Is Injury Occurrence Related to Lunar Cycles?

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Abstract: Injury data were analyzed to determine if any relationship existed between the dates of injury occurrences and the varying positions of the moon. Since the analysis of injury data from a single construction project yielded inconclusive results, a larger sample was sought. Data were obtained on all industrial injuries that were reported to the Missouri Division of Worker's Compensation in the years 1980 and 1981. The analysis of these injuries showed that there is no discernable pattern of injury occurrence relative to the lunar cycle.

Introduction

The study of the causes of industrial injuries is in its infancy. Much has been learned, but basic research in this broad area is sorely lacking. This paper will describe research conducted to isolate one variable as a possible contributory factor in job injuries. Specifically, this study was conducted to establish the relationship between the occurrence of industrial worker injuries and the varying cycles of the moon.

Phases of Moon

Before describing the possible effects of the changing phases of the moon on our physical environment, it is worthwhile to first review the movement pattern of the moon. To astronomers, the most general description of the motion of the moon concerns its relative position to the stars. In this movement pattern, the moon follows a path that repeats itself every 27 days. This is known as the sidereal cycle (10).

A more common moon cycle is the synodic, which merely describes the moon's position relative to the sun and earth. This is the cycle most often mentioned in discussions about cycles of the moon. The most common positions in this cycle are known as the new and full moons. A full moon occurs when the *approximate* position of the earth is between the moon and the sun. In a less frequent event, when the earth is *directly* between the sun and the moon, a lunar eclipse will occur as the light of the sun is shaded from the moon by the earth. This does not occur at every full moon, however, as the moon's orbit does not always place it in straight alinement with the earth and sun.

A new moon occurs when the moon is strongly between the sun and the earth. A perfect alinement, of course, will result in a solar eclipse, i.e., the view of the sun from the earth is obstructed by the moon. Again, this eclipse phenomenon is a less frequent occurrence, as the orbit of

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the moon varies so that a straight line is rarely formed by the earth, moon and sun. Although the moon's rotation does not result in identical relative positions of the earth, sun and moon during each lunar cycle, its orbits are quite predictable. A full orbit is completed every 29.5306 days. That is, during every 29.5306 days, a full moon and new moon occur (10).

The moon's orbit around the earth is characterized by two other positions. In addition to the new and full moon positions are the first and third quarters. The first quarter position occurs between the new moon and full moon, while the third quarter occurs between the full and new moons.

Effects of Lunar Cycle

There has been long-standing interest in the phases of the moon. The effects of the moon's changing positions on the earth and its inhabitants are not fully understood. Some, however, are well-documented, the most widely accepted being the moon's effect on tides. High tides occur immediately after the full moon, while low tides follow the new moon (3,12,16). Scientific study has also shown that certain oysters time the opening of their shells with the positions of the moon (2,3). It is documented that, with the waning period of the moon, eels begin their migration from European rivers to spawning grounds in the Sargasso Sea, and that particular tropical worms emerge from their coral habitat twice a year on precisely the first day, in both October and November, that the moon enters the last quarter (2). The foregoing effects occur reliably even when the moon is obscured by clouds. Fishermen have reported that the biggest herring catches occur during the full moon (2), and it has been established that the moon's cycles coincide with the reproductive cycles of some marine animals (3). Lunar influence is also noted in the atmospheric tides, as observed by effects on the transmission of radio broadcasts (12). As noted, the moon's influence on a wide range of phenomena has been reported in the literature.

Not all of the effects attributed to the moon are based on scientific fact. Nonetheless, some of these beliefs, myths, "old wives tales" or superstitions are deeply rooted among certain people, e.g., the belief in Central America that felled mahogany trees become infested with termites unless they are cut during a full moon (9). Many farmers still believe that it is best to plant root crops when the moon is full or waning, while flower and vegetable crops that bear above the ground should be planted between the new and full moons (2,10,12). Not only do beliefs relate to agriculture, but to human fertility and children as well. For example, some women in Greenland believe they will become pregnant if they sleep in moonlight (2). There are myths that the cycle of the moon determines the sex of unborn babies (2) or, as still another primitive society beleves, that weddings should take place in moonlight for fertility (13). Some women in New Guinea and Africa hold their babies up to the new moon so they will grow to be strong (2). Beliefs about the lunar influence based on myth or authority, or both, and not on scientific reasoning, tend to obscure and complicate valid scientific research findings.

