Changes in the Human Gestation Period due to Variations in External Environmental Forces

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ABSTRACT

This study examines the influence of environmental forces on the human gestation period. The existence of synergetic relationships between atmospheric pressure, changes in atmospheric pressure, and gravitational forces on the length of the human gestation period is demonstrated through rigorous observational, computational, and statistical evidence.

Over 1,259 patient records were analyzed from June 30th, 1998 through October 30th, 2000 to obtain an array of detailed gestation data. In conjunction with this data, hourly reports of barometric pressure, daily lunar and solar orbital data, and daily lunar phase data were collected. Pre-delivery three and six-hour pressure gradients and deviations from the average gestation period and average barometric pressure at the time of delivery were calculated for each patient. Collected and calculated data points relevant to barometric pressure at time of delivery, three and six-hour pressure gradients prior to delivery, deviation in average gestation periods, and the lunar phase at time of delivery were compiled and presented in graphical format. The chi-square goodness-of-fit test was performed on the study dataset.

It was found that the vast majority of the births occurred during periods when the barometric pressure was at or near normal values, and that the magnitude of the barometric pressure at the time of birth had no significant effect on either the frequency or timing of deliveries. Additionally, the greatest number of births occurred when the barometric pressure was either constant or changing only slightly. Specifically, there was a significant increase in the number of births when the barometric pressure was falling gradually over the previous three and six hours prior to delivery.

Unlike barometric pressure, gravitational forces were found to have a significant influence on the frequency of deliveries. In particular, a significantly greater number of births occurred during the full and new moon phases of the lunar cycle.

Neither the singular effect of gravitational forces, nor the combined effects of barometric pressure and gravitational forces were found to cause significant deviations in the human gestation period.

(Key words: lunar cycle, barometric pressure, solar orbit, pregnancy, delivery).

INTRODUCTION

The effect that the natural forces of weather and gravity have upon human physiology and psychology is undeniable. Precisely what those effects are has been the focus of superstition, speculation, observation, and scientific investigation for thousands of years.

Almost from the beginning of recorded history, man has recognized the synergistic relationship between the forces of nature and the human condition. Certainly many of these relationships are direct and obvious. The potentially vast and immediate hazards presented to human health, comfort, and safety from the power of lightning, fire, earthquakes, droughts, floods, tornados, and hurricanes are irrefutable. But nature can also have much less obvious influences on human physiology and psychology such as aiding in the promotion and proliferation of pests that transmit dangerous infectious diseases or the disruption of the integrity of fresh water drinking supplies (Baron-Faust, 2000).

In our early history, man has attempted to describe the more mysterious and unexplainable causes of his misery as best he could, with little more to go on than observation and anecdotal evidence. Of course, we now know that most of these early attempts at explanations reside more in the realm of folklore, myth, superstition, or legend than in science. But even today, many of these initial speculations continue to exist, and even thrive as pseudoscience in many parts of our popular culture. Biorhythms, for example, a popular fad of the 1960s and 1970s, supposedly was able to precisely determine our moods, physical abilities, and mental clarity based on determining the position and amplitude of the naturally occurring, regular, rhythmic cycles that occur within our bodies.

The "science" of astrology has been around for thousands of years and strongly persists even to this day in many sectors of our society. Astrologers tempt our logic and reason and dilute our basic understanding of gravity with the notion that the complex combination of the sun, moon and planet's gravitational forces are somehow able to control the characteristics of our physical and spiritual nature.

But even fringe sciences, although not rooted solidly in research, may not be entirely without some degree of merit. For example, although the notion of "lunacy" probably resides somewhere between the shadows of astrology and the light of science, there have been enough credible studies with equally credible results to make the outright dismissal of lunacy difficult. The historic concept of lunacy (so named after the moon - luna) being responsible for periods of insanity and antisocial activities is based primarily on the idea that gravitationally induced tidal forces are somehow at work applying pressure to various sensitive, but undefined, regions of the human brain.

Even if the psychological effects of barometric pressure and solar, lunar, and planetary gravitational forces on the human body remain highly uncertain, there can be no doubt about the physical effects. Tidal and barometric pressure forces have been well established for centuries. If one accepts the concept that variations in lunar gravity can cause the water in the Bay of Fundy to rise over 20 feet in just a few hours, it is not entirely unreasonable, at least superficially, to believe, there might also be a change in pressure on a woman's womb during the later stages of pregnancy.

This sudden pressure change might also cause the woman's membranes to rupture prematurely (PROM), thus inducing the onset of labor. Of course, the problem with this reasoning is that the moon does not actually directly affect the water in a pregnant woman's womb any more than it affects the water level in the Bay of Fundy. The tidal mechanism is, in fact, caused by the difference in the gravitational pull at different parts of the earth, resulting in an extremely complex deforming of the Earth.

Because of this variation in the gravitational force, water moves horizontally from one place to another. Once the water gets to a point of resistance, such as a shoreline, it has no place to go but up (i.e. high tide). Conservation of mass dictates that while high tides are present on the side of the Earth closest to the Moon, high tides also exist on the opposite side of the Earth, thus causing two high tides every diurnal cycle.

Certainly even lakes and ponds experience tidal forces as well, but what about the human body? After all, much of the human cranium, as well as the womb, is filled with fluid. As far as tides building and receding within the human body, most current researchers feel that while they are surely present, they may be so miniscule as to be not measurable.

Nonetheless, scientists from a variety of disciplines continue to make earnest efforts at correlating full moons and gravitational variations with abnormal behavior and human physiology, often with mixed results. Today, with the advent of extended space travel and habitation, scientifically advanced countries around the globe continue to spend countless millions of dollars investigating the exact nature of human response to gravitational fields.

If we assume that lunar gravity plays an important role in human physiology and/or psychology, it is only natural then to hypothesize that other external environmental forces, such as changes in barometric pressure or variations in surface gravity might affect humans in similar ways.

For example, one of the more prevalent bits of emergency medicine folklore surrounds the effect that severe storms or the full moon have on pregnant women. Commonly held views among Emergency Medical Technicians (EMTs), Paramedics, and hospital emergency room personnel attest to the opinion that more than the usual number of labors begin (or at least seem to begin) in the midst of severe weather conditions or during a full moon - presumably as a direct result of a sudden decrease in barometric pressure or increased lunar gravitational influences.

The tides are produced by the gravitational pulls of the sun and moon on the oceans. Since the moon is responsible for the mass of fluid movements of the ocean tides, and since the fetus is surrounded by amniotic fluid, it is thought that perhaps the same gravitational force acting on the ocean is exerted on the amniotic fluid, resulting in the rupture of mechanically weak membranes. Even without the presence of changing gravitational forces, sudden drops in the barometric pressure outside the womb may increase the pressure difference across the membrane and may also induce premature membrane rupture.

Whereas several creditable studies have attempted to ascertain the presence of a significant relationship between the forces of barometric pressure or gravity on human gestation, previous investigators have failed to consider the potential synergistic interaction that gravitational forces and barometric pressure might have on gestation.

To this end, this study attempts to reveal the existence of any potential significant synergistic relationships between changes in barometric pressure and lunar forces that may influence human gestation. Therefore, this study is designed to determine:

1) if a relationship exists between changing barometric pressure and variations in human gestation periods,

2) if a relationship exists between lunar/solar gravitational forces and variations in human gestation periods, and

3) if there exists any synergy between variations in the atmospheric barometric pressure and the changing gravitational forces caused by the movement of the sun and moon, causing variations in gestational periods.

THE ENVIRONMENTAL FORCES

The gravitational forces created by the mass and proximity of the sun and the moon are responsible for the earth's tides. While tides are generally associated with the oceans and other large bodies of water, gravity is also responsible for tides in the gaseous atmosphere and the solid lithosphere of the earth. These same gravitational forces, as well as the force exerted by weight of the atmosphere also combine to apply a component force to objects on the earth's surface.

Although small, these environmental forces may also act on the embryonic fluid in the womb so as to influence the gestation period. The major environmental forces that are evaluated in relation to variations in a patient's gestation period are the:

1) gravitational attraction between the sun and the earth,

2) gravitational attraction between the moon and the earth,

3) gravitational attraction between the sun and the moon,

4) gravitational attraction between the sun and the patient,

5) gravitational attraction between the moon and the patient,

6) gravitational attraction between the earth and the patient,

7) gravitational attraction between the sun and the Earth's atmosphere,

8) gravitational attraction between the moon and the Earth's atmosphere,

9) gravitational attraction between the earth and its atmosphere, and

10) barometric pressure at the patients location.

Taken individually, each of the gravitational forces can be represented by Newton's law of universal gravitation (Lindeburg 44-18):

$$\text{Force} = G\frac{M_1 \times M_2}{R^2}$$

where G is the Gravitational Constant (equal to $6.673 \times 10^{-11} N\text{-}m^2/kg^2$), M_1 and M_2 are the masses of objects 1 and 2 respectively (in units of kilograms), and R is the distance between objects 1 and 2 (in units of meters).

