Bratisl Lek Listy 2010; 111 (9)
489 – 492

CLINICAL STUDY

Time course of nontyphoid salmonellosis in Slovakia 1957–2008

Mikulecky M Jr [1], Mikulecky M Sr[2]

Department of Infectology and Geographic Medicine, School of Medicine, Comenius University, Bratislava, Slovakia. **statistics@nel.edu**

Abstract: *Aim:* To test in time salmonellosis data the hypothesis respecting the Moon gravity.
Methods: Daily numbers of admissions at Clinic of Infectology 2005–2006 were processed on significance level α=0.05, after finding out their non-Poisson distribution, by cosinor regression in relation to the cycle new moon – full moon – new moon, lasting in average 29.53 days. In yearly incidence of this disease in Slovakia 1957–2008, presence of 18.6-year periodicity, connected with nutation of Moon axis, was tested.
Results: In agreement with our results 20 years ago, statistically significant 14.76-day rhythm was revealed,with pronounced swings downwards and upwards near full and new moon again. It is matching the cycling of lunar gravity. In the yearly data, statistically significant 18.6-yearly period, roughly reciprocal against the lunisolar gravitation, is apparent. It has been confirmed by cross-linear regression.
Conclusions: This study may testify to a causal relationship between the gravity and the occurrence of salmonellosis. The 18.6-years´ cycling could explain the allegedly global phenomenon – steep decrease of incidence since about 2000. Nevertheless, it succeeds to an equally long and steep increase since 1990, corresponding so far to the found periodicity without proving a supposed new trend.The next years will decide whether the decrease will continue in the sense of this trend towards eradication of this disease or repeated increase will occur in the frame of continuing periodicity. Our findings are indirectly supported by the laboratory documentation of increased virulence of Salmonella in microgravity, published from NASA laboratories 10 years ago. Its practical exploitation for protecting the health of crew of cosmic flights is expected *(Fig. 4, Ref. 15)*. Full Text in free PDF *www.bmj.sk.*
Key words: nontyphoid salmonellosis, time occurrence, lunisolar gravitation, trends, periods.

At early nineties of the last century, papers were published by ourselves and coauthors (1–4) documenting in nontyphoid salmonellosis but also in diarrheal infections of other etiology certain parallelism of their occurrence with the phases of synodic lunar cycle – from the new moon over full moon back to the next new moon. A marked swing – tending downwards but immediately followed by a sudden and steep upwards direction - in the daily numbers of cases was unequivocally observed around the full and usually also new moon, i.e. at the maximal lunisolar gravitation in all studied samples (5). The first purpose of the present contribution is therefore to repeat this analysis on the new sample of daily numbers of cases from 2005-2006. Moreover, the assumption of a nonrandom time sequence of the daily numbers will be examined.

The second part of the present contribution was stimulated by sudden and pronounced decrease of the incidence of salmonellosis, observed since the late nineties worldwide and interpreted (6; p.519, right column, paragraph 3) as "…reversal of trend**…**after three to four decades of constant increase in the incidence of NTS worldwide" . Nevertheless, the previous increase was not constant – it displayed waving (6; p.514) (Fig. 1). Again, the Moon gravitation will be related to the Slovak salmonellosis data 1957–2008.

Bibliographic analysis of the subject (Ovid MEDLINER[R]) revealed that since the year 1950 till October 2009 there are registered 65 208 papers about Salmonella or salmonellosis and 6862 under key words "moon or lunar or lunisolar or planet" but a conjunction of both has been found only in one article (4). Analogically, there was 11 680 titles published till November 2008 about gravitation with 12 covering also the Salmonella or salmonellosis topics. One of these contributions (7) will be discussed in the present article.

[1] Department of Infectology and Geographic Medicine, School of Medicine, Comenius University, Bratislava, Slovakia, and [2]Department of Statistics and Biometry, Neuroendocrinology Letters, Stockholm – Bratislava, Sweden – Slovakia and BioCos, University of Minnesota, Minneapolis MN, USA

Address for correspondence: M. Mikulecky, MD, PhD, KIGM, Teaching Hospital Kramáre, Limbova 5, SK-833 05 Bratislava, Slovakia.
Phone: +421.2.64780666

Acknowledgements: Our thanks are due to Prof. RNDr. Dipl. Ing. Ľubomír Kubáček, DrSc., Director Emeritus, Mathematical Institute of Slovak Academy of Sciences, and to Prof. RNDr. Jozef Komorník, DrSc., Dean Emeritus, Faculty of Management,Comenius University, for the support in mathematical-statistical methodology cultivated 1981-89 at the former Biometry Unit of the Ist Medical Clinic, Faculty of Medicine, Comenius University, furthermore to RNDr. Eduard Pittich, DrSc.,Astronomical Institute of Slovak Academy of Sciences, to RNDr. Jaroslav Střeštík, CSc., Geophysical Institute, Academy of Sciences of Czech Republic, Prague, for their help in the astronomical and geophysical aspects, to MUDr. Erika Macháčová, CSc., Faculty of Medicine, Comenius University for the access to the salmonellosis data bases, as well as to Dipl. Ing. Irina Fialková, National Center for Health Information of Slovak Republic, for the valuable bibliographic work.

