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RESEARCH ARTICLE

# FALL-RELATED TRAUMATIC BRAIN INJURIES IN A RURAL HINTERLAND: A PROSPECTIVE STUDY

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**ABSTRACT**

**Summary:** Fall has been with us for ages. Our forefathers experienced it. They made proverbs from falls. The consequences of falls are enormous, including traumatic brain injuries. It is one of the most common causes of traumatic brain injuries. The need to prevent it from happening cannot be overemphasized.

**Objective:** The aim was to determine the treatment outcomes in patients we managed in our center for traumatic brain injuries from falls

**Methods:** It was a prospective observational study of patients we managed in our center for traumatic brain injuries from falls from August 2010 to July 2016. The patients were managed in accident and emergency using Advanced Trauma Life Support protocols. After resuscitation patients were admitted in the wards or intensive care units based on severity of injury. Those who needed surgery were operated and admitted in the appropriate wards. Treatment continued in the wards until discharged. They were followed up in surgical out-patient clinic. Their Glasgow Outcome Scores were assessed three months post-injury. Data were collected using structured proforma which was component of our prospective data bank that was approved by our ethics committee. Data were analyzed with Environmental Performance Index 7 software.

**Results:** There were 69 patients in the study. Males were 53. The ages ranged from four months to 86 years. The most common cause was slip on the floor. Forty one patients fell at home. The favorable outcome was 85.51%. Severity of injury and age affected the outcome, while age alone affected the hospital stay.

**Conclusion:** Slipping, fall from balcony and home materials cause majority of falls. The favorable outcome was 85.51%. Fall prevention campaign is essential.



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## INTRODUCTION

Fall has been with us for ages. In Aku town, Eastern Nigeria, many proverbs were coined by our ancestors from their experience with falls and passed them from generation to generation. One proverb says 'The man who wants to harvest all the fruits produced by *Ukpaka* (oil bean tree) will come down from a route different from the one he climbed the tree'. Another one says '*Otaba*, the comedian *Odo* masquerade, tripped and fell with its buttocks and told the on-lookers that he fell into the place he wanted to sit.' Still another says 'The lizard that fell from *Iroko* tree, watched the on-lookers and nobody praised his resilience. He nodded several times and said he praised himself if no one else did'. Our ancestors coined these proverbs from their experiences with falls to indirectly express other happenings in life. With civilization, falls from balcony, scaffold, roof tops, moving vehicle, stairs, tiles and many other ways, have widened where people fall.

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The dangers posed by this modernization was depicted by a man who slipped and fell in his bathroom and had brief loss of consciousness. When he regained his consciousness, he started removing all the floor tiles in his house, quipping 'I cannot use my money to buy my death'. In United States, falls are responsible for a third of all traumatic brain injuries (TBI), rising to 60% in those 65 years and older (Faul *et al.,* 2002). In Nigeria, falls constituted about 12% (Jasper *et al.,* 2014) of etiologies of traumatic brain injuries, rising up to 48% (Emejulu and Shokumbi, 2010) in children. This prospective study was carried out on patients who sustained traumatic brain injuries from falls over a six year period.

## MATERIALS AND METHODS

### Setting

It was a prospective, observational and cross-sectional study of patients who were managed for fall-related traumatic bring injuries in a young neurosurgical center catering for people in rural hinterland of a developing country from 1st August 2010 to 31st July 2016.

**Inclusion criteria**

All patients admitted and managed for fall-related traumatic brain injuries and followed up to three months post-injury.

**Exclusion criteria**

Patients with fall-related traumatic bring injuries who were brought in dead or who died during resuscitation in accident and emergency unit. Patients who were thrown off vehicles during car crashes were not included. Patients who ran away from the hospital during treatment or who discharged against medical advice were excluded. Those who failed to attend the out-patient clinic three months post-injury and we could not reach them or their relatives on phone (usually due to lack of network coverage) were also excluded.