Many opinions have been voiced on how the moon's positions affect the human mind. For example, many believe that some people act differently during the full moon. This has been observed and reported by people employed in hospitals, nursing homes and mental institutions (6,7). It is common for people to say they have observed patients acting "crazy" during the full moon. In fact, the term "lunatic" is derived from luna, the Latin word for moon (2). Although these are commonly referred to as myths, evidence does exist which lends support to the idea that lunar positions have differing effects on the mind (6,7,11,12).

Scientific evidence is available that the moon's effects can be observed in people. A study in Dade County, Florida, indicated that aggravated assaults cluster, in time of occurrence, around the full moon. In the same county, it was noted that psychiatric emergency room admissions were noticeably lower during the new and full moons, while homicides occurred more frequently during the new and full moons (3,5). Similar patterns were observed in Cuyahoga County, Ohio (3). A four-year study conducted at Patna Medical College Hospital in India revealed that more poisonings occurred on full-moon days (16). Another study reported that the "electrical potential" of man is charged "twice a month coincident with the full and new moons" (2). This phenomenon was studied in detail by Ravitz, who used a microvoltmeter to measure the electric potential of mental patients. He observed the most radical changes in the patients' electric potential during the phases of the new and full moons (6,7,11,12). Another researcher, Lieber, concluded that there is a strong relationship between human aggression and the lunar phases. His work was conducted on subjects who were alcoholics, drug addicts, accident-prone or criminally-inclined, or mentally unstable (2). Related to this phenomenon, it was observed that the Phoenix fire department received more calls on full-moon nights than at any other time (9). Another study indicated that the waxing of the moon was closely related to increased incidences of assaults or rapes, or both (14).

But not all studies have shown that the moon affects human behavior. One researcher, Pincher, found indications of changing moods coinciding with the changing phases of the moon, but failed to show any causal relationship (2). One study of people seeking emergency psychiatric help found no variations in patient numbers linked to the lunar cycle (8). Another researcher, Richter (2), "found no evidence of a consistent link between the mood changes of his subjects and the changing phases of the moon." Thus, research findings are equivocal, and the controversy continues.

Researchers are still trying to establish a direct link between the changing phases of the moon and human behavior. Since that link has not been made conclusively, no extensive research has been conducted on the lunar positions' physiological influence on the human body. It has been theorized, however, that since the moon affects the oceans' tides, influence on the human body is possible, since the body consists of more than 50% water and might be subjected to "biological tides" which, in turn, might affect human behavior (3). It has also been postulated that since the electrification of the upper atmosphere varies with the moon's phases, so too might the moon affect the mental processes of humans who respond to electrical charges (2). The moon's influence on human

behavior may, in fact, result from a combination of its effect on fluids in body tissue coupled with electrolyte or hormone shifts (3).

Pilot Study

The literature review resulted in conflicting reports of the effects of the lunar cycles on human behavior; thus, the controversy over lunar influences continues. This search through the literature failed to turn up any studies conducted to determine the relationship between injury occurrences and the lunar cycles. Because no such studies were noted, this research was undertaken.

The original purpose of this research was to determine whether construction injuries fluctuate with the varying phases of the moon. Essentially, this required information on the dates of a number of construction injuries. These dates would then be translated into terms related to the varying positions of the moon. The analysis of the data would determine whether the injuries were randomly distributed in the lunar cycle or whether the frequency of injuries was significantly higher or lower during particular lunar phases.

The data for the pilot study were obtained from the injury records of one large construction project. All of the first aid and doctor case injuries were retrieved from the project's injury files for the first seven months of 1978.

