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Ergonomic Evaluation of In-Vehicle Interface Design of Taxicabs in Nigeria

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ABSTRACT

The ergonomic implications of vehicles used in public transportation is no longer a trivial factor in the choice of mobility particularly in the face of large variety of brands and models of vehicles rolled into the market by various manufacturers in the automobile industry. The variations in the design of in-vehicle interface and other components of taxicabs found on the streets in Nigeria form the focus of this investigation. The principle behind Participatory intervention approach was adopted in capturing the opinion of a sample of 1046 taxicab drivers on selected in-vehicle elements. The study revealed the chaotic state of public transport operating in Nigeria. Users friendliness of the fleets of disused cabs is generally unsatisfactory. Policy framework and conduct of comprehensive ergonomic survey of Nigerian adult was a suggested solutions to the continue health hazard imposed by the unfit vehicle imported into the country.

***Keywords*:** Ergonomics, Risk Factors, models, in-vehicle elements, Driver's interface.

I. Introduction

The need for the movement of people, equipment and commodities from one place to the other, is the basis for the establishment of various kinds of transportation means and the transportation industry in particular. In Nigeria, a well known and most affordable mode of public transportation is road transportation in which there are fleets of automobiles. The automobile remains a novel invention of human kind devised to ease the problem of movement of material, machine, men and commodities from one place to another. Ever since the advent of the first motorcar fleets of models, makes and designs of vehicles have been introduced by various automobile companies. This is the result of improvements on the cars and attempts to enhance safety, efficiency and comfort of the users. In spite of all the efforts made to improve the user friendliness of motor vehicles, there are still major complaints about their associated health problems by millions of people worldwide[1]. Such problems include lower back pain and other musculoskeletal disorder. Lower back pain (LBP) has been reported to be the main cause of sick leaves in developing world. Efforts made to understand the etiology of LBP as well as their causes are yet to yield a good result [2][3][4]. Other studies demonstrating the association between occupational factors and low-back disorder have also been reported by [5] [6] [7] and [8].

Driving automobiles especially public transportation is a serious and tedious task that requires high level of responsibility on car operator (driver). The underlying causes/risk factors involved in public driving have been studied and reported widely as being at an increased risk of LBP, whole body vibration and fatigue [4][9-15].

Several ergonomic factors have been identified as potential causes of fatigue and occupational stressors responsible for many uncomfortable experiences of drivers. Predominant occupational stressor in driving are postural stress (PS) whole body vibration, lower back pain, musculoskeletal disorder and fatigue.Occupational low back pain (LBP) is a major cause of morbidity and cost [16]. Byrns *et al.*[17] noticed that effort to control LBP has been unsuccessful hence the need for better understanding of the risk especially the psychological factors.

A study on low back pain and working conditions was conducted by Funakoshi *et al.* [18] among male taxi drivers employed in a company in Fukuok. It was revealed that the drivers' seat, whole-body vibration (WBV) and job stress contribute to LBP among drivers. Also in another study, Funakoshi *et al.* [19] measured whole body vibration on the driver's seat pan of 12 taxi operators under actual working condition. The result was evaluated according to the health guidelines in International Standard ISO 2631-1:1997 [20] and it was found that the majority of the frequency-weighted r.m.s. accelerations of the taxis fell into the "potential health risks" zone under the standard. The increasing interest in the introduction of ergonomic principles into the design of vehicle interiors is a recent development which comes up along with efforts of industries to introduce ergonomic concept into industrial products, consumers' requests and expectations. As a matter of fact, major car manufacturers have created bodies and laboratories concerned with ergonomics, some of which indeed have been active since the 1960s [21].

It is very important that ergonomics is considered right at the product design stage. Though with time possibilities of making reasonable changes may be inevitable but possible with ease. Attempt to wait until a prototype is available to carry out ergonomic verifications as it is the order of the day in developing countries leading to the possibility of making significant changes becomes almost zero and any possibility would generate high cost of intervention.

Work-Related Musculoskeletal Disorders (WRMD) and other forms of postural damage may result in physiological illnesses that are developed due to prolonged mechanical stresses imposed on the musculoskeletal system [22]. WRMDs are prevalent in those who engage in occupational driving especially among taxi drivers operating in Nigeria [23]. This is evident by the observed number of hawkers of herbal medications as well as western medicine patronized by the drivers at their various public transport garages.

