Chapter

Suicide Attempts from Height and Injury Patterns: An Analysis of 64 Cases

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Abstract

Falls from height are a common cause of death and disability. A majority of free falls occur accidentally and only a minority result from suicidal behaviour. Adolescents in many countries show high rates of suicide attempts and their repetition is a common feature. We describe the demographic characteristics of these patients, their psychiatric diagnosis at the time of the attempt and the injury patterns. We present 64 patients who sustained injuries as a result of a fall from height. They were divided into those without mental disorders (n = 32, group I) and those with mental disorders (n = 32, group II). The mean height from which the fall occurred was 5.4 m (range, 3–25 m). The mean injury severity score was 19 (range, 6–58) for all fall victims. Upper extremity fractures were found in 37 patients, while pelvic and lower extremity fractures were found in 198 cases. Spinal fractures were noted in 32 patients. Head injuries were revealed by CT scan in 16 patients. Patients following a suicidal high fall mostly had lower limb fractures, pelvis fractures, spinal fractures and head injuries.

Keywords: attempted suicide, spinal cord injury (SCI), limb and spinal fractures

1. Introduction

Falls from height cause significant death and disability worldwide, due to the severe traumatic load inflicted on their victims [1–4]. According to the WHO, the yearly mortality due to suicide worldwide is approximately 800,000 people. What is more important is the fact that it affects mainly young people, suicide being the primary cause of death in the age group of 25–34 years [5]. The mean incidence of suicides across Europe in 2013 was of 11.7 deaths per 100,000 people. Low rates, under 8 deaths per 100,000 inhabitants were recorded in Italy, Malta, Cyprus and the United Kingdom. The lowest incidence was observed in Greece (4.8 cases per 100,000 people) [6]. There was a lag between the beginning of the economic crisis in Europe, and the manifestation of its effects on the Greek population. These became evident 3 or 4 years later, in the form of a reduction of household income and an increase in the rate of unemployment [7–9].

Causes for this mechanism of injury include both accidental falls and deliberate suicide attempts [10]. The latter constitutes a major social problem, with implications for the entire society, but particularly for the affected family. The psychological profile of people committing suicide is complex and unique for each case [11]. Thus, identifying contributing factors that may lead to suicide and establishing strategies for the safekeeping of mental health in communities are of paramount importance.

The type of injuries incurred after a fall constitute a unique pattern of blunt trauma, with a characteristic distribution of damage (multiple lesions in a variety of body areas) [1, 12, 13]. The most common form of trauma are fractures, followed by other areas, such as the head, the thorax, the abdomen as well as the retroperitoneum, being injured by varied degrees [14]. The quantity and the quality of traumatic load absorbed depend on factors like the height from which the fall occurred, the part of the patient's body that had the first impact, the surface where the impact occurred and the victim's age, taking into account the associated comorbidity, and reduced physiologic reserve that advanced age implies [15–17]. Anticipation and prediction of the exact areas being injured are not possible, because of the multitude of factors involved, and the exact unpredictability of the fall's kinematic [18, 19].

As aforementioned, one can infer that the differential diagnosis of falls from height from other types of blunt trauma (for example, a road-traffic-collision with expulsion of the occupants from the vehicle) is difficult. Thus, a high index of suspicion must be maintained concerning the initial cause in cases of polytrauma in victims with an unknown history [20]. An array of papers have dealt with injury-related deaths in general, while others have differentiated between unintentional and intentional injury-related deaths [21–24]. There are few studies though that have looked into patients with intentional or unintentional injuries, due to a fall from height, at a single centre [13, 25].

As noted by research in the past, self-harm due to a fall is a rare phenomenon, being responsible for 4–7% of deaths from suicide in the developed world [26–29]. On the other hand, studies have shown that psychiatric disorders are a frequent finding in patients suffering trauma [30–32]. Nevertheless, the connection between mental disorders and specific injury patterns has not been adequately described. Furthermore, the elucidation of patterns of injury incurred after accidental falls and after intentional suicide jumps, might be of help to forensic pathologists while investigating the circumstances of a death after a fall from height.