The analysis of the data began with the translation of injury dates into terms related to the days of the lunar cycles. An injury could occur on any one of 30 days (precisely 29.5306 days) in the lunar cycle. The translation of injury dates into lunar times is a mathematical manipulation. The day on which the full moon occurred was referred to as "Day 1." Thus, the injury dates were changed to integer numbers representing the days the injuries occurred relative to the full moon. For example, if an injury occurred on January 27, 1978, that date would be translated to Day 4 of the lunar cycle, as the previous full moon had occurred on January 24. The full moon on January 24, 1978, in Missouri, occurred exactly 2 hr and 56 min after midnight. Since the hour of occurrence of the various injuries was not consistently reported, it was deemed adequate to use integer values to describe the days in lunar terms.

If the data had covered a span of several years, it might have been sufficient to assume that the occurrence of injuries relative to the lunar cycle would be random. This would be postulated if no correlation between the lunar cycle and the occurrence of injuries was expected. In a study covering a shorter period of time, however, this assumption would be invalid. This is true because it would be assumed that the chance of being injured is the same on any lunar day. One could envision a condition in which a full moon occurred on a Saturday in one month, a Sunday the next month and a holiday in the following month. An analysis of injury data over this three-month period might reveal that very few or no injuries occurred on full-moon days. Obviously, the data would be biased if the analysis did not recognize Saturdays, Sundays and other non-working days as days of reduced exposure to injury. Data analysis must be focused only on the days that were regular working days or on days that most workers were potentially exposed to injuries.

The data were analyzed in several different ways. First, the injury dates were changed to dates corresponding to the lunar cycle. The next step was to determine whether the injuries were randomly distributed throughout the lunar cycle (see Appendix II). This distribution was tested, to ensure a random sample, by considering each day individually.

In further analysis, the data from groups of days in the lunar cycle were consolidated. The analysis then assessed whether injuries occurring during these time periods were randomly distributed.

The data from this construction site included 1,431 injuries that occurred during the first seven months of 1978. This time period included 148 working days, or days on which most workers might be injured. The injury dates were translated into lunar times as shown in Table 1. This table summarizes the data which determined the results.

The first calculation was to determine whether injuries occurring on the full-moon days were any different from the frequency that would normally be expected. It was recognized that any association made be-

TABLE 1.—Distribution of Injuries During Lunar Cycle in Pilot Study

Day of lunar cycle (1)	Days of exposure (2)	Number of recorded injuries (3)
1 (full moon)	6	36
2	5	36
3	6	58
4	5	45
5	3	48
6	4	55
7	6	63
8	5	57
9	5	42
10	7	78
11	6	69
12	4	39
13	5	39
14	5	38
15 (new moon)	4	54
16	5	42
17	6	61
18	6	44
19	4	38
20	4	26
21	5	48
22	5	64
23	5	58
24	6	75
25	6	36
26	4	21
27	4	37
28	5	49
29	5	58
30 (partial day)	2	17
Total	148	1,431

TABLE 2.—Summary of Results for Selected Lunar Periods (Pilot Study)

Position of lunar cycle (1)	Days of exposure to job injuries (2)	Average number of injuries incurred per day (3)	Is number of observed injuries different from population? (4)
All days (population)	148	9.7	—
Day 1 (full moon)	6	6.2	No
Day 14 or 15 (new moon)	5	13.2	Yes ($Z = 2.006$)
Days 1 through 7 (third quarter)	35	9.7	No

tween the lunar cycle and the incidence of injuries might have an effect that spanned more than the period of one day. Following this assumption, the data were analyzed by considering the injury frequency associated with those days that coincided with the week of the full moon or the third quarter of the lunar cycle. The results of this analysis are shown in Table 2.

Most of the results indicate that injuries were randomly distributed. There is one clear exception—more injuries were observed on days that coincided with the new moon. No other discernable patterns of injury occurrence were noted. A possible explanation for the high incidence of injuries on days coinciding with the new moon is related to the days of the week on which the new moon occurred. Upon closer examination of the "new-moon days," it was discovered that two of the five days of exposure occurred on Wednesdays. This factor may contribute to the high incidence of injuries, since Wednesday was the day of the week associated with the highest incidence of injuries for this sample.

