Recorded Cases at the Emergency Department of the General Hospital of Lamia Town during the Year 2005 in Association with Helio-geomagnetic Activity.

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Abstract

Background: The terrestrial life owes its existence to the sun which is a source of electromagnetic radiation, light and heat. The adverse effects of eruptive solar phenomena on biosphere and especially on human health became of interest during the last twenty years (heliobiology), while their influences on terrestrial and space technological instrumentation is already well known. Although several studies over the world have been performed and possible mechanisms have been proposed; this issue remains under scrutiny.

Objective: We aimed to study the increase or not of the emergency cases arrival at the Emergency Department of the General Hospital at the city of Lamia during 2005, in order to examine the possible effects of geomagnetic storms on human health, physically and psychologically, resulting in possible increased demand of Health Services.

Method and material: The sample of our study included all patients of any age that attended the Medical and Surgical Sections of the Emergency Department at General Hospital of Lamia from 1/1/2005 to 31/12/2005. We used patients' records to collect data. Anonymity and confidentiality were always kept. There were 37.513 recorded cases. Data was encoded according to diagnosis and stored electronically. Microsoft Office Excel 2003 program was used. Data was then associated, according to time, with the geomagnetic index Dst; Dst is utilized to assess and depict geomagnetic storms evolution, the number of flares and CMEs (Coronal Mass Ejections) as well as solar wind parameters. All previous information was extracted from space observations after proper processing. Microsoft Office Excel 2003 and Origin 7 were also used.

Results: The helio-geomagnetic activity (non-photic effect) seems to affect human health since there was an increased number of cases that arrived at the Emergency Department of Lamia's General Hospital during periods of increased geomagnetic activity as well as intense flares. It appears that there is a time coincidence with the helio-geomagnetic activity. The influence is more evident on cardiological, oncological, neurological, orthopedical and, partially, on pathological cases. For these categories of patients, higher incidence was recorded generally on January (a month with extraordinary helio-geomagnetic activity), March (a month of maximum occurrence of flares in the last 12 years), May and August (months with strong geomagnetic storms).

Conclusions: The present conclusions add to the existing international literature, strengthening the estimated situation of the middle latitudes and especially Greece where little research has been conducted.
Implications for clinical practice: This study could contribute to adequate staffing as a prognostic index and play a role in the preparation of Health Services.

Key words: helio-geomagnetic activity, geomagnetic storms, solar activity, solar-terrestrial relations, health, cardiological cases, oncological cases, neurological cases, orthopedical cases.

I. Introduction

Space weather is the sum of all conditions in Sun, solar wind, magnetosphere, ionosphere and thermosphere that influence the work and credibility of space and terrestrial technological systems as well as may endanger human life and health (NOAA, Space weather Center). Space weather also influences biosphere. All sorts of this kind of influence on various biological and physiological systems are very important. The issue of solar phenomena during solar activity (non-photic effects) and their consequences on terrestrial magnetosphere phenomena that influence human health is under discussion over the last decades. Moreover, there is a new scientific branch called heliobiology that studies these phenomena. Large studies all over the world have suggested probable mechanisms through which a number of solar and geophysical parameters can influence human health.

During solar activity, which appears with sunspots increase, unforeseen intense solar eruptive events can be observed; flares and coronal mass ejections (CMEs) which set free enormous amounts of energy and mass (solar plasma). Those born waves, particles, especially of high energy (electrons and protons) and radiation from radio to X and Gamma rays arrive on Earth's magnetosphere and ionosphere through the solar wind. The solar wind is the continuous solar plasma flux into the interplanetary space (Kivelson, 1995). Serious disturbances in the magnetosphere (terrestrial magnetic field), the ionosphere (electric currents), the upper atmosphere and the atmospheric electric current are observed. These disturbances are called magnetic storms. The arrival time of these particles or electromagnetic radiation resulting from solar phenomena (flares and CMEs) (not necessarily at the same time), is about 8 min for radiation (X and gamma rays, radio bursts etc.), a few hours for cosmic rays and high energy particles and 2-3 days for CMEs (fast magnetic solar plasma).

When the terrestrial geomagnetic environment is disturbed, a direct or indirect influence on human physiology is normal to occur. A person is associated with the external environment (e.g. temperature) and is dependent of its fluctuations. However, the environment is not only about the atmosphere and the visual radiation. It also encompasses the electromagnetic field, the acoustic waves, the earthquakes etc. Not being able to see these events (e. g. the ultraviolet radiation) does not mean they don't exist. This is the case for the electromagnetic field.

The idea that these phenomena can have an influence on people was faced with skepticism at first. However, the last twenty years studies add up to the conclusion that the association between helio-geomagnetic disturbances (geomagnetic storms) and human health has true biophysical grounds. Among other studies (Palmer et al, 2006), researches in the middle latitudes similar to Greece, i.e. Israel (Stoupel et al, 1994), Italy, (Gavryuseva et al, 2002), Bulgaria, (Dimitrova, 2006), Mexico and Cuba (Mentoza et al, 2004), suggested such an influence.

The objective of this pilot study is to investigate the fluctuation of emergency arrivals at the Emergency Department of the General Hospital of Lamia during 2005 in order to assess any time association between geomagnetic storms and human health, physically and psychologically, resulting in increased demand of Health Services.

Ethical considerations: The authors obtained permission from the administration of the General Hospital of Lamia town. Data collection was based on patients' records. Anonymity and confidentiality were kept at all times.

Sample: Our sample included all recorded cases of any age, at the Emergency Department of General Hospital of Lamia town who attended Medical and Surgical Sections from 1/1/2005 to 31/12/2005.