**Methods**

Patients were managed in accident and emergency using Advanced Trauma Life Support protocols. We aimed at oxygen saturation of ≥95% in room air or by augmentation with oxygen via face mask, nasal prongs or endotracheal intubation. Intravenous Normal saline or 5%Dextrose/saline for adults or 4.3%Dextrose/1/5 saline for children were given ensuring normtension and euvolemia. Those with open wounds were given intramuscular (i. m.) Tetanus toxoid 0.5ml stat. Intravenous (i. v.) Ceftriaxone 1gm for adults and 50-100mg/kg for children was also given to those with open wounds. Paracetamol was given 900mg or 1gmfor adults and 15mg/kg for children via i.m./i.v. (route depends on constitution) every 8 hours. Full history and physical examinations were carried out. The Glasgow Coma Scale scores after resuscitation was also documented. Full blood count, electrolytes/urea/creatinine, urinalysis and/or random blood sugar were done. Computerized Tomography (CT) scan of the brain was done (for those who could afford it). Patients who were comatose were admitted in intensive care unit (when functional) while others were admitted in the wards. Those with lesions requiring surgery were operated and admitted to the appropriate wards. Other organ injuries were managed by the specialist units. Nasogastric tube feeding for the unconscious patients was started from the third day post-injury using high energy/high protein diet. The diet was constituted thus: 500ml pap, two tablespoonful powdered milk, two tablespoonful soya bean powder, one tablespoonful crayfish powder, and one tablespoonful red oil. They were given five to six times daily. Their daily fluid requirements were factored into the diet. Intravenous and intramuscular drugs were converted to oral drugs and administered via the nasogastric tube. Intravenous fluid was stopped once daily requirement was achieved by enteral route. Multivitamin, Vitamin C, Vitamin B-Complex and Encephabol one tablet each were given three times daily. On discharge, the patients were followed up in surgical out-patient clinic. Data were collected using structured proforma which was component of our prospective data bank that was approved by our ethics and research committee. Biodata, history and physical findings, including Glasgow Coma Scores (GCS), and investigative findings were documented in accident and emergency. The GCS prior to surgery and the procedure carried out were documented in theater. The progress of the patients and length of hospital stay were documented in the wards. Their Glasgow Outcome Scores (GOS) were documented in the clinic three months post-injury. Those who failed to attend clinic were contacted on phone. Those we could not reach, their relatives were contacted and the conditions of the patients documented based on the information given. Data were analyzed using Environmental Performance Index (EPI) info 7 software (Center for Disease Control and Prevention, Atlanta, Georgia, USA). Add analysis of the visual dashboard component was used. The frequencies were done using frequency and pie chart components. The Mean component was used for continuous variable such as age and length of hospital stay. The MXN/2X2 component was used for univariate analysis, while its advanced component was used for multivariate analysis. At 95% confidence interval $P < 0.05$ was considered significant.

## RESULTS

There were sixty nine patients in the study. Males were 53 (76.81%), while females were 16 (23.19%). The age ranged from four months to 86 years with a mean of 30.39 years. Patients aged 0-10 years formed the highest frequency, 20 (28.99%). Twenty six (37.69%) of the patients were less than 20 years (children), 24 (34.78%) were 20 to less than 50 years (adults), while 50 years and above (older adults) were 19 (27.54%), table 1.

**Table 1. Age group frequency**

| Age group | Number | Percent (%) |
|---|---|---|
| 0 - <10 | 20 | 28.99 |
| 10 - <20 | 6 | 8.70 |
| 20 - <30 | 8 | 11.59 |
| 30 - <40 | 11 | 15.94 |
| 40 - <50 | 5 | 7.25 |
| 50 - <60 | 8 | 11.59 |
| 60 - <70 | 6 | 8.70 |
| 70 - <80 | 3 | 4.35 |
| 80 - <90 | 2 | 2.90 |
| Total | 69 | 100 |

**Table 2. Where patients fell from**

| Fall from | Number | Percent (%) |
|---|---|---|
| Balcony | 10 | 14.49 |
| Home materials | 10 | 14.49 |
| Tree | 2 | 2.90 |
| Off care giver | 4 | 5.80 |
| Moving motorcycle | 2 | 2.90 |
| Moving vehicle | 9 | 13.04 |
| The roof/scaffold | 6 | 8.70 |
| Others | 5 | 7.25 |
| Slip on the floor/bathroom | 18 | 26.09 |
| Stairs | 2 | 2.90 |
| Trip by something | 1 | 1.45 |
| Total | 69 | 100 |

