International Journal of
Aviation Research

Volume 16 | Issue 01 Peer-Reviewed Article

Safety climate of aircraft maintenance personnel in Nigeria

KOLE OSARETIN UHUEGHO
Nigerian College of Aviation Technology,
Zaria Kaduna State, Nigeria
[1]kolek45@yahoo.com

SHAIBU JIBRIL MOHAMMED
Ahmadu Bello University
Zaria, Kaduna State, Nigeria[2]
msjibril@abu.edu.ng

PIUS CHUKWU
Nigerian College of Aviation Technology,
Zaria Kaduna State, Nigeria
pcegwu2000@gmail.com

AKIN OLATERU
Nigerian Safety Investigation Board, Nigeria
akinolateru@gmail.com

Abstract

This study used a safety climate questionnaire adapted from Commercial Aviation Safety Survey (CASS) as data collection instrument to investigate safety climate factors of aircraft maintenance personnel in Nigeria aviation industry. The CASS questionnaire was modified to accommodate the peculiarities of the safety climate in maintenance repair and overhaul organization (MRO)using four main factors and twelve sub factors. Multiple regression model was used as tool to analyse the data on safety climate of aircraft maintenance personnel. In the first case scenario, the multiple regression results using error tendency against the linear combination of the safety climate factors indicated that the equation containing the 15 variables accounted for 41.2 percent of the variations in error tendency in aircraft maintenance in MRO personnel that is significant at the 5 percent level. In the second case scenario, the multiple regression results using error tendency against the linear combination of the 7 safety climate factors indicated that the factors accounted for about 27.3 percent of the variations in error tendency in aircraft maintenance. It is recommended that focus should be shifted by management to response and feedback on reported safety issues, safety fundamentals, reward system, employee empowerment, and management involvement that are unfavorable in ranking in this study. This shift in focus is expected to drive relevant and necessary changes that can help improve safety with the MROs.

Recommended Citation:

Uhuegho, K.O., Mohammed, S.J., Chukwu, P., & Olateru, A. (2024). Safety climate of aircraft maintenance personnel in Nigeria. *International Journal of Aviation Research*, *16*(1).

1.0 Introduction

In recent times, it is common knowledge that human behaviour makes considerable contribution to most accidents at workplace. Considering the influence of culture (organizational culture in terms of professional behaviour, attitude to safety, and reporting of incidents) on safety climate in the aviation industry there is a need for a high level of interpersonal collaboration, communication and coordination within the stream of maintenance personnel in order to reduce or prevent accidents or incidents in the industry. Human error involvement as causal or contributory factor to accidents ranges from 58 percent in medicine, 70 percent in aircraft accidents to 80 percent in shipping accidents (Hobbs & Williams, 2002). In some accidents such as the Japanese aircraft Boeing 747 that crashed into Mount Osutaka in 1985 and claimed 520 lives; investigation revealed that the accident was due to the rupture of the rear pressure bulkhead occasioned by improper repairs. The British Airways BAC-111 Jet that blew out its windscreen on climbing to cruising altitude in June, 1990, ejecting the pilot partially through the open window was adjudged to be due to installation of wrong bolts by a shift maintenance manager (Air Accident Investigation Branch, 1992); a Boeing 757 that crashed into the sea shortly after take-off from Lima in October, 1996, claiming the lives of all seventy souls on board was discovered be due to non-removal of masking tape over the static port of air data sensor after the aircraft had been washed; and it departed without notice by pre-flight inspections, causing the cockpit instruments to malfunction, leading to eventual loss of control by the Pilots (Walters & Sumwalt, 2000).

In Nigeria, the air crashes of Belview Airline B737-200 aircraft on 22nd October, 2005; the Sosoliso Airline DC-9-32 aircraft on Saturday 10th December, 2005, that of ADC Airline B737-200 Aircraft on Sunday 29th October, 2006 and the more recent crash of Dana Airline Ltd – Boeing McDonnell Douglass MD-83 aircraft on 20th February, 2018, in Port Harcourt International Airport all had human errors implicated in the crashes including maintenance human factors (Accident Investigation Bureau, Nigeria, 2019). These and other risk climate related accidents in the aviation industry and across related industries such as human medicine and shipping have raised credible concerns on a global scale that elicits research activities in order to enrich the debate on the critical role of maintenance personnel and the climate of risk associated with their performance. This is the premise on which this paper is based and focused.

The assessment of safety climate is often based on the assumption that errors that emanate from maintenance are considered as high level features in safety management and process auditing. Schmidt and Figlock (2001) suggested that safety climate is assessed based on the assumption that errors in maintenance manifest high level features in organization such as safety management in organization and process auditing. A survey study of 1300 aviation mechanics showed that events like memory lapses, violation of procedures, misunderstandings and wrong assumptions were quite common in aviation maintenance.

There are quite a number of organizations that have assessed safety climate and performance on the basis of lagging indicators (indicators that show that a safety outcome has not been realised or failed altogether) such as fatalities and or rate of mishaps (Paul, et al; 2010). Much earlier, a debate was raised as to the relevance and usefulness of lagging indicators as a measure of safety performance due to consistent improvement in safety and reduction in the frequency of mishaps (Shrivastava, 1986). Consequently, there is a sharp decline in the use of mishap rates as metric for measuring safety performance (Paul, et al; 2010). However, attention is being presently focused on improving safety further. Thus, high risk organizations (HROs: organizations that have attained a higher level of avoidance of catastrophes in high risk environment; Roberts & Rousseau, 1989) have started giving priority to investigating leading indicators of safety (measures of process or inputs essential to deliver the desired safety outcomes: safety climate and hazard reports; HSE, 2006) in view of the declining status of accidents (Paul, et al; 2010). In the opinion of Pau, et al. (2010) leading indicators of safety give a methodological option that is critically proactive in the quest to gain insight into the safety performance of an organization. In recent times in Nigeria, there has been some level of decline in accidents in the aviation industry. It is in consideration of the furtherance of safety performance that this study is focused on investigating the safety climate of aircraft maintenance personnel in Nigeria.

According to Hafiz, et al. (2017) research on safety issues has progressed from the identification of safety climate factors to the investigation of safety outcomes, establishment of causal relationship between safety climate and safety performance, and examination of the mediating role of factors such as safety knowledge and motivation. Most of such studies that have focused on what Hafiz, et al (2017) has referred to have been carried out in developed countries such as USA, UK and Canada (Barbaranelli, et al; 2015), and other advanced countries like China, Singapore, Hong Kong and Australia (Choudhry, et al; 2009; Zhou, et al; 2011; Hon, et al; 2013). While this shows a progression in research endeavours which is an indication of the importance of safety climate in the workplace; safety climate factors in the aviation industry in Nigeria as a developing country requires further researches using multiple approaches in order to provide findings that will constitute a pool of information necessary for consistency in safety in the industry. This is a key justification for this study.