Poor design of driver's workplace and poor sitting posture are part of what is responsible for stresses and strains experienced by drivers. Driving public transport vehicles frequently entails long term adoption of cramped postures and whole-body vibration. Problems of back pain in driving are known to be caused by constrained work postures and vibration-induced fatigue on muscles and tendons [24]. Consequently, there is a need to integrate both the driver's (operator/user) capabilities and vehicular performance requirements adequately in order to reduce the untold occupational hazards to which they are frequently subjected.

The result of prolonged exposure to occupational risks such as low back pain, discomfort and stress, resulting from unfit workplace in which a driver is confined can lead to fatal accidents, resulting in loss of life, the motor vehicle and properties contained in it. To effectively reduce the fatigue and enhance drivers' performance and safety, there is need to study cumulative trauma disorder and other stress-induced problems mentioned. Also to be studied is the interaction between anthropometric characteristics of human body, the biomechanical properties and physical dimensions of workplace. It is therefore necessary to survey and compile the anthropometric data of the vehicle operators in Nigeria in order to specify appropriate automobiles that should be allowed into the country, especially as it pertains to automobiles like taxis. Major causes of motor accidents are human factors that have to do with the physical, physiological, anatomical and psychological peculiarity of operators of the complex technological system known as a vehicle [25]. In the design of facilities like motor vehicle interior, human body characteristics must be considered in order to enhance performance and improve productivity, comfort and safety at work.

Nigeria is recognized as a major importer of vehicles, most of which have been found to be a potential contributor to risks experienced by Taxicab operators [23]. These risks can be associated with design error which results from the use of anthropometric dimensions of population whose body measurements do not include that of Nigerians. Though there are legislative controls on the types and condition of imported vehicles, lack of effective enforcement of the controls persist. Where there are no anthropometric database to assist automobile manufacturers in the design of user-friendly vehicle, people are forced to be fitted into the non-fitting technological systems that are available in the market. Usual cases of body pains and other musculoskeletal disorders will be minimized, if statutory government agencies in charge of consumer protection, like the Federal Road Safety Commission (FRSC) of Nigeria in collaboration with International Standard Organization (ISO) could ensure that required data are collected and used by both local and foreign automobile industries.

II. Materials and Methods

Four urban centers which represent adequately the distributive spread of Southwestern Nigerian were selected and a sample size of 1406 derived from ISO15535 was used for the survey. Six out of ten prominent makes of vehicles were considered in this work. About thirty three different These are Nissan, Mazda, Toyota, Mitsubishi, Peugeot and Opel. Noticeably, driver's workspace elements which consist of dashboard, controls, seat, gear lever, steering wheel, clutch, brake and acceleration pedals, side door, side mirror and seat belt were studied in relation to their ergonomic suitability. The participatory ergonomic (PE) intervention approach used includes structured questionnaire, interview, operators and ergonomic expert opinion poll and physical assessment of relevant elements of driver-taxicab system. Other tools used in data collection are writing board, survey form and other writing materials.

2.1 Personal Data

Personal information about respondent like name, sex, nationality, state of origin, town, city, age, and educational background were requested. Also included in this section were information about driving license, years of experience in public vehicle driving, hour per day on wheel, model of vehicle used and number of passenger capacity of the vehicle used.

1.2. Evaluation of Some Selected In-Vehicle Components

Six components of driver's environment were considered for personal opinion and assessment

of operators of different models of taxi cabs. The components evaluated were: wind screen, pointer, wiper, dash board, side mirror, and seat belt. Criteria employed as appropriate for evaluation include functionality, ease of use, effectiveness, positioning, availability and mode of operation. Drivers were allowed to make general remark at the end of the major assessment. In anticipation of a low level of education of public vehicle and in order to make simple the filling of the form, the questions were designed for yes or no response.

III. Results and Discursion

3.1 Demographic Characteristics of Respondents

The demographic characteristics of the operators determined included the age and sex. As shown in Table 4.2. The ages of the operators were observed to be normally distributed around 30-39 age group. However, the average age of the drivers in study area was the same (38years) which falls in the age group 36-39. It is important to note that operation of Taxicab and public transportation in particular is largely the job for the adults. Less than one percent of the respondents were 60years and above. This suggests that old age and the associated musculoskeletal troubles impede safe and comfortable operation of Taxicabs. None of the drivers belong to teenage age (13-19) in all the centers. This is in agreement with the Federal Government regulation on the requirements for obtaining driver's licence. Less than six percent of respondents were 50 years of age and above. Likewise less than five percent of the respondents are less than 25 years of age. Out of eight hundred and thirty seven (837) operators surveyed only one of them was a female. This is an indication that occupational driving is predominantly a male job in Oyo State, Nigeria. This observation was also reported by [4] Okuribido *et al.* (2007) in similar study of City bus drivers in UK.