The most common cause of falls was slip on the floors, followed by falls from balcony and home materials, table 2. Home was the most common place for falls, 41 (59.42%), fig 1. There was a significant relationship between age groups and location of falls, with children and older adults falling at home, while the adults fell on the roads and work places, $P = 0.0016$, table 3. Based on their GCS scores, 43 (62.32%) had mild, 11 (15.94%) had moderate, while 15 (21.74%) had severe TBI. Forty nine (71.01%) were able to do CT scan of the brain. The most common CT finding was subdural hematoma, 15 (30.61%), table 4. There was significant relationship between age group and CT findings, with 80% of subdural hematoma seen in older adults, $P=0.0076$, table 5.

**Table 3. Age group vs location of fall**

| Age group | Location where patients fell | | | | | |
|---|---|---|---|---|---|---|
| | Home (%) | School (%) | Road (%) | Others (%) | Work (%) | Total (%) |
| 0 - <10 | 19 (95.00) | 0 (0) | 1 (5.00) | 0 (0) | 0(0) | 20 (100) |
| 10 - <20 | 2 (33.33) | 1 (16.67) | 2 (33.33) | 0 (0) | 1 (16.67) | 6 (100) |
| 20 - <30 | 1 (12.50) | 1 (12.50) | 5 (62.50) | 0 (0) | 1 (12.50) | 8 (100) |
| 30 - <40 | 1 (9.09) | 0 (0) | 4 (36.36) | 1 (9.09) | 5 (45.45) | 11 (100) |
| 40 - <50 | 2 (40.00) | 0 (0) | 0 (0) | 0 (0) | 3 (60.00) | 5 (100) |
| 50 - <60 | 7 (87.50) | 0 (0) | 1 (12.50) | 0 (0) | 0 (0) | 8 (100) |
| 60 - <70 | 5 (83.33) | 0 (0) | 1 (16.67) | 0 (0) | 0 (0) | 6 (100) |
| 70 - <80 | 2 (66.67) | 0 (0) | 1 (33.33) | 0 (0) | 0 (0) | 3 (100) |
| 80 - <90 | 2 (100) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 2 100() |
| Total | 41 (59.42) | 2 (2.90) | 15(21.74) | 1 (1.45) | 10 (14.49) | 69 (100) |
| *P* = 0.0016 | | | | | | |

**Table 4. CT findings**

| CT findings | Number | Percent (%) |
|---|---|---|
| Contusions/ICH | 5 | 10.20 |
| DAI | 2 | 4.08 |
| Edema | 3 | 6.12 |
| EDH | 5 | 10.20 |
| Multiple | 6 | 12.24 |
| None | 6 | 12.24 |
| Others | 7 | 14.29 |
| SDH | 15 | 30.61 |
| Total | 49 | 100 |

ICH (intracerebral hematoma), DAI (diffuse axonal injuries), EDH (extradural hematoma), SDH (subdural hematoma)

**Table 5. Age group vs CT findings**

| Age group | CT findings | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | C/ICH | DAI | Edema | EDH | Multi | None | Others | SDH | Total |
| 0 - <10 | 1 | 0 | 0 | 1 | 3 | 3 | 3 | 0 | 11 |
| 10 - <20 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 3 |
| 20 - <30 | 1 | 2 | 1 | 0 | 0 | 0 | 2 | 0 | 6 |
| 30 - <40 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 3 | 7 |
| 40 - <50 | 2 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 5 |
| 50 - <60 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 4 | 7 |
| 60 - <70 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 5 | 6 |
| 70 - <80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| 80 - <90 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| Total | 5 | 2 | 3 | 5 | 6 | 6 | 7 | 15 | 49 |
| *P = 0. 0076* | | | | | | | | | |