2.0 Overview of Literature

There a number of literature that have focused on the relevance and crucial role of maintenance and inspection within the domain of risk climate and the outcome of activities that are risk focused with respect to the trajectory of aircraft maintenance personnel actions; that have implications for safety. For instance, Saleh, et al. (2019) found that maintenance and inspection are risk factors in aircraft accidents. Also, the study found a significant clustering of maintenance accidents within a short number of flight hours after maintenance was performed. According to Schmidt, Figlock and Lawson (2001), the most common workplace factors with implications for aircraft safety are inadequacies in design, supervision, procedure, documentation, coordination, training and qualification that have bearing on issues of organizational culture or climate. Similarly, Hobbs and Williamson (2002) identified the most common local factors that have implications for safety to include time pressure, inadequate training, equipment deficiencies, coordination breakdown, fatigue, deficient procedures, and poor supervision. Each of these factors was related to certain errors and maintenance outcomes. For instance, poor supervision was associated with poor work quality; time pressure gave rise to violations such as omission of functional checks; equipment deficiencies resulted in secondary errors such as improper job accomplishment; deficient procedures resulted in unsafe release of aircraft to service; coordination breakdown was related to delays in accomplishment of jobs, fatigue was related with lapses in memory such as filler caps and cowlings unsecured, and training deficiencies were related to knowledge – based errors such as wrong component assembly. From the general perspective, these factors can lead to issues of organizational safety climate challenges.

Schmidt, Figlock and Lawson (2001) study suggested that safety climate is assessed based on the assumption that errors in maintenance manifest high level features in organization such as safety management and process auditing. A survey study of 1300 aviation mechanics showed that events like memory lapses, violation of procedures, misunderstandings and wrong assumptions were quite common in aviation maintenance. Dhillon (2009) found that human error data remains the backbone of any human error prediction and that data are gathered by means of expert judgments, field experience, experimental studies, self-made error reports and published literatures.

Aviation maintenance engineers/technicians are subject to a number of factors that impact their performance at work. According to ICAO (2018) report, these factors are over 300. They range from temperature to boredom. Some of the error provoking reasons include: time pressure, work tools, inadequate training, inexperience, complex maintenance tasks, poorly written maintenance procedures, outdated maintenance manuals, poor equipment design, fatigued maintenance personnel, poor work layout and poor work environment such as temperature, humidity and lighting.

Studies in maintenance human error such as Latorella and Prabhu (2000) and Dhillon (2007) identified a number of major categories of human errors in aircraft maintenance and inspection tasks to include incorrect assembly sequence, wrong parts, defective procedure, wrong configuration, missing part, functional defects, defective parts and tactile defects. It was strongly argued by Shan Lu and Tsai (2008) when studying the safety climate on accidents; that many safety problems have their origins in poor attitude of management towards safety audits; and unsafe attitude almost always precedes accidents and suggested that workers' perception of the safety climate of their workplace is also important. Also, factors such as management's commitment to safety, status of maintenance personnel and officers within the organization, the level of training, the communication system within the organization and work force stability are critical help providers in accident control. While the antecedents of safety climate have been widely discussed in many safety related literatures, an understanding of the perception of safety climate and its relationship within the context of Maintenance, Repair and Overhaul (MRO) organization is lacking. Therefore, the purpose of this study is to investigate the factors of safety climate that can lead to accidents within the MRO in Nigerian aviation industry.

The relevance of safety climate has been investigated as stated by Haji, et al. (2018) at higher levels using structural equations and mediator variables and the results indicated that occupational factors and stress have impact on safety behaviours and safety performance; Also, Liu et al. (2015) investigation on the relationship between safety climate and safety culture indicated that safety climate could predict safety behaviours and safety behaviour play a mediator role between safety climate and occupational accidents. In Haji et al. (2018) safety climate was recognized as reliable predictor of behaviour and outcomes safety and indicated that safety climate could be based on the understanding of the organization's employees with respect to policies, values and beliefs that are safety related. This thought was with specific focus on the personal motivation of individuals to perform assigned duties and responsibilities that have capacity to influence safety behaviour and attitude, and occurrence of events. It is not uncommon to find a divergence between the organization and employees' understanding of policies, values and beliefs in the modern workplace. This, specifically arising from the personal vision of the individuals that comprise an organization's management and the employees. Such divergence has critical implications for safety behaviour and safety performance as functional constituents of safety climate. It is in view of this, that a key aspect of the focus of this study is on the evaluation of how maintenance personnel actions and activities impact on the safety climate in the Nigerian aviation industry.

Safety climate is a multidimensional concept reflecting employee's perception of the policies and procedures and practices related to safety within the organization (Baring, Loughlin & Kelloway, 2002). In most studies that focused on safety climate there has been no consensus on the factors that constitute safety climate to date (Guldermund, 2000). However, Huang, et al. (2006) indicated that the choice of safety climate factors is partially determined by practical interest and characteristic of the industries and region of study. But Flin, et al (2000) identified five key factors of safety climate which are management, safety system, risk, work pressure and competence. This study nonetheless agrees with Hung, et al. (2018) that to a great extent the region of study, industry standard determine the factors that defines safety climate. Consequently, this study adapted the CASS questionnaire to assess safety climate in Nigeria.

According to Haji, et al. (2018) safety climate has been assessed with diverse tools such as questionnaires, interview, injury and fatality rates. However, Haji, et al. (2018) noted that among a number of other studies, it is the self-reporting questionnaires that have been commonly used. Specifically, Ajsley, et al. (2017) used the Nordic Safety Climate Questionnaire (NOSACQ-50) developed by a team of Nordic researchers based on safety and organizational climate theory to assess safety climate.

This study used a safety climate questionnaire adapted from Commercial Aviation Safety Survey (CASS) developed by Gibbon, Von Thaden and Wiegmann (2006) to assess the safety climate of aircraft maintenance personnel in the Nigerian aviation industry.

3.0 Methodology

Research Design

This study adopted the explanatory correlational research design as proposed by Ary, Jacobs and Sorenson (2010). According to Ary, Jacobs and Sorenson (2010), an explanatory correlational study enables us to unravel and identify the relationship between variables, on the basis of which some level of clarity and understanding regarding some phenomena can be achieved.