3.2 Models of Taxicab Used

Table 1 shows that 33 models of 11 makes of Taxicabs were found operating in the urban centres studied. Ninety-five percent of the Taxicabs are used vehicles also referred to as "*Tokunbo*". The cabs were manufactured in different countries ranging from developed countries such as United States of America (USA), Germany, Japan, France, Europe and other developing countries like India, China, South Africa and Taiwan.

Percentage difference in the makes of the Taxicabs is in the following order: Toyota(28.1%) > Opel(15.8%) > Nissan(13%) > Mitsubishi(11.7%) > Mazda(9.4%) > Volkswagen(8.9%) > Peugeot(8.3) > Tercel(2.1%) > Audi(1.7%) > Honda(0.8%) > Mercedes Benz(0.2%). Each of this makes has various models. Toyota has the highest percentage (21%) of models followed by Nissan(15%), Mitsubishi(15%), Opel(10%), Volkswagen(10%), and Peugeot(10%) Mazda(10%). Others are Mercedes Benz(6%), Honda(3%), Tercel(3%) and Audi(3%). Physical observation and measurement of the in-vehicle characteristics of each model show significant difference in design and aesthetics.

Investigation reveals that the choice of the type of cab used by driver was based on factor such as Axle type, fuel economy, maintainability, availability, reparability, salvage value, useful life and price.

3.3 Taxicab's Pointer Evaluation

An ergonomic risk factor that has both external and internal negative consequences is the non-functional lighting system. Taxicabs and commercial vehicles in particular are expected to have functional traffic light. Figure 1 shows a general approval of all the studied vehicle's lights, especially the pointers or turn indicators. This suggests the recognition of failed or broken indicator light as a serious regulatory offence.

3.4 Wind Screen Evaluation

Part of the roadworthiness test required for Taxicab and any other types of car is the test of the clarity of the windscreen. A number of human factors responsible for obscuring of windscreen are observed as follows: (1) Poor use of non-transparent stickers placed at driver's normal line of sight, (2) Illegal tinting of front and/or rear windscreen and (3) Poor location of labels, directional cards and other personal effects. Vehicular factor however attributed to windscreen problem by observer are (1) Poor reflection of images and induced glaring problem, (2) Poor seat design in relation to its closeness to the windscreen and (3) Production of secondary image of the display on the windscreen during darkness. (4) Failure or absence of heater to remove fog during wintry weather or icy condition. Figure 2 reveals the general observations and opinion of operators of Taxicabs on the state of vehicle windscreen. There is a general approval of the functionality and effectiveness of windscreen of all

TABLE 1: TAXICAB MAKE/MODEL

Make	*Model*	*Respondents*	
		N	%
Volkswagen	Golf	43	58.11
	Passat	26	35.14
	Jetta	5	6.76
		74	8.92
Toyota	Carina	65	27.90
	Corolla	105	45.06
	Celina	4	1.72
	Starlet	45	19.31
	Isuzu	1	0.43
	Celica	1	0.43
	Camry	12	5.15
		233	28.07
Nissan	Sunny	55	50.93
	Micra	2	1.85
	Bluebird	16	14.81
	Datsu	30	27.78
	Lx	5	4.63
		108	13.01
Mitsubishi	Gallant	12	12.37
	Lancer	65	67.01
	Cam	1	1.03
	Space Wagon	19	19.59
		97	11.69
Mercedes Benz	190	1	50.00
	200	1	50.00
		2	0.24
Peugeot	504 (Wagon)	32	46.38
	505 (Salon)	24	34.78
	505 (Wagon)	13	18.84
		69	8.31
Audi		14	1.69
Mazda	323	28	35.90
	626	32	41.03
	2000	18	23.08
		78	9.40
.Opel	*Kadet*	50	38.17
	Omega	9	6.87
	Ascona	72	54.96
		131	15.78
Tercel	4WD	17	2.05
Honda	Accord	7	0.84
		830	100.00

% = Percent Responded N = Number of Responses

the vehicle models considered with a minimum percent respondent of 65% except in the case of Toyota and Opel where nearly 60% of the respondent in each case did not approve of the state of their vehicle's windscreen. This result suggests a 0.4 to 0.6 possibility of accident being caused by obscure, expiring and crack windscreen. Enforcement of relevant safety regulation by Federal Road Safety Commission (FRSC) and Vehicle Inspection Officers (VIO) would serve useful purpose in eliminating or reducing this type of hazard. Driving with damaged windscreen is punishable under traffic law of the country. With the efforts of road safety commission the unsafe condition imposed by the non-functionality or poor lighting system especially in the night and enforce that vehicles are generally road-worthy.

