S 29°57′36″E	1,820	2,408
Kajjansi	Central	HUKJ		Kajjansi Airfield	00°11′48″N 32°33′09″E	1,180	1,100
Kakira	Eastern	HUKK		Kakira Airport	00°29′56″N 33°16′57″E	1,200	1,278
Kasenyi	Western	HULA		Kasenyi Airport		930	
Kasese	Western	HUKS	KSE	Kasese Airport	00°10′59″N 30°06′05″E	959 [8]	1,570 [8]
Kidepo	Northern	HUKD		Kidepo Airport	03°43′09″N 33°45′15″E	1,190	1280
Kihihi	Western		KHX[9]	Savannah Airstrip	00°43′10″S 29°42′00″E	1,100	2,000
Kisoro	Western	HUKI		Kisoro Airport	01°16′48″S 29°43′09″E	1,890	1,300

City served	Region	ICAO	IATA	Airport	Coordinates	Elev. (m)	Rwy. (m)
Kitgum	Northern	HUKT		Kitgum Airport	03°16′43″N 32°53′24″E	929	1900
Kotido	Northern	HUKO		Kotido Airport	02°57′6″N 34°7′21″E	1,180	1,600
Lira	Northern	HULI		Lira Airport	02°14′52″N 32°54′35″E	1,091 [10]	846 [10]
Masindi	Western	HUMI	KCU	Masindi Airport	01°45′29″N 31°44′12″E [11]	1,173 [11]	2,042 [11]
Matany	Northern			Matany Airstrip	2°26′58″N 34°23′45″E	3895	960
Mbarara	Western	HUMA	MBQ	Mbarara Airport (Nyakisharara International Airport)	00°33′19″S 30°35′58″E [12]	1,402 [12]	1,635 [12]
Moroto	Northern	HUMO		Moroto Airport	02°30′18″N 34°35′41″E [13]	1,280 [13]	1,500 [13]
Moyo	Northern		OYG	**Moyo Airport**	03°38′57″N 31°45′54″E	980	1160
Murchison Falls National Park	Northern	HUGG		Bugungu Airstrip	02°12′08″N 31°33′16″E		
Murchison Falls National Park	Northern			Chobe Safari Lodge Airport	02°14′25″N 32°08′30″E	3140	1,555
Mutukula	Central			Mutukula Airport	00°55′30″S 31°27′00″E	1,190	2700
Mweya	Western	HUMW		Mweya Airport	00°11′34″S 29°53′45″E	980	1254
Nakasongola	Central			Nakasongola Airport	01°25′12″N 32°28′12″E	1,100	3,000
Namulonge	Central	HUNA		Namulonge Airport	00°30′51″N 32°37′48″E	1,180	560
Nebbi	Northern			Nebbi Airport	02°30′49″N 31°07′57″E	900	
Patongo	Northern			Patongo Airfield	02°45'43"N 33°19'02"E	1,027	1200

City served	Region	ICAO	IATA	Airport	Coordinates	Elev. (m)	Rwy. (m)
Murchison Falls National Park	Northern	HUPA	PAF	Pakuba Airfield	02°19′35″N 31°29′52″E	721 [14]	1,760 [14]
Queen Elizabeth National Park	Western			Ishasha River Camp Airport	0°36′50″S 29°39′55″E	3,140	1,006
Soroti	Eastern	HUSO	SRT	**Soroti Airport**	01°43′39″N 33°37′22″E [15]	1,110 [15]	1,900 [15] 770
Tororo	Eastern	HUTO	TRY	Tororo Airport	00°40′48″N 34°10′05″E	1,170 [16]	1,707 [16]

Source: https://en.wikipedia.org/wiki/List_of_airports_in_Uganda: accessed 03 July 2023

Airports and airstrips in Kenya

Location	ICAO	IATA	Airport name

Location	ICAO	IATA	Airport name
Civil airports			
Amboseli	HKAM	ASV	Amboseli Airport
Angama Mara		ANA	Angama Mara Airport
Bamburi		BMQ	Bamburi Airport
Bungoma	HKBU		Bungoma Airport
Bura	HKBR		Bura East Airport
Busia	HKBA		Busia Airport
Eldoret	HKEL	EDL	Eldoret International Airport
Eliye Springs	HKES	EYS	Eliye Springs Airport
Embu	HKEM		Embu Airport
Garba Tula	HKGT		Garba Tula Airport
Garissa	HKGA	GAS	Garissa Airport
Hola	HKHO	HOA	Hola Airport