The CASS questionnaire was modified to accommodate the peculiarities of the safety climate in the aviation industry in Nigeria using four main factors and twelve sub factors. The four main factors are formal safety systems (reporting system, response and feedback, safety personnel); safety accountability (accountability maintenance personnel authority, professionalism); operations personnel (maintenance chief, mechanics, instructors/trainer), and organizational commitment (safety values, safety fundamental, going beyond compliance). The key modification to the CASS original questionnaire which was used for airlines (Pilots) was the inclusion of other factors such as formal safety system, safety accountability, operations personnel and organization commitment in order to address maintenance personnel and maintenance organizations in this study. This was considered necessary to reflect the peculiarities of the safety climate in the aviation industry in Nigeria. Cronbach's alpha was used to address issues of validity and reliability of the instrument used in this study (Cronbach, 1951). Thus, based on the sample data used in this study a range between 0.912 – 0.942 reliability coefficient was calculated using Cronbach's alpha to ensure internal validity and reliability of the modified CASS instrument for this study (Cohen, et al., 2003; Gibbon, Von Thaden and Wiegmann (2006)).

A two case scenario is adopted in the presentation of the relationship between maintenance safety climate factors and error tendency. In other words, the predictors of error tendency are split into two. In the first part, which represents case 1, the predictors are broken into 15 variables in order to identify the basic and key variables that contribute to error tendency in the maintenance work environment. This will allow for the measurement of the speed of adjustment of error tendency to changes in the basic variables. The second scenario which is case II, is necessary to reinforce the results of the relationship between the predictors of error tendency in case 1. For instance, formal safety system in case I is subdivided into three variables (safety personnel, reporting system, and response and feedback), safety accountability is also subdivided into three variables (professionalism, maintenance personnel authority and accountability), while operations personnel is represented by instructors/trainers, mechanic and mechanic chief. Thus, there are 15 predictors of error tendency in Case I. However, these predictors are aggregated in case II. The aggregation is intended to help find out if there is any significant difference in the results from the disaggregated variables. Also, many times error tendency predictors are lumped together thus making it difficult to precisely locate the point of error in the maintenance work environment.

3.1 Research Questions/Hypothesis/Limitations

Research Questions

The key research questions that drive this study are: i. how do safety climate factors affect error tendency within an MRO? ii. Which of the predictors of safety climate are determinants of safety climate in an MRO? iii. What safety climate factors determine error tendency in maintenance that results in accidents?

Hypotheses

H_o: Safety climate factors do not affect error tendency in an MRO
Ho: Predictors of safety climate do not determine safety climate in an MRO
Ho: Safety climate factors are not the cause of error tendency that results in accidents

Limitations

The key limitations to this research lies within the context of the fact that the CASS instrument developed by Gibbon, Von Thaden and Wiegmann (2006) and modified for this study may not be necessarily applicable to all MROs in the aviation industry. This is irrespective of the fact that the modifications are consistent with safety climate theory and construct validity. In view of this, the results and findings should be understood, treated and applied within a spectrum of the peculiarities of each country's aviation industry. However, the maintenance safety climate factors considered in this study are timeless and non-subjective.

3.1.1 The Model

This study is modelled as depicted in figure 1.

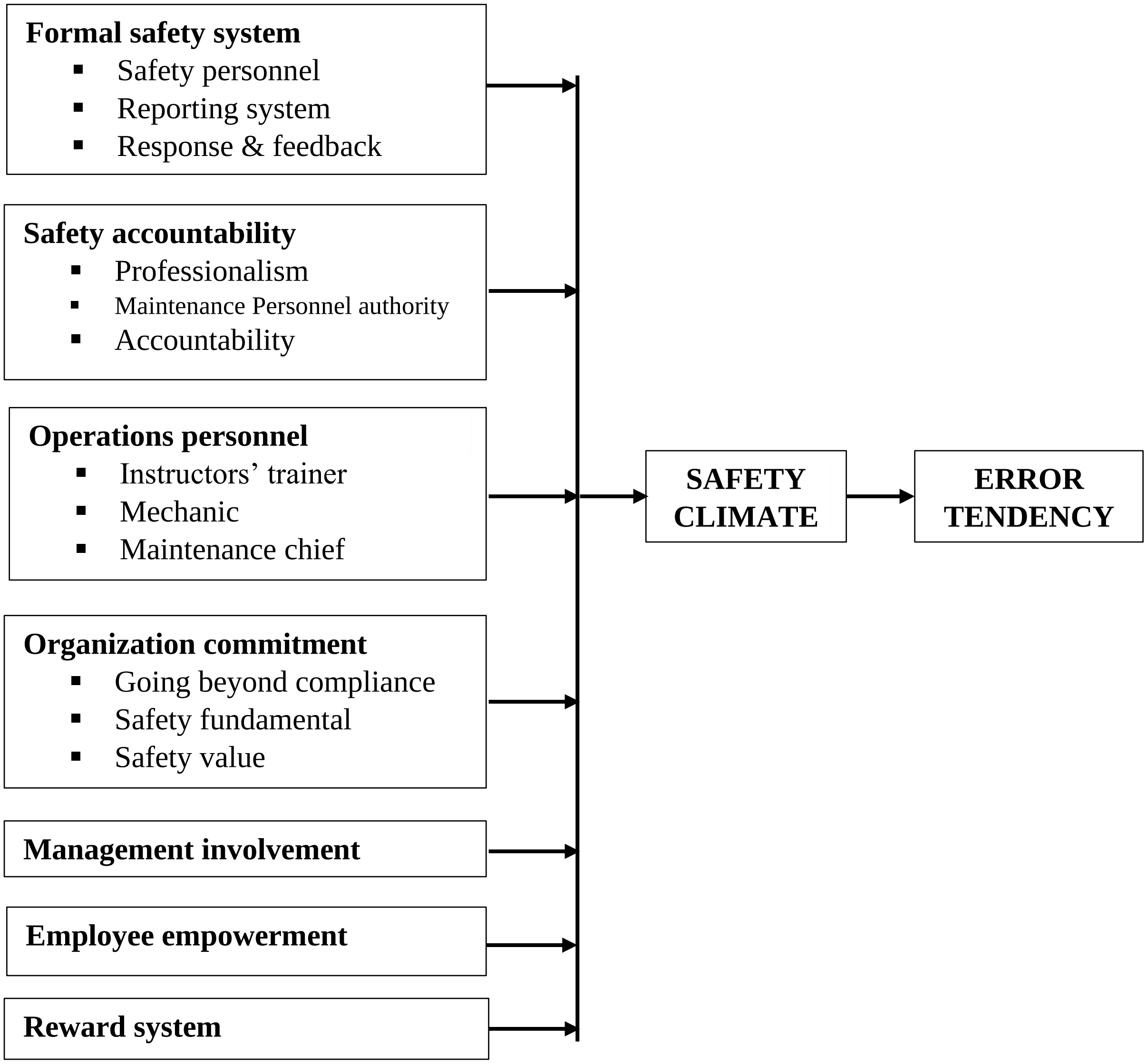

Figure 1: Safety Climate in Relation to Error Tendency

To address an MRO Safety concerns the organization must have an effective formal reporting system. Within the dispensation of safety management system, implementing a non-punitive approach can help the formal reporting system. This is unlike the punitive approach which has the capacity to devastate the usefulness of the reporting system in the context of any MRO; that can cause fear of reporting safety issues whenever there is the need to resolve safety concerns (Patankar, Brown, Sabin & Bigda Peyton, 2012). In this study, formal reporting of safety concerns was used to evaluate the effectiveness of the reporting system, response, feedback and the authority that oversee safety personnel within the MRO in Nigeria.