2. Materials and methods

From January 1990 to October 2012, 64 patients (15 males and 49 females) were studied as a result of falls from height. Fall from height ≥ 3 m is classified as high energy trauma in accordance to ATLS guidelines [33]. The mean patient age was 34 years (range 16–65 years). These 64 cases comprised our series and, for comparison, were divided into those without mental disorders (n = 32, group I) and those with mental disorders (n = 32, group II). Group II cases were further stratified according to their psychiatric diagnosis.

The principles of Advanced Trauma Life Support were followed in the management of all patients. Basic laboratory screening included haemoglobin level, prothrombin time, type and crossmatch and arterial blood gas analysis. Data collected included age, gender, associated trauma, injury severity score (ISS), Glasgow Coma

Scale (GCS), haemodynamic status (systolic blood pressure less than 90 mm Hg on arrival), length of intensive care unit (ICU) and hospital stay.

Also, the following trauma variables were analysed: specific intracranial injuries (epidural, subdural and subarachnoid haemorrhage and brain contusion), spinal injuries (cervical, thoracic and lumbar spine), thoracic injuries, specific intra-abdominal injuries (liver, spleen, kidney, and hollow viscus) and specific fractures (pelvis, femur and tibia). The diagnosis of mental disorder was ascertained by psychiatric specialists using the criteria of the International Classification of Disease Ninth Version Clinical Modification (ICD-9CM).

3. Results

The mean height of fall was 5.4 m (range, 3–25 m). The patients were separated in two groups: group I, without mental disorders (n = 32), and group II, with mental disorders (n = 32). The demographic data, including age, gender, height of fall, ISS, GCS, initial shock (SBP <90 mm Hg), hospital stay (days), ICU stay (days) and deaths are summarized in **Table 1**. The mean hospital stay was 29 days (range 19–45) and the mean ICU stay was 9 (range, 5–13) (**Table 1**).

Concerning their background psychiatric disorder in group II, the diagnosis was schizophrenia in 32 patients, depression in 12, drugs or alcohol abuse in 3, personality disorder in one, manic depression in one, another psychiatric condition in one and 14 cases without a specific diagnosis (generally marital or work related).

Data	Patients
Age	35 (18–65)
Gender (M:F)	15:49
ISS	20 (12–58)
GCS	9 (6–13)
Haemodynamic status-SBP <90 mmHg	34
Hospital stay (days)	29 (19–45)
ICU stay (days)	9 (5–13)
Deaths	13

Table 1.
Comparisons of demographic data of patients with suicide attempts from height.

4. Socioeconomic factors

Patients due to suicide attempts from height comprised of 15 males and 49 females with a mean of age 35 years (range: 18–65 years). Of those, 16 were single, 14 were married and 2 were divorced. Thirty-three patients were employed, 6 were housewives, 7 were unemployed, 3 were students/pupils and 15 had various occupations. As far as religion was concerned, 48 were Christian Orthodox, one Roman Catholic, one Jewish, one Muslim and 13 of other religions.

Regarding their family status: 20 had children, 6 had only their parents, 3 had only their spouse, 2 had a step family, 2 had parents who were divorced, 6 had parents and/or siblings, one had both parents and children and 24 had no family at all.

5. Mechanism of fall, severity of injuries and associated lesions

The falls had occurred from a roof or balcony in 39 cases, from a window in 12, from a bridge in 7 and inside the house in 6. The mean injury severity score (ISS) was 20 (range 12–58) for all victims of fall. Sixteen patients arrived at the emergency department in shock. The most common body region having sustained severe trauma were the fractured extremities and/or spine, followed by the chest, the head and the abdomen for both groups (**Table 2**).

Head injuries were revealed by CT scan in 16 patients. The mean GCS was 9 (range 6–13) for both groups. The most common intracranial injury was brain contusion and subarachnoid haemorrhage, followed by subdural hematoma and epidural hematoma. The incidence of subarachnoid haemorrhage in the suicide group was significantly higher than in the accidental group.

Associated abdominal injuries were present in 4 patients. The most common injury was liver laceration, followed by kidney and spleen laceration. One died with an operative finding of a large central retroperitoneal haematoma due to a vena cava rupture. In the remaining 3 patients, ultrasonography showed minimal intraperitoneal blood and these patients were not operated on. Thoracic injuries were present in 32 patients. The most common of these were rib fractures—26 cases. Twelve of these patients had a haemopneumothorax and 6 had a sternum fracture. Conservative treatment with assisted ventilation was necessary in these cases (**Table 3**).