Location	ICAO	IATA	Airport name
Homa Bay	HKHB		Homa Bay Airport
Isiolo	HKIS		Isiolo Airport
Kakamega	HKKG	GGM	Kakamega Airport
Kakuma	HKKM		Kakuma Airport
Kalokol	HKFG	KLK	Kalokol Airport
Kericho	HKKR	KEY	Kericho Airport
Kilaguni	HKKL	ILU	Kilaguni Airport
Kimwarer		KRV	Kimwarer Airport
Kisii	HKKS		Kisii Airport
Kisumu	HKKI	KIS	Kisumu International Airport
Kitale	HKKT	KTL	Kitale Airport
Kiwayu		KWY	Kiwayu Airport
Lake Baringo		LBN	Lake Baringo Airport

Location	ICAO	IATA	Airport name
Lamu	HKLU	LAU	Manda Airport
Lewa Downs			Lewa Airport
Liboi		LBK	Liboi Airport
Lodwar	HKLO	LOK	Lodwar Airport
Loitokitok			Loitokitok Airport
Loiyangalani	HKLY	LOY	Loiyangalani Airport
Lokichogio	HKLK	LKG	Lokichogio Airport
Lokitaung	HKLG		Lokitaung Airport
Mackinnon Road	HKMR		Mackinnon Road Airport
Magadi	HKMG		Magadi Airport
Makindu	HKMU		Makindu Airport
Malindi	HKML	MYD	Malindi Airport
Mandera	HKMA	NDE	Mandera Airport

Location	ICAO	IATA	Airport name
Maralal	HKMI		Kisima Airport
Marsabit	HKMB	RBT	Marsabit Airport
Masai Mara	HKKE	KEU	Keekorok Airport
Masai Mara	HKMS	MRE	Mara Serena Airport
Meru National Park	HKMK	JJM	Mulika Lodge Airport
Migori	HKMM		Migori Airport
Mombasa	HKMO	MBA	Moi International Airport
Moyale	HKMY	OYL	Moyale Airport (Moyale Lower Airport)
Mtito Andei	HKMT		Mtito Andei Airport
Nairobi	HKJK	NBO	Jomo Kenyatta International Airport
Nairobi	HKNW	WIL	Wilson Airport
Naivasha	HKNV		Naivasha Airport
Nakuru	HKNK	NUU	Nakuru Airport

Location	ICAO	IATA	Airport name
Nanyuki	HKNL	NYK	Nanyuki Airport
Narok	HKNO		Narok Airport
Nyeri	HKNI	NYE	Nyeri Airport
Samburu	HKSB	UAS	Samburu Airport
Ukunda	HKUK	UKA	Ukunda Airport
Voi	HKVO		Voi Airport
Wajir	HKWJ	WJR	Wajir Airport
Military airports			
Nairobi	HKRE		Moi Air Base
Nanyuki	HKNY		Laikipia Air Base

Appendix 7 Airports and airstrips in Kenya and Uganda

A map of Airports in Kenya

Source:https://www.mapsofworld.com/international-airports/africa/kenya.html, accessed 04/July 2023

Map of Airports in Uganda

Source:https://www.mapsofworld.com/international-airports/africa/uganda.html, accessed 04/July 2023

Appendix 8 Research Ethics Committee clearance

MENGO HOSPITAL

Christian Medical Witness

Our Ref : MH / 2169

MH/2021-9

RESEARCH ETHICS COMMITTEE

18th March, 2021

Florence Nassimbwa
Principal investigator
Kyambogo University

Dear Madam,

RE: HUMAN FACTORS RISKS IN EASTERN AFRICAN AVIATION OPERATIONS.

This is to inform you that the Mengo Hospital Research Ethics Committee (MHREC) has approved the above research study subject to final approval from UNCST. The approval period is from **18th March, 2021** to **17th March, 2022**. Your study number is MH/2021-9. Please be sure to reference this number in any correspondence with the MHREC.