3.2 Instrument of Data Collection and Description

The instrument of data collection used in this study is questionnaire; which was used to collect data on the following sixteen variables: reporting systems, response and feedback, safety personnel, accountability, maintenance personnel authority, professionalism, maintenance chief, mechanic, instructor/trainer, safety value, safety fundamental, going beyond compliance, reward system, employee empowerment and management involvement.

3.3 Scale of Measurement of Variables

In this study, formal safety system has fourteen item questions for the variables of reporting system, response and feedback and safety personnel authority and these items were measured on a traditional Likert Scale ranging from 1 = strongly disagree to 5 = strongly agree. Reporting system was used to rate the usefulness of reporting system within the maintenances organization; willingness of maintenance personnel to report unsafe actions of other maintenance personnel and discrepancies without fear of negative repercussion and failure to report unsafe situation caused by their own actions with five item questions. *An example of a question in the five items is: maintenance personnel don't bother reporting maintenance errors since these events don't cause any real damage.* Response and feedback were used to rate the effectiveness of the response and feedback system in the maintenance organization. This is with regards to safety concerns of the management based on the issues raised by the maintenance personnel and the timely corrective actions taken by the management. Also, four item questions were used to rate the ability of the maintenance organization to ensure the effective communication of safety concerns in order to guarantee conscious improvement in safety climate within the provision of the safety management system. An example of the items raised is: *in my organization we only keep track of major safety problems and overlook routine ones.*

Safety personnel authority was used to rate the ability of people responsible for safety in the airlines to make changes; and their understanding of the risk involved in maintenance operations, as well as their authority to demonstrate consistent commitment to safety. This was measured using five items. A sample of the five items is: *safety personnel demonstrates a consistent commitment to maintenance operations in my organization.*

This study used fourteen items of safety accountability for the variables of accountability, maintenance personnel authority and professionalism among maintenance personnel. Accountability subscale reflects the standard of consistency in accountability application in the organization, fair treatment when maintenance personnel make a mistake and management reaction toward maintenance staff when an accident or incident occurs; was measured using four question items. A sample of the four items raised is: *standards of accountability are consistently applied to all maintenance personnel in this organization.*

Maintenance personnel authority was used to determine maintenance personnel authority input when developing maintenance procedure, their involvement in identifying and resolving safety concerns and the extent to which they can make changes regarding safety issues. This was measured using five items. A sample of the items is: *maintenance personnel are seldom asked for input when maintenance procedures are developed or changed in my organization*. Professionalism was used to measure maintenance perception of their colleagues regarding maintenance safety. Their views on maintenance safety records, attitude toward unprofessional and unethical practices, and unsafe behaviour and their tendency to compromise safety as a result of operational pressure were measured using five items. A sample item is: *maintenance personnel don't cut corners or compromise safety regardless of the operational pressure to do so in my organization*.

In this study maintenance operation personnel have thirteen items for variables of maintenance chief, mechanic, inspectors/trainers, supervisors and other maintenance staff, the level and degree of interaction between middle management and maintenance staff, trainers and mechanics in the maintenance environment. While maintenance chief sub-scale was used to address the relationship between the maintenance personnel and the chief of maintenances who interacts with maintenance personnel regularly on how maintenance tasks are performed; clear understanding of the risk associated with maintenance tasks and operation and how they handle report of maintenance safety concerns within the organization. This was measured using five items. An example of the items is: maintenance chief has a clear understanding of risk associated with maintenance operations in this organization.

Mechanic sub-scale was used to measure how maintenance personnel are consistent with the use of maintenance manual, work card and checklist and inspection procedures with commitment to safety. This was measured using four items. A sample of the four items is: *mechanics inappropriately use MEL (e.g. use minimum equipment list (MEL) when it would be better to fix equipment) in my organization.* And Inspectors/trainers sub-scale was used to measure the interaction between maintenance personnel and trainers during recurrent training and refresher programs to understand if the trainees have a clear understanding of risk associated with maintenance operations, their emphasis on safety during training, and if they use shortcuts and get around safety requirement in the organization. This was measured using four items; and a sample item is: *safety is consistently emphasized during training at my organization*.

Organizational commitment was used to address the MRO commitment to safety and fourteen items were used as variables of safety value, safety fundamental and beyond compliance. Safety values were used to measure how management and leadership value safety in the operational activities of the MRO, management dilemma between safety as core and making money in preference to safety, whether they consider safety when there is an accident or incident in the MRO. The measurement was done using five items; and a sample item is: *management doesn't show much concerns for safety until there is an accident or incident in this organization*. Safety fundamental was used to measure the maintenance organization management's willingness to invest in safety improvement. This includes commitment to equipping maintenance facilities with up to date equipment, updating manuals and ensuring that maintenance on aircraft is adequately performed and that aircraft are safe to operate. The measurement was done using five items, with a sample as: *my organization is committed to equipping maintenance facility with up-to-date technologies*.

Going beyond compliance was used to measure the capacity of management's commitment to meeting or exceeding safety concern and requirements. The ability of management's compliance beyond regulatory minimum in terms of sleep schedule and fatigues risk management considerations and attitude toward regulatory violations was measured using four items. A sample of the four items is: *management views regulation violation very seriously even when they don't result in any serious damage in my organization*.

Reward system dimension was used to determine ways in which reward is used to promote safety; and how involvement of a maintenance personnel in accident or incident has an adverse effect on his/her reputation in the organization, treatment of action of consistent violation of safety procedure or rule. How management uses reward to promote high performance and negatively manages and evaluate personnel who behaves recklessly in the organization under a non-punitive reporting system. This was measured by seven items, and a sample of these items is: *our reward system promotes high performance even if it means acting unsafely in my organization*.

Employee empowerment dimension was used to measure how management empowers employee engineers, technicians, and mechanics to improve maintenance safety and motivate them to do so by giving them opportunities to make suggestions regarding safety issues; and by taking pride in airline safety records, encourage them to stop maintenance activities that are unsafe and ensure that they have responsibility and accountability for safe maintenance. This measured using ten items, and a sample of the items is: *peer influence is effective at discouraging violation of operating procedures and maintenance in my organization*.