The Study

Because of the widespread implications of the pilot study results, the writers were hesitant to publicize the information that more injuries may have occurred on days coinciding with the new moon. Two alternatives were considered. The first was simply to analyze the data more closely to see if other factors could be identified to explain the injury occurrences. It was felt, however, that any finding would still be speculative and inconclusive. A second alternative—that of analyzing the data of a second and larger sample—was more desirable. If the results of this analysis replicated the findings of the pilot study, the findings would be almost irrefutable. If the results of the second study differed from the pilot study, however, they would be more reliable if the sample size was significantly larger.

In searching for injury data for the second sample, it was considered imperative that the data base be quite large. Such a data base was obtained from the Missouri Division of Worker's Compensation, and it consisted of all job-related injuries reported in Missouri in 1980 and 1981. This included 131,650 injuries reported in 1980 and 74,344 injuries re-

ported in 1981. The noticeable decline in the number of reported injuries in 1981 resulted from a legislative change concerning the definition of the injuries to be included in the report.

In analyzing the Worker's Compensation data, samples from each of the years were analyzed separately. As in the pilot study, only the injuries occurring on regular workdays were considered. An additional modification omitted injuries occurring in December from the analysis in order to avoid any bias created by the varying December holiday policies of different businesses. This modification resulted in 112,436 valid injury cases in 1980, and 62,033 valid injury cases in 1981. Other analyses were similar to that described for the pilot study.

The injuries for each year were sorted by the days of the lunar cycle, beginning with Day 1 representing the full moon (see Tables 3 and 4). The results of the data analysis indicate that the lunar cycle does not influence the distribution of injuries. The only clear exception is Day 24 in the 1981 data, which shows that fewer injuries occurred on that day

TABLE 3.—Distribution of Injuries During Lunar Cycle for 1980 Sample

Day of lunar cycle (1)	Days of exposure (2)	Number of recorded injuries (3)
1 (full moon)	8	3,897
2	8	3,640
3	9	4,293
4	7	3,482
5	8	3,725
6	9	4,546
7	7	3,354
8	8	3,841
9	8	3,831
10	8	3,995
11	6	3,028
12	7	3,487
13	9	4,535
14	9	4,408
15 (new moon)	8	3,797
16	8	3,783
17	8	3,941
18	6	2,938
19	7	3,610
20	9	4,437
21	9	4,227
22	8	3,786
23	8	3,656
24	8	3,781
25	6	3,069
26	7	3,349
27	8	3,724
28	9	4,339
29	8	3,655
30 (partial day)	5	2,282
Total	233	112,436

TABLE 4.—Distribution of Injuries During Lunar Cycle for 1981 Sample

Day of lunar cycle (1)	Days of exposure (2)	Number of recorded injuries (3)
1 (full moon)	9	2,294
2	8	2,046
3	9	2,302
4	8	2,124
5	5	1,365
6	7	1,895
7	8	2,146
8	9	2,539
9	8	2,150
10	9	2,429
11	8	2,203
12	5	1,406
13	7	1,903
14	9	2,410
15 (new moon)	9	2,399
16	8	2,153
17	8	2,191
18	9	2,522
19	6	1,574
20	8	2,123
21	8	2,153
22	8	2,251
23	8	2,148
24	8	1,996
25	9	2,392
26	6	1,596
27	7	1,923
28	8	2,166
29	8	2,121
30 (partial day)	4	1,113
Total	231	62,033

than would be expected if the injuries had occurred at random (see Table 5).

Further analysis was conducted in order to determine whether this finding could be explained independent of the lunar cycle. Through this analysis it was determined that eight workdays in 1981 occurred on the 24th day of the lunar cycle. Further analysis showed that five of these eight days occurred on a Thursday or Friday. This fact is of particular significance, as the data for these years showed a strong relationship between the days of the week and the frequency of injuries, i.e., the frequency of injuries was highest on Mondays and declined progressively through Friday. Thus, it appears that the finding can be explained simply by understanding the days of the week on which the 24th day of the lunar cycle occurred most frequently.

