MEDICAL PROBLEMS ARISING FROM SOLAR STORMS

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ABSTRACT

Data collected over many decades strongly suggest a connection between solar activity and enhanced illness in at-risk patients, with numerous studies indicating an approximate 10% increase in cardiovascular events when the sun is active. Similar correlations have been established for neurological problems and suicide rates. The interaction pathway for these effects is the solar wind. Interacting with the earth's magnetosphere it generates a concomitant change in the earth's magnetic field that can reach levels of 100s of nT or greater. The bioeffects associated with solar storm downstream interactions are very likely derived from the same (unknown) mechanism responsible for the dozens of reports showing that weak ELF magnetic fields affect living systems. The most likely explanation for both effects is that they reflect a similar response of the biological clock to disruptive magnetic signals.

INTRODUCTION

It goes without saying that the sun has an influence on human beings. It is necessary for life on earth through its gift of warmth. Our evolutionary make-up in large part derives from the physical attributes of the sun. The maximum sensitivity of the eye is adjusted to the green wavelengths that are at the peak of the sun's spectral output. Our kinetic energy expenditures are cyclically apportioned for wakefulness and sleep in synchrony with the side of the spinning earth that faces the sun. Metabolic activities are consistent with the range of temperatures on earth from the sun. One of the most frightening doomsday scenarios is that of the solar winter, where an enduring cloud cover would severely interfere with photosynthesis, thereby reducing food production to catastrophically low levels.

It should not be surprising, therefore, to learn that relatively small disturbances in the sun's activity can also affect humans in serious ways. Indeed a large body of literature has been generated to indicate that there are robust connections between solar activity and human health. Interestingly this connection is not reflected in the thermal energy received at the earth's surface. Terrestrial temperatures do not scale with solar activity. Rather the effects on

human health are due to an intermediary between sun and earth, namely the solar wind that causes perturbations in the earth's magnetic field (GMF).

Although the present work is focused on illness, we should not forget the deep historical context that preceded this, where attempts were made to relate the sun to human behavior. In the 1920s a Russian school of thought was generated specifically highlighting what was claimed to be the close relationship between solar activity and human events. This work, largely developed by the father of heliobiology, Chizhevsky[1] argued that the sun is far more important in social affairs than usually acknowledged. Not only were matters of health addressed but also effects on climate and political matters. From a scientific standpoint, however, establishing a connection between solar activity and biological change is difficult enough without venturing forth into the grey areas surrounding societal impact. Much maligned as this research was at the time (and still is) it had the virtue of serving as a springboard for a multitude of Russian scientists that followed, all studying various aspects of the interactions between the geomagnetic field and living things. A more recent version of these studies, somewhat more acceptable scientifically, has been developed by Halberg and Cornellisen[2]. This approach stresses the painstaking delineation of the various frequencies attached to the sun's cycles, coupled to putative cycles gleaned from human medical and social records.

THE NATURE OF SOLAR ACTIVITY

A variety of electromagnetic signals, either as directly delivered radiofrequencies or indirectly as transients caused by solar wind interactions are part of solar storm activity. Magnetic disturbances on the solar surface have been visibly recorded since at least the 1600s, conveniently listed in terms of the number of sunspots observed daily. These world-wide data, collected over centuries, show that sunspot numbers enjoy a persistent 11-year periodicity (Fig. 1), with maxima corresponding to times when the sun is "active" and minimum numbers occurring halfway between, when the sun is "quiet". The summer of 2013 corresponded, for example, to a time of maximum solar activity.

The active sun emits ionized plasma (dense regions of highly energetic charged particles), some of which escapes solar gravity to stream into space (Fig. 2), becoming what is referred to as the solar wind, traveling at about 400 km/s, even faster for extremely violent storms. Depending on where the earth is in its yearly orbit and the initial direction of this wind, the earth's magnetic field may be impacted by this wind, leading to measurable changes in the GMF at the surface of the earth. This lengthy journey from the sun, taking about 3 or 4 days to reach the earth, is the pathway that relates magnetic storms on the sun to human health problems.