The importance of this equation is that the gravitational force is directly proportional to the combined masses of two objects, but inversely proportional to the square of the distance between them. For example, the great mass of the sun becomes important when determining the gravitational influence it has over the earth (as well as earth bound objects), but the great distance between the sun and the earth acts to moderate this influence.

In reality, the combination of the above listed component forces results in an extraordinarily complicated force vector that acts among, and on, the earth, moon, sun, the earth's atmosphere and the patient. Practically however, many of the component gravitational forces under study may possibly be neglected because of their near zero, or at least, neutral effect on the patient. This results because the forces are either 1) a very small component of the overall force, or 2) near constant, thereby exerting very small temporal variations in the component force.

SOLAR GRAVITATIONAL FORCE

The earth revolves around the sun in an elliptical orbit (as defined by Kepler's first law) with an orbital eccentricity (ε) of 0.0167. The Earth's orbit is very nearly circular (see Figure 1A); the distance from the sun at perihelion being 147.09×10^6 km, and 152.10×10^6 km at aphelion (Weast and Selby, 1968). This is a change in the orbital parameter of approximately 9.7 percent. The elliptical orbit (with the sun at one foci) also means that the gravitational influence exerted by the sun on the earth is in a state of continual change. The ratio of the difference in gravitational force due to the earth's elliptical orbit can be expressed as:

$$\frac{F_{Aphelion}}{F_{Perihelion}} = \frac{(147.09x10^6\,km)^2}{(152.10x10^6\,km)^2} = 0.935$$

This means there is an approximately 6.5 percent difference between the maximum and minimum gravitational force exerted on the earth by the sun.

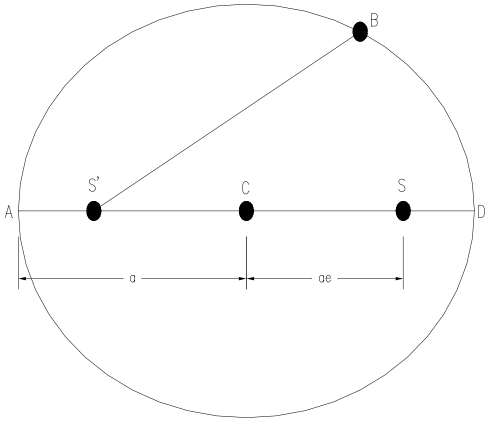


Figure 1A: Geometric orientation of Earth's orbit about the Sun. S and S' are the focal points of the elliptical orbit; C is the center of the ellipse; 'a' is the semi-major axis, and 'ae' is the semi-minor axis. Point B is the Earth's relative position.

LUNAR GRAVITATIONAL FORCE

Much as the earth revolves around the sun, so does the moon revolve around the earth. The moon's orbit is also elliptical (ε = 0.0549) with a perigee of 0.3633×10^6 km and an apogee of 0.4055×10^6 km. As the moon journeys around the earth once every 29.5 days, it presents its familiar lunar phases (see Figure 1B) of full moon (disk 100% illuminated), first quarter (50% illumination), new moon (no illumination), and 3rd quarter (50% illumination). When the earth, moon, and sun are in-line, the combined gravitational forces are at their maximum. With the positioning of the moon at the first and third quarter, the sun and moon are at a 45-degree angle to each other, rendering the influence of their gravitational pull at a minimum.

As in the case of the sun-earth system, equation 2.03 or equation 2.01 can be modified to calculate the gravitational influence of the moon on the earth as follows:

$$Force = G\frac{M_e M_m}{R^2}$$

where M_e is the mass of the earth (5.9736×10^{24} kg); M_m is the mass of the moon (0.07349×10^{24}

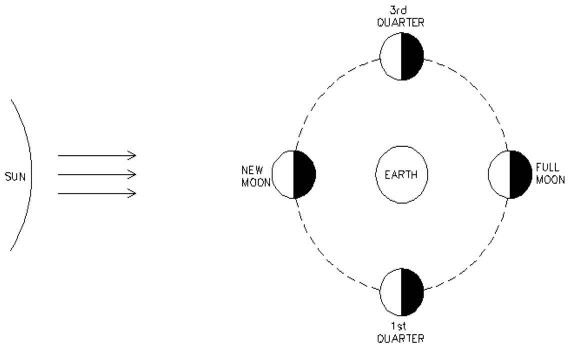


Figure 1B: Sun, Earth, Moon orientation for four lunar phases.

kg), and R is the distance between the earth and the moon. At perigee, the maximum gravitational force is equal to 2.22 x 10^{20}N, and at apogee the minimum gravitational force is equal to 1.78 x 10^{20}N.

EARTH'S GRAVITATIONAL FORCE

The earth has its own gravitational field that exerts a force upon objects on its surface. Because of the direct influence and close proximity to objects on the surface, the gravitational force is dependent upon even relatively minor variations in the distance between the defined source of earth's gravitational force (the geographical center of the earth) and the surface. Because the earth is ellipsoid instead of spherical, the gravitational force on an object on the surface is dependent upon both its latitude and altitude. The acceleration due to gravity acting on an object on the surface of the earth can be closely approximated by the equation (Lindeburg):

$$g = g' [1+(5.305 \times 10^{-3}) \sin^2 \phi - 5.9 \times 10^{-6} \sin^2 2\phi)$$

where g' is the generalized gravitational acceleration (equal to 9.78045 meters/second-squared), and ϕ is the geographical latitude of the patient. The equation for the acceleration due to gravity, corrected for latitude and altitude, but neglecting the rotation of the earth and the influence of gravity from the sun and moon, can be given by (Lindeburg):

$$g_h = g\left(\frac{R_e}{R_e + h}\right)^2$$

where R_e is the average radius of the earth (equal to 6.37 x 10^6 meters), and h is the height above mean sea level. From Newton's second law, the corrected force due to gravity on the patient at any given latitude and at any given height above sea level is:

$$Force = (M_P \times g_h)$$

where M_P is the mass of the patient.

One final complication: the earth's total gravitational force is the variation caused by the rotation of the earth. This force (centripetal force) is given by the equation

$$F = \frac{M_e v^2}{r}$$

where M_e is the mass of the earth, v is the rotational velocity of the earth, and r is the earth's radius. This force acts to reduce the effects of the earth's gravity and is latitude dependent.

ATMOSPHERIC BAROMETRIC PRESSURE

The barometric pressure is a measured quantity that represents the weight (per unit area) of the atmospheric gases, liquids, solids, and particulates above the level of the instrument (barograph). Pressure is a force per unit area and is usually given in units of Inches of Mercury (In.) at the earth's surface or in millibars (mb) above the surface. The standard (average) barometric pressure at sea level is 29.92 inches of mercury (1013.25 millibars, or 14.7 pounds per square inch).

In a very real sense, atmospheric pressure is also a form of gravitational force in that the atoms and molecules that provide the weight (force) of the atmosphere are held in place by earth's gravitational attraction.

A general comparison of the relative influences on an earth bound object by the solar gravitational force, the lunar gravitational force, and the barometric pressure can be accomplished by looking at the average values of each. Using average sun-earth and moon-earth distances, the gravitational forces are:

$$F_{(\text{sun-earth})} = G\,\frac{M_e M_s}{R^2_{se}} = 3.6 \times 10^{22} \text{ Newtons}$$

$$F_{(\text{earth-moon})} = G\,\frac{M_e M_m}{R^2_{em}} = 1.98 \times 10^{20} \text{ Newtons}$$

The gravitational attraction of the moon-earth system can therefore be seen to be approximately 182 times the gravitational attraction of the sun-earth system.

The difference in tidal force is defined as the mass ratio times the cube of the distance ratio (Sverdrup, et al.), so that the individual contributions to the total gravitational influence over the earth's tides can be given by:

$$\frac{M_s}{M_m} \times \frac{R_m}{R_s}$$

$$= \frac{1989100 x 10^{24}\,kg}{0.07349 x 10^{24}\,kg} \times \frac{(380000\,km)^3}{(150000000)^3} = 0.44 = 44\%$$

At 44 percent, the sun is therefore a significant contributor to the overall tidal energy on the earth. By comparison, the average atmospheric pressure of 29.92 In. is approximately equal to 1.01×10^5 N/m^2.

From the above discussion, it has been demonstrated that the magnitudes of the solar and lunar gravitational forces exert a significant influence upon the earth. Although much smaller in magnitude than the gravitation force, variations in barometric pressure are also a significant contributor to the overall external force component. By comparison, temporal and magnitude variations in the solar gravitational field are much smaller than that of the lunar gravitational field.

RESEARCH METHODOLOGY

The research presented here represents a form of low-constraint, naturalistic study that is generally characterized as archival research (Graziano and Raulin, 1999). Though the research base in this area of study is sparse, the database is sufficiently large enough to ensure statistical reliability.