2. Data selection and analysis

2.1. Data selection from the Emergency Department

At first, the selection of Emergency specialties was necessary since emergency cases of different diagnosis arrive in this Department every day. As a consequence, a triage according to diagnosis is made. The increased incidence of diseases was associated with seasonal variations (weather, climate), as well as with increased or not helio-geomagnetic activity (space weather).

Data was collected from the Emergency Department's registry (medical and surgical sections, table 1). Demographic characteristics (age and sex), arrival date and time, nursing details and diagnosis were recorded. The sample consisted of 21.872 and 15.641 cases from the Surgical and Medical section respectively.

Cases	Medical section	%	Surgical section	%
n	15641	42%	21872	58%
Male	7872	51%	11904	54%
Female	7769	49%	9969	46%
Adolescents				
<20 YEARS	1071	7%	4367	20%
Young adults				
20-40	3488	22%	6445	30%
Middle aged				
40-60	3457	22%	4664	21%
Older adults				
60-80	5580	36%	4839	22%
Overaged >80	1722	11%	1303	6%
Without age entry	323	2%	254	1%

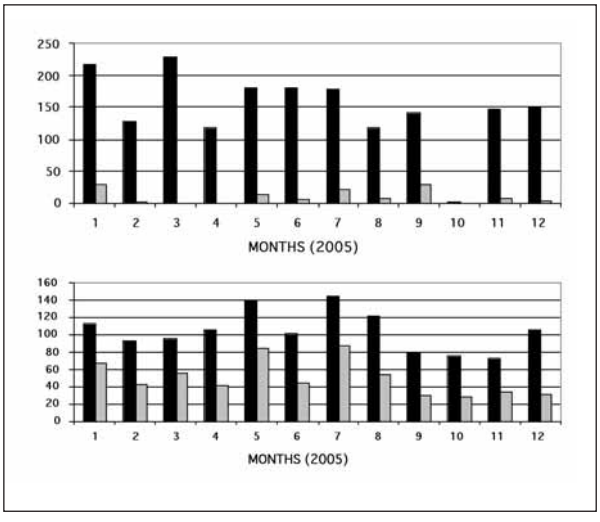

Table I: Recorded cases in two Emergency Department's sections at Lamia General Hospital, during 2005, according to section, gender and age.

Data collection was performed under a specific protocol for retrieving info from patients' records by using digital cameras, taking into account anonymity and confidentiality. Then, data was encoded and inserted in a PC for analysis. Microsoft Office Excel 2003 was employed. Results are presented in tables, graphs with monthly and daily distributions.
Figure I: Distribution of eruptive solar activity, flares and CMEs during 2005. Major flares and CMEs are presented in gray color.

2.2. Solar and Geomagnetic Activity during 2005

Solar activity is reported according to sunspots number observed on the solar disk and appears in almost eleven year cycles (solar cycle). The 23rd solar cycle started in 1996 with low sunspots number (solar minimum), peaked (high sunspots number) in 2000-2001 (solar maximum) and ended in 2007 with low sunspots number (solar minimum). Many and intense solar eruptive events (flares and CMEs) are generally observed during the solar maximum periods triggering geomagnetic storms. However, some extraordinary, intense solar eruptive events can be observed during solar minimum. During 2005 (solar minimum), this happened especially on January and it is the reason why we selected this particular year in our pilot study.

The monthly flares and CMEs numbers (eruptive events) are indicative of the extreme solar activity (Figure 1). From solar eruptive events, which are randomly emitted to interplanetary space, apart from electromagnetic radiation, high energy particles (mainly protons) called solar particle events (SEP) are also emitted, with usual energy levels >30 MeV per nucleon. Also, solar cosmic rays (energy of GeV) called Ground Level Events (GLE) arrive on Earth surface in extreme conditions. Only 69 GLEs are reported since 1942. The last two were observed on 17th and 20th of January 2005. Moreover, a high flare number (230!) was recorded on March 2005, which is way over solar maximum. On the contrary, the absence of flares characterized October 2005.

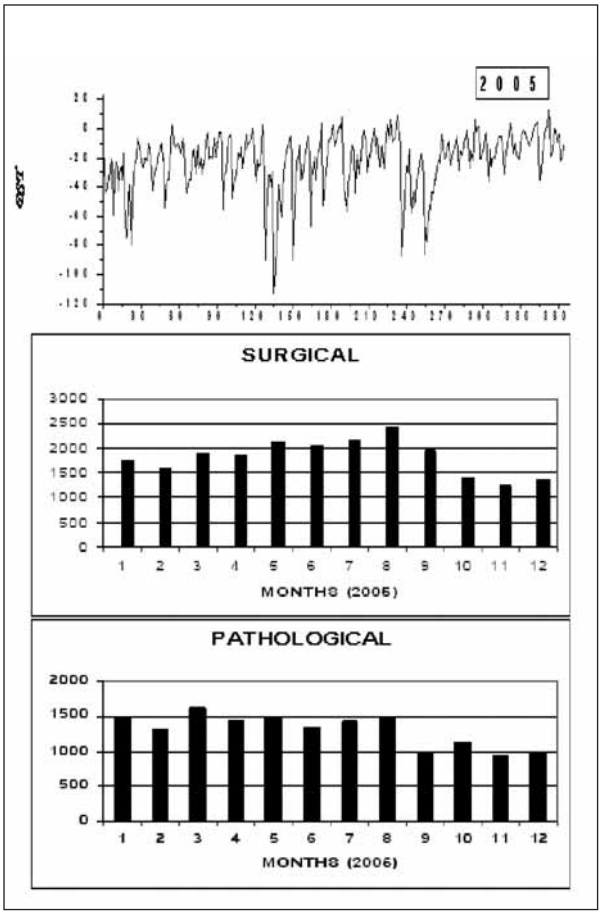

Figure 2
Upper graph: Dst geomagnetic index depicting the sequence of magnetic storms during 2005. Values under -40nT indicate magnetic storms, while, values under -100nT indicate very strong magnetic storms.
Middle-Lower graphs: volume of recorded cases by month at surgical (middle) and medical (lower) sections of E.D.