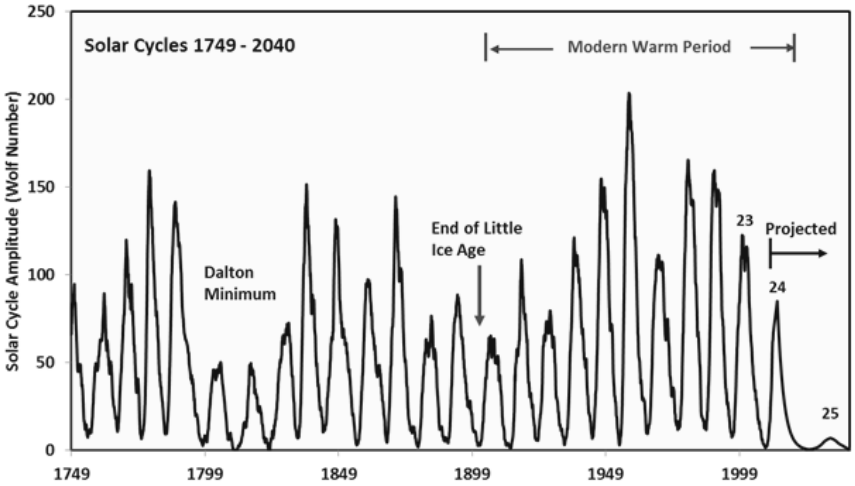

Fig. 1. Record of solar sunspot numbers *since 1749. Cycle 24 peaked in 2013.*

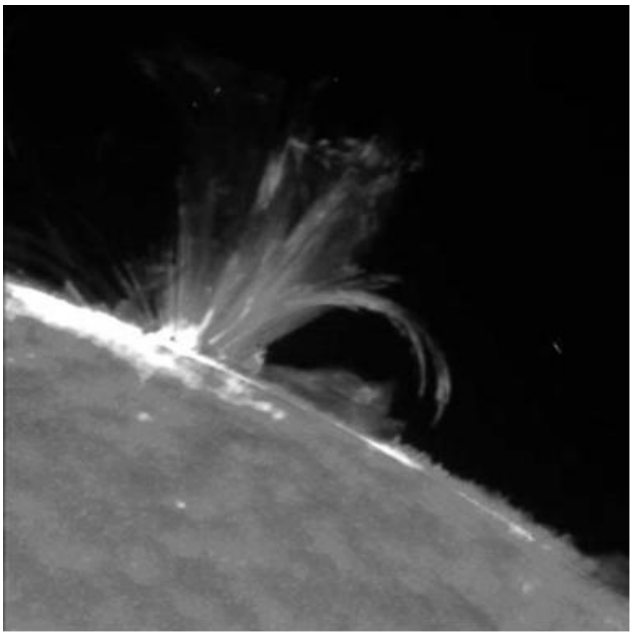

Fig. 2. A solar flare photographed on the edge of the sun, showing both the partial return of ejected material in the form of a loop as well as what appears to be a total loss moving directly outward, presumably constituting a coronal mass ejection. In this photograph the sunspots appear as bright regions.

How does one reckon short-time changes in the GMF? By international agreement geomagnetic perturbations are studied using a variety of yardsticks as a measure of the change at the earth's surface due to the solar wind. Two such indices, A and K, are reported at various geomagnetic stations; when averaged globally, they are designated Ap and Kp (Table 1). Each index is

determined by taking three hour averages of the local magnetic field, which in turn is averaged over 13 locations around the globe. In practice the daily average is mainly used, constructed from the eight values measured over each 24-hour period.

Kp	Ap	Magnetic change, nT	Description
0	0-2	0-5	Very quiet
1	3-5	5-10	Quiet
2	6-9	10-20	Quiet
3	12-18	20-40	Semi-Quiet
4	22-32	40-70	Unsettled
5	39-56	70-120	Minor Storm
6	67-94	120-200	Major Storm
7	111-154	200-330	Severe Storm
8	179-236	330-500	Severe Storm
9	300-400	>500	Extremely Severe

Table 1. Geomagnetic indices used to categorize different levels of geomagnetic perturbation.