Upper extremity fractures were found in 37 patients, while pelvic and lower extremity fractures were found in 198 cases. Spinal fractures were noted in 32 patients. As far as the level of injury was concerned, in 16 cases, it was in the lumbar level, in 9 cases in the cervical, in 5 cases in thoracic and in 2 cases the sacral vertebrae were concerned. Regarding the neurologic deficit, in 23 cases, the injury was incomplete (14 with ASIA C and 9 with ASIA D), and in 9 cases, it was complete (4 with ASIA A and 5 with ASIA B). Further details with our data of 32 patients with spinal cord injury as a result of deliberate self-harm have been published previously [34]. It seems that the neurological complications of spinal injuries were correlated with the increase of the height from which the fall occurred.

Patients with psychiatric disorders were more frequently shocked on arrival at the emergency department than those in the accidental group, the most common reason for death being head injury. Fatalities were more common when patients fell from greater heights (over 4 m), or when their head hit a hard surface, such as concrete.

Fall from	**Patients**
Roof/balcony	39
Window	12
Bridge	7
Inside the house	6
Associated injuries	
Abdominal trauma	4
Thoracic trauma	32
Head injuries	16
Extremity fractures	199
Spinal fractures	32

Table 2.
Location where the fall occurred and associated injuries.

	Patients
Skull, thorax and upper extremities	
Skull	16 (25%)
Shoulder	4 (6.2%)
Scapula	6 (9.3%)
Sternum	6 (9.3%)
Ribs	26 (40.6%)
Humerus	8 (12.5%)
Elbow joint	8 (12.5%)
Distal radius	7 (10.9%)
Hand	4 (6.2%)
Spinal fractures	32 (50%)
Pelvis	27 (42.1%)
Lower extremities	
Acetabulum	9 (14%)
Femoral neck	38 (59.3%)
Femur	18 (28.1%)
Knee joint	17 (26.5%)
Tibia	19 (29.6%)
Ankle joint	36 (56.2%)
Calcaneum	34 (53.1%)

Table 3.
The distribution of fractures in percentage across body region for the two groups of patients.

The final causes of inpatients' death were: head injury in 8 cases, multiple organ failure in 3 cases, pneumonia in one case and cardiac complications in another one. The majority of patients who died of organ failure had sustained significant head injury. In one case, death occurred after a second suicide attempt 2 years later.

6. Medical management—outcome

Each patient underwent a psychiatric evaluation by a consulting psychiatrist as soon as his condition and cooperation permitted. The assessment comprised of an interview. Regarding the type of treatment for the spinal fracture—dislocations, instrumentation devices included titanium rods, transpedicular screws, sacral bars and bone grafting in all patients. No new suicide attempt was recorded during the hospital stay.

All patients were discharged from hospital approximately 6–8 weeks after the operation with a custom-made thermoplastic thoracolumbar or lumbosacral orthosis for another 8 weeks and instructions for physical therapy and rehabilitation programs. The mean follow-up was 6 years (12 months to 10 years range). At follow-up, 27 patients were available for evaluation due to the death of 5 patients, 1–3 years post initial injury, because of suicide in one case (patient 7 of group II) and medical complications in 4 cases [renal failure in 3 cases (patients 8, 14 and 30 in group II) and pneumonia in one (patient 21)]. In the remaining patients, new

unsuccessful attempts were recorded in 2 cases (7%) due to psychiatric disorders, 1–3 years after the first attempt (patients 10 and 24). All survivors received psychiatric follow-up. The overall mortality was significantly higher in those patients who fell from more than 10 m.

7. Discussion

Suicides and suicide attempts constitute a major concern for public health services, with implications for both families and society [35]. Trauma incurred due to falls from height poses a great burden on health services due to its severity. This is particularly important if we take into account the fact that this is a largely preventable mechanism of injury. Prior knowledge of the possible traumatic patterns incurred after a fall from height can prove helpful in the initial evaluation of this group of patients. From an epidemiologic point of view, trauma due to falls may occur across all age groups, but it is the two extremes, the very young and elderly, which are particularly susceptible to it [36].