Finally, strong geomagnetic storms were recorded on May until September (the most intense on May and August) and a sequence of magnetic storms followed the solar extreme events on January (Figure 2, upper part). Absence of solar and geomagnetic activity was observed after September. We used Dst index, which is the world average value of equatorial geomagnetic field disturbance, to estimate and depict the evolution of geomagnetic storms. Values smaller than -40 nT present geomagnetic storms, while values smaller than -100 nT indicate intense geomagnetic storms. Thus, three periods with different helio-geomagnetic characteristics are observed (Figure 2):

1) January–April: On January, extreme solar activity with high flares number, 2 GLE- SEP (17-20th of January) as well a sequence of geomagnetic activity is observed. This activity decreases until April. However, on March the highest monthly flares number (230 flares) of the 23rd solar cycle 23 was recorded.

2) May-September: Strong geomagnetic storms which peaked on May, with a decreasing rate until July. A second sequence of strong geomagnetic storms followed on August-September.

3) October-December: Absence of geomagnetic storms. Also, on October (and only during that month) no flares were observed.

2.3. Data Analysis

Based on the above description, monthly and daily associations between emergency cases number and flares number, CMEs number, solar wind parameters and geomagnetic storms (Dst index), were examined. Data from the Emergency Department's registry was encoded and inserted in a PC. It was classified according to diagnosis. Tables, monthly and daily graphs are presented.

The increased or not helio-geomagnetic activity is expressed by the geomagnetic index Dst, number of flares, CMEs number and solar wind parameters (velocity, density, temperature and magnetic field). These data was obtained by space observations (GOES and SOHO satellites) and OMNI DATA BASE. Tables and graphs derived using appropriate calculations.

An association between spatial data and collected data from patients' records was attempted, taking into account seasonal factors.

3. Results

3.1. Monthly distribution of Emergency cases during 2005

Dst geomagnetic index and monthly recorded cases of Emergency Department (Medical and Surgical sections) for the year 2005 are presented in figure 2. There is an evident increase in cases on May until August; a period with strong geomagnetic storms. On the contrary, a reduction in cases was recorded after September which is the period of absence of helio-geomagnetic activity. Moreover, an increase of cases appeared on March; a month characterized by the maximum number of flares of the 23rd solar cycle. Especially in medical section, increased number of cases was reported on January, March, May and August.

In surgical section patient arrivals (58%) is higher than in medical section (42%) (table I). Also, there is an increased number of males in surgical section (54%) while there is almost no difference between genders at medical section. With regard to age, rates differ between the two sections. Thirty percent of surgical section's cases fall between the age of 20-40, while 36% of medical section's cases were between 60-80 years of age. Patients of 40-60 years of age visited both sections equally (21-22%). Patients under 20 visited mainly the surgical section, while, patients over 80 mainly visited the medical section. A monthly cases' analysis according to diagnosis follows.

3.1.1. Emergency cases and seasonal variations

Monthly distribution of cases for Medical and Surgical section according to diagnosis (pathological, gastrointestinal, otorhinola ryngological (ENT), pneumonological, dermatological and ophthalmological cases) is presented in Figures 3 and 4. Increased number of cases was recorded in spring and summer time.

Pathological cases: Increased number of cases appeared on March to August at medical section with three peaks appearing on January (extreme helio-geomagnetic activity), on March (solar flares maximum) and May (strongest geomagnetic storms) for patients at surgical section. In summary, increased number of cases was recorded in spring and summer time. However, there is a time coincidence between the number of recorded cases and helio-geomagnetic activity at surgical section.

Gastrointestinal cases: There was an increased number of cases at medical section on March, May and July, while the maximum number of cases appeared on January. For the surgical section, increased number of cases was recorded on May-September with maximum reached on July –August, March and January. This shows that increased number of cases was reported in spring and summer time as well as on January.

Pneumonological cases: In medical section, there was an increase from February to May with maximum on March. In surgical section, increased number of cases was reported on February to April with maximum on April, that is, increased number of cases was recorded in spring time.

ENT cases: There was an increase in medical section on January to April with maximum on March. In surgical section there was an increase from January to March and May to August, with maximum on August. There is a different distribution of cases between the recordings of two sections. In surgical section increased number of cases was reported in summer time while in medical section increased number of cases was reported in spring time as well as in winter.

Ophthalmological cases: A higher number of cases was reported in medical section on May and July-August, while, in surgical section on March, May-June and August-September, which means that that increased number of