DATA COLLECTION

The data set for this study includes both collected and calculated patient gestation data, lunar phase data, atmospheric barometric pressure data, and astronomical data related to solar and lunar orbits. The patient gestation data, obtained through cooperation with Memorial Hospital, located in York, Pennsylvania consists of the following information derived from 1259 patient admission records from June 30th, 1998 through October 31st, 2000:

- Patient age (at time of delivery)
- Patient race
- Date/Time patient was admitted to the hospital
- Date/Time of patient delivery
- Patient's actual gestation period (in weeks)
- Number of previous patient births (parity)
- Patient's home address (zip code only)

Patient data was filtered to include only patients who had spontaneous onset of labor. This eliminated all patients that had induced deliveries, surgical deliveries, or otherwise non-normal, non-natural deliveries. The patient's age, race, previous number of births, and date/time of admission to the hospital were included for reference and record completeness only and were not used in the analysis.

The collected environmental data consists of barometric pressure, lunar phase, and solar/lunar positioning within the Sun-Moon-Earth system complex. Barometric pressure data was gleaned from hourly reports from the Lancaster, Pennsylvania office of the National Weather Service (NWS - station KLNS, 40.12 degrees latitude and – 76.30 degrees longitude, 123 meter altitude) and the Millersville University weather station.

Millersville University is approximately ten miles east of the NWS station and at roughly the same altitude. Lunar phase data and Sun/Moon positioning was calculated using a personal computer (PC) based software application (NOVAS) provided by the United States Naval Observatory (USNO) through their Astronomical Applications Department. The primary source of the barometric pressure data was the Millersville University weather station reports. This source was used largely because the data are reported in Eastern Standard Time (EST) and in units of inches of mercury rather than the more standard Greenwich Mean Time (GMT) and millibars used by the National Weather Service. The use of Eastern Standard Time makes correlations with hospital patient records easier and more convenient. The Lancaster National Weather Service Station data was used to validate the accuracy of the Millersville data and to fill in missing or under-reported periods where needed.

The patient's home zip code was used to ascertain that each patient included in the analysis lived within a twenty-five mile radius of the two weather stations used to record barometric pressure. A twenty-five mile radius greatly increases the likelihood that the recorded barometric pressure did not vary from patient to patient at selected times. It should also be noted that the general topography within the selected twenty-five mile radius is within +/- fifty feet so that no altitude corrections to the barometric pressure were required.

The following environmental data points were calculated from the available environmental data resources:

- Average barometric pressure over the reporting period
- Barometric pressure at time of delivery
- Barometric pressure at 6 and 3 hours prior to delivery
- Rate of pressure drop 6 and 3 hours prior to delivery
- Range/Magnitude of solar forces
- Range/Magnitude of lunar forces
- Estimated contribution of barometric force to total environmental forces
- Estimated contribution of lunar force to total environmental forces
- Estimated contribution of solar force to total environmental forces
- Lunar Phase (on day of delivery – in percent of moon illuminated)
- Lunar apogee/perigee, and
- Solar apogee/perigee.
- Statistical Treatment and Analysis

The raw, filtered patient data as described above was received from Memorial Hospital in spreadsheet format. To this spreadsheet, the barometric pressure at time of delivery, barometric pressure three hours prior to delivery, barometric pressure six hours prior to delivery and lunar phase on the day of delivery was added. Various patient data that were not used in the final analysis, such as patient's age, race, parity, and hospital admission date/times were deleted from the spreadsheet to ensure patient confidentiality.

Calculations were then performed to obtain the average barometric pressure over the study period, the three and six-hour pressure trends prior to delivery, and the average patient gestation period. The difference between the average gestation period (39 weeks) and the actual patient gestation period were also calculated.

In addition, supporting calculations were performed to determine the range and magnitudes of the solar, lunar, and terrestrial gravitational forces, as well as the range of barometric pressure. These values were made in order to determine their overall significance as part of the total environmental force and, if appropriate to the final calculations, each assigned a weighting factor.

Once the required data was calculated and recorded, relevant correlations were determined using graphical and statistical methods. The primary statistical analysis consists of computing the chi-squared test-of-goodness. The chi-square test was chosen because it can satisfactorily be used to compare the experimental results to a normal distribution rather than to data in a control group. The inclusion of a control group was impractical with the design and implementation of this study.

CHI-SQUARED ANALYSIS

The chi-square statistic was applied to test the significance of the lunar phase (e.g. variations in gravitational pull from the moon at different times of the month) and barometric pressure on the variation of the human gestational period. What is determined is whether variations in the external environmental forces of gravity and/or barometric pressure are likely to alter the normal human gestation period. The initial steps of the study began by plotting the date/time of the recorded deliveries along with the lunar phase and barometric pressure at the time of delivery. Histograms were then developed to display the data and to see if they revealed any obvious trends.

The average (i.e. *expected*) gestation period (39 weeks) is included on selected histograms as a straight horizontal line for a comparison value. Each graphical representation was used to assist in the initial analysis as to whether the data represents a real, reliable difference between the proportions in the patients who deliver early (or late) and the general population of patients.

The analysis started by stating the null hypothesis, that is: all patients are equally likely to deliver, on average, during the 39th week of gestation. On the basis of this null hypothesis, a table of expected frequencies based on barometric pressure and lunar phase grids was created. For each phase of the moon, or increment of barometric pressure, the total number of births was recorded and compared to the average gestation period. The expected (E) and actual (A) frequencies were then compared.

The greater the difference, the less likely the distribution is to have arisen within a single population. The chi-square statistic was then determined from the expected and actual frequencies. The size of chi-square value depends on the magnitude of the differences and how many differences are involved. For each increment of lunar phase and pressure, a chi-square and the total of the chi-squares will be calculated as:

$$\chi 2 = \text{SUM}\ [(E - A)^2\ ] / E$$

where:

SUM = Mathematical Summation

E = expected (average) gestation period (39 weeks)

A = actual gestation period of patient group

STUDY DATA

The study data represents a compilation of the filtered patient data and includes deviations from average gestation period (Delta Gestation Period), observed barometric pressure (BP), observed barometric pressures three hours prior to delivery (BP-3), observed barometric pressures six hours prior to delivery (BP-6), calculated three hour pressure gradients (DBP-3), calculated six hour pressure gradients (DBP-6), and lunar phases (in percent of disk illuminated).

Each graph was constructed to draw attention to significant relationships and were divided into three general categories: 1) barometric pressure and pressure trends, 2) charts relating the lunar cycle (in the form of lunar disk illumination), and 3) combined effects of barometric pressure and lunar gravitation on the number of deliveries and gestation periods.

Figure 2 is a background/support chart designed to illustrate the frequency at which the barometric pressure varied between the minimum recorded barometric pressure of 29.00 inches and the maximum recorded barometric pressure of 31.00 inches throughout the entire data collection period. Barometric pressures are grouped in segments of 0.40 inches centred roughly on the average barometric pressure. A value of 0.40 inches was chosen as the pressure increment because this represents a reasonable boundary between local variable fluctuations and an absolute pressure trend.

Figure 3 is a histogram representation of the frequency of recorded deliveries for each of the same pressure ranges used in Figure 2.

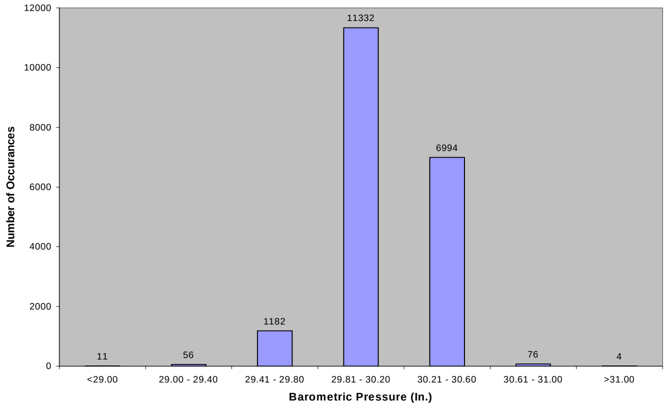


Figure 2: Frequency of pressure range occurrences.

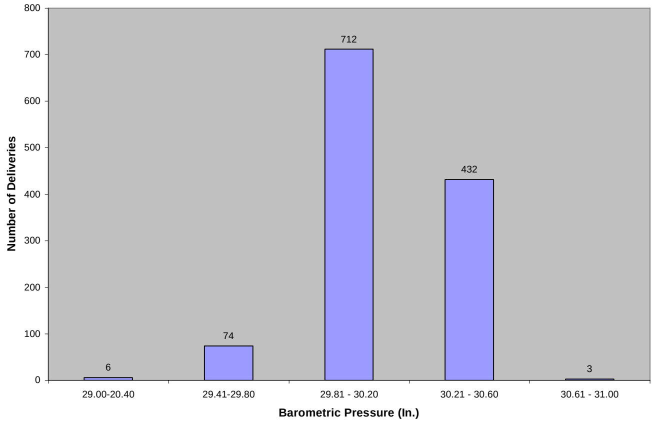


Figure 3: Frequency of deliveries verses barometric pressure ranges.

