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Contribution of Locally Designed and Fabricated Vehicle Seats to Accident Injuries in Ghana.

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ABSTRACT

Buses and minibuses account for a large number of reported Road Traffic Accidents in Ghana. Most of these vehicles are used goods transport vans, modified for passenger transportation purposes. One of such modifications is the provision of seats. These seats are designed and fabricated locally by artisans, but not according to any known safety standards. This among other reasons has resulted in a hypothesis among some medical personnel that, the design of these seats may be responsible for some of the injuries sustained in accidents.

This paper sought to find evidence support of this hypothesis. The results of a kinematic analysis performed with the Working Model 2D software were compared with the results from a Mini Survey that was conducted between November 2011 and January 2012, at the Accident and Emergency Centre of the Komfo Anokye Teaching Hospital, Kumasi, Ghana.

Findings include injuries that are mostly sustained by occupants of accident vehicles, fitted with the seats in question, as well as design features of the seats, that may cause these injuries.

Keywords: *accident injury, road traffic accident, occupant safety, vehicle seat, mini -survey*

1. INTRODUCTION

Ghana's records an estimated 11,400 Road Traffic Accidents (RTAs) resulting in 1,800 fatalities and 14,000 injuries annually [1], [2]. Efforts to address this problem have resulted in the establishment of agencies such as the National Road Safety Commission (NRSC) and the Motor Traffic and Transport Unit (MTTU), which have been running road safety campaigns and enforcing safe driving practices on roads. However, it appears little or no attention is given to programmes which aim at protecting occupants of vehicles in the event of accidents.

Buses and minibuses are among the commonest forms of transport for many people in Ghana. In 2005, they accounted for over 35% of all reported road crashes in the country [3]. They are mostly 12 or 15 Seat minibuses of various makes and models as well as the Mercedes-Benz Sprinter and its 207, 208, and 308 predecessors. These vehicles are mostly converted from used goods transport vans and are modified to suit the purpose of public passenger transportation. The seats fitted in these converted vans are designed and fabricated locally by local artisans.

Fig. 1: Locally Fabricated Vehicle Seat during Construction (Arrows Pointing To Base Rear Connecting Member)

Fig. 2: Locally Fabricated Vehicle Seat

These seats basically comprise a metal frame fabricated from mostly galvanized or mild steel pipes, to which plywood of about 2 cm thickness is attached to complete the base and backrests. The assembly is then padded with foam and covered with synthetic leather. The seats lack safety features such as anti-submarining pans and seatbelts, and are not known to be designed according to any safety standards.

The seats used by the 12 and 15 Seat Buses are of the Bench type as shown in Fig. 2. They are generally shorter (in terms of height from the ground) as compared to those found in the Mercedes-Benz Buses which are taller. A seat under construction for a Mercedes-Benz Bus can be seen in Fig. 1. The width of the seats vary, depending on where they are located within a vehicle. The average dimensions of the seats as measured from selected vehicles at two vehicle stations within the Kumasi metropolis are presented in Table 1.

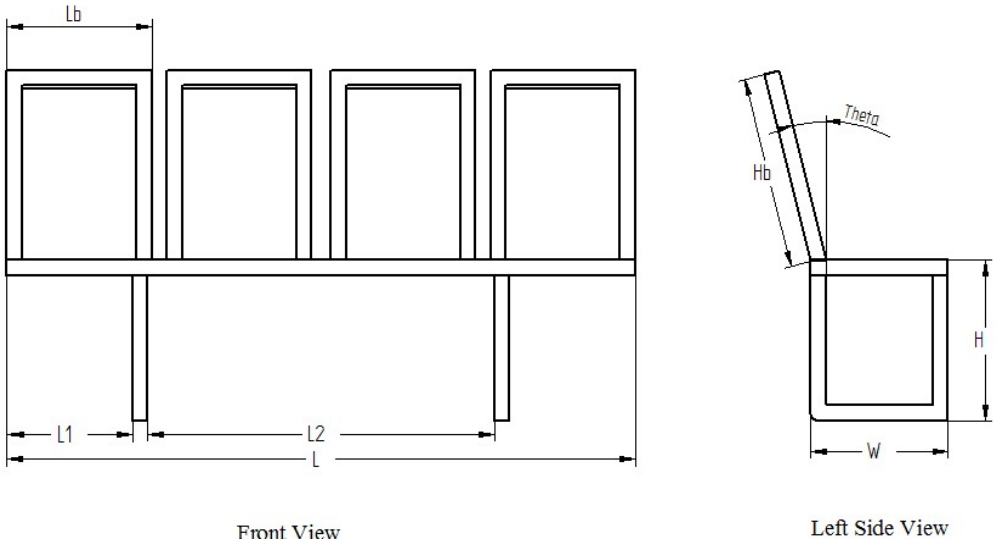


Fig. 3: Dimensions used in Table 1

Table I: Average Seat Frame Dimensions (Dimensions generally vary from artisan to artisan)