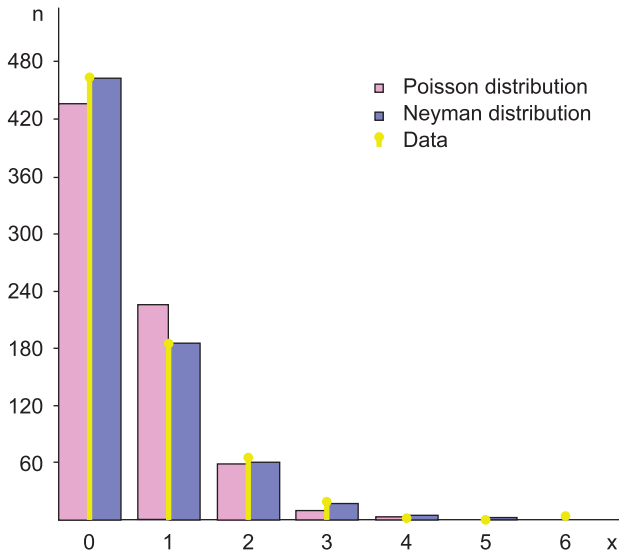

Fig. 1. Numbers (X, horizontal axis) of admissions for salmonellosis per one day plotted versus numbers (n, vertical axis, dots) of the corresponding days occurring during the 730 days of observation in 2005–6. Left columns show the nonsatisfactory approximation of n by Poisson distribution (rejected with p=0.001 due to visible overdispersion), right columns an appropriate one by Neyman distribution with m=8 (nonrejected with p=0.457).

Methods

Daily numbers of the hospital admission for salmonellosis at the Clinic of Infectology and Geographic Medicine in Bratislava between January 1, 2005 and December 31, 2006 (n=377 patients, in the year 2005 there were 205 and the next year 172, with 54 % and 48 % of children, respectively) were at first subjected to testing on randomness of their sequence with the aid of the Poisson, negative binomial and Neyman distributions (8, 9). The hypothesis of randomness was rejected (Fig. 1), a continuing statistical examination is therefore justified.

The daily numbers of admissions were related to the days of synodic lunar cycle, standardized on 30 days since its idealized 0th to 29th day. At the same time, theoretically calculated daily averages of the lunisolar gravitation (10–12) were plotted against the lunar cycle. The data are presented as plexogram of the synodic lunar cycle: the time is repeatedly returning from the day 29 of one cycle back to the start of the next cycle, i.e.to the day 0. Altogether, more than 24 synodic lunar cycles are comprised in the plexogram. To remove disturbing short fluctuations, the resulting numbers of salmonellosis cases for each day of this idealized lunar cycle were transformed by moving averages, from three successive values each.The number of degrees of freedom was therefore divided by three.

The yearly incidence of this disease in Slovakia 1957–2008 was taken from (13). Yearly averages of the lunisolar gravity were calculated again according to (10–12).

Using Halberg´s cosinor regression (14), the presence of the period length of synodic lunar cycle (29.53 days) and its 2nd to 6th harmonics (the period lengths of 14.76, 9.84, 7.38, 5.91 and 4.92 days) was tested for either plexogram, for the salmonellosis at the three times reduced degrees of freedom, equal to 5. Only the presence of the 18.6 years´ period of Moon nutation (10, 11) was tested by cosinor regression in either yearly time series. In salmonellosis, also presence of a linear trend was tested.