In this study, we have considered two groups of patients. Group I represented patients with no mental disorders and group II with mental disorders. It is quite difficult to identify someone who is prone to committing suicide. In addition, the observed number of suicides and suicide attempts being committed at a younger age (i.e. adolescence) has been a cause of concern worldwide and particularly in Europe [37]. The male-female ratio of suicide attempts varies across age groups. Thus, in the younger age group (15–24 years old), it is 1:1.9; and in the middle age group (45–54 years old) it is 1:1.7. This ratio further decreases for those older than 55 years to 1:1.4 [38]. In this study, the male-female ratio was 1:3. The female sex was associated with an increased likelihood of death due to a higher amount of energy involved in their attempted fall.

According to other studies [39, 40], young males tend to repeat suicide attempts more frequently than females and the methods used by them lead to an increased mortality. A suicide attempt in the past is a red flag for a possible attempt in the future; so, there is a strong correlation between suicide attempts and deaths from suicide both regionally and nationally, and particularly in young males [41]. Also, there is a strong correlation between repeated attempts and completed suicide, especially in the group of males who have used a violent method [42, 43].

The study by Dickson et al. had the aim of establishing a correlation between mortality and various factors, such as the patients' injury severity score (ISS), the height from which the fall took place, the patient's intention and the body regions that were injured. In addition, the height of the fall strongly correlated with the patient's ISS and was an important predictor of mortality [44]. Head and/or chest injuries, if due to a fall from height, were strongly associated with an increased incidence of death. According to the authors, this mechanism of injury should be a triage priority when tasking ambulances. In addition, the best way of treating these injuries is their prevention. No other significant predictors of mortality were found in this study.

In the case series by Kent and Pearce, 282 suicide attempts were studied, 13 of which were completed. Of those, 8 happened at home, all patients were older than 49 years; and in 7 out of 8 deaths, ladders were implicated [45]. The retrospective study by Petratos et al. analysed in detail the musculoskeletal traumatic pattern resulting from falls from height, and focused particularly on the correlation between specific fracture patterns and the height from which the fall happened, as well as on the causation of the fall (suicide attempt vs. accident). According to their findings, with an increase in the height from which the fall occurred, the frequency

of limb, thoracic and pelvic fractures also increased. Such a correlation was not evident for head injuries. Nevertheless, the anatomical regions having sustained fractures (including the cranium) varied in accordance with the height of the fall. Thus, we can infer a mechanism of injury that is varying proportionately to the height of the fall. There was no significant difference between the patients who attempted suicide and those who fell by accident as far as the number of fractures incurred or the regions having been injured were concerned. Nevertheless, with regard to our results that have been published previously, patients who attempted suicide had a significantly greater number of bilateral lower limb fractures than their accidental fall counterpart. In addition, logistic regression analysis shows a significant correlation between the cause of the fall and the presence of lower limb fractures. According to the authors, further research is necessary in order to establish a correlation between incurred traumatic pattern, the height of the fall and the patient's intention [46].

Choi et al. in his recent study attempted to differentiate the characteristics of traumatic pattern between intentional and non-intentional falls [47]. In addition, he attempted to determine prognostic factors for suicide attempt-related injury and promote adequate measures for the prevention and management of such injuries. In this study, 8992 patients with an accidental fall (non-intentional group) and 144 patients who committed a suicide attempt (intentional group) were included. Falls from a height greater than 4 metres were more frequently encountered in the intentional group. Death prior to patient's arrival in the accident and emergency department occurred in 54.9% of the cases of suicide attempt. Patients within the intentional group, having sustained increased traumatic load, had fallen from higher, were older and were more likely to be of lower educational level (high-school graduates, instead of college). Due to the fact that injuries sustained after an intentional fall were more likely to have a reserved outcome, the authors highlighted the importance of prevention. Such measures include telephone support and counselling lines, the installation of signs advising against suicide in high risk areas for an intentional fall, such as bridges, along with suggestions for government-coordinated programs aiming for the education of the public and the improvement of social conditions generally and the support of the community and family in particular.

The reasons behind a suicide attempt are multifactorial, hard to quantify and unique in every case. Nevertheless, the study of multiple suicide attempts puts into evidence some risk factors that would lead to such a decision. These are common across all age groups and include: the presence of mental illness, either currently or in the past, a history of alcohol or drug dependence, as well as the presence of depression [10]. Epidemiologically, one out of five persons who have attempted suicide will try once more within a year, and 10% of them will succeed in the end. Drug ingestion is the most common mechanism for a suicide attempt. Violent mechanisms such as hanging, falls from height and use of weapons are not common [48]. The persons who have attempted suicide by falling from height usually become polytrauma patients. The types of injuries incurred are two: deceleration injuries due to inertial phenomena, usually at viscera with vascular pedicles, and direct impact injuries [49].