Management involvement dimension was used to assess management's close monitoring of the performance of the safety department, receptiveness of learning about safety concerns, the clarity of management's understating of the risk associated with flight and maintenance operations, the level of priority given to safety in meetings and non-hesitance to discuss safety issues, ability to stop unsafe operations in maintenance and willingness to communicate about safety issues. This was measured using twelve items, and a sample item is: *results of NCAA (Nigerian civil aviation authority) safety inspections are made available to maintenance personnel for review and information in my organization.*

Error tendency was used to measure the maintenance personnel manner of treating and handling of maintenance task that induce error, such as doing things not intended as they perform their tasks, taking action that are proven to be incorrect, the tendency to use deliberation act against written procedures, working under pressure resulting in slip action or missing steps in a task sequence, the tendency of error being detected by supervisor. Thirteen items were used to accomplish the measurement, and a sample item is*: I make error in my job from time-to-time.*

3.4 Sample Size, Source of Data and Instrument Administration

The principal source of data is the primary source with the use of questionnaire. Secondary sources such as aviation library materials, documented statistical data, airline annual publications were also consulted. 600 questionnaires were administered to the maintenance personnel at the maintenance bases of five of the leading airlines in the aviation industry in Nigeria. The consent of the airlines management was sought in writing and approval granted before the research assistants were allowed into the maintenance facilities. 280 of the administered questionnaires were returned, representing a response rate of 46 percent. This was considered to be a good result, given the generally low return rate on questionnaires. The questionnaires were administered for a period of three months from October to December, 2019. Out of the 280 questionnaires returned, 266 respondents provided complete data for analysis.

3.4 Tool of Data Analysis

The tool of analysis used in this study is the stepwise multiple regression analysis and ranking of variables. Regression analysis was considered suitable as a tool of data analysis in this study on the basis of the fact that the preliminary data screening was carried out, which consisted of outlier analysis, missing data analysis, and the outcomes confirmed that the data set was compliant with the BLUE (Best, Linear, Unbiased, Estimator) assumptions of regression (Larry, 2009; Data Science, 2020; Fundamentals of Statistics, 2020). The constructs represented in the model are not necessarily hierarchical, but each of the dependent variables is influenced by a set of independent factors that exert some level of influence on the dependent variable under consideration. Thus, stepwise multiple regression and ranking of variables were used to determine and rank the level of influence of maintenance safety climate and to examine the relationship between the variables of safety climate and error tendency of maintenance personnel in the aviation industry in Nigeria.

4.0 Results and Discussions

This section presents the results of the estimates of multiple regression as well as variable ranking; analysis and discussion of the statistics generated from the estimates based on the data obtained by survey on the maintenance safety climate of the Nigerian aviation industry.

4.1 Descriptive Statistics

The maintenance safety climate survey consists of 15 variables that form the subscales for the measurement of the maintenance safety climate. A summary of the descriptive statistics result for the subscales of the maintenance safety climate survey is presented in table 1:

Table 1: Summary of Descriptive Statistics Results for the Subscales of Maintenance Safety Climate Survey

Subscale	Possible Range	Midrange	M	SD	Ranking	Cronbach α
Reporting system	5 – 25	15.0	13.42	2.75	5	0.927
Response and feed back	4 – 20	12.0	17.14	2.87	11	0.921
Safety Personnel authority	5 - 25	15.0	15.99	4.61	9	0.912
Accountability	4 - 20	12.0	12.40	2.9	1	0.917
Maintenance Personnel Authority	5 - 25	15	14.88	3.27	5	0.913
Professionalism	5 - 25	15	16.31	3.95	10	0.967
Maintenance Chief	5 - 25	15	15.27	2.99	7	0.917
Mechanic	4 - 20	12	12.69	2.70	2	0.916
Instructor/Trainer	4 - 20	12	13.02	3.26	3	0.916
Safety Value	5 - 25	15	15.74	3.78	8	0.916
Safety Fundamental	5 - 25	15	17.57	3.08	12	0.919
Going Beyond Compliance	4 - 20	12	13.30	3.63	4	0.916
Reward System	7 - 35	21	22.84	2.79	15	0.917
Employee Empowerment	10 – 50	30	34.88	7.40	13	0.916
Management Involvement	12 – 60	36	41.95	8.32	14	0.912
Error Tendency	13 – 65	39	39.98	9.37	X	0.942

Source: Own computation

The mean value for each subscale is used as a basis for the descriptive statistics as in Ochoa-Pachas (2021). Ochoa-Pachas (2021) is of the view that descriptive statistics can be explained using the mean, the mode, the median, absolute frequencies, relative frequencies, the average, and the standard deviation. Ochoa-Pachas (2021) further indicated that descriptive statistics forms the basis for quantitative investigations, that allows for statistical inference to be made with respect to the subscale variables of the phenomenon under investigation. Thus, the sublevel that corresponds to the description of the fact or phenomenon can present numerical values (mean, mode, median, etc.) or categorical variables. Note that the value (positive or negative) of the difference between the mean (M) and the mid-range of each variable indicates the participants' perception of a variable as used to assess maintenance safety climate (Ochoa-Pachas, 2021).

Reporting system was used to assess the willingness of maintenance personnel to report unsafe actions and discrepancies without fear of negative repercussion among maintenance personnel within their maintenance setting. As indicated in table 1, the mean is M = 13.42 (SD = 2.75) which is 1.58 point less than the midrange of 15. This indicates the strength of the participants' perception of the formal reporting system; which is negative, showing that participants generally disagreed with the *safety reporting system as convenient and easy to use, and maintenance personnel are willing to report information regarding marginal performance or unsafe actions of other maintenance personnel in their organization.*

Response and Feedback were used to assess the effectiveness of response and feedback in maintenance organization with regards to safety concerns. As shown by the result in table 1, the mean of this factor is higher than the midrange; implying that maintenance personnel's perception of their response and feedback is positive. Thus, it follows that *safety issues raised by maintenance personnel are communicated regularly to all other maintenance personnel in their organization and when maintenance personnel report a safety problem; it is corrected in a timely manner.*

Safety personnel authority was used to assess people responsible for safety and their capability to make changes and their understanding of maintenance risk. The statistics in table 1 reveal that the mean of this safety factor is higher than its midrange. This means that safety personnel authority is positive. In other words, *safety personnel have a clear understanding of the risk involved in maintenance operations and have little or no authority compared to the maintenance personnel.* Accountability was used to assess consistency of accountability and treatment of maintenance personnel when they make mistake. The mean of this factor is higher than the midrange. This implies that the *standard of accountability of maintenance personnel was consistently applied to all personnel and when they make mistake or do something wrong they are dealt with fairly by the organization*.