Figures 4 and 5 are histograms of the frequency of deliveries and their relationship to the rate of barometric pressure change during the three and six-hour periods prior to delivery.

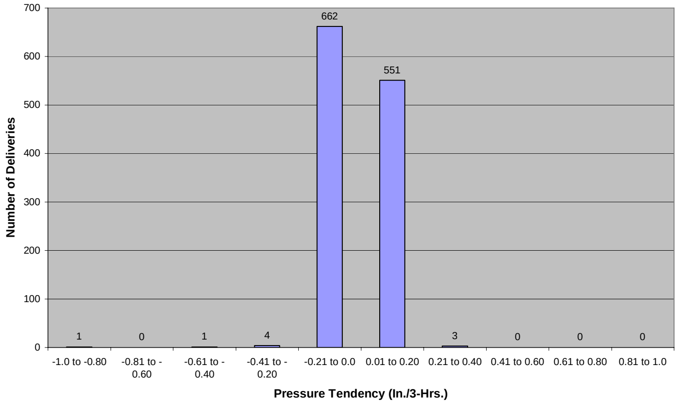


Figure 4: Frequency of deliveries for a three-hour barometric pressure gradient.

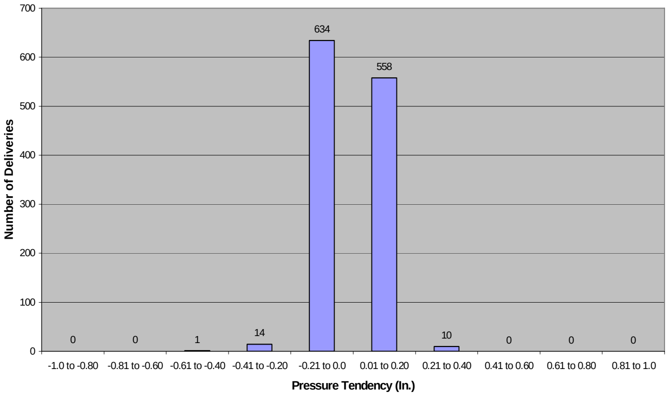


Figure 5: Frequency of deliveries for a six-hour barometric pressure gradient.

These graphs are designed to highlight potential variations in the frequency of deliveries due to changes in local pressure. Negative pressure ranges (in increments of 0.20 inches.) represent falling barometric pressure and positive pressure ranges represent increasing barometric pressure. The smaller pressure increment was chosen to provide increased graphical detail.

Figure 6 is designed to illustrate how deviations from the average barometric pressure influence the frequency of deliveries. As in Figures 4 and 5, the ranges in pressure gradients are in increments of 0.20 inches.

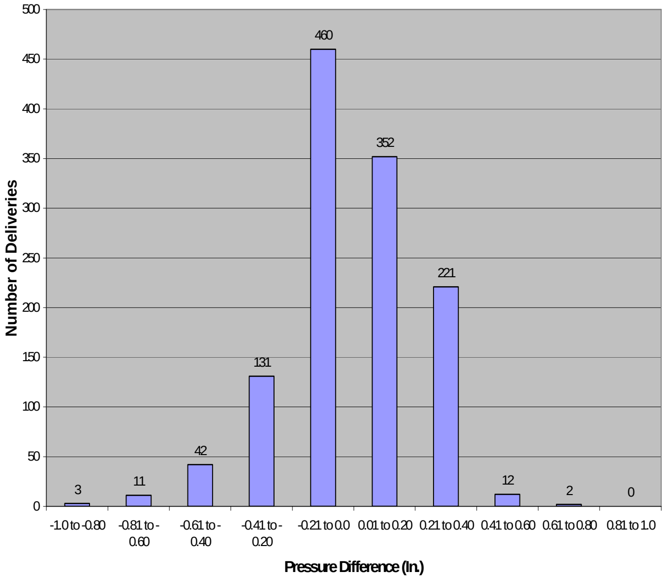


Figure 6: Frequency of deliveries per deviation from average pressure.

Figure 7, constructed from Table 1, is a collection of five plots that present the change in gestation period due to barometric pressure. Each pressure range is plotted separately against deviations from the average gestation period of 39 weeks. Gestation deviations vary from seven weeks prior to average (i.e. expected) gestation, indicated by negative values, to seven weeks after the average gestation period as indicated by positive values.

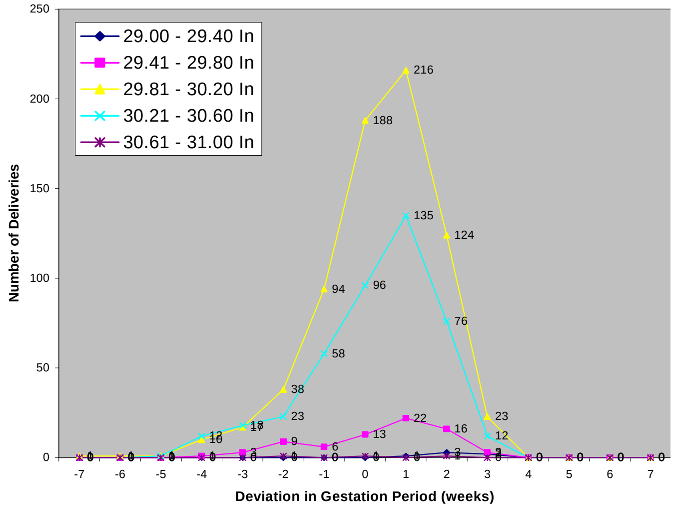


Figure 7: Frequency of deliveries: barometric pressure range vs. deviation in gestation period.

Figures 8 and 9 depict the relationship between the change in gestation period, frequency of deliveries, and the rate of pressure change during the three and six-hour periods prior to delivery. Each figure consists of a set of ten plots and is designed to highlight potential variations in gestation period due to changes (gradients) in barometric pressure. The negative pressure ranges (in increments of 0.20 inches) represent falling pressure and the positive pressure ranges represent increasing pressure. Table 2 contains the data used to construct Figure 8 and is included to aid in its interpretation. Table 3 contains the data used to construct Figure 9.

Changing focus toward potential gravitational effects, Figure 10 is intended to explore how gravitational forces, in the form of lunar phase, influence the frequency of deliveries. The gravitational component is divided into distinct increments centred on the four major lunar phases. The full moon represents lunar phases from +75 to -75 percent illumination, 1st quarter from +25 to +74 percent illumination, new moon

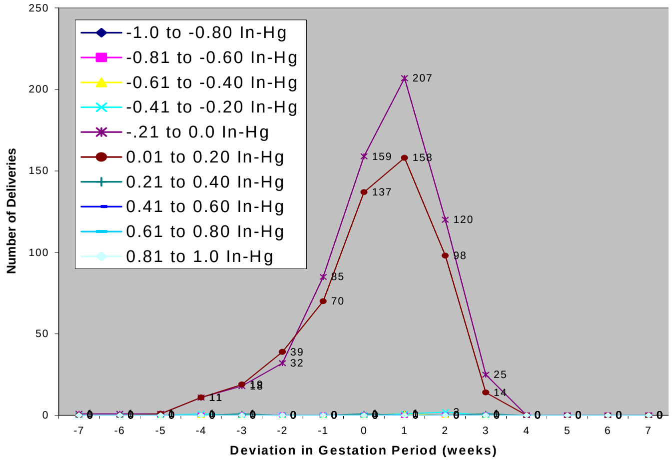


Figure 8: Frequency of Deliveries: Three-Hour Pressure Gradient vs. Deviation in Gestation Period.

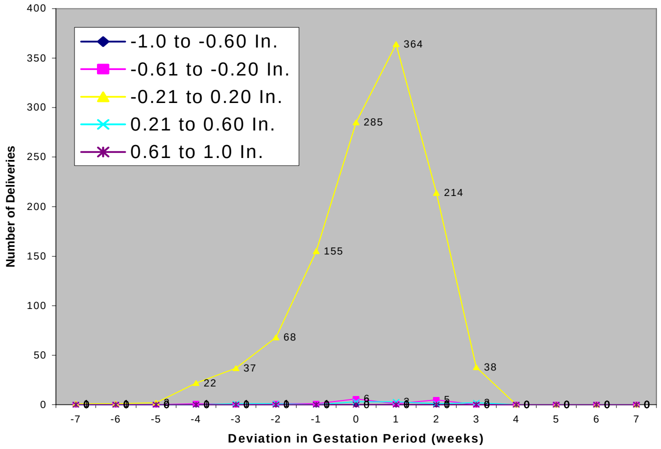


Figure 9: Frequency of Deliveries: Six-hour Pressure Gradient vs. Deviation in Gestation Period.