BIOLOGICAL SENSITIVITY TO WEAK ELF MAGNETIC FIELDS

In principle, it is difficult to link solar storms to biological activity. Not only are the effects of these storms delayed in arriving at the earth's surface and extremely weak, but they are also short-lived and aperiodic in nature. The consequent changes measured at the earth are greatly reduced in intensity, and only indirectly reflect the original magnetic events on the solar surface, several days earlier. The alterations in the geomagnetic field are the result of currents of electrons being formed in the vicinity of the earth following the emission of a solar flare from the sun. This causes the magnetic field at the earth's surface to change for a short period of time, until the currents above the earth are dissipated.

The net effect at the earth's surface is very small. Apart from local iron ore anomalies the total geomagnetic field intensity ranges from 25-60 μT. One has to answer exactly how biological systems are affected by changes in this field of perhaps 0.2 μT over the course of several hours. Despite what seem so clear to those studying the decades-long correlations between illness and magnetic storms, claims suggesting that such fields can have physiological effects have evoked deep suspicion by the physics community.

Nevertheless, there is continuing evidence to lend support to the idea that solar activity does have biological significance. Despite the fact that a remarkable array of human illnesses

correlates positively with solar storms, it is only now that one finds independent evidence to corroborate the notion that weak, low-frequency magnetic fields are capable of impacting biological clock function in humans.

Even though there was considerable statistical evidence since the 1920s showing that humans are affected by solar activity, it was not until the groundbreaking work of Adey[3] some 50 years later that a reasonable physical explanation began to emerge. The subsequent hypothesis of ion cyclotron resonance (ICR), introduced by Liboff[4] in 1984, and later confirmed in dozens of experiments[5], implicated low frequency magnetic fields, showing conclusively that they are biologically interactive, even to levels as weak as 10s of nT[6].

This resonance concept holds that combined time-varying and static magnetic fields act in concert to stimulate biologically sensitive ions, thereby altering physiological response. This condition requires that the frequency of the time-varying magnetic component be related to the static field value through a constant of proportionality equal to the charge-to-mass ratio of the specific ion. Accordingly many early ICR experiments focused on stimulating the calcium ion, an obvious choice considering its well-known second messenger capabilities.

Particularly noteworthy is that when the ICR hypothesis was introduced for the very first time, in 1984[4], specific mention was made that this resonance process would lend itself to interactions involving the GMF. The ICR process provides a physical basis for explaining how weak low frequency magnetic fields of the sort associated with geomagnetic disturbances due to solar storms, can affect living things. Most important it strengthens the decades-long history of reports finding statistical connections between human well-being and solar activity.

The geomagnetic changes arising from solar storms range from 100s of nT to 1000s (0.1 μT- 1.0 μT), well below prior published predicted lower limits on biological sensitivity. Nevertheless, these latter constraints are clearly invalid considering the dozens of reports to the contrary. Furthermore, the relevance of the ICR response to geomagnetic effects on humans has in recent years been strengthened by Zhadin[6], who found that the physical characteristics of amino acids are affected by vanishingly small magnetic fields, as little as 40 nT. This extension of ICR effects to very weak magnetic fields opens the door to the possibility that even the slightest changes in the geomagnetic field are capable of affecting life on earth.

CORRELATING STORMS WITH SICKNESS

There have been numerous reports indicating positive correlations between various medical problems and solar/geomagnetic storms. These have included a wide range of problems: behavioral difficulties[7-9], effects on embryonic development[10], sudden infant death syndrome[11],

influenza[12-14], and, notably, heart disease[15-25]. As early as 1931 Alexander Chizhevsky[26] reported evidence linking sudden death from cardiac arrest to solar activity. Many of these claims have not been thoroughly reproduced, the one prominent exception being the extensive work focused on cardiovascular disease. On the other hand only a few observers have failed[27-29] to find connections to solar storms. Thus it is now widely believed that these effects, although still unexplained, are indeed real. Nonetheless, because different statistical approaches have been used, some seeking to correlate daily effects and others, monthly averages, the picture is less than perfect.