**Table 6. Severity vs GOS**

| Severity | Glasgow Outcome Scores | | | | | |
|---|---|---|---|---|---|---|
| | 1 (%) | 3 (%) | 4 (%) | 5 (%) | ≥4 (%) | Total (%) |
| Mild | 0 (0) | 0 (0) | 2 (4.65) | 41 (95.35) | 43 (100) | 43 (100) |
| Moderate | 1 (9.09) | 0 (0) | 1 (9.09) | 9 (81.82) | 10 (90.91) | 11 (100) |
| Severe | 8 (53.33) | 1 (6.67) | 3 (20.00) | 3 (20.00) | 6 (40.00) | 15 (100) |
| Total | 9 (13.04) | 1 (1.45) | 6 (8.70) | 53 (76.81) | 59 (85.51) | 69 (100) |
| *P* = 0.00 | | | | | | |

**Table 7. Age group vs GOS**

| Age group | GOS | | | | | |
|---|---|---|---|---|---|---|
| | 1 (%) | 3 (%) | 4 (%) | 5 (%) | ≥4 (%) | T0tal (%) |
| 0 - <10 | 0 (0) | 0 (0) | 1 (5.00) | 19 (95.00) | 20 (100) | 20 (100) |
| 10 - <20 | 0 (0) | 0 (0) | 0 (0) | 6 (100) | 6 (100) | 6 (100) |
| 20 - <30 | 2 (25.00) | 0 (0) | 2 (25.00) | 4 (50.00) | 6 (75.00) | 8 (100) |
| 30 - <40 | 5 (45.45) | 0 (0) | 0 (0) | 6 (54.55) | 6 (54.55) | 11 (100) |
| 40 - <50 | 1 (20.00) | 0 (0) | 0 (0) | 4 (80.00) | 4 (80.00) | 5 (100) |
| 50 - <60 | 0 (0) | 1 (12.50) | 1 (12.50) | 6 (75.00) | 7 (87.50) | 8 (100) |
| 60 - <70 | 1 (16.67) | 0 (0) | 0 (0) | 5 (83.33) | 5 (83.33) | 6 (100) |
| 70 - <80 | 0 (0) | 0 (0) | 1 (33.33) | 2 (66.67) | 3 (100) | 3 (100) |
| 80 - <90 | 0 (0) | 0 (0) | 1 (50.00) | 1 (50.00) | 2 (100) | 2 (100) |
| Total | 9 (13.04) | 1 (1.45) | 6 (8.70) | 53 (76.81) | 59 (85.51) | 69 (100) |
| *P* = 0.0433 | | | | | | |

**Table 8. Age vs LOS**

| Age group | LOS in days | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1-10 | 11-20 | 21-30 | 31-40 | 41-50 | 51-60 | 61-70 | Total |
| 0 - <10 | 14 | 3 | 2 | 0 | 0 | 1 | 0 | 20 |
| 10 - <20 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 6 |
| 20 - <30 | 6 | 0 | 0 | 0 | 0 | 0 | 2 | 8 |
| 30 - <40 | 4 | 5 | 0 | 0 | 1 | 0 | 1 | 11 |
| 40 - <50 | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 5 |
| 50 - <60 | 2 | 2 | 3 | 0 | 1 | 0 | 0 | 8 |
| 60 - <70 | 1 | 4 | 1 | 0 | 0 | 0 | 0 | 6 |
| 70 - <80 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 3 |
| 80 - <90 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 |
| Total | 37 | 16 | 7 | 3 | 2 | 1 | 3 | 69 |
| *P = 0.0005* | | | | | | | | |

LOS (length of hospital stay)