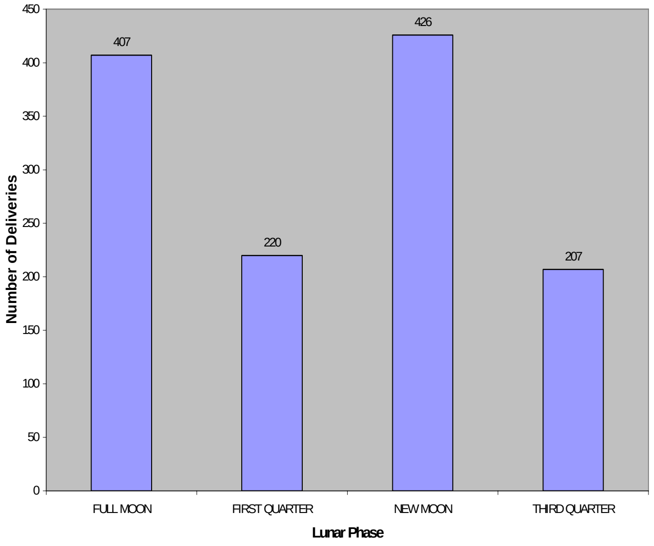


Figure 10: Frequency of Deliveries for Four Phases of the Moon.

Table 1: Frequency of Deliveries: Barometric Pressure Range vs. Deviation in Gestation Period

	Deviation in Gestation Period (weeks)														
Pressure Range (In.)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
29.00 - 29.40	0	0	0	0	0	0	0	0	1	3	2	0	0	0	0
29.41 – 29.80	0	0	0	1	3	9	6	13	22	16	3	0	0	0	0
29.81 – 30.20	1	1	1	10	17	38	94	188	216	124	23	0	0	0	0
30.21 – 30.60	0	0	1	12	18	23	58	96	135	76	12	0	0	0	0
30.61 – 31.00	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0

Table 2: Frequency of Deliveries: Three-Hour Pressure Gradient vs. Deviation in Gestation Period

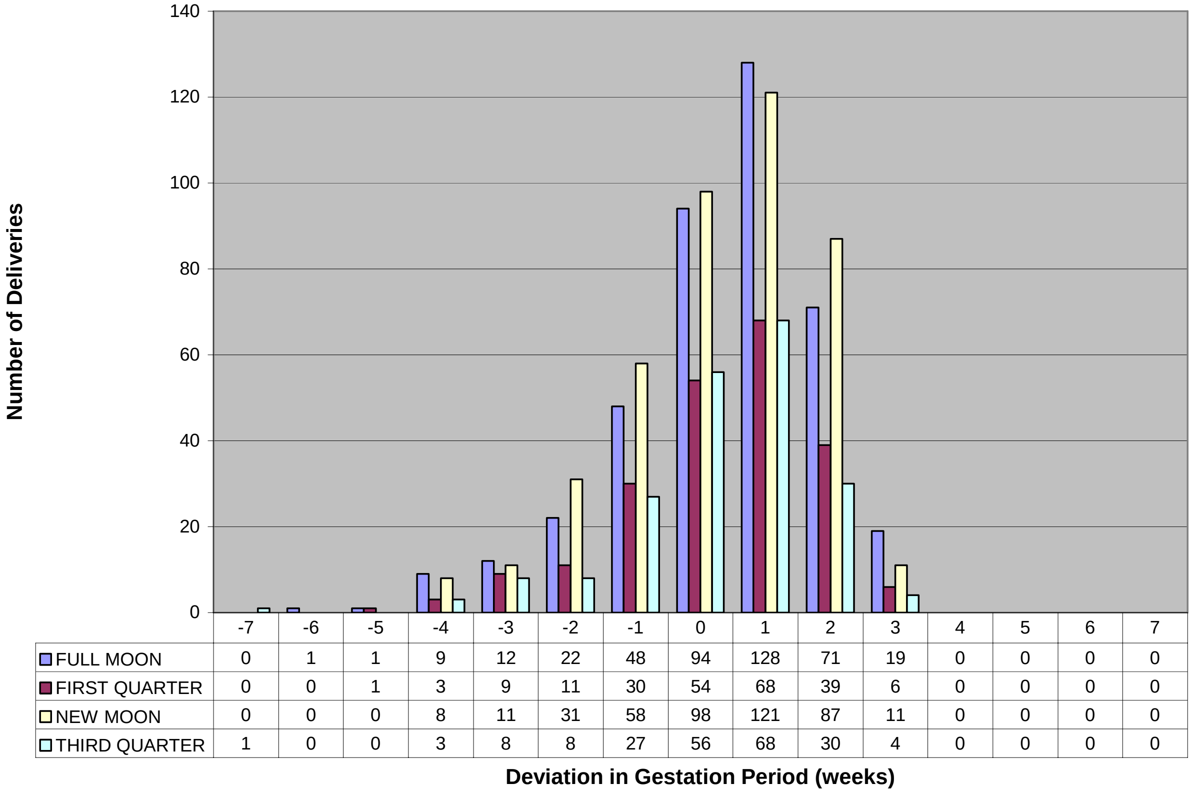
	Deviation in Gestation Period (weeks)														
Pressure Range (In.)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
-1.00 to –0.80	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
-0.81 to –0.60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-0.61 to –0.40	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
-0.41 to –0.20	0	0	0	1	0	0	0	0	1	2	0	0	0	0	0
-0.21 to 0.00	1	1	1	11	18	32	85	159	207	120	25	0	0	0	0
0.00 to 0.20	0	0	1	11	19	39	70	137	158	98	14	0	0	0	0
0.21 to 0.40	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0
0.41 to 0.60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.61 to 0.80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.81 to 1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3: Frequency of Deliveries: Six-Hour Pressure Gradient vs. Deviation in Gestation Period

	Deviation in Gestation Period (weeks)														
Pressure Range (In.)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
-1.00 to –0.80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-0.81 to –0.60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-0.61 to –0.40	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
-0.41 to –0.20	0	0	0	1	0	1	1	6	1	4	0	0	0	0	0
-0.21 to 0.00	1	1	1	13	18	34	82	143	204	112	22	0	0	0	0
0.00 to 0.20	0	0	1	9	19	34	73	142	160	102	16	0	0	0	0
0.21 to 0.40	0	0	0	0	1	1	0	3	3	1	2	0	0	0	0
0.41 to 0.60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.61 to 0.80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.81 to 1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

from +24 to -24 percent illumination, and 3rd quarter from -74 to -25 percent illumination.

Figures 11A and 11B are respective histogram and graphical plots of the potential influence that lunar gravitation has on the gestation period. The separate graphical representations of the same data set were constructed in order to highlight subtle trend differences. As in Figure 10, the lunar gravitational component is represented by the four primary phases of the moon, and changes in the gestation period is plotted from 7 weeks prior to the average 39 week gestation period (negative values), and 7 weeks after the average gestation period. A table is appended to Figure 11A to aid in interpretation and as a reference to the histogram peaks.



	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
FULL MOON	0	1	1	9	12	22	48	94	128	71	19	0	0	0	0
FIRST QUARTER	0	0	1	3	9	11	30	54	68	39	6	0	0	0	0
NEW MOON	0	0	0	8	11	31	58	98	121	87	11	0	0	0	0
THIRD QUARTER	1	0	0	3	8	8	27	56	68	30	4	0	0	0	0

Figure 11A: Frequency of Deliveries: Lunar Phase vs. Deviation in Gestation Period.

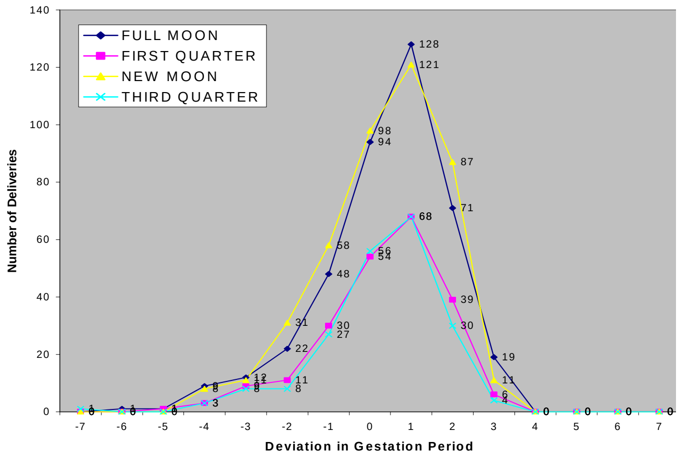


Figure 11B: Frequency of Deliveries: Lunar Phase vs. Deviation in Gestation Period.

Finally, Figure 12 represents the potential combined effect that barometric pressure and lunar gravitational force have on the frequency of deliveries. The values for lunar gravitation and barometric pressure are represented as discussed in previous figures.