Maintenance personnel authority was used to assess the level of maintenance personnel input in developing maintenance procedure and their involvement in identifying and resolving safety concerns. The statistics in table 1 show that the mean of maintenance personnel authority is less than its midrange. This indicates that participants' perception of their *authority was on the negative side of maintenance personnel directing activities involved in identifying and resolving safety concerns and having a weak authority to make decisions that affect the safety or normal maintenance operations in their organization.*

Professionalism was used to assess the attitude of maintenance personnel to safety record, unprofessional and unethical practices and unsafe behaviour and the tendency to compromise safety as a result of operational pressure. As indicated in table 1, the mean of professionalism is higher than the midrange. Thus, professionalism is positive; implying that in terms of professionalism, maintenance personnel viewed the *organization's safety record as their own and takes pride in it, furthermore, they do not cut corners or compromise safety regardless of the operational pressure to do so in their organization.* Maintenance Chief was used to assess relationship between maintenance chief and the maintenance personnel. The mean of this factor is higher than the midrange as indicated in table 1. This means that maintenance chief relationship is positive, implying that the *maintenance chief does not hesitate to contact line maintenance personnel to proactively discuss safety issues and have a clear understanding of risks associated with maintenance operations in their organization.*

Mechanics subscale was used to assess maintenance personnel consistency in the use of manual, work-card and checklist during inspections. The results presented in table 1 indicate that the mean of this factor is higher than the midrange; meaning maintenance personnel *consistently emphasize information or details on maintenance manual, work card, checklist and inspection procedure that affects maintenance safety and are responsive to maintenance safety concerns*. Inspector/Trainer was used to assess the interaction between maintenance personnel and trainers during training and refresher programs. The results show that the mean of this factor is higher than its midrange; indicating that participants' perception of inspector/trainer are positive. In other words, *safety is consistently emphasized during training and trainers prepare maintenance personnel for various situations including uncommon or unlikely ones in my organization.*

Safety value was used to assess how management and leadership value safety. The results show that the mean is higher than the midrange. This indicates that the *management is more concerned* *with making money than with safety*. Furthermore, the result indicates that the management could be pushing for on-time performance, even if it means compromising safety in their organization. While Safety Fundamentals was used to assess management's willingness to invest in safety improvement. As indicated in table 1, the mean of safety fundamentals is higher than its midrange of 15; which indicates that *management is willing to invest money and effort to improve safety and committed to equipping maintenance facilities with up-to-date technology*.

Going beyond compliance was used to assess capacity of management's commitment to meet and enhance safety concern and requirements. In this regard the result in table 1 shows that the mean of this factor is higher than the midrange. This implies that the *management goes above and beyond regulating minimums when it comes to issues of maintenance safety and is concerned about fatigue and view regulation violation as a serious damage in the organization.* Employee empowerment was used to assess how management empowers employee to improve maintenance safety and motivate them to do so. The statistics show that employee empowerment mean is higher than the midrange. Thus, this means that the *management gives sufficient opportunities to maintenance personnel to make suggestions regarding safety issues and ensure that they are responsible and accountable for safe maintenance operations.*

Rewards system was used to assess how management used reward to promote safety in maintenance operations. As indicated in table 1, the mean of reward system is higher than its midrange; implying that *management evaluation of involvement in an accident or incident will have an adverse effect on some personnel in future; while the reward system promotes high performance.* Also, the result indicates that the management takes action against maintenance engineers who violate safety procedures or rules in the organization. Management involvement was used to assess the way upper management monitors performance of safety engineers in terms of receptiveness to learning about safety concerns. The mean of management involvement is higher than the midrange as indicated in table 1. This points to the fact that *management assigned high priority to safety and stops unsafe operations or activities and do not hesitate to approach persons to discuss safety issues in their organization.*

Error tendency was used to evaluate operations personnel manner of treating and handling maintenance task that induce error. The results in table 1 show that the mean of error tendency is higher than its midrange. This indicates that *maintenance personnel performing maintenance tasks sometimes jump a step in a test sequence and sometimes do things they don't intend to do and at times act contrary to written procedures.* These results are consistent with the findings of Gibbons, Von Thaden and Wiegmann (2006) in their assessment of safety culture within commercial flight operations; and Paul, et al. (2010) finding on the measurement of safety climate in aviation.

Safety climate variables of formal safety system (measured as reporting system, response and feedback and safety personnel); safety accountability (measured as accountability, maintenance personnel authority and professionalism); operation personnel (measured as maintenance chief, mechanic and inspector/trainer); organizational commitment (measured as safety value, safety fundamental and going beyond compliance); reward system, employee empowerment and management involvement were analysed using JMP software for all statistical analysis. The original data was modified to prepare it for analysis and checked for linearity, multi co-linearity, and specification error of independent variables. The data set used for estimation and analysis satisfied statistical assumptions for correct specification of the independent variables, reliability, independence of residuals and normality checks.

4.2 Ranking of Participants' Perception of Safety Climate Factors

The ranking of the top 10 perception (those with lowest means) reported by participants relative to their belief about the safety climate of maintenance environment is based on the result presented in table 1. The top 10 perceptions are ranked as follow:

(1) Accountability, (2) Mechanic, (3) Instructors/Trainer, (4) Going Beyond Compliance, (5) Reporting System, (6) Maintenance Personnel Authority, (7) Maintenance Chief, (8) Safety Value, (9) Safety Personnel, (10) Professionalism. While remaining 5 variables of participant perception of safety climate in maintenance environment range from a mean of 17.15 to 41.95 in ascending order: Response and Feedback, Safety Fundamental, Reward System, Employee Empowerment, and Management Involvement.

4.3 Inferential Statistics Results

4.3.1 Case 1: Fifteen Safety Factors as Predictor of Safety Climate

Generally, the purpose of this study is to examine the contribution of maintenance safety factors to error tendency in MROs. This is to enable us gain relevant insight into the safety climate within aircraft maintenance environment. Therefore, this study described in quantitative terms the degree to which variables are related and helps to examine the nature of the relationship between and among variables (Locks, Silverman & Spirduso, 2010). The analysis was carried out using stepwise multiple regression.

Using the stepwise multiple regression, error tendency was regressed against the linear combination of safety climate factors of reporting system, response and feedback, safety personnel authority, accountability, maintenance chief, mechanic, inspectors/trainers, safety value, safety fundamental, going beyond compliance, management involvement, reward system and employee empowerment. Thus, the dependent variable is error tendency and the independent variables are the safety climate factors. The equation containing 15 variables accounted for 41.2 percent of observed variations in error tendency.