The severity of fractures incurred will depend on factors like the area over which the impact is applied [50]. The smaller the area of spread of the impact, the greater the local load. Therefore, patients landing on their legs tend to suffer more severe injuries than those who have landed on their flanks, or prone, or supine [51]. Patients due to accidental falls mostly suffered spinal fractures and upper extremities fractures in an attempt to protect themselves. Patients due to suicidal high falls attempts suffered mostly of lower limb fractures, pelvis, spinal fractures

and head injuries. Distal radius and hand was the most common affected region in upper extremities in patients with non-intentional falls, in an attempt to protect mainly the head and grab something stable to prevent further fall. In patients with intentional falls, kinetic energy is absorbed mainly by the lower limbs, pelvis, spine and head, leading to characteristic fracture patterns [52]. The most common cause for death is head injury [51, 53, 54] and this is accordance to our results. Turk and Tsokos reviewed 68 medicolegal autopsy cases (22 females, 46 males, age range 13–89 years) of fatal falls from height from 1997 to 2001 [55]. The cause of instant death was head trauma in 24 (35%), internal blood loss in 9 (13%) and polytrauma in 30 (44%) cases. Other causes of death, when the individuals survived the trauma for a longer period, included septic multiple organ dysfunction syndrome and pulmonary embolism. In general, suicides were from greater heights than accidents (mean height 22.7 m for suicides and 10.8 m for accidents, respectively). Strikingly, severe head injuries predominantly occurred in falls from heights below 10 m (84%) and above 25 m (90%). Head trauma was the cause of death in 11 of the 19 cases that were from 9 m or less (58%). Of all cases, 51 (75%) died within a few minutes. A survival time of several hours up to 1 day was observed in 8 cases. Nine patients survived for several days (up to 16 days). Five of them fell from heights below 10 m. Patients with intentional fall from height have a higher early mortality than patients due to accidental fall from height [56].

The easiest way to underline the suspicion that the mode is suicide is if a suicide note is found at the jumping site; this is, however, closer to being the exception than the rule. Analysing the distance of the body from the site of descent may sometimes also help us determine the manner of death. The distance of the body from the site of descent includes the falling height and the horizontal distance. The falling height in suicide was statistically higher than that in accident [57, 58]. For similar heights, Wischhusen et al. have demonstrated that in passive falls, the horizontal distance is usually farther than jumps [59]. From a mechanical point of view, during a fall from height, potential (dynamic) energy is converted into kinetic and this leads to fractures upon impact. Another important factor of the severity of injuries is the height of fall, as the kinetic energy is increasing due to acceleration during the fall and is maximum at the time of impact [60]. In suicide falls, kinetic energy is absorbed mainly by the lower limbs, pelvis and spine, leading to characteristic fracture patterns. In accidental falls, patients most probably extend their arms and flex their hips, which lead to a damping effect that protects the spine [61]. Hence, the most important determinant of survival after a free fall is the position of the body at the time of impact [49]. There were only 3 patients (cases 1, 22 and 31) in group II who have sustained solely upper extremity fractures. The most common body position at the time of impact is with the patient standing and landing with the lower extremities first. This usually leads to calcaneal or pilon fractures, as well as thoracolumbar fractures. If the impact takes place with the patient seated, then higher thoracic or cervical injuries are more likely to happen, which are associated with a higher rate of mortality. Finally, an unpredictable fracture pattern takes place when the victim suffers multiple secondary impacts, in various postures, after bouncing from the primary impact. The amount of injury incurred will depend on the rate of dissipation and absorption of energy, through the patient's body.