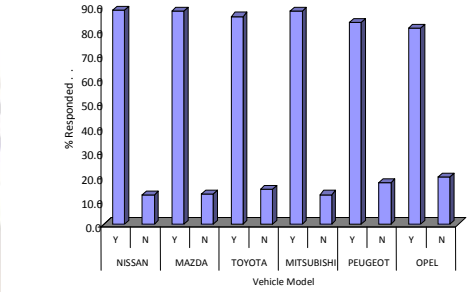

Figure 1: Assessment of Vehicle Point

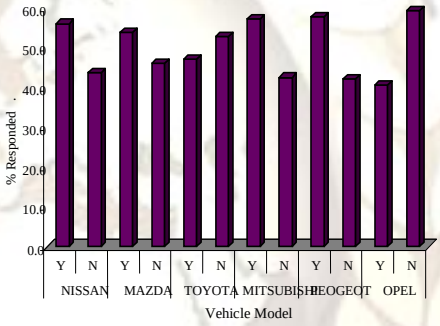

Figure 2: Assessment of Windscreen Clarity

3.5 Windscreen Wiper Evaluation

The Windscreen wiper plays an important role in cleaning the windscreen especially during fogy and dusty weather condition. It is expected to be functional in roadworthy vehicle. Figure 3 shows that in each case of the cabs type considered, respondents approve of the current state of their cab's windscreen wipers. The evaluation considered the state of cabs windshield wiper for minimum requirements such as availability, functionality, accessibility, and effectiveness rather than for secondary feature such as automation, design and ease of use of the control. Modern windshield wipers have been designed to enhance user-friendliness and ease of use though with the consideration of limited anthropometric data

3.6 Dashboard Evaluation

The Dashboard consists of mechanical systems as well as digital displays which produce information that are visibly communicated to the driver. From observation some of the drivers give little or no attention to the dashboard and its elements. Due to sheer negligence a number of

displays which were physically present on the dashboard have stopped functioning. This evaluation was limited to the opinion of Taxicabs operators whose level of educational may have influenced their perception of the significance and contributions of ergonomics in the design of a dashboard. This can be seen in Figure 4

3.7 Evaluation of Side and Inner Mirrors

A Taxicab operator who is in full control of the vehicle and aware of the dynamic road scene gaze occasionally at the mirrors to have a view or information about what goes on at the rear. The assessment of driver's area by the drivers, whose personal interest should be considered, is

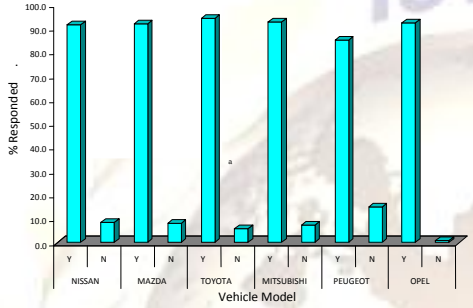

Figure 3: Assessment of Windscreen Wiper

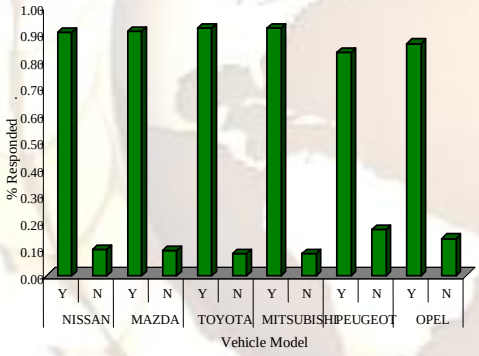

Figure 4: Assessment of Vehicle Dashboard

of great importance. Respondents' assessment of side mirror of the cabs is at variance to each other. Figure 5 shows that nearly 60% of the respondent agreed that the side mirror of Mitsubishi, Mazda, and Peugeot are ergonomically satisfactory. About half of the respondents approved the side as satisfactory while in the case of Toyota and Opel, 50% and 58% respectively show disapproval of side mirror. The result suggests that not all the cabs has functional side mirror that can be easily and comfortably controlled. Figure 6 present the respondents' opinion on ergonomic suitability of the inner mirror. Respondents generally agreed that the inner mirror is available, functional and adjustable.