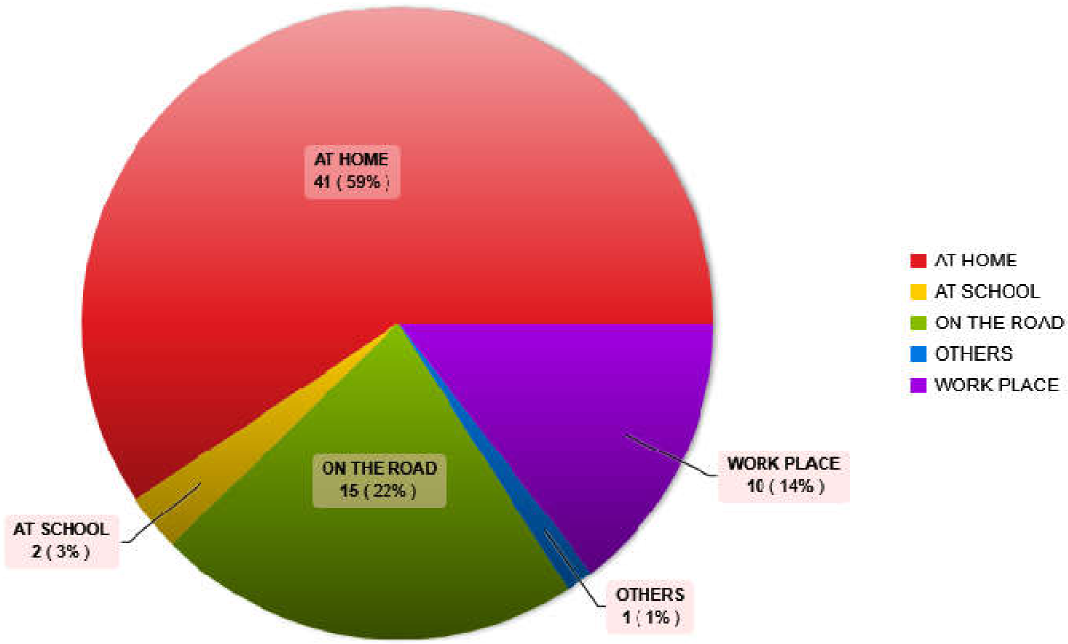


**Fig. 1. Location fall occurred**

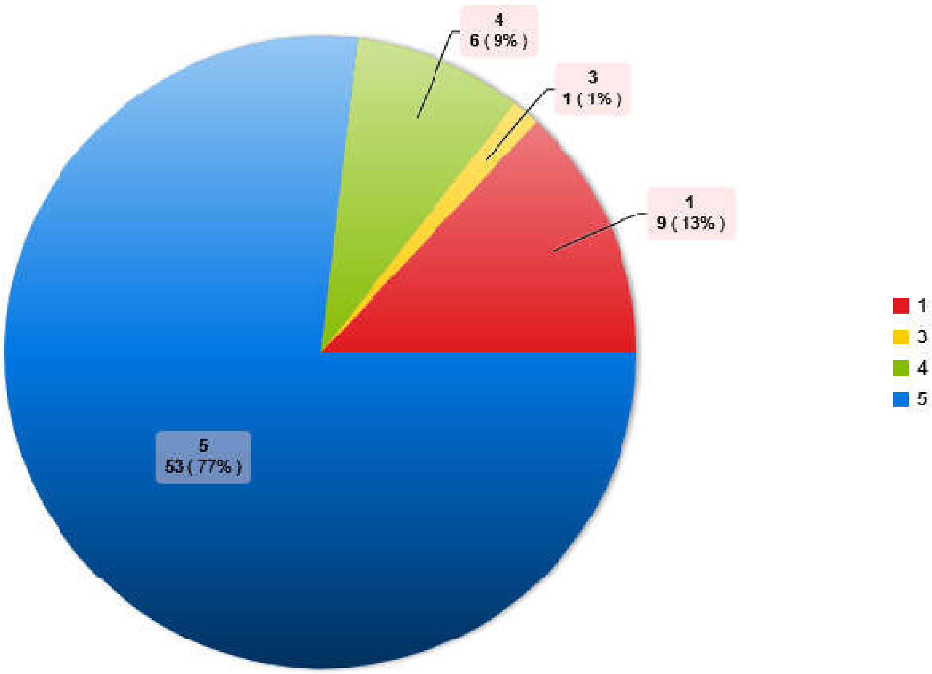


**Fig. 2. Treatment Outcome (GOS)**

Forty two patients were managed conservatively, eleven had burr hole, eleven also had craniotomy, two had craniectomy and primary bone replacement, while three had skin closure. Favorable outcome (GOS ≥4) was seen in 59 patients (85.51%), while 9 patients died (13.04%), Fig 2. There was significant relationship between severity of injury and treatment outcome, *P = 0.00*, table 6. There was significant relationship between age groups and outcome, with children having 100% favorable outcome, *P = 0.0433,* table 7. There was no significant relationship between location of fall and outcome, *P = 0.0791*. The hospital stay ranged from one day to 70 days with a mean of 14.26 days. There was significant relationship between age group and length of hospital stay with 73.08% of the children, 54.17% of the adults and 26.32% of the older adults, being discharged in first ten days, (*P = 0.0005*), table 8.