Because of our natural tendency to seek correlations, often at the expense of reasonable expectations, a variety of other periodic biophysical phenomena have also been explored for their possible connection to the human condition. Two such examples are pC oscillations[30,31] and Schumann resonances[32]. However, even if these correlations are indeed viable they probably bear little connection, if any, to the more generally accepted outcomes for human health derived from solar wind interactions.

In the one case, although it is true that geomagnetic pulsations are indeed due to solar activity they are less dependent on solar storms. They occur within low-frequency bands, the most intense being the Pc 1 band covering the range 0.1 to 5 Hz. Their approximate 1 nT intensity is far less than the bulk of the signals resulting from magnetic storms, which are usually measured in the 100s of nT, and separately known from laboratory studies to be biologically interactive. One speculative physiological argument is that Pc 1 signals make the heart particularly susceptible because their frequencies overlap those associated with the heart rate. However it is difficult to describe a physically reasonable coupling process in this regard.

Schumann resonances represent another geophysical phenomenon widely studied for their potential impact on humans. It may very well be the case that there are biological effects connected to Schumann resonances, but such effects, if real, would be completely independent of those related to solar activity. Simply stated Schumann resonances are not geomagnetic phenomena, and are completely unrelated to solar activity. They result from electric discharges due to lightning that is launched into the well-defined spatial gap between the two conducting sheets defined by the ground and the ionosphere.

In general the approach to studying the effects of solar activity on biological system has consistently employed correlation analysis, an approach often found scientifically wanting without further evidence either in the laboratory or theoretically. Most often this type of analysis uses clinical endpoints such as the records of rate of suicides, heart attacks or hospital admissions that are also registered regularly by government agencies. Because such registers can provide enormous numbers of cohorts, sometimes in the hundreds of thousands, the statistics often appear to be quite reasonable. But until recently scientists were slow to accept

stand-alone correlative studies such as these as reasonable evidence, regardless of the statistics. In our opinion, the supportive evidence has reached levels where credibility is no longer in question. Further, as has already been pointed out, the data obtained this way is consistent with parallel independent research implicating weak low frequency magnetic fields in a wide range of biological effects[5].

COSMIC RADIATION

Our understanding of how solar activity affects humans is confounded by the fact that there are likely biological effects due to cosmic rays, the ubiquitous high energy particles originating not only in the sun but also in galactic and extra-galactic regions. Some reports claim that solar-related health problems appear to be greater at higher geomagnetic latitude, an association that might perhaps follow from a similar effect observed in cosmic rays, where the intensity is greater at the poles than at the equator[33].The problem is that increased cosmic radiation always accompanies *reduced* GMF levels. This well-established inverse relationship occurs because the GMF dipole acts to deflect cosmic rays away from the earth. When the earth's magnetic field is reduced the cosmic ray intensity increases. Although no direct evidence exists specifically showing that enhanced cosmic radiation has biologic consequences, it is reasonable to make this assumption, given the fact that cosmic radiation is known to be highly ionizing.

A direct illustration of the inverse connection between cosmic ray intensity and geomagnetic field is the phenomenon of the Forbush decrease (Fig. 3), where the cosmic ray flux falls precipitously when the solar wind arrives to sharply increase the geomagnetic field. Note that correlations have been reported between myocardial infarcts and Forbush decreases[25]. It is reasonably certain that the prime causative factor in such associations must be the change in magnetic field, not the change in cosmic ray intensity.

One common error in reporting possible cosmic ray effects is to give special significance to the specific monitoring technique employed. Statements[34] such as "…neutrons, produced by cosmic rays…can play a significant role [in the] timing of cardiovascular diseases…" are made without realizing that neutron monitoring is but one experimental method of many, chosen because of its simplicity, with which cosmic rays are studied. Whatever the biological effects of cosmic radiation it is far more likely to result from ionization events than to the method of measurement itself.