Table 2: Summary of Stepwise Multiple Regression Analysis Results of Safety Climate Factors and Error Tendency

Predicator	Estimate	Stand Beta	Stand Error	t Ratio	Prob. >(t)
Intercept	14.051	0	4.130	3.40	0.0008*
Reporting System	-0.586	-0.169	0.194	-3.02	0.0028*
Response Feedback	0.681	0.208	0.221	3.07	0.0023*
Safety Personnel	-0.033	-0.016	0.279	-0.12	0.9048
Accountability	0.152	0.047	0.331	0.46	0.6454
Maintenance Personnel Authority	0.640	0.224	0.259	2.47	0.0142*
Professionalism	0.255	0.108	0.304	0.84	0.4030
Maintenance Chief	0.209	0.067	0.296	0.71	0.4807
Mechanic	0.739	0.213	0.290	2.55	0.0114*
Instructor/ Trainer	-0.831	-0.292	0.334	-2.51	0.0128*
Safety Value	0.739	0.247	0.268	2.80	0.0055*
Safety Fundamentals	-0.865	-0.335	0.307	-2.81	0.0053*
Going Beyond Compliance	0.076	0.023	0.404	0.19	0.8503
Management Involvement	-0.162	0.128	0.158	1.03	0.3060
Reward System	-0.173	-0154	0.146	-1.18	0.0403
Employee Empowerment	0.409	-0.205	0.190	2.15	0.0327*

Note: $P < .005$, $R^2 = 0.412$, $F (15;266) = 11.69$, R^2 Adj. = 0.377

The Beta Weights (standardized multiple regression coefficients) were reviewed to assess the relative strength and importance of the 15 variables of maintenance safety climate factors in the prediction of error tendency as reported in table 2. Nine variables namely reporting system, response and feedback, maintenance personnel authority, mechanic, inspector/trainer, safety value, safety fundamental, employee empowerment and reward system indicated significant Beta Weights at the 5 percent level. Specifically, safety fundamental had the largest Beta Weight that is negative; while inspector/trainer, reporting system and reward system also had negative Beta weights; while the Beta weights of safety value, maintenance personnel authority, mechanic, employee empowerment, and response and feedback are positive as indicated in table 2. The coefficients of inspector/trainer, safety value, maintenance personnel authority, mechanic and response and feedback meet the study's a priori expectation as predictor of error tendency.

4.4 Interpretation of the Multiple Regression Results

Formal safety system had reporting system and response and feedback as significant; while safety accountability had only maintenance personnel authority as significant at the 5 percent level. On the other hand, operation personnel had both mechanic and instructor/trainer as significant while organizational commitment had both safety value and safety fundamental as significant at the 5 percent level. The results showed that employee empowerment is the only significant stand-alone variable at the 5 percent level. When all the variables of safety climate were regressed against error tendency, the results indicated that these variables explained 41 percent of the variations in error tendency. The collective contribution was satisfactorily significant at 5 percent level as indicated in table 2.

The results of the maintenance safety climate are presented in table 2. The result indicates that reporting system has a negative relationship with error tendency that is significant at the 5 percent level. Also, the result shows that for every unit increase in reporting system score, error tendency on average decreases by 58.6 percent. This implies that as the quality of reporting system increases, the tendency to commit error by maintenance personnel decreases. In other words, improving the reporting system in the maintenance environment will lead to reduction in the tendency to commit errors. This is consistent with Wiegmann, et al. (2003) that showed that reporting system is key factor in developing a foundation for sustainable safety culture in commercial aviation.

Again, the results presented in table 2 show that the response and feedback variable has a positive relationship with error tendency that is significant at the 5 percent level. This means that for every unit increase in the response and feedback scores within the maintenance organization, error tendency score increases on average by 68 percent. Therefore, it can be established based on the results that when maintenance personnel get good response and feedback in their work place with respect to error tendency there is an increase in level of error tendency. This implies that not all safety problems are tracked and resolved despite the safety issues raised by mechanics and communicated regularly to the appropriate unit in the organization. The implication is that only major errors are corrected while minor errors are overlooked.

The maintenance personnel authority variable has a positive coefficient that is significant at the 5 percent level as indicated in table 2. This means that a unit increase in maintenance personnel increases error tendency by 64 percent. The implication is that for every unit increase in maintenance personnel authority, there is a corresponding improvement in the confidence and professional authority of the maintenance personnel in the workplace. This has capacity to raise the maintenance personnel's tendency for error due to over confidence and engender the tendency to ignore laid down procedures and rules in the workplace (complacency). This also implies that maintenance personnel may not have adequate control of the maintenance functions in these organizations; since they may not be involved at the initial stage in the development of maintenance programs, procedures and their changes. Also, breaches may abound when different aircraft types are introduced into an existing fleet.

The mechanic safety climate factor has a positive relationship with error tendency that is significant at the 5 percent level. This implies that for every unit increase in mechanic score (maintenance personnel) consistency in the use of manual, work card and checklist during maintenance and inspections, error tendency score increases on the average by 73.9 percent as indicated in table 2. This implies an abnormal situation and calls for the attention of supervisors on accuracy and currency of maintenance data and procedures and incorrect use of minimum equipment list (MEL). Inspector/trainer has a negative relationship with error tendency that is significant at the 5 percent level (table 2). This means that for every unit increase in interaction between maintenance personnel and trainers, error tendency decreases by 83.1 percent. Consequently, error tendency increases when training has less emphasis on safety at work place, which is generally expected.

Safety value has a positive relationship with error tendency that is significant at the 5 percent level as shown by the results in table 2. This shows that every unit increase in safety value score within the maintenance organization, the tendency for error on the average increases by 73.9 percent. this presupposes that, when maintenance personnel perceive that management's preference for safety in the organization is high, their tendency for error increases. This indicates abnormality that requires a critical assessment of the situation. A probable cause of this situation is a disconnection between maintenance personnel and management due to abnormally low morale arising from the socio-technical system of the work environment.

Safety fundamental has a negative relationship with error tendency that is significant at the 5 percent level. Meaning that a unit increase in safety fundamental score within the maintenance organization decreases error tendency on the average by 86.5 percent as indicated in table 2. The implication is that when management's willingness to invest in safety improvement increases there will be a reduced tendency for error in the maintenance unit of the organization. This agrees with the findings of Wiegmann, et al. (2003) on development and initial validation of safety culture survey for commercial aviation, that indicated improvements in safety fundamentals such as organizational factors, decreases error tendency by pilots. Also, employee empowerment variable coefficient indicated a positive relationship with error tendency that is significant at the 5 percent level. In other words, a unit increase in employee empowerment increases error tendency by 41 percent. This suggests that improvement in employee positions in terms of emoluments, promotions and greater latitude for independent decisions; could be counterproductive in form of complacency on the part of maintenance personnel promoted to senior ranks who might have abandoned maintenance jobs to junior officers with little or no requisite work experience. This has great potentials for error tendency in maintenance. This means when maintenance personnel are given greater responsibility and accountability with regards to safety measures in the organization their tendency for error may increase. This is consistent with Gibbons, Von Thaden and Wiegmann (2006) findings for senior pilots in private commercial flights who rarely speak up regarding flight safety issues in open conversations among junior pilots.