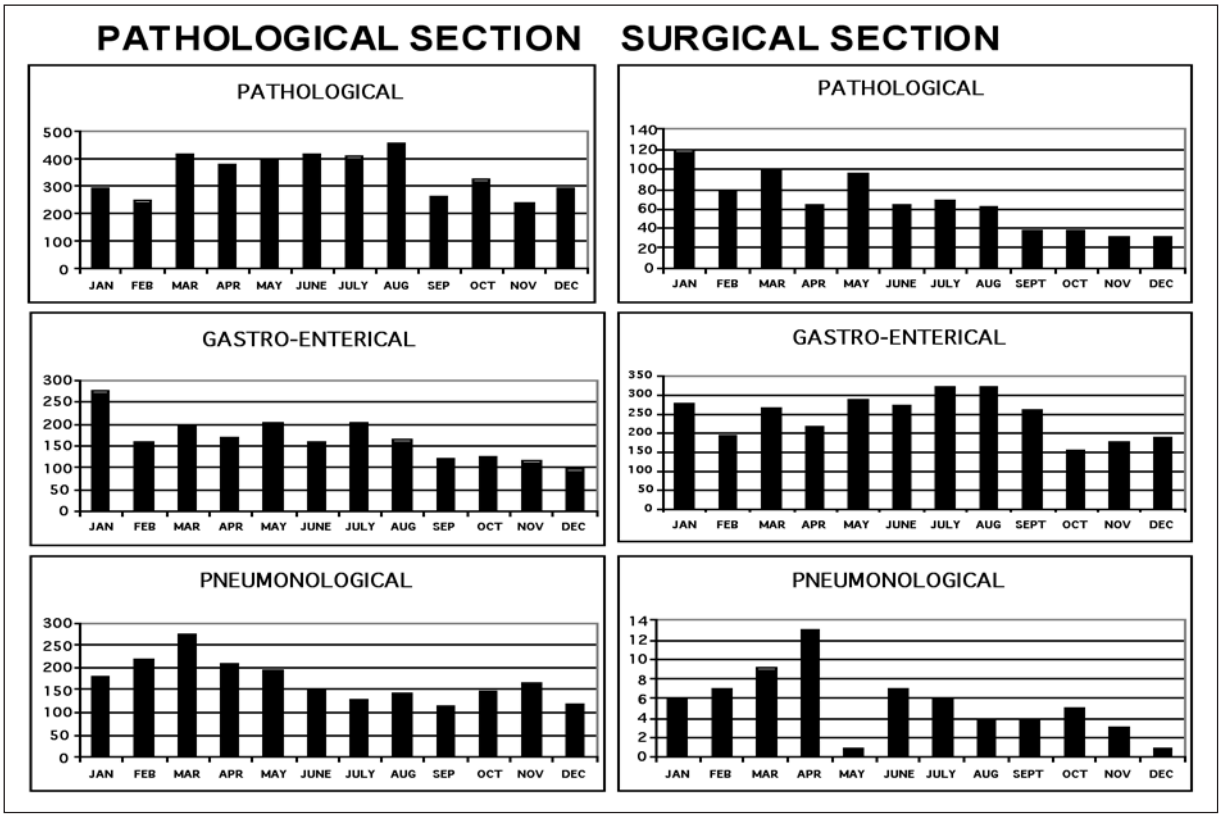

Figure 3: Monthly distribution of recorded cases at Lamia's General Hospital.

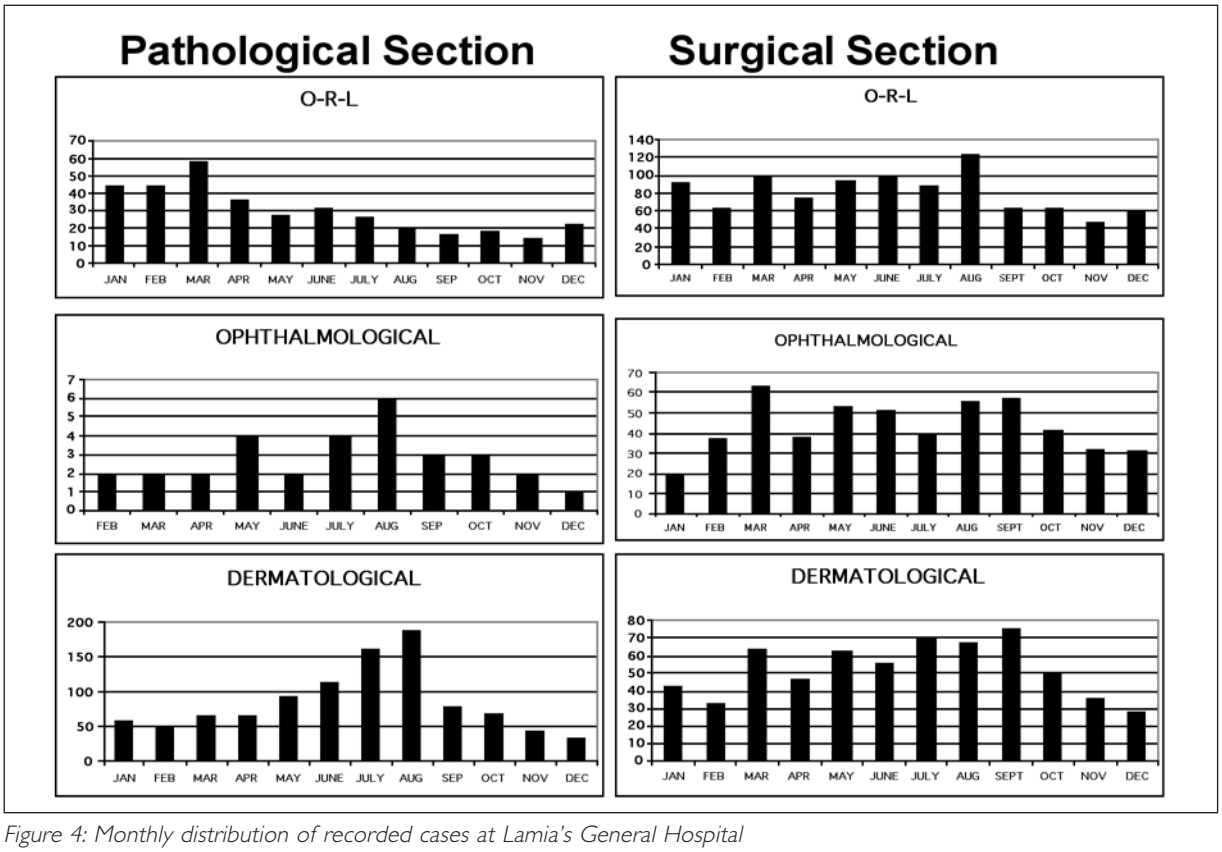

Figure 4: Monthly distribution of recorded cases at Lamia's General Hospital

cases was recorded in summer time and on March.