In one instance[35] it was reported that adverse health effects appear to correlate with both lower as well as higher geomagnetic activity. This might conceivably be tied to the concomitant cosmic ray increase at reduced GMF levels. However other data based on medical admissions at

lower latitudes in Mexico City[19] and Havana[20] found similar rates for solar-related myocardial infarcts as had been reported at higher latitudes. In any event although it is very clear that weak magnetic fields can have physiological consequences it is seems unreasonable to think that the absence of such fields would have similar effects.

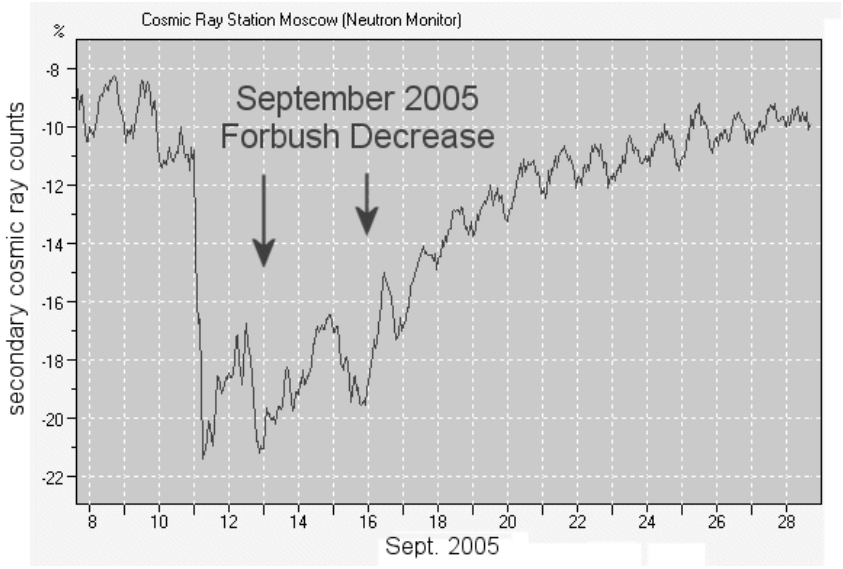

Fig. 3. A typical Forbush decrease in sea-level cosmic ray intensity accompanying a solar storm.

CARDIAC PROBLEMS

The effects of solar disturbances on blood, specifically on the erythrocyte sedimentation rate (ESR) have been studied for some time[36, 37]. These earlier in vitro report inevitably led to a large number of related observations on humans. More than any other medical condition, morbid effects relating to the cardiovascular system have been repeatedly correlated with geomagnetic activity. These are detailed in a number of excellent reviews[18,34].

Ghione[16] found higher systolic and diastolic blood pressures related to solar storm activity in 447 outpatients tested over a five year period. Gurfinkel[24] investigated the effect of enhanced geomagnetic indices on 80 heart patients, using perivascular edema, red blood cell aggregation, and blood flow rate as observables. Fully 70% of these individuals were significantly affected. A positive correlation between GMF and heart attacks was found for 1192 patients in Sofia[22] between 1995 and 2004. Another, separate, very large data set, based on ambulance calls in Moscow[34] during 1979-1981 found a 13% increase in heart attacks and a 7% increase in strokes. Additionally examination of the daily incidence of 2290 myocardial infarcts in Mexico City from

1992-1996 revealed a 13% increase on geomagnetically active (GMA) days[19]. One study in Havana[20] conducted between 1992 and 1999 supported the connection between heart attacks and increased GMA, and went so far as to suggest the effect had a threshold in the 50-100 nT range. Positive correlations between 7798 myocardial infarctions in one Greek hospital and geomagnetic indices were observed[23] for the ten year period beginning in 1997.

Using medical data originating in Lithuania this question has been examined in some detail by Stoupel[38]. A study of more than 850,000 deaths, grouped by monthly rates, was made, covering 20 years. Although this study lacked the specificity of the daily correlations used elsewhere, the approach was noteworthy in that care was taken to separate out the individual correlations associated with key variables: solar activity (SA), geomagnetic activity (GMA), and cosmic ray activity (CRA). In so doing one can distinguish between effects related to direct observation of solar activity, by counting sunspots, and by the geomagnetic perturbations on the earth's surface, thereby taking account of the time lag introduced by the solar wind. One can readily correct for this lag, but cosmic ray effects are more difficult to disentangle. According to Stoupel monthly averages of deaths from heart disease strongly correlate with cosmic ray activity and solar activity, but less so with geomagnetic activity. However, by restricting the analysis to individual monthly averages of GMA, this approach becomes insensitive to the few days per month when the effect may be more vivid.