4.4.1 Case II: Seven Safety Factors as Predictor of Safety Climate

The second case scenario deals with the model of safety climate as formal safety system, safety accountability; operational personnel, organizational commitment, reward system, management involvement and employee empowerment using multiple regression. In this case, safety climate as a formal safety system, safety accountability, operational personnel, organizational commitment, reward system, management involvement and employee empowerment are regressed against error tendency in a lower combination of safety climate factors. The equation contains 7 variables that accounted for 27.3 percent of observed variations in error tendency.

The Beta Weights (standardized multiple regression coefficients) that indicate the relative strength and importance of the 7 variables of maintenance safety climate factors in the prediction of error tendency are reported in table 3. From the results, three variables namely operations personnel, reward system and employee empowerment indicated significant Beta weights at the 5 percent level. All the variables have positive Beta weights. Specifically, organizational commitment, employee empowerment, and safety accountability have the largest Beta weights respectively.

These were followed by management involvement, operations personnel, reward system and formal safety system. With respect to Beta weight, the coefficients of all the seven variables meet the study's a priori expectation as predictor of error tendency.

The coefficients of the multiple regression results as presented in table 3 show that operations personnel and employee empowerment variables are positively related to error tendency and significant at the 5 percent level; while reward system is negatively related to error tendency and significant at the 5 percent level. Specifically, a unit increase in operations personnel score leads to an average increase in error tendency by 30.2 percent. In other words, as operational personnel relationship and interaction with all levels of management in work place increases tendency for error increases. This result generally gives the impression that, as issues affecting operations personnel are improved upon within the maintenance work environment, the tendency to commit error increases. This is another clear case of abnormality; that points to maintenance personnel complacency especially when there are no cases of accidents or incidents. Thus, abuse and or misuse of minimum equipment list (MEL) as well as use of shortcuts in getting around safety requirements could be rife in maintenance work environment.

Also, a unit increase in employee empowerment score leads to about 69 percent increase in error tendency in maintenance work environment. This raises a great concern for safety climate. There is a tendency for operations personnel such as maintenance chiefs, mechanics and inspectors/trainers to become negligent when by reason of promotion to more senior ranks they abandon maintenance jobs to inexperienced junior officers. This attitude poses serious safety threat arising from the maintenance work environment.

Table 3: Summary of Stepwise Multiple Regression Analysis of Formal Safety System, Safety Accountability, Operations Personnel, Organization Commitment, Reward System, Employee Empowerment, Management Involvement and Error Tendency

Predicator	Estimate	Stand Beta	Stand Error	t-Ratio	Prob. >(t)
Intercept	18.477	3.440	0	5.37	<0.001*
Formal Safety System	0.074	0.112	0.062	0.66	0.508
Safety Accountability	0.253	0.161	0.247	1.57	0.117
Operations Personnel	0.302	0.148	0.255	2.05	0.0416*
Organizational Commitment	0.021	0.177	0.018	0.12	0.9036
Reward System	-0.486	0.114	-0.431	-4.26	0.0001*
Employee Empowerment	0.690	0.162	-0.346	4.27	0.0001*
Management Involvement	-0.051	0.155	-0.040	-033	0.7422

Note: P<.005 R^2 = 0.273, F (7;266) = 13.85, R^2 Adj. = 0.253

The coefficient of the reward system variable indicates that a unit increase in reward system decreases error tendency by an average of 48.6 percent. Rewards in terms of improved remuneration, timely promotion and other work related incentives serve as morale booster to maintenance personnel and consequently help to enhance due diligence that guarantees reduction in error tendency. Wiegmann, et al. (2003) findings highlighted organizational commitment, reward system, employee empowerment and management involvement as key indicators of safety climate with respect to pilots. The findings of this study has also indicated that reward system and employment empowerment are significant safety climate predictors with respect to aircraft maintenance personnel in the Nigerian aviation industry.

5.0 Implications of the Findings of the Study and Recommendations

Most literature in the public domain regarding the causes of accidents and safety interventions focus strongly on individual task factors with little emphases on organizational factors. The focus of this study is organizational factors that affect the climate of the maintenance personnel in maintenance workplace that are precursor to accidents.

The pattern that emerged from the ranking of the fifteen safety climate factors in this study are relatively clear with accountability, mechanic (person), instructors/trainers, going beyond compliance and reporting system as priority areas for strong consideration of management and policy makers. The results show that focus should be shifted by management and policy makers to response and feedback on reported safety issues, safety fundamentals, reward system, employee empowerment and management involvement that are unfavourable in ranking in this study. This shift in focus is expected to drive relevant and necessary changes that can help improve safety with the maintenance, repair, and overhaul organization in most cases that managers may consider less important or irrelevant. Managers may apply ordering principles of standardized practice to these factors that ranked low in the climate factors of MRO, thereby helping maintenance personnel to make actual progress in safety improvement leading to the prevention of maintenance related accidents in the aviation industry in Nigeria.

Considering those factors that are significant in this study, managers must understand their role in a formal safety system and ensure that variables such as reporting system, and response and feedback are key factors that must be upheld to improve safety attitude and reduce error tendency thereby influencing employees to engage in decisions that can help reduce accidents within maintenance activities and in the industry at large. Furthermore, managers must understand how to help in safety accountability; while maintenance personnel authority whose responsibility is to act in different task situations must be allowed and given priority in the maintenance work environment. Management must consider the person of the mechanic and their trainers as an important component of the safety chain. The person of the mechanic and their trainers should be a supremely adaptable and effective problem solver that is often able to resolve situations within limited information and is able to download accurate statistics of incidents caused by human input or errors.

Management should consider the conduct of regular systematic analysis of identified factors that are not significant in their organizational commitment. In the area of safety value and safety fundamental, issues such as improvement of maintenance personnel through periodic staff discussion groups to identify factors within the organization that could result in accidents and ways to manage them should be encouraged. This may also require task analysis to identify potentiality and effectiveness of current controls that are in place within the organization.

It is recommended that management of MROs should implement good operational processes with respect to the factors that were non-significant in this study such as; management involvement, going beyond compliance, safety fundamentals, maintenance chief and their roles and with policy signed by those in critical leadership/management positions stating the important organizational factors through updating and systematizing procedures in areas where weaknesses have been clearly identified. Employee empowerment should be accompanied with strong oversight and clearly established hierarchical supervision procedures to avoid complacency on the part of operational personnel who have been promoted to senior positions.

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