Vehicle	Seat Location in Vehicle	L	L1	L2	Lb	W	H	Hb	Theta*
207 and Sprinter	Back Seat	163	36	83	39	36	45	59	14º
	Other Seats	158	36	78	39	36	45	59	14º
12 and 15 Seat Bus	Back Seat	127	25	94	127	36	40	50	14º
	*Middle seats (for 2 passengers)	82	0	55	82	36	40	50	14º
	*Middle seats (for a passenger)	38	0	38	38	36	40	50	14º
	Seat behind driver	110	20	82	110	36	40	50	14º

*A middle row of seats has each of the two middle seats.

Since the seats are not designed to meet any accepted safety standards, some Medical Personnel of the Accident and Emergency (A&E) Centre of the Komfo Anokye Teaching Hospital (KATH), Kumasi, have hypothesized that, some of the injuries sustained by RTA victims may be due to the design of these seats. This aim of this paper was to support this hypothesis with computer simulations and accident injury data that was gathered from the hospital.

2. TOOLS AND METHODS

A kinematic analysis was carried out using the Working Model 2D software. This helped determine injuries that are most likely to be sustained by occupants of vehicles using the seats in question, in the event of an accident. The human body parts dimensions required for the simulation were approximated using human body proportion charts that are available in literature, whiles seat dimensions were measured during visits to some

vehicle stations within the Kumasi metropolis. Vehicle dimensions were approximated from vehicle brochures. The dummies were modelled as rigid bodies and it was also assumed that seats remained attached to the vehicle floor and not damaged during or after the accident.

The mini survey was conducted at the A&E Centre of KATH, between November 2011 and January 2012 to determine the predominant injury points of occupants of RTA vehicles. The mini-survey was most appropriate for this research, primarily because of a lack of enough information, to determine an appropriate sample size for a full survey. A mini-Survey has a sample size between 25 and 70 [4]. Information gathered from survey included accident vehicles of victims, location of injury occurrences on victims, victim heights (to determine body part proportions) and types of accidents the vehicles was involved in.

3. RESULTS AND DISCUSSIONS

Occupant behavior during vehicle accidents basically, is governed by Newton's Laws of Motion. Before most accidents, the occupants are normally in equilibrium with the vehicle according to the first law. At impact, an occupant normally experiences a high rate of acceleration, the magnitude of which mainly depends on factors such as the relative velocity of the vehicle at impact, its mass, as well as how well the vehicle absorbs the impact forces, bringing into play, the second and third laws. In the absence of safety features such as seat belts to restrict the occupant motion that results from this acceleration, impacts between the occupant and contact surfaces in the vehicle occur, resulting in injuries.

The type of injuries sustained may also depend on the kind of motions that the occupant experiences. In typical Front impacts (the commonest form of accident recorded during the survey, with 24 of the 31 victims interviewed involved in this type of accident), sliding and rotary motions are experienced by various part of an occupant's body as illustrated in Fig. 4.