A total of 15543 myocardial infarcts occurring in 1989 and 1990 in St Petersburg[25] was compared to solar storms using the returning phase of Forbush decreases as a measure of geomagnetic perturbations. This work stands out because a credible attempt was made to establish a precise measure for the percentage increase in morbidity, reported as 10.5 ± 1.2 %.

Novikova and Ryvkin[39] compiled lists of those who had heart attacks in the city of Sverdlovsk (presently Yekaterinburg) during the years 1961-1966. Both the total daily number of myocardial infarctions, or morbidity, as well as related deaths or mortality, were categorized as either occurring on a quiet solar day or active solar day. These results, covering a total of approximately 3600 cases are shown in Table 1. The increase in heart attacks due to solar storms, according to these data, is roughly 8-9%. A 5% increase in cardiac-related deaths was recorded in another study in Minnesota[40] that compared years of maximal solar activity to years of minimal solar activity.

	MORBIDITY			MORTALITY		
YEAR	ACTIVE	QUIET	% INC	ACTIVE	QUIET	% INC
1961	78.8	70.4	8.4	24.5	18.8	5.7
1962	73.5	65.3	8.2	35.0	25.7	9.3
1963	77.6	73.2	4.2	24.9	20.6	4.3
1964	62.0	57.0	5.0	36.4	21.7	14.7
1965	79.1	75.0	4.1	27.9	25.3	2.6
1966	90.8	75.4	15.4	59.5	40.9	18.6
Mean %			7.5			9.2

Table 2. Percentages of cases of myocardial infarction in one Russian city separated according to whether these occurred during solar active or solar quiet periods. Thus, in 1964 heart attacks occurred 57% of the time on quiet days but 62% on active days, suggesting that there was a 5% greater chance of having a heart attack that year because of solar activity. Note that the year 1966 was marked by a large increase in solar storms, as the sun began to move into its more active mode consistent with its 11-year cycle. (Novikova and Ryvkin, 1977).

Such abundant evidence makes it is difficult to avoid the conclusion that solar/geomagnetic activity can increase the rate of heart attacks by approximately 10 %, compared to periods when the sun is quiet. The influence of geomagnetic activity on heart disease is further revealed in separate studies showing that the occurrences of stroke, as well as known risk factors such as high blood pressure, pulse rate, and coagulation rate also correlate with GMA[34]. Stoupel[18], in reviewing these data, suggested that when geomagnetic activity is sufficiently great, this can overcome a hypothesized homeostatic response to a changing magnetic field, resulting in “heart rhythm disturbances and related sudden death, cardiovascular accidents, cardiovascular insufficiency, and vascular thrombosis, including myocardial infarction.” It must be emphasized that the approach taken in all these cases, where the studies focused on hospital admissions or individuals that already had cardiovascular problems, implies that the correlational associations were established solely for high risk individuals. In other words, there is nothing to indicate that the larger population exhibits the same response to geomagnetic disturbances.

Perhaps the strongest evidence yet found linking cardiovascular problems to solar activity was reported by Feigin et al[41]. Data collected on nearly 11,500 patients in five countries during the period 1981-2004 indicated a 19% increase in strokes for Ap values equal to or greater than 60, corresponding roughly to a 100 nT increase at the earth’s surface. Even more striking is that when this data set is parsed, one finds that the risk of geomagnetically-induced stroke is markedly increased as the Ap value increases.