Dermatological cases: In medical section there were more cases on June, July and August with maximum on August. In surgical section there were more cases on March, May and July-September; that is, an increase appears in summer time and spring.

3.1.2. Emergency cases and space weather

The increased number of cardiological, oncological, neurological and orthopedical cases (Figures 5, 6 and 7) coincides with the three helio-geomagnetic periods.

Cardiological cases (Figure 5): In medical section there was an increased number of cases during the first months of the year (January- May) with a maximum on January (extreme helio-geomagnetic activity). In surgical section there were more cases on March (solar flares maximum) as well as on May and August (months with strong geomagnetic storms). Unfortunately, there is a lack of data on January in surgical section's recordings. A small increase in medical section's cases was also recorded on August.

Oncological cases (Figure 6): We noticed an increased number of cases in medical section from January to March with a maximum on March (solar flares maximum). Also, evident peaks appeared on May and August (months with strong geomagnetic storms). Cases decreased after September, a period which is characterized by absence of helio-geomagnetic activity. A similar distribution appears in surgical section's cases. Increased number of cases is reported from April to September (with peaks on May, July and September), a period characterized by geomagnetic storms. A decrease of cases appeared after September (absence of geomagnetic storms).

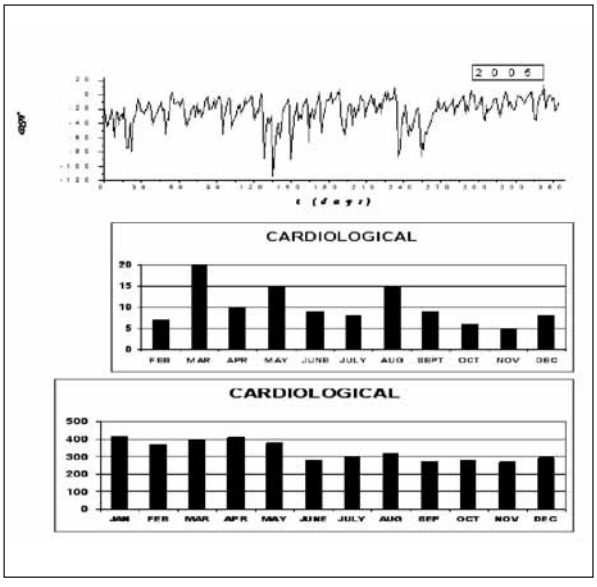

Figure 5: Monthly distribution of cardiological cases in surgical (middle) and medical (lower) sections. Dst geomagnetic index appears on top.

Orthopedical cases (Figure 6): Increased cases were reported on January-February (extreme solar activity) in medical section, while, in surgical section there was an increase

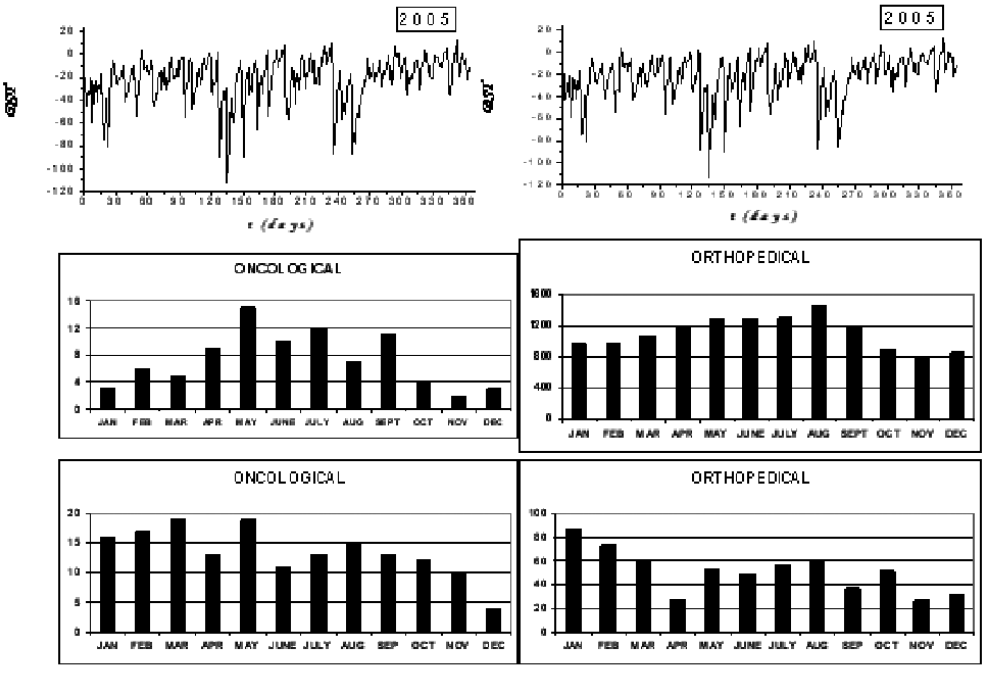

Figure 6: Monthly distribution of oncological and orthopedical patients in surgical (middle) and medical (lower) section. Dst geomagnetic index appears on top.

from April to September with a peak on August (strong geomagnetic storms). There is a difference between medical and surgical cases' distribution, although there is also an increase of cases in medical section in August. Notably, there was a decrease in cases after September. The small increase in medical section on October may be the result of increased traffic accidents (autumn rains). However, there is a difference (Medical section) in distribution during winter months. There is a peak on January-February and a minimum on November-December. Winter months account for more traffic accidents caused by bad weather conditions. Also, more people travel during Christmas Holidays and near Lamia town there is a dangerous road section where many accidents occur. We note that there is an increase of cases on January (after Christmas Holidays) while a decrease of cases is reported on December (before Christmas Holidays). Keep in mind that there was an absence of geomagnetic storms after September.