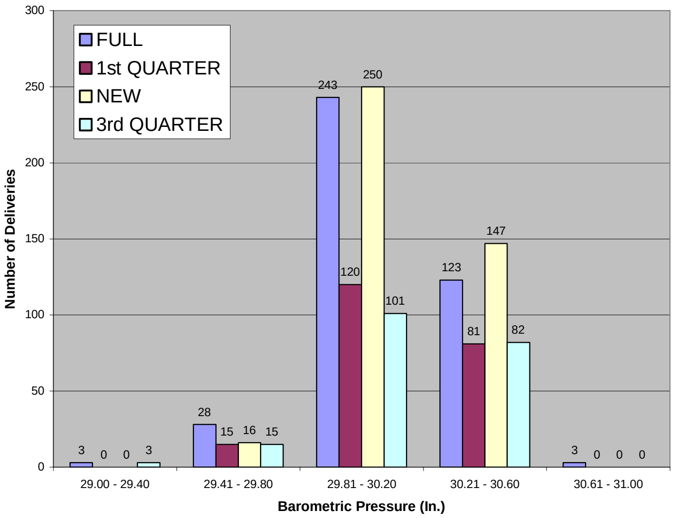


Figure 12: Frequency of Deliveries: Lunar Phase vs. Barometric Pressure.

STATISTICAL TREATMENT

The data tables and graphs are used to identify data regions to be examined through detailed statistical treatment. Of particular interest are those periods where the solar and lunar gravitational force contributions are high (strong external attraction) and the barometric pressure is relatively low, or rapidly falling. From this population, a percentage of patients with a delivery date prior to the projected delivery date may be determined. This number can then be compared to the general population to determine if a statistical significance exists.

Statistical analysis was performed by applying the chi-square goodness-of-fit test for the following primary areas of interest:

Three-hour rate of barometric pressure change

The three-hour rate of barometric pressure change (i.e. pressure gradient) on the length of the gestation period is presented in Figure 4. As Figure 4 illustrates, the number of deliveries outside the –0.21 to +0.20 inches barometric pressure range is low, so concentration was focused on the number of deliveries inside this range. The question then becomes, is there a significant difference in delivery frequency between the positive pressure gradient (0.01 to 0.20 inches) and the negative pressure gradient (-0.21 to 0.00 inches)?

The null hypothesis for this analysis is that the three-hour rate of barometric change does not affect the frequency of deliveries and that the number of deliveries in both pressure gradient ranges should therefore be equal. This reduces to the expectation that the number of deliveries within the –0.21 to 0.00 In. pressure gradient range and the 0.01 to 0.20 In. range will each approach 606 deliveries. As seen in Figure 4, the actual values are 662 deliveries for the negative range and 551 deliveries for the positive range. For this situation, the value of chi-square is equal to 10.16, with one degree of freedom. The probability then that the null hypothesis is valid is less than 1 percent.

Change in barometric pressure over the six-hour period

The six-hour change in barometric pressure prior to delivery on the length of the gestation period is presented in Figure 5. As in the previous case, the number of deliveries within the –0.21 to 0.00 In. pressure gradient range is expected to be equal that of the 0.00 to 0.20 In. pressure range. This expected number of deliveries is 596. The actual number of recorded deliveries is 634 in the negative range and 558 deliveries in the positive range. This results in a chi-square value of 4.84, with one degree of freedom. The probability that the null hypothesis is valid is therefore less than 5 percent.

Departure from average barometric pressure

The effect of the departure from average barometric pressure on the frequency of deliveries is depicted in Figure 6. The null hypothesis for this case is that the departure from average barometric pressure does not affect the delivery frequency. One would therefore expect to see an even number of deliveries on the positive (higher than average pressure) departure side of the histogram as on the negative (lower than average pressure) departure side. This equates to 617 deliveries during periods when the barometric pressure was lower than normal, and 617 deliveries when the barometric pressure was higher than normal.

The actual recorded values were 647 deliveries on the negative side of the histogram and 587 deliveries on the positive side of the histogram. This results in a chi-square value of 2.92 with one degree of freedom, which means that the probability that the departure from average barometric pressure does not affect the number of deliveries is less than 10 percent. The null hypothesis for this instance cannot be rejected.

If the area of interest is reduced to exclude all but the barometric pressure ranges from –0.041 to 0.40 In., there were 647 deliveries (52.43%) during periods of lower than normal barometric pressure and 587 deliveries (49.23%) during higher than normal barometric pressure. This results in a chi-square value of 0.278 with one degree of freedom, which means that the probability of the null hypothesis being valid is greater than 20 percent.

If the area of interest is further reduced to exclude all but the pressure gradient range from –0.21 to 0.20 In. there are 460 deliveries during periods of lower than normal barometric pressure and 352 deliveries during periods of higher than normal pressure. This results in a chi-square value of 14.37 with one degree of freedom, which means that the probability that the null hypothesis is valid is less than 0.5 percent. We therefore reject the null hypothesis within this range.

Frequency/Deviations in gestation for various ranges in barometric pressure

The frequency of deliveries and deviations in gestation period for various ranges in barometric pressure is presented in Figure 7 and Table 2. As per Figures 2 and 3, over 99 percent of the deliveries were recorded within the 29.41 to 30.60 In. pressure range. As we focus on this range of pressures, it should be expected that most of the deliveries would occur within this range and in similar proportions to those depicted in Figures 2 and 3. It should further be expected that there would be no significant deviations in length from the average 39-week gestation period. The null hypothesis therefore states that within the barometric pressure range between 29.41 to 30.60 In., the barometric pressure will have no effect on the length of the gestation period.

To effectively perform a chi-square test, the gestation range must be initially narrowed to ±3-weeks. Analysis of this selected gestation deviation range reveals a chi-square value of 384.74 with six degrees of freedom. That yields a probability that the chosen null hypothesis is representative of the sample population of less than 0.5%.

If the gestation range is reduced to ±2-weeks, the chi-square value is calculated to be 140.82 with three degrees of freedom. The p-value for this analysis is less than 0.001. Further restriction of the gestation range to ±1-week yields a chi-square value of 48.01 with one degree of freedom and a p-value of less than 0.001. Therefore, in all three cases the null hypothesis must be rejected.

If the data presented in Table 2 is analyzed via a two-way chi-square test to determine the significance of the relationship between the barometric pressure and gestation length, we find that for the ±3-week gestation range, chi-square is equal to 14.58 with 12 degrees of freedom (p-value of 0.263). Similarly, chi-square p-values of 0.190 was obtained for ±2-weeks, and 0.557 for ±1-week. Given the chi-square values obtained, the null hypothesis cannot be rejected.

Three-hour pressure gradients on the deviation in gestation

The effect of three-hour pressure gradients on the deviation in gestation period is presented in Figure 8 and Table 3. Table 3 indicates that over ninety-nine percent of all deliveries occurred within the –0.21 to 0.20 In./3-hour pressure gradient range, so it is appropriate to concentrate the analysis on this area. If the pressure gradient had no effect on the gestation period, an equal number of deliveries in each of the gestation weeks would be expected. The number of deliveries on each pressure trend side of the 39th week would be expected to be 459.5. In actuality, there were 291 deliveries prior to the 39th week and 628 deliveries after the 39th week. These values result in a chi-square of 123.58, with one degree of freedom. The probability of the null hypothesis being true is therefore less than 0.1 percent.

A two-way chi-square test is performed to determine the significance of the pressure gradient on the length of the gestation period. Analysis of the gestation deviation range of ±3-weeks yields a chi-square value of 5.172 with 5 degrees of freedom, 3.257 with 3 degrees of freedom for a ±2-week range, and 0.155 with 1 degree of freedom. The respective p-values of 0.395, 0.354, and 0.694 indicate that in this analysis, the null hypothesis cannot be rejected.

Six-hour pressure gradient effect on deviation in gestation

The effect of the six-hour pressure gradient on the deviation in gestation period is presented in Figure 9 and Table 4. Inspection of Figure 9 and Table 4 reveals that the data is virtually identical to the three-hour pressure gradient data presented above and the differences in the values of chi-square are inconsequential.

Lunar Gravitational Effect on Delivery Frequency

The effect of lunar gravitation on the delivery frequency is presented in Figure 10. If the lunar phase has no effect on the number of deliveries one would expect the 1260 deliveries to be equally divided between each of the four lunar phases. Actual values for the full moon phase are 407, 220 for 1st quarter phase, 426 for new moon phase, and 207 for 3rd quarter phase. The one-way value of chi-square is calculated to be 131.66 with three degrees of freedom, making the probability that the lunar phase (and therefore lunar gravitational forces) has no effect on the number of deliveries much less than 0.1%. A comparison of proportions was used to compare the number of deliveries recorded during the full and new moons and for the 1st and 3rd quarters. These comparisons yield z-values of 0.658 and 0.628 respectively, indicating no significant differences.