SUICIDES

Because suicide data are carefully maintained by most countries, the effects of solar activity on this particular observable have been widely investigated. One of the earliest attempts to establish such a correlation was made by Düll and Düll[42] in 1935 when they examined suicide records covering five years in comparison to solar activity over the same period. They reported that more suicides occur during periods of heightened solar activity. Although the work was initially criticized as statistically flawed, subsequent approaches to this question served to reinforce this early observation. A study of all suicides[9] in Australia from 1968 through 2002 involving nearly 70,000 individuals compared the dates of each death to solar-induced changes in the GMF. Looking only at events resulting in changes 100 nT and greater, sufficient correlation was found to conclude that "perturbations in ambient electromagnetic field activity impact behavior in a clinically meaningful manner". The identical conclusion was reached following a similar search[43] using suicide records in South Africa covering the years 1980-1992. One alternate view to these reports on GMF-related suicides suggests that it may be more correct to correlate the suicides with changes in solar radiance, but this possibility is not widely shared.

NEUROLOGICAL EFFECTS

Geomagnetic perturbations have been linked to a variety of neurological problems ranging from migraine headaches[44] to altered EEG responses[45, 46]. Persinger[47] found these effects so striking as to describe them as "geopsychopathology". Various studies have reported a connection between the rate of psychiatric hospital admissions and solar storm indices. Admissions at two hospitals totaling 28, 642 individuals were studied[48] for the years 1957 through 1961. The correlation ratios for both hospitals were not only statistically significant, but also very close, 0.26 and 0.27, with similar correlation levels were found by other observers. More recently, Kay[7] found a 26% increase in male hospital admissions due to bipolar disorder, which he attributed to disturbances in pineal circadian rhythms. A connection between solar activity and schizophrenia was noted by Kay[49], as were apparent changes in psychiatric ward patients[50].

DISCUSSION

It is clear that certain medical problems are exacerbated by solar activity. Many of the underlying factors are still murky, in part because different investigators often employ different

approaches. Some use monthly averages of the geomagnetic indices, some use daily levels, and others probe times immediately before or immediately after the geomagnetic perturbation.

The simplest explanation as to how these problems are related to solar activity is that the biological interactions are enabled by the solar wind transporting charged particles ejected as plasma by the sun. If this wind reaches the earth's magnetosphere the geomagnetic field is temporarily disturbed resulting in changes ranging from 100s to 1000s of nT. A most important fact generally missing from discussions regarding this phenomenon is that this same range of short-term changes in magnetic field correspond to those that have been independently determined to be biologically interactive in laboratory settings.

Although the empirical evidence for these geomagnetic effects has been well established this research has suffered because it seems physically unreasonable to some that small transient changes in the background magnetic field could possibly have any effect on human health. A solution to this long-standing puzzling connection between solar activity and exacerbated human illness was suggested by Liboff[51] in 2013. This involves the fixed daily variation of ~ 50 nT in the GMF, more noticeable during periods when the sun is quiet (Fig. 4).

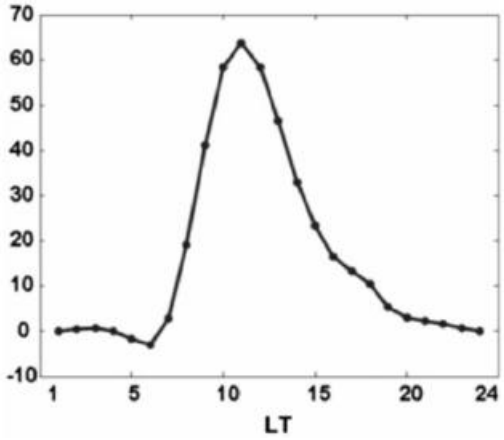

Fig. 4. Change in the horizontal component of the GMF measured in nT plotted against local time in hours (LT) clearly showing the 24-h variation.

This phenomenon is initiated in the upper levels of the atmosphere where the side of the earth illuminated by the sun undergoes a daily movement of electrons that in turn affects the magnetic field at the surface of the earth. Because this daily variation is always exactly in phase with the solar cycle, there is likely considerable evolutionary advantage in using this swing as a surrogate for the solar diurnal change. In effect this magnetic swing enables living systems to utilize the 24-hour biological clock even more completely than it does with its dependence on sunlight. Consider for example that this daily change in magnetic field occurs even on cloudy

days. In other words it is hypothesized that this small daily variation is an adjunct to the larger solar diurnal phasing of the biological clock.