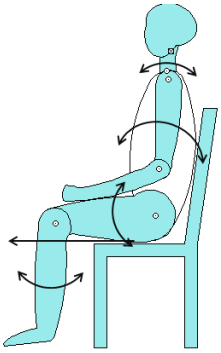
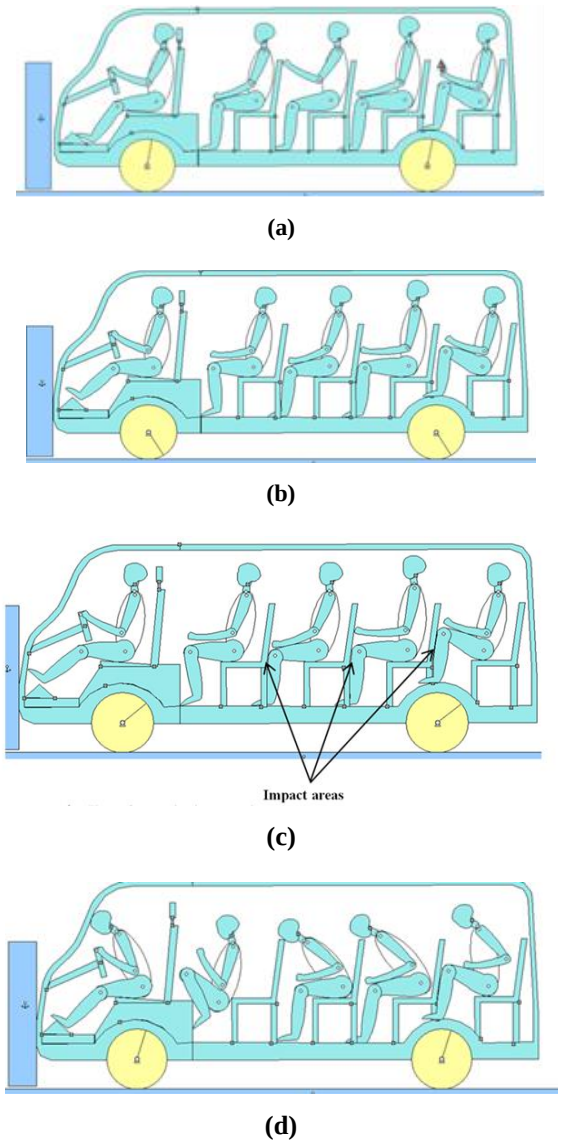


Figure 4: Motions that can be experienced by Occupants of Vehicles during Front End Impacts

A typical Front End collision was considered in four stages as illustrated in Fig. 5. It was realized that, occupants slide in their seat after the vehicle impacts, hitting the seats in front of them as there are no restraints to arrest their forward sliding movement (See Stages 2 and 3 in Fig. 4).

Impacts that will most likely result in injuries are mostly between the base rear connecting member of the seat frame (indicated in Fig. 1) and occupant's knees and legs. The sitting posture of the occupants also permits the transmission of the impact forces directly through their thighs to their hips, resulting in the possibility if hip dislocations.



(a)

(b)

(c)

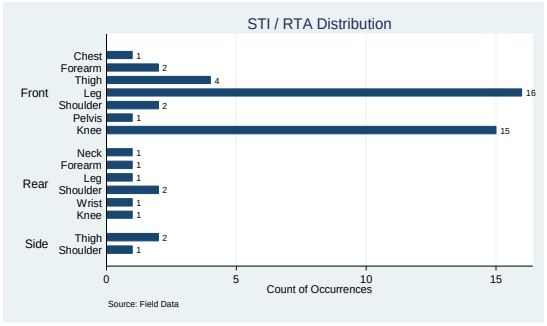
(d)

Fig. 5: Stages of a Typical Front Impact [(a) Before Impact (b) Vehicle Impact (c) Primary Impact Between Seats And Occupants, and (d) Secondary Impact between seats and occupants]

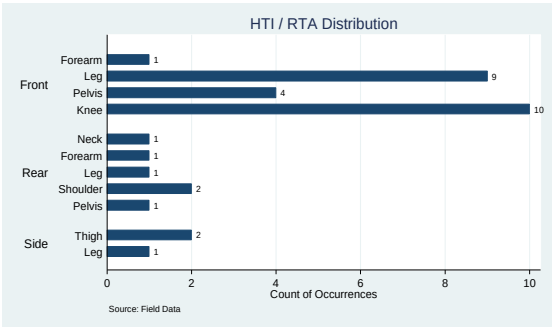
Injury data was collected from thirty-one accident victims between November 2011 and January 2012. Eighty-four injury occurrences were recorded. The injuries were grouped into Soft Tissue Injuries (STIs), which refer to flesh and muscle injuries, and Hard Tissue Injuries (HTIs) which refer to fractures and dislocations. An analysis of the recorded injury occurrences are shown in Fig. 5 and Fig. 6.

It was realized that, as was been observed from the simulation, most of the injuries recorded (both STIs and HTIs) were sustained in the knees and legs of victims (See Fig. 5). A few pelvic injuries were also recorded, confirming that impact forces are transferred to victims' hips during these accidents.