3.8 Evaluation of Seat Belt

A basic safety requirement for a driver is the use of seat belt while driving. Barbaras (2005) reported that the use of seat belts reduces the risk of death or serious injury by about 45%. In this survey all the cab studied were observed to come with seat belts which are fixed on both the passengers' seats as well as that of the driver. Also observed is failure of majority of the drivers to wear their seat belt. Investigations were however made to assess the functionality, the location and availability of seat belt in the studied Taxicabs. Figure 7 show that more than 70% of the respondents have functional seatbelts that are satisfactorily located

3.9 Vehicle Horn Evaluation

Horn is a necessary facility in a vehicle needed for safety of both the commuters and other road users. Figure 8 suggests that the horn of at least 60% of the cab surveyed have functional horn with the control located at the centre of the steering wheel. Less than 40% of the horns of the

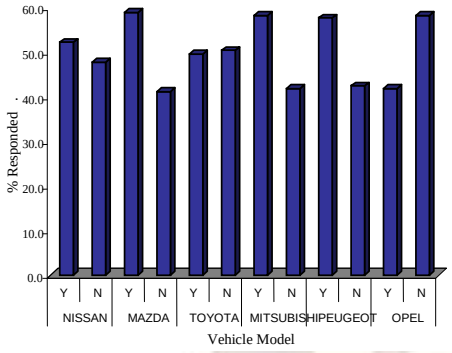

Figure 5: Assessment of Side Mirror

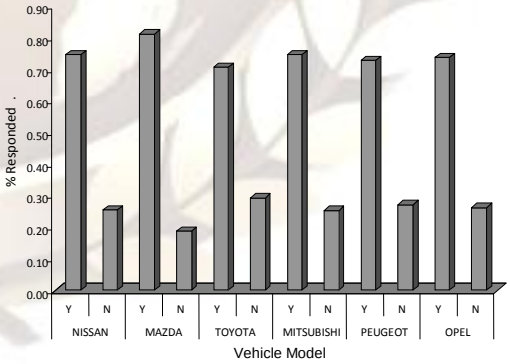

Figure 6: Assessment of Vehicle Inner Mirror

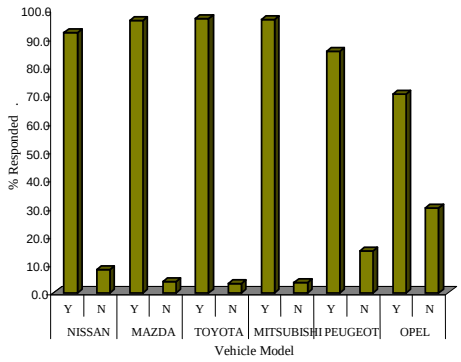

Figure 7: Assessment of Seat Belt

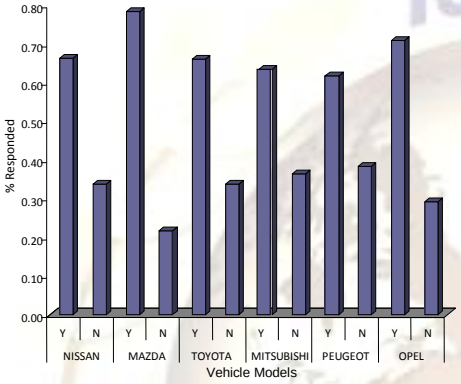

Figure 8: Assessment of Vehicle Horn

vehicles are in state of disuse with respect to location of the vehicle horn. Some cases of relocation of horn noticed were the result of failure of the horn control on the steering wheel which did not yield positively to repairs. Less than 20% of the respondent subscribe to the relocation of horn from its designed location. in their cab. In Opel however a comparatively larger percent (30%) of the respondent may not be satisfied with the functionality of their seat belt.

IV. Conclusions

Though automobile Industry has come of age, room for improvement as a result of ergonomic reasons still keeps the stakeholders in the industry in continues search for system that meet up with current challenges of user population requirements, established technical standards, and other basic specifications for research uses. The fundamental platform for addressing these is through research and development (R&D). Each player in the industry expresses her capability to continue in business by investing adequately in the effective participatory ergonomic intervention programmes. Reason for preference of a particular brand of vehicle to the other has shifted from economic factor to ergonomic feature. For instance, people show more attraction to vehicles with esthetic, comfortable and safe interior features. A number of car types have been traded off for new ones with satisfactory ergonomic features and with the present level of competitiveness among manufacturer of automobile the need to give reasonable consideration to users' opinion which this study has successfully addressed is highly important.

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