Another simple method of analysis was conducted in order to more-closely examine the possible lunar effects on injury occurrences on Day

TABLE 5.—Summary of Results for Selected Lunar Days (1980 and 1981 Data)

Position of lunar cycle (1)	Days of exposure to job injuries (2)	Average number of injuries incurred per day (3)	Is number of observed injuries different from population? (4)
1980 sample			
All days (the population)	233	482.558	—
Day 1 (full moon)	8	481.5	No
Day 14 or 15 (new moon)	7	475.6	No
1981 sample			
All days (the population)	231	268.541	—
Day 1 (full moon)	9	254.889	No
Day 14 or 15 (new moon)	9	266.556	No
Day 24	8	249.500	Yes[a]

[a]Day 24 of the 1981 data was the only day associated with a significantly different frequency of injury occurrence. None of the 1980 data showed significant differences.

24. This was done by independently considering each of the eight workdays corresponding to the 24th day of the lunar cycle in 1981. The injury rate for each of these days was compared with that of the corresponding workday in the two prior and two succeeding weeks. For example, the number of injuries occurring simultaneously on Day 24 and a Thursday was compared with the number of injuries recorded on the two previous and two succeeding Thursdays. Through this analysis, no discernable pattern was noted to indicate that the lunar cycle was affecting injury occurrence. Note also that Day 24 of the lunar cycle in 1980 did not correspond to any marked change in injury frequency. Thus, it appears logical to conclude that, for the 1981 data, the injury frequency on Day 24 is simply a reflection of the days of the week on which Day 24 fell most often.

Another stage in the analysis concerned the number of injuries that corresponded to each of the four quarters of the lunar cycle. Again, no particular phase of the moon was associated with a frequency of injuries different from what would be expected of a normal distribution.

Conclusion and Recommendations

The results of this study do not indicate that job-related injuries are related to the phases of the moon. These results are based on an examination of all industrial injuries reported to the Missouri Division of Worker's Compensation in 1980 and 1981.

This study does not support much of what has been written concerning research linking the lunar cycle to various phenomena. Neither does

it refute the findings of any other studies, as the studies cited herein relate to phenomena other than job injuries. The writers simply conclude that job injuries are not noticeably influenced by the lunar cycle.

Since the lunar cycle does not have a noticeable influence on job injuries, employers need not be concerned with the changing phases of the moon when implementing safety programs. As was noted in this study, a safety program might well be focused on the weekly cycle of injury occurrence. In the state of Missouri, injuries during an average week are most numerous on Monday and decrease steadily through Friday. This is the cyclic pattern of injuries for all industries in the state of Missouri. It is reasonable to expect, however, that this pattern might be quite different for a single employer. Since this weekly pattern is quite distinctive, employers should evaluate their injury records to see if a company wide pattern can be discerned. Effective measures can then be taken to try to reduce this cyclic impact.

A note of caution is offered to researchers who conduct data analysis of this nature. Although the pilot study consisted of a sample of nearly 1,500 data points, the data were not sufficient enough to lead to any firm conclusions. As further analysis showed, the wrong conclusions would have been drawn without any additional study. Thus, the researcher must be wary of accepting the results of a preliminary analysis without then conducting a thorough analysis.

Appendix I.—Means Tests

The following are means tests for two independent samples, in which the standard deviation is known.

Definitions:

Information in parentheses is data related to the pilot study.

X_1 = mean of sample 1 (sample 1 is related to phenomenon being sampled);
X_2 = mean of sample 2, the population (X_2 = 9.668 per day)^2;
s_1 = standard deviation of sample 1;
s_2 = standard deviation of sample 2 (s_2 = 5.866);
m_1 = number of elements (sample size) in sample 1;
m_2 = number of elements in sample 2 (m_2 = 148); and
Z = standard score having a mean of 0 and unit standard deviation.

Statistical Test:

$$Z = \frac{X_1 - X_2}{\sqrt{\frac{s_1^2}{m_1} + \frac{s_2^2}{m_2}}}$$

Significance of Difference Between X_1 and X_2

0.01 level of significance: $-2.58 \leq Z \leq +2.58$
0.05 level of significance: $-1.96 \leq Z \leq +1.96$

APPENDIX II.—REFERENCES

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