In this scenario chronodisruption is facilitated by the arrival of solar winds that generate magnetic fields that are not only greatly in excess of 50 nT, but are also out of phase with the solar-adjusted biological clock. In effect the various physiological responses to geomagnetic activity are relegated to similar chronodisruptive problems[52-54] that are closely associated with jet-lag, night shift work, etc. Note that this does not actually explain the actual magnetic detection mechanism, only that we are somehow sensitive to very weak time-varying magnetic perturbations, a sensitivity that has its provenance in an ancient evolutionary adaptation.

Additional support for explaining solar-related changes in biological clock function is seen in reports[15] connecting coronary disease to changes in melatonin during geomagnetic disturbances. Close[55] also argues that the biological clock is the prime suspect in trying to understand why solar storms tend to exacerbate illness. He points to the very specific photosensitive protein cryptochrome that is widely believed to be the magnetic receptor utilized in animal navigation. He suggests that solar storm changes in magnetic field "lead to disorientation of hormonal systems…thus explaining the effects…on human health". However cryptochrome pigments are not only restricted to the retina but also appear to transmit information concerning the level of the magnetostatic field, not its time-varying characteristics.

One wonders about the reports claiming an association between cosmic radiation and the increased levels of illness that are associated with solar storms. It is certainly true that the inverse relation between cosmic ray intensity and the magnitude of the geomagnetic field can confound the already confusing connection between solar activity and illness. It is possible that some prefer to advance cosmic rays over changing magnetic fields as an explanation because of their reluctance to admit the likelihood of magnetic field responses at intensities well below 1 μT. This may also be the case because there is a convenient alternative, namely knowing that cosmic rays can exhibit ionizing interactions with biological tissues. However we note that this reluctance to link weak magnetic fields to biological response is mirrored in the similar resistance within the scientific community to acknowledge the great many laboratory reports indicating that such fields are indeed interactive.

Further, one also must consider that the cosmic ray energy distribution at the earth is only partly due to radiation emitted by the sun. Cosmic rays arriving at the earth originate not only from the sun but also from other areas of our galaxy as well as from extragalactic regions. The energies attached to the latter particles are fully ten orders of magnitude greater than those with a solar origin. The events attached to these very high energy cosmic rays are totally independent of solar storms, often worldwide, causing ionization cascades with still unknown biological consequences over an entire hemisphere. Whatever the relation between cosmic

radiation and human well-being, it is simplistic to consider that it can be folded into the basic data package regarding solar-derived magnetic changes. Where necessary, cosmic ray dependences should only be treated as corrections to the human response to solar activity, not as alternative causes.

Saher[56]argues that "… epidemiological and genetic evidence indicates that the [solar] disruption of circadian rhythms might be directly linked to disease". However, there is reason to look beyond this simple linkage. Perturbations to the biological clock may be far more important to our wellbeing than previously believed, perhaps even extending to the question of electromagnetic hypersensitivity. Consider that the methods employed to find the connection between solar activity and illness focused solely on those at risk. In addition the correlations, in order to relate the medical problems to a single day, made practical use of cohorts who presented their illnesses in sudden fashion. Thus the associations that were established were only tested for illnesses that could be related to a single day, or at most, a few days of exposure. Myocardial infarctions are ideally suited for this approach, as are hospital admissions for sudden onsets.

But other medical problems do not manifest themselves in such discrete fashion. Consider how difficult it would be to determine whether the onset of cancer or its sudden worsening is connected to solar activity. In the course of such a disease which day could be chosen to see if it correlates with one that may be geomagnetically active? We can think of no reason to suggest that geomagnetic perturbations affect the enhancement of different diseases in different ways. We therefore conclude that solar-activated geomagnetic perturbations have the potential to increase the severity of all diseases, not merely those that have been successfully correlated. It may very well be the case that chronodisruption due to solar storms has a far greater effect on the expression of illness than currently believed.

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