# DISCUSSION

The study showed that the patients were predominantly males, 76.81%. There have been high male preponderance in traumatic brain injuries. Demas (2006) in USA found 52% males in his study. Chabok *et al.,* (2012) in their study of 668 pediatric head trauma, found that 487 (72.9%) were males. Among patients with mild traumatic brain injuries Jacobs *et al.* (2010) found that males constituted 68%. In their study of severe traumatic brain injuries Jiang *et al.* (2002) found that males formed about 79%. High male preponderance in TBI has been attributed to males being more active than females. The highest number of falls was seen in children, followed by the adults, and then older adults. Majority of children and older adults fell at home, while the adults fell on the road or work place. Kim *et al.* (2008) in their analysis of pediatric head injury from falls found that most of the children fell from windows, balconies, stairs and other home materials. This was likely due to high play rate among children, especially male toddlers who play football everywhere at home. When they see their mates from balcony or window playing downstairs, they want to join them through the balcony or window leading to falls. When the rails of balconies are in disrepair, the children slip through with ease. Many of the toddlers fell through this way in nearby military barracks. Older adults were mainly victim of wet floors at home especially floors with slippery ties/carpets. They also fall on the stairs because of their frailty and tendency to hit their feet against the step. In their study of slipping and tripping in patients 65 years and older, Rosen *et al.* (2013) found that 72.8% of 30467 patients fell at home. It had also been found that the risk of experiencing a fall at home increases with advancing age (Campbell *et al.,* 1989; Nevitt *et al.,* 1991; Rubenstein and Josephson, 1996). Adults fell mainly on the roads and at work places. Many of them who fell off moving vehicles were ‘conductors’ and traders who sat on top of goods being conveyed by trucks from one city to another. They fell off while asleep. Due to nonfunctional rail system in our country goods are conveyed by trucks and conductors and traders sit on the goods. At times they discovered that somebody had fallen when somebody woke up and did not see the person next to him. Many of the adults also fell from roof tops and scaffolds. These are carpenters, bricklayers and painters who work without protective devices, thus predisposing themselves to traumatic brain injuries in event of fall. During rainy season, the planks used in building scaffolds got soaked with water and became weak. Many of them broke while the workers were on them leading to falls.

The CT findings had significant relationship with age, with 80% of the subdural hematoma occurring in older adults. Majority presented with chronic subdural hematoma, weeks after trivial TBI.

The brain shrinks (atrophy) with age and in the elderly it weighs approximately 200mg less, resulting in increase in volume of the extra-axial space (Misra *et al.,* 1996) with tension on the bridging veins, which can rupture with trivial force leading to subdural hematoma. Many presented at chronic stage of the hematoma, weeks after the injury. High number of subdural hematoma in this study corroborates other authors who have noted increasing incidence of chronic subdural hematoma in developing countries due to increasing life expectancy (Mori and Maeda, 2001; Spallone *et al.,* 1998; Zingale *et al.,* 1997). The favorable outcome was 85.51%. There was significant relationship between severity of injury and outcome. In traumatic brain injury, the extent of brain injury mirrors the GCS scores and the extent of the repair that will be carried out by the body. The extent of repair achieved reflects the clinical outcome in the patients. Park *et al.,* (2004) in their study found favorable outcome of 86.76%. In Oklahoma, Demas (2006) found favorable outcome of 70% in patients with TBI from falls from stairs/steps. There was significant relationship between age and outcome with children having 100% favorable outcome. Age was also significantly related to length of hospital stay. These could be due to faster reparative process in children due to faster metabolism. There is more oxidative stress with increasing age. Oxidative damage to mitochondrial components has been shown to accumulate in an age-dependent manner in certain mitochondrial fractions, (Gilmer *et al.,* 2010) and can alter several mitochondrial and cellular functions (Stowe, 2009). The mitochondrial impairment leads to reduction in the production of energy needed for the reparative processes. The extent of mitochondrial damage is much pronounced in pathological conditions (Finsterer, 2008) such as traumatic brain injury. Gilmer *et al.,* (2010) in their study of age-related mitochondrial changes after traumatic brain injury found that there was increased oxidative stress after traumatic brain injury which was significantly related to age, and are more pronounced in synaptic mitochondria.