A further analysis of the injury locations, from the vehicles in which they were sustained indicated that, most of the knee injuries (both STIs and HTIs) were sustained by victims from the 207 and Sprinter type of minivans as indicated in Fig. 6. This, it is believed is due to the fact that, the bases of the seats found in these types of buses are generally higher of the ground than those found in the 12 and 15 Seat Buses (See Table 1).

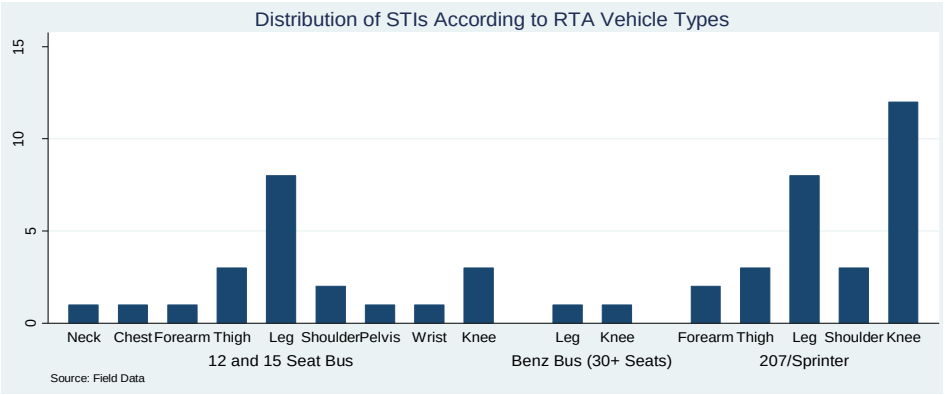


(a)



(b)

Fig. 5: Analysed Injury Data
[(a) Analysed Data on STIs (b) Analysed Data on HTIs]



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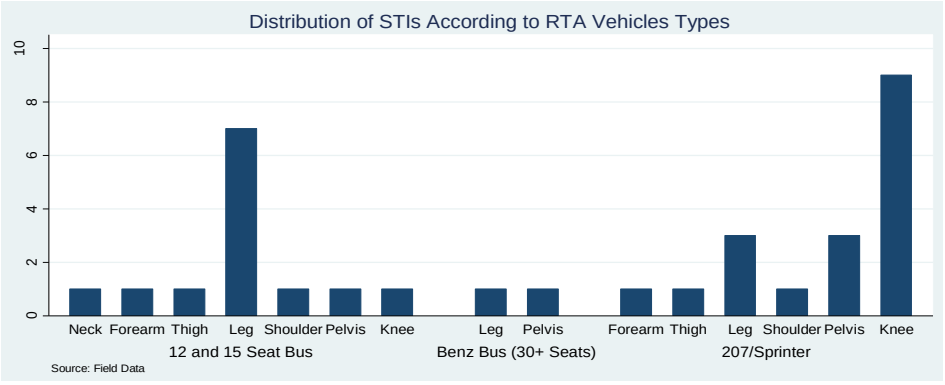

(b)

Fig. 6: Locations of Injuries Sustained in Various Vehicle Types. [(a) STIs (b) HTIs]

4. CONCLUSION

This paper aimed at using results from an accident simulation and analysed injury data to support the hypothesis that, some of the injuries sustained by RTA victims may have been as a result of the design of these seats.

The following findings were made:

- Front Impact injuries from these seats should be expected in the legs, knees, thighs and pelvis.
- Predominant Front Impact injury occurrences recorded at the A&E Centre of KATH were recorded in the legs, knees and thighs.
- The injuries are as a result impacts between occupants' knees and legs and the base rear connecting member of the seats (due to its location). The sitting posture of the occupants (which is determined by the design of the seats), also permits the transmission forces directly through their thighs, resulting in pelvic injuries.
- The absence of seat belts to arrest the forward sliding motion of occupants, the horizontal elevation of the seat bases (instead of elevating their fronts to incorporate anti-submarining pans), as well as the close spacing of these seats, also contribute to the sustaining of these injuries. The spacing between most of these seats averaged 60 cm, which was found to be below what is specified in some known international safety standards.

Based on these findings, it was concluded that the design of these seats do probably cause some of the injuries sustained by victims of RTAs.

This work did not consider the severity of the injuries sustained from these seats as compared to the severity of injuries sustained from foreign seats. It is recommended that any future work take this into consideration. It is also recommended that an evaluation of the locally fabricated vehicle seats be carried out to determine if they meet any accepted safety standards.

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