According to the paper by Teh et al., there is a difference to the traumatic pattern incurred by jumpers compared to fallers [13]. Namely, the jumpers tend to impact their dominant lower limb first, as well as sustaining right sided thoracic injuries in the process. We did not confirm the above-mentioned findings in our study. The severity of spinal cord injuries was more important in the suicide than the accidental group [52]. This was in accordance with studies performed in the past, which also showed the early neurologic involvement in such cases. As far as prognosis of

spinal cord injury is concerned, complete injuries will be unaltered both in level and extent in a year's time. On the other hand, incomplete injuries may show signs of improvement for a period of 2 years after the impact [62]. Our results regarding prognosis for ambulation in ASIA A patients and for functionality in ASIA C patients are in accordance with current knowledge [63].

Anderson et al. performed a retrospective study, regarding the rehabilitation outcome of patients with spinal cord injury, as a result of deliberate self-harm (DSH) [29]. According to them, spinal fractures in the DSH group were mainly the result of falls from height. Underlying causes were revealed, such as psychiatric disorders and substance abuse, necessitating formal psychiatric review. There was no difference in short-term rehabilitation results between the DSH and accidental spinal cord injury group. In addition, DSH seemed to impact the length of stay only in patients with a spinal fracture, but without cord injury.

According to the literature, there are three studies on the subject of acute spinal cord injury following a suicide attempt that stand apart. The first is by Stanford et al. In his paper, 56 cases were followed over a period of 30 years (1970–2000). Fifty five cases were due to a fall from height and one open injury, through the use of a gun. Follow-up of 8 years on average was available for 47 cases (84%). The vertebral levels most frequently injured were C5 and L1. About 23 patients suffered from a complete spinal cord injury and 32 had a severe traumatic load (ISS > 15). The psychiatric background of these patients included personality disorder in 27, schizophrenia in 16, depression in 14 and substance abuse/dependence in 20. Of these patients, 4 were successful in subsequent suicide attempts [28].

The following two studies on this subject are from the UK [26] and Denmark [27]. Both of those are observational and retrospective, with a long follow-up. According to the latter, there is an increasing incidence of suicide attempts and associated spinal cord injury from 1965 to 1987. Approximately one third of the patients who attempted suicide suffered from schizophrenia. According to other papers [64, 65], schizophrenia is strongly correlated with falls from height (from bridges in particular). There were 7 patients in our study who have sustained a fall from a bridge. Damage control surgery principles are followed initially for the treatment of life-threatening injuries and for both limb and spinal trauma [66]. The primary goals of fracture fixation are timely mobilization and safe transfer to psychiatric services. Conservative treatment measures are not usually recommended for this group of patients.

Our findings are in accordance with relevant bibliography [67, 68], regarding the psychiatric background of patients who attempt suicide by falling from height. The spectrum of conditions encountered encompasses bipolar disorder, substance dependence and abuse, personality disorder and schizophrenia.

From an epidemiological point of view, schizophrenia is encountered in 5–10% of cases of suicide attempt. These patients may have well planned their suicide or even suffered from an active self-harm ideation. From the above-mentioned, we gather that management of these patients from a trauma point of view must take into consideration their psychiatric needs. The latter may cause significant disturbance in the delivery of medical care [69]. Most of the patients in this study had a positive response following adequate psychiatric intervention. Hence, we gather that prevention and early identification of persons at risk for a suicide attempt with the use of appropriate screening tools by health care professionals are invaluable.

Education of medical and nursing staff regarding the demands and particularities of care of this population, suffering from both spinal cord injury and psychiatric disorders, cannot be overemphasized. Regular follow-up with multidisciplinary team input and future research are necessary for the provision of high-quality care to this population.

8. Conclusions

According to the literature, it has been difficult to obtain comparable international data on suicide attempts, owing to disparities in definitions, survey designs and study methods, because the combination of free falls and mental disorders produces a unique group of patients. It has been our experience that psychiatric conditions, and especially the suicidal risk, should be evaluated and treated as early as possible during the orthopaedic or surgical hospitalization. Management requires both psychopharmacological therapy and psychotherapy. It has to be directed towards the achievement of symptomatic relief and, if possible, towards the remission of the primary psychiatric disorder.

The management of these patients in the orthopaedic or surgical ward is difficult, because of restlessness, non-cooperation of the patient and the problem of staff inexperienced in handling the psychiatric patient. When prolonged orthopaedic and rehabilitation management are necessary, it is suggested that the patient be transferred to a psychiatric hospital while continuing the necessary orthopaedic treatment. The outcome data provide critical information concerning those individuals who have attempted suicide and suggests future methods for the identification of suicidal factors.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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