There was alteration in respiratory control ratio value which showed impairment of coupling of ATP in the electron transport chain. These could explain why the children recovered faster and stayed less in hospital. Why adults who fell from roofs and scaffolds sustained more injuries and had poorer outcome than children who fell from balconies and windows could not be completely explained by oxidative stress and higher metabolism. In their analysis of pediatric head injury from falls, Kim *et al.,* (2000) found that there was no correlation between admission GCS and height of falls. They also found that falls from a height greater than 15 feet (high level fall) were not associated with a higher incidence of intracranial bleeding; most hemorrhages were related to low-level falls that occurred at 6 feet or less. Some authors found no incidence of death in children who fell from heights of three stories or fewer (Barlow *et al.,* 1983). Humans have the ability to breathe in more air into their lungs. In adults, we can do this during ‘breathe in and out’ exercises. In children it is seen in many ways.

- When you play with a child by throwing him up and catching him on descent, he spreads the upper limbs in the air, breathes in multiple times, then hold his breath until he is in your arms.

- When a child cries for a while, and then stops, you notice he breathes in multiple times, holds his breath for a moment, then follows with a loud breathe out.
- When a child is startled, he breathes in multiple times, holds his breath for sometimes, then follows it with loud cry. The third mechanism likely comes into play when children fall from high heights.

The multiple breathing in and holding increases the volume of air in the lungs, reducing their density in the air. Expansion of the chest by the hyperinflation of the lungs help them displace more atmospheric air and helps in making them more buoyant in the air. Trunk expansion by large volume of air in the lungs helps the child fall with larger area, reducing the impact per area. On falling, the loud cry deflates the lungs back to normal. This loud cry brings the attention of the parents to the fall. This protective mechanism likely exists to some extent in adults. One of our patients was thrown off second floor of a building by high tension electric cable which he touched with Aluminium roofing sheet he was carrying. He fell about two meters away from the building and sustained mild TBI. Gerber *et al.,* (2009) in their study of impact of falls on early mortality from severe traumatic brain injury found that mortality was significantly higher in people who fell less than three meter than those who fell more than three meters (31% vs 25%). Among patients 65 years and older, mortality from falls <3m was 48%, while >3m was 42%. Patients who could not activate this likely protective mechanisms such as those falling while asleep and through woods used in building scaffolds had worst mortality in the study. Those falling close to the ground will not bring this mechanism into play, hence they fall with their full weights. This expansion of trunk to gain buoyancy in air is not limited to humans as we have seen animals fly by increasing the width of their trunk to help them gain buoyancy in the air also. Notables here are flying squirrel, flying lizard and flying snake.

**Conclusion**

Males fell more than the females. Majority fell at home from slipping on floors (older adults), fall from balconies and home materials (children), while adults fell at work places. Majority of Older adults had subdural hematoma. The favorable outcome was 85.51%. Severity of injury and age affected the outcome. Age affected the length of hospital stay.

**Recommendation**

- Children should not be allowed access to balconies. Balcony rails should reach the roof and should not be allowed to go into disrepair.
- Parents should take proper attention to where their children are playing and guard them against climbing chairs, tables or playing on the bed.
- Floor and bathroom tiles should be anti-slip tiles. People should mop up water on tiles and carpets once water pours on them.
- Protective devices should be worn by people working on roof tops and on scaffolds.
- Trunks carrying goods should not allow people sit on them. The road safety should ensure that truck drivers comply with this.

**Conflict of interest:** There is no conflict of interest.

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