Variations in Lunar Gravitation on the Length of Gestation

The effect of variations in lunar gravitation on the length of the gestation period is presented in Figures 11A and 11B. Analysis of the data represented by Figure 10 indicates that there is a significant variation in the number of deliveries based on the phase of the moon. It is now appropriate to determine if there is also a change in the length of the gestation period, based on the phase of the moon. The null hypothesis for this case is that each week of gestation will have an equal occurrence of deliveries based on the percentages derived from Figure 10. The two-way chi-square test for the ± 3-week gestation range is calculated to be 14.984 with 18 degrees of freedom, so that the probability that the null hypothesis is valid is 0.663. The null hypothesis can therefore not be rejected for this case.

Similar two-way chi-square tests for the ± 2-week gestation period and the ± 1-week gestation period yields values of 8.757 with 12 degrees of freedom and 1.462 with 6 degrees of freedom respectively. Again, in each case the null hypothesis cannot be rejected.

Combined Effect of Barometric Pressure and Lunar Gravitation

The combined effect of barometric pressure and lunar gravitation on the number and timing of deliveries is presented in Figure 12. The null hypothesis in this case is the number of deliveries will be distributed according to the pressure range frequencies given in Figure 2 and equally over each lunar phase. Analysis of Figure 12 shows that the percent of deliveries per barometric pressure range was very similar to the frequency of barometric pressure given in Figure 2 and the number of deliveries per lunar phase was not equal, but distributed as in Figure 10.

ANALYSIS AND DISCUSSION

The hypothesis of a relationship between atmospheric pressure or gravitational forces (via tidal forces) and premature rupture of the membranes, leading to the eventual onset of labor, is based on the assumption that pressure *in utero* remains relatively constant in the absence of uterine contractions, while atmospheric pressure and gravitational forces are constantly changing. Very high or low values of barometric pressure, sudden large changes in pressure, and/or an increase in the local gravitational force could create a force gradient across the membranes, potentially resulting in the rupture of mechanically weak ones. This study was designed to identify and evaluate those external forces that may contribute to a variance in the gestation period from that which might otherwise be expected.

Based on the calculations developed and presented above, the solar component of the total gravitational force acting on a patient on the earth's surface is obviously significant. There are however, other factors to consider besides the sheer magnitude of the force. What is perceived to be significant is not necessarily simply the overall force, but rather how the magnitude and direction of the force varies with time. Based on the aphelion and perihelion distances, the difference between the maximum and minimum values of the solar gravitational force is only 6.5 percent. In addition, due to the 365.25-day period of rotation, the solar component of the gravitational force changes too slowly over a two to three week period to be of significant biological consequence. For this reason the decision was made not to include the solar component as part of the total gravitational force in the final analysis.

The earth's gravitational force can also be negated, but for a host of very different reasons. First, the earth's gravitational influence on the average patient (someone of approximately 150lbs - or 667 Newtons) represents only a small fraction of the overall force component, and acts opposite to the direction of the solar and lunar forces.

One of the primary considerations during the data gathering process, and the reason for obtaining the patient's zip code was to ensure that each patient lived within a 25-mile radius surrounding the hospital. Within this range, the altitude is relatively constant. This consistency is a benefit for two reasons. First, the earth's gravitational field is virtually constant from both the latitude and altitude aspects. This means that within the confines of the supposition that changes in the primary external forces that may induce variations in the gestation period, the earth's gravitational force can therefore also be neglected.

Secondly, with no appreciable variation in altitude, the barometric pressure does not vary greatly within such a small geographical range. Additionally, confining the patient data group to a 25-mile radius ensures that the centripetal force caused by the rotation of the earth can be assumed to be constant for each patient.

The relevance of the lunar gravitational force, however, cannot be as easily dismissed. The moon revolves around the earth every 29.5 days, approximately 12 times as fast as the earth revolves around the sun. Even though the elliptical orbit of the moon is nearly circular, because of its close proximity to the earth, the rotation is important. The lunar gravitational force can therefore not be assumed to be constant within a two to three week period and must be regarded as a potentially significant contributor. However, when dealing with the concept of lunar gravity, certain assumptions can be made. Rather than performing complicated calculations to obtain exacting values of the daily lunar gravitational force, accurate approximations can be made with little harm to the study's intent.

Due to the geometry of the system (see Figures 1A and 1B), the positions of the earth, moon, and sun can be used to approximate the relative magnitude and direction of the lunar gravitational force. For example, when the moon is fully illuminated, the gravitational force due to the distance and positioning of the sun and the moon will be maximized. A similar effect (but to a lesser degree) occurs during the new moon. The minimum lunar gravitational forces will be felt at the first and third quarter moons. In many credible studies (see Witter as an example) the lunar phase is used as an acceptable alternative and simplification to calculations of actual lunar gravitational forces for a particular geographical region (as in tidal forces).

This same technique has been used in many other lunar related studies dealing with such diverse topics as human psychology, animal migration and breeding patterns, and in determining optimum fishing/crabbing opportunities. Geometrically, this technique is akin to simulating the magnitude of a single body gravitational force (as opposed to tidal variations, for example). The use of lunar phase as a reliable indicator of lunar gravitational force component is, in fact, supported by single-body calculations.

With the above rationale, assumptions, and simplifications in place, the focus may now be placed on how barometric pressure and pressure changes influence the initiation of labor and the length of the gestation period. If barometric pressure does not influence the frequency of deliveries, an equal number of deliveries would be expected at any particular value or range of pressures. One caveat here is that in reality, not all values of pressure are equally obtainable. This fact is highlighted in Figure 2, which shows that during the study period, 0.285 percent of the 19,655 recorded hourly pressure values were observed between 29.00 and 29.40 In.; 6.01 percent fell in the 29.41 to 29.80 range; 57.66 percent in the 29.81 and 30.20 In. range; 35.58 percent in the 30.21 to 30.60 In. range, and 0.387 percent in the 30.61 to 31.00 In. range. These same percentages are therefore expected to parallel the frequency of deliveries. In fact, Figure 3 clearly confirms this hypothesis. Of the 1,227 total patient deliveries, 0.49 percent were recorded within the 29.00 to 29.40 In. range, 6.03 percent within the 29.41 to 29.80 In. range, 58.03 percent within the 29.81 to 30.20 In. range, 35.21 percent within the 30.21 to 30.60 In. range, and 0.25 percent within the 30.61 to 31.00 In. pressure range. The calculated percent differences within similar pressure ranges between Figures 2 and 3 are statistically insignificant. The conclusion then is that the magnitude of barometric pressure at or near the time of birth alone has no significant effect on the frequency distribution of deliveries.

If our attention is now turned to the three and six-hour barometric pressure trends prior to delivery (Figures 4 and 5 respectively), we observe that over 99 percent of the deliveries occurred within the –0.21 to +0.20 In./3-hour range (Figure 4). The percentages for the six-hour pressure trends are very similar to the three-hour pressure trends with almost 98 percent of the deliveries occurring between –0.21 and +0.20 In./6-hours (Figure 5). One item of note in both Figures 4 and 5 is that the greatest percentages of births occur during a slightly negative (i.e. falling slowly) pressure trend region. For example, in Figure 4, more than 54 percent of the total number of deliveries occurred when the pressure was falling between 0.0 and 0.2 In. over the three hours prior to delivery, as opposed to 45 percent in the 0.0 to +0.2 In./3-Hr pressure band. In Figure 5, just over 52 percent of the total number of deliveries occurred in 0.0 to –0.2 In./6-Hr. (slightly negative trend) region, while just under 46 percent of the patients delivered when the pressure was rising from between 0.0 and 0.2 In./6-Hrs. The chi-square test p-values of less than 0.01 for the three-hour pressure gradient and 0.05 for the six-hour pressure gradient indicates that slightly negative changes in barometric pressure significantly affect the frequency distribution of deliveries.

Although the data used to construct Figures 4 and 5 most likely indicates that a low-pressure system was entering the patient's region over the entire six-hour period prior to delivery, this appears to validate the previous assumption that approaching storms (i.e. declining barometric pressure) are thought to increase the number of deliveries by decreasing the gestation period. It is noteworthy that the data does not indicate that large pressure changes, positive or negative, have much, if any, influence on the frequency distribution of deliveries.

With the hypothesis that the initiation of patient delivery may perhaps be more related to the deviation in pressure from the normal (average) 30.12 In. barometric pressure that was recorded over the 15-month study period, Figure 6 represents this deviation from average pressure at the time of patient delivery and shows a decidedly different view than revealed in either Figures 4 or 5. As previously discovered, most of the deliveries (65.81%) occurred when the barometric pressure was in the near normal range (-0.2 to +0.2 In. from average), but Figure 6 reveals a more normal (Gaussian) distribution.

Although the greatest number of deliveries occurred when the barometric pressure was slightly lower than normal (37.28%, compared to 28.53% for slightly higher than normal), the overall percentages were more even at 47.57 percent of the deliveries occurring during higher than normal pressures and 52.43 percent of the deliveries occurring during lower than normal pressures. Again, this points to the preference for patient deliveries during periods of slightly lower than normal (i.e. 0.0 to –0.2 In.) barometric pressure. However, as seen in Figures 4 and 5, chi-square testing indicates that the significance of the influence of pressure gradients on the frequency of deliveries as the gradient range widens beyond the –0.21 to +0.20 In. range decreases rapidly.