Neurological cases (Figure 7): There was an increase of patients in medical section from April to August (a period with geomagnetic storms). A decrease of cases appeared after September except a small increase on December. Similar decrease was also recorded after September in the surgical section cases. It is not unusual to have more neurological cases near Holidays (Christmas Holidays and Easter Holidays). Indeed, there was a small increase on December and January as well as on March-April (Easter date 1/5/2005). Also, there was an increase in surgical section cases reported on May and August (strong geomagnetic storms) as well as on February (a few days after the period of extreme solar activity). Moreover, increase of psychiatric cases was recorded on February, following the extreme solar activity of January. Considering that battering cases may be associated with neurological system in conjunction with the fact that there was a great number of such recorded cases, battering was examined separately. Increase of cases was also reported on May and August-September, months with strong geomagnetic storms.

3.2. January 2005: Emergency cases distribution on daily base.

We examined in detail this month because of the extreme helio-geomagnetic activity with rare characteristics (Figure 8): a sequence of geomagnetic storms (especially after 15 January), high number of solar flares (with peak of 34 flares /day at 12-15th of January) and two GLE, a rare event (paragraph 2.2) during three days (17 and 20th of January). We focused on cardiological, oncological, neurological and orthopedical cases as well as in pathological cases since, according to the above, there appears to be a time coincidence between increased number of cases of these categories and helio-geomagnetic activity.

Pathological cases (Figure 8): An increase of cases after Christmas Holidays is expected. However, the increase of January 12 coincides with solar activity increase (solar flares

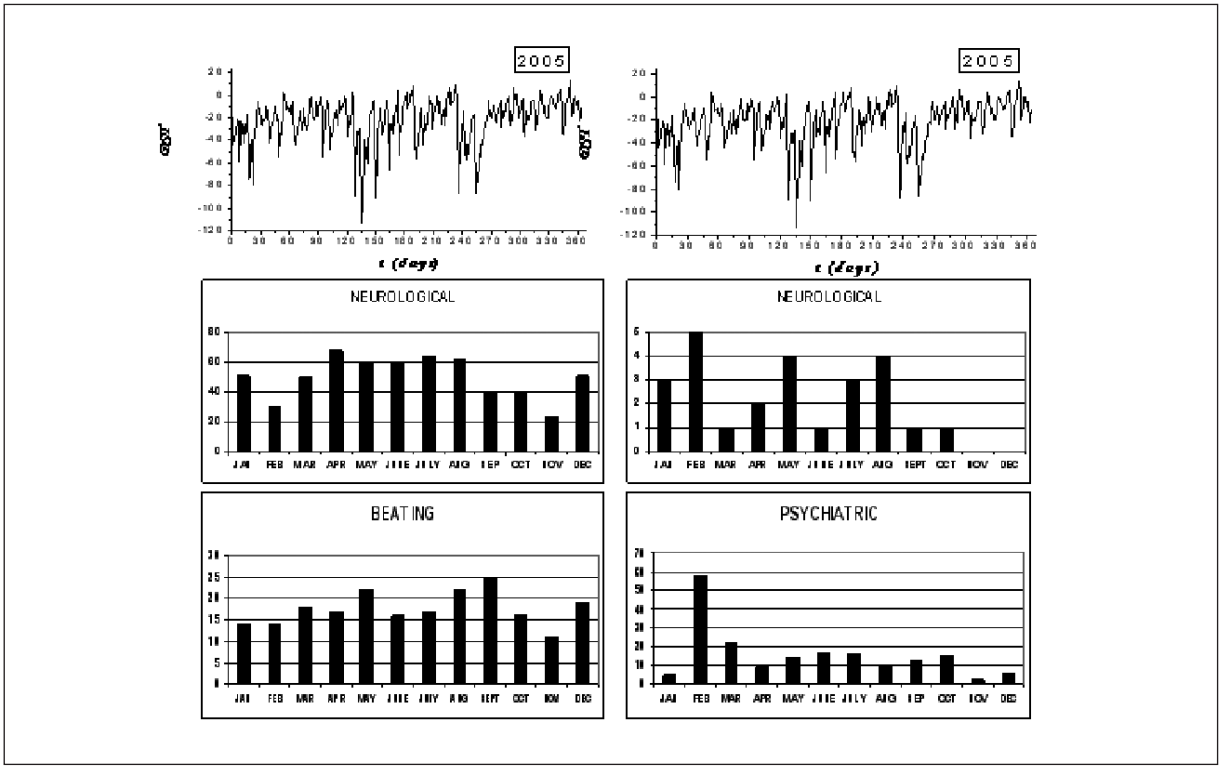

Figure 7: Monthly distribution of neurological cases in surgical (middle right) and medical section (middle left), psychiatric cases (lower right) and battering incidents (lower left). Dst geomagnetic index appears on top.