Continued approval is conditional upon your compliance with the following requirements:

1)A copy of the **Informed Consent Document** approved as of **18th March, 2021** is enclosed. No other consent form should be used. It must be signed by each subject prior to initiation of any protocol procedures. In addition, each member must be given a copy of the signed consent form.

2)All protocol amendments and changes to approved research must be submitted to the MHREC and not be implemented until approved by the MHREC except where necessary to eliminate apparent immediate hazards to the study subjects.

3)Significant changes to the study site and significant deviations from the research protocol and all unanticipated problems that may involve risks or affect the safety or welfare of subjects or others, or that may affect the integrity of the research must be promptly reported to the MHREC.

4)Please be informed that MHREC has a right and mandate to monitor your research to ensure compliance to UNCST regulations. This monitoring may be by making a visit to your site. The choice of the site to be visited is entirely under the prerogative of MHREC and may be done any time without prior notice.

5)All studies need Human Subject Protection (HSP) training and Good Clinical Practice (GCP) training for clinical studies. MHREC will not approve study protocols whose Principal Investigators have not presented the referred to certificate/certificates.

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www.mengohospital.org

6) All deaths, life threatening problems or serious or unexpected adverse events, *whether related to the study article or not*, must be reported to the MHREC in a timely manner as specified in the National Guidelines for Research Involving Humans as Research Participants.

7) Please complete and submit reports to the MHREC as follows:

   a) Renewal of the study-complete and return the Continuing Review Report- Renewal Request (Form 404A) at least 8 weeks prior to the expiration of the approval period. The study cannot continue after **17th March, 2022 until** re-approved by the MHREC.

   b) Completion, termination, or if renewing the projects –send the report upon completion of the study.

8) You are required to disseminate a copy of your research findings to the community/ organisation where your research was conducted.

9) Before commencing with study activities and data collection, you will be required to register it with the Uganda National Council for Science and Technology.

Please call the chairman if you have any questions about the terms of this approval. Enclosed is the approved informed consent document dated **18th March, 2021.**

NB: Final approval is to be granted by the Uganda National Council for Science and Technology

Yours sincerely,

Dr. Nakiguddde Janet
Vice Chairperson (MHREC)

MENGO HOSPITAL
APPROVED
VALID UNTIL
17 MAR 2022
RESEARCH ETHICS COMMITTEE
P. O. BOX 7161 KAMPALA (U)

Appendix 9 Uganda National Council of Science and Technology clearance

Uganda National Council for Science and Technology

(Established by Act of Parliament of the Republic of Uganda)

UNCST

Our Ref: NS251ES **22 August 2022**

NASSIMBWA FLORENCE
Mengo Hospital Kampala
Kampala

Re: Research Approval: <u>HUMAN FACTORS RISKS IN EASTERN AFRICA\r\nAVIATION OPERATIONS\r\n</u>

I am pleased to inform you that on **22/08/2022**, the Uganda National Council for Science and Technology (UNCST) approved the above referenced research project. The Approval of the research project is for the period of **22/08/2022** to **22/08/2023**.

Your research registration number with the UNCST is **NS251ES**. Please, cite this number in all your future correspondences with UNCST in respect of the above research project. As the Principal Investigator of the research project, you are responsible for fulfilling the following requirements of approval:

1. Keeping all co-investigators informed of the status of the research.
2. Submitting all changes, amendments, and addenda to the research protocol or the consent form (where applicable) to the designated Research Ethics Committee (REC) or Lead Agency for re-review and approval **prior** to the activation of the changes. UNCST must be notified of the approved changes within five working days.
3. For clinical trials, all serious adverse events must be reported promptly to the designated local REC for review with copies to the National Drug Authority and a notification to the UNCST.
4. Unanticipated problems involving risks to research participants or other must be reported promptly to the UNCST. New information that becomes available which could change the risk/benefit ratio must be submitted promptly for UNCST notification after review by the REC.
5. Only approved study procedures are to be implemented. The UNCST may conduct impromptu audits of all study records.
6. An annual progress report and approval letter of continuation from the REC must be submitted electronically to UNCST. Failure to do so may result in termination of the research project.