The influence of barometric pressure on the duration of the gestation period is highlighted in Figure 7 and Table 2. This data represents the relationship between barometric pressure (from 29.00 In. to 31.00 In. in increments of 0.40 In.) and the departure (in weeks) from the average 39.28-week gestation length. As in Figure 3, most of the deliveries are found to occur within the 29.81 to 30.20 In. range (58.2%) with the second highest percentage within the 30.21 to 30.60 In. range (35.2). Of additional interest is that each of the plotted pressure ranges peak on the +1 week deviation from average gestation (i.e. indicating the preference for a 40-week gestation period).

Of the 1,226 total deliveries throughout the period, 298 deliveries (24.3%) were recorded during the 39th week (zero deviation); 294 deliveries (24.0%) were recorded as negative deviations (before the 39th week), but the largest numbers of deliveries recorded (51.7%) were positive deviations (after the 39th week). The implication appears to be that during the period of observation, most deliveries that occurred during periods of higher than normal pressure resulted in longer than normal gestation periods. The significance of this impression is confirmed by the chi-squared test at the ± 3-week (p-value = 0.005), 2-week (p-value = 0.001) and 1-week (p-value = 0.001) intervals. However, if we look at the possible synergistic relationship between barometric pressure and deviations in the gestation period, chi-square tests reveal no significant trends.

Figure 8 and Table 3 represent the relationship between the three-hour barometric pressure trend prior to delivery and the departure from the average gestation period. As in the case of the instantaneous barometric pressure's influence on the gestation period, the peak number of deliveries is skewed toward a 40-week gestation length. As seen in the previous pressure trending charts, the two highest peaks on this chart (representing over 99% of the recorded deliveries) correspond to the slightly increasing and slightly decreasing pressure trends between –0.21 and +0.20 In./3-Hrs. Again, a statistically significant number of deliveries were observed during a slightly negative pressure trend (i.e. pressure decreasing from 0.0 to 0.20 In./3-Hrs.), but the effect of barometric pressure on the length of the gestation period proved to be insignificant at the ± 3-week, ± 2-week, and ± 1-week intervals. Figure 9 and Table 3, which represent the relationship between the six-hour barometric pressure trend prior to delivery and the departure from the average gestation period, show virtually identical results.

Focusing now upon the possible influences that gravity (specifically lunar gravity) might have on the human gestation period, Figure 10 reveals a very interesting relationship between the timing of deliveries and the lunar phase (displayed in terms of percent of the lunar disk illuminated).

This chart clearly shows that the number of deliveries during the new and full moons (66.1%) is roughly twice that of either the first or third quarter moons (33.9%). This is confirmed by a chi-square p-value of less than 0.001. The difference in the number of deliveries between the new and full moons, or the 1st and 3rd quarters is not significant. If, however, the focus is narrowed to the distribution of deliveries around the full moon, an interesting point emerges. At ± 10%, (i.e. +90% illuminated to –90% illuminated, or roughly a four day time span), the number of deliveries drops to 62% of the original number. At ± 95% illumination (roughly ± 1 day) the number of deliveries drops to 47.6% of the original number. Similar analysis of the new moon data is also interesting when compared with the full moon data.

One might suspect that the reductions in the number of deliveries would be similar to those of equal full moon reductions, but this does not appear to be the case. At ± 10% illumination, the number of deliveries drops to 40.6%, and at ± 5% illumination the number drops to 30.75%. These values are almost 12% and 17% greater reductions than those for the full moon and represent a significant difference between the number of deliveries as the gravitational pull of the new and full moons crest. Although not conclusive, this might indicate that though the number of deliveries during the new moon is virtually equal to the number of deliveries during the full moon, the propensity for delivery is more concentrated around the time of full moon.

The conclusion that births are more concentrated around the full and new moons is a compelling and perhaps understandable result. During full and new moons, the earth-sun-moon system aligns linearly to produce a maximal gravitational force (see Figure 1), whereas the earth-sun-moon system alignments during the first and third quarters produce minimal gravitational and tidal forces. What is most interesting about this result is that it is the full moon that has traditionally been associated with peculiar physiological and psychological events and, while this data seems to confirm this effect relative to the frequency of deliveries, the new moon seems to play an equally important role.

Figures 11A and 11B illustrate the relationship between lunar gravitation and the length of the gestation period. As in the case for Figure 9, the lunar phase is displayed in units of quarter moons from new moon (0% illuminated) to full moon (100% illuminated). Although deviations in the gestation period were recorded seven weeks prior to average gestation and seven weeks after average gestation, this was reduced to ± 3-weeks to accommodate chi-square testing and decrease the potential of biologically induced effects associated with premature deliveries. As in the case of barometric pressure, the peaks for all lunar phases maximize toward slightly longer than normal gestation periods (i.e. 40 weeks), with over twice as many deliveries being recorded for all phases of the moon in the positive deviation range (51.9%) as in the negative deviation range (24%). This result is not surprising in light of the results obtained from the barometric pressure and pressure trend data. A corollary in support of these findings is the known relationship between the strength of lunar gravitational fields and atmospheric tides.

This relationship was recently dramatically demonstrated by a rare celestial event. From 4:15 PM on September 23rd through 2:15 AM EST on September 24th, 1999, the moon was at perigee; the earth was at perihelion, and the moon was at full illumination. With this orientation, the gravitational influence on the earth from the sun and moon was at its greatest since 1930. During this same time frame (and accounting for tidal lag), the barometric pressure showed a prominent depression, averaging only 29.78 inches of mercury (considerably lower than its average 30.12 In.) immediately followed by a substantial recovery to near average pressures. Although this time period witnessed a high number of births (eleven deliveries from + 90% to –90% illumination), this number of deliveries was not atypical throughout the study period.

Two-way chi-square tests designed to determine the existence of synergistic relationships between the lunar gravitational force and barometric pressure to affect the length of the gestation period failed to reveal any significance at the ± 3-week, ± 2-week, or ± 1-week intervals.

The trend can also be seen in Figure 12. The percent of deliveries per barometric pressure range are very similar to the frequency of barometric pressures given in Figure 2. The number of deliveries per lunar phase was not equally distributed over the four lunar phases, but distributed as in Figure 10. From the data presented, the conclusion must therefore be that there is no proven synergistic relationship between barometric pressure and gravitational force that act to influence the frequency or timing of deliveries.

RESULTS AND CONCLUSIONS

This study was designed to determine if, and to what extent, barometric pressure and combined gravitational forces influence the timing of human births. The major difference between this study and similar earlier studies is that the emphasis here is placed on the change in magnitude of the external forces and the possible synergistic relationships between the forces that may lead to a change in the frequency distribution and/or length of the human gestation period.

This investigation analyzed over 1,259 patient records from Memorial Hospital in York, Pennsylvania, recorded hourly values of barometric pressure and calculated daily gravitational force components from June 30th, 1998 through October 30th, 2000.

Collected and calculated data points relevant to barometric pressure at time of delivery, three and six-hour pressure gradients prior to delivery, deviation in average gestation periods, and the lunar phase at time of delivery were compiled and presented in graphical format. The chi-square goodness-of-fit test and comparison of proportions were performed on data of interest to determine significant relationships in data trends.

It was found that the majority of the births occurred during periods when the barometric pressure was decreasing slightly over periods of 3 and 6 hours prior to birth, but that the magnitude of the barometric pressure at the time of birth or large pressure gradients prior to birth had no significant effect on either the frequency or timing of deliveries.

Unlike barometric pressure, gravitational forces were found to have a statistically significant influence on the frequency of deliveries. In particular, a significantly greater number of births occurred during the full and new moon phases of the lunar cycle.

Although this study attempted to establish the existence and magnitude of a synergistic relationship between barometric pressure and gravitational forces that might lead to deviation in the duration of human gestation, none could be ascertained.

This investigation is intended to bridge the knowledge gap between those previous efforts designed to determine the effects of barometric pressure on human gestation and similar studies designed to determine the effects of the lunar phase on human gestation. This goal was effectively accomplished by analyzing the effect of pressure and gravitational forces separately, then statistically combining the two forces to establish the existence of synergistic relationships. This study also provides additional information to a field where serious scientific research is severely lacking by lending more credence to the theory that lunar gravitational forces has a significant effect on some aspects of human psychology and/or physiology.

Although neither the magnitude of the barometric pressure, nor the pressure gradient were found to have a significant effect on human gestation, the gravitational influences of the new and full moons did have an effect on the frequency of deliveries. The effects associated with the new moon were found to be as significant as the effects associated with the full moon. A detailed analysis of the delivery frequency associated with the full and new moons found that the full moon had a greater effect than the new moon as the gravitational force increased. This fact had not been reported in previous studies, and the awareness of this information could help hospitals and clinics to better prepare their staffs and allocate resources more effectively.

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