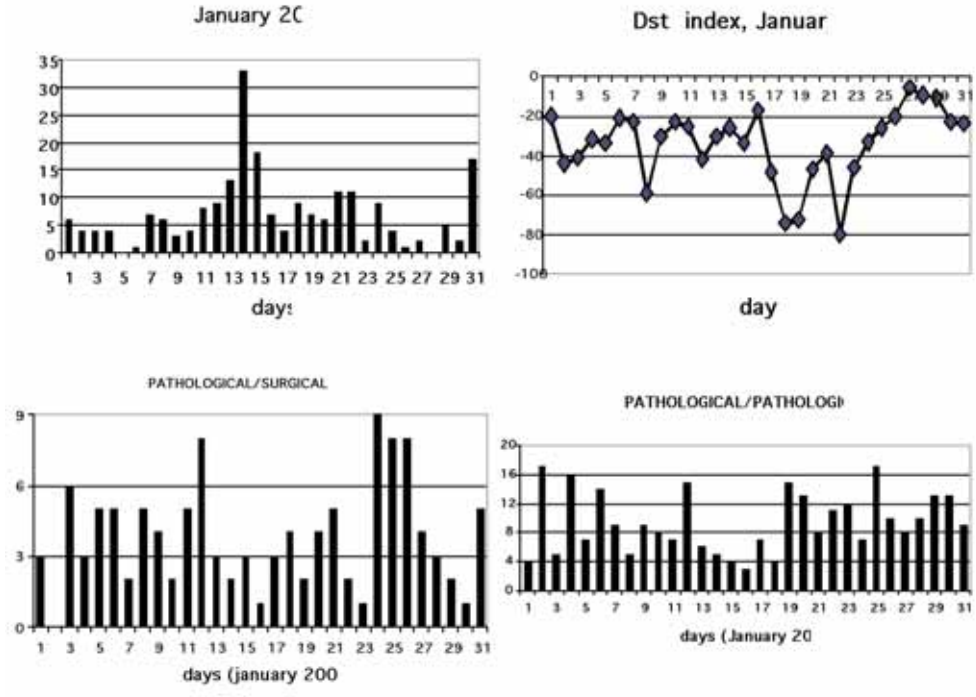

Figure 8: Daily distribution of solar flares (upper left), Dst index (upper right). Recorded cases of pathological cases in medical (lower left) and surgical (lower right) sections at the Emergency Department of Lamia's General Hospital.

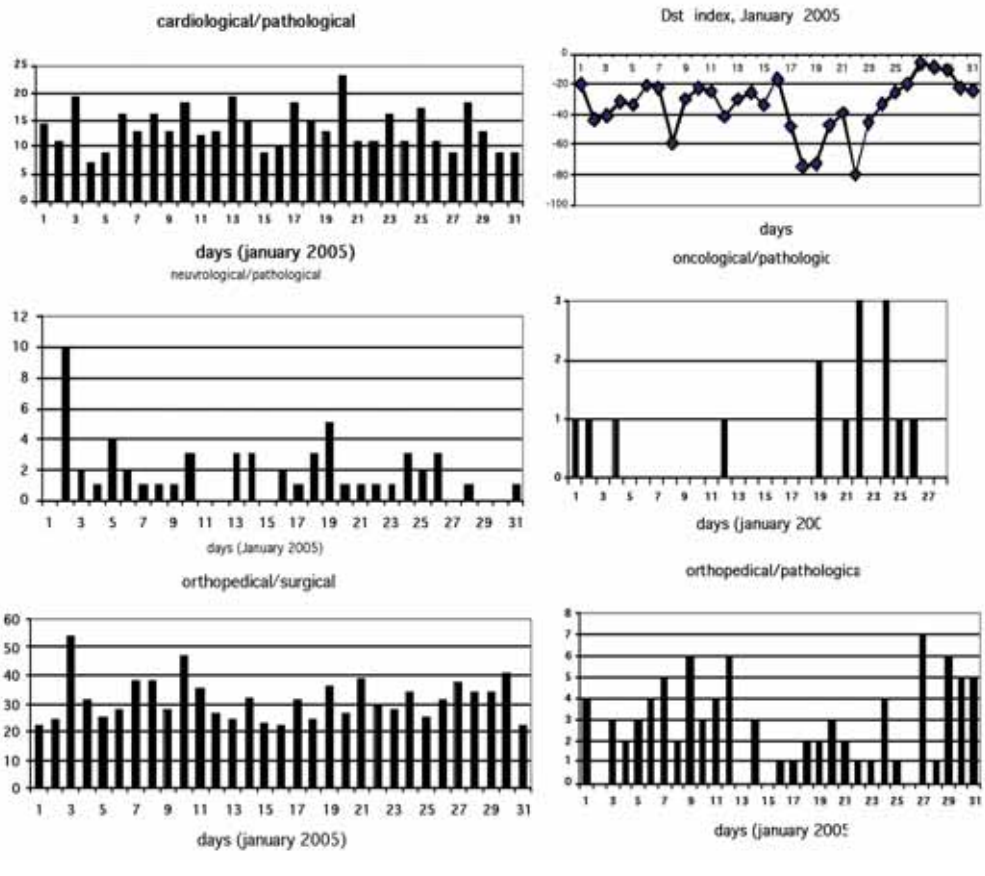

Figure 9: Daily distribution of cases at E.D. in January. Dst index appears on top right.

increase). Moreover, the significant increase of cases appeared after the 19th (Medical Section) and 24th (Surgical Section) of January, during the sequence of geomagnetic storms. Notably, the majority of cases in surgical section during 2005 was recorded on January.

Orthopedical cases (Figure 9): Although we observed an increase of patients in surgical section during this month, in medical section there are two periods of increased volume of patients; after Christmas Holidays (until January 12) and the last days of the month (after January 27). The later coincides with the recovery phase of geomagnetic storms.

Cardiological cases (Figure 9): Notably, the major increase in cases all over the year 2005 was recorded on January and the day with the highest number of arrivals all over the year 2005 that was recorded in medical section, is the 20th of January. The rare GLEs and the strongest one over the last 20 years was recorded on the 20th of January too. Unfortunately, data from surgical section is missing for this period of time.

Oncological cases (Figure 9): Medical section's recordings include only 16 cases. However, 11 of them were recorded after January 19. Surgical section's recordings include only three cases on the 7, 18 and 21st of January. The increased number of cases coincide with the period of extreme helio-geomagnetic activity (15 to 28th of January) and the major increase in cases was recorded during the period of two GLEs (17 and 20th of January) or a few days later (1-4 days).

Neurological cases (Figure 9): There was an increase in medical section on the 2nd of January (Christmas Holidays), while another small increase was noted on the 19th of January. Surgical Section recordings include only three cases on the 13th, 21st and 22nd of January. However, these dates coincide with the solar flares increase date as well as the dates of helio-geomagnetic activity; especially with the GLEs dates. We note that there is an increase in surgical section in the following month of February (Figure 7). Moreover, a major increase of psychiatric cases (Figure 7) is recorded on February after January's extreme helio-geomagnetic activity.

4. Conclusions

In this pilot study we examined the association between the monthly distribution of emergency cases according to diagnosis with the helio-geomagnetic factors (space weather). Medical data that covered year 2005 was obtained from the Emergency Department of the General Hospital of Lamia town. We conclude that the helio-geomagnetic activity (non-photic effects) seems to influence human health as we observed an increase of emergency cases during the periods of geomagnetic storms as well as most of and during intense solar flares. There is a time coincidence between the increase of emergency cases and the helio-geomagnetic activity.

This influence is more clear in the cardiological, oncological, neurological and orthopedical cases and partially in pathological cases. Generally, the major increase of these cases is recorded on January (extreme solar activity (GLEs) along with a sequence of geomagnetic storms), March (highest number of solar flares in the last 12 years), May and August (months with strong geomagnetic activity). On the contrary, increase of pneumolological, otorhinolaryngological, gastrointestinal, ophthalmological and dermatological recordings appear in spring and summer time (seasonal variations, weather effects).

Especially for January of 2005, we examined the daily distribution of the various categories of emergency cases. Two intense GLEs (17th and 20th of January) were observed on January, apart from the sequence of geomagnetic storms (extreme helio-geomagnetic activity). January's 20 GLEs are characterized as the most intense of the last twenty years.

The extreme helio-geomagnetic activity (15th to 28th of January) coincide in time coincident with the increase in emergency cardiological cases. Most of them (in monthly values) are recorded on January. The day with the highest number of cardiological cases is the 20th of January (simultaneous GLEs). Also, increase of emergency oncological and neurological cases (small number of cases) is reported 1-4 days after the 20th of January. The pathological cases of both Sections and the orthopedical cases of surgical section, increase after January 19th and during the last days of the month, a period with a sequence of geomagnetic storms and especially in their recovery phase.

5. Discussion

Our conclusions add to the existing international literature providing useful information about the situation in the middle latitudes countries and especially Greece where very little work has been done on this subject so far (Petropoulos et al., 2006& 2007). An increased arrival of patients with cariac problems in the Emergency Department has been demonstrated by our findings. This is supported by the study of Breus et al (1989), where there had been a significant number of ambulance calls in Moscow during a three years period of increased solar activity (1979-1981) and found a positive correlation between myocardial infarction (M.I) and geomagnetic activity. Cornelissen et al (2002), claim that the incidence of mortality due to M.I increases in Minnesota, U.S.A, by 5% during years of maximal solar activity compared with years of minimum activity. Chermouss et al (2001), came to the same conclusions and they also noticed that sympathetic responders have a higher adaptive ability to changes in the geophysical environment. Stoupel et al (1995), in a study which took place at Tel Aviv university hospital, Israel over a period of 180 months, supported that there is a positive correlation between solar activity and death from myocardial infarction.

Our study also indicated an increase of neurological cases arriving at the hospital from April to August which was the period of geomagnetic storms. From the daily analysis of the neurological cases during January, there was a significant

increase on days of solar magnetic activity and flares. The above finding is in agreement with the results of a study by Palmer et al (2006) according to which, 75% of geomagnetic storms is followed by an increase of 50% in hospital arrivals with cardiac and neurological problems (M.I., cardiological episodes, suicides)

In addition, in our study we found that increased hospital arrival of patients with orthopedical problems has been apparent during months with strong geomagnetic activity. Stoupel et al. (1995) presented evidence that accidents increase during periods of increased geomagnetic activity. Dorman et al., (2001) in their study in Moscow confirm the possible connection of space weather changes and train and car accidents.

In our study we also observed increase in mental cases on February after a solar storm. The above finding is in agreement with the results of the study by Kay (1994) which showed a statistically significant increase in male hospital admissions in the U.K., with a diagnosis of mental illness in the second week following a solar storm. Partonen et al (2004), claim that periods of time with predicted maximum risk of suicide coincide with those of maximum geomagnetic disturbance: spring and autumn. This is caused by the seasonal change of Earth's magnetic field. Halberg et al (2005) show that suicides in Minnesota also exhibit a similar bi-modal distribution.

Our study could be used as a predictive index for calculating Emergency Department's personnel needs and as an additional factor in order to take all necessary measures (more nursing personnel, pharmacy, material and equipment, reception areas, etc).

Nursing considers people as bio-psycho-social entities. Sun and helio-geomagnetic activity influence these aspects. Nursing is also interested in those factors as well as any other factor that influences directly or indirectly human health. National accumulation of data from all Greek hospitals and the construction of an electronic data base could be accomplished with the participation of nursing personnel in order to study the problem of non-photic effects in human health more carefully.

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