Moreover, the relationship between lunisolar gravitation and salmonellosis´ yearly data was analyzed by cross- "correlation" (15), in fact linear cross-regression expressed with the aid of the coefficient of common correlation. The values of correlation coefficient for separate lags are plotted versus corresponding successive time lags between both variables – gravity and salmonellosis – in either direction. If there is a periodicity with the same period length in either time series, then will the mentioned function of the correlation coefficient be cycling again with the

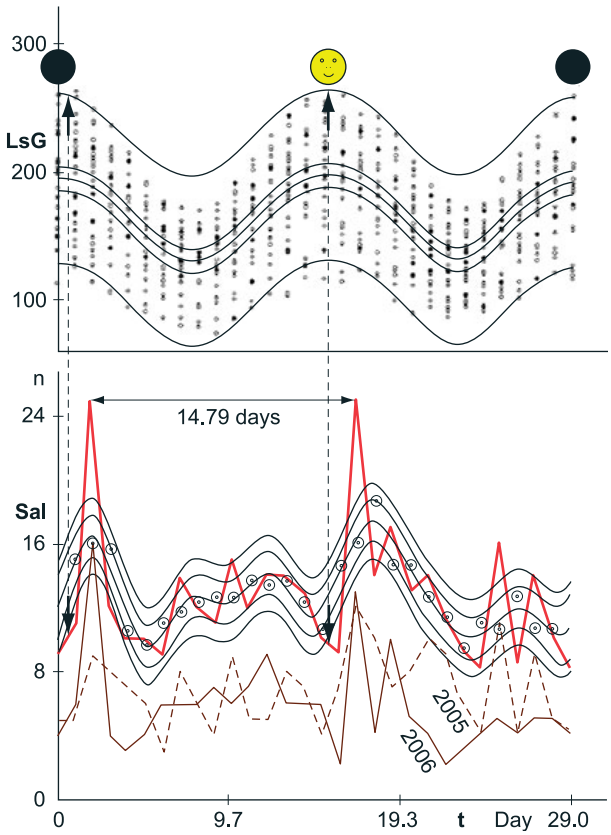

Fig. 2 a, b.Top. Lunisolar gravity readings (LsG, microGal; the data by courtesy of RNDr. Jaroslav Střeštík, CSc.) from all complete synodic lunar cycles within the years 2005–6, plotted versus time of one idealized synodic lunar cycle (t, days), as approximated by the period of synodic lunar cycle (29.53 days) and its harmonics up to the 6th. The narrower corridor corresponds to 95 % confidence, the wider one to 95 % tolerance.
Bottom. Synodic lunar plexogram of the daily numbers of hospital admissions (sum for 2005 and 2006 by heavy broken straigth lines, for either year separately by light broken straight lines, the resulting moving averages by open dots). The confidence and tolerance corridors analogical as in the top Figure.

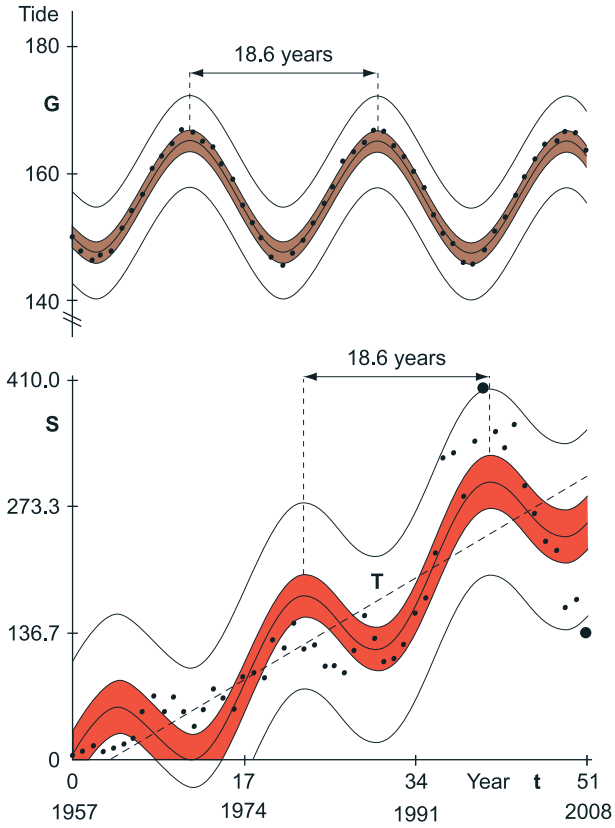

Fig. 3 a, b.Top. Secular (1957–2008) cycling of theoretically calculated lunisolar gravity (G, microGal, light dots; data by courtesy of RNDr. Jaroslav Střeštík, CSc.) approximated by the period of 18.6 years and shown with the corridors of 95 % confidence (narrower) and 95 % tolerance.
Bottom. Analogy for yearly incidence of salmonellosis in Slovak Republic during the same time span. The linearly increasing trend (T) is shown as dashed straight line. Two tolerance outliers by heavy dots.

same period length. The resulting cycling of the correlation coefficient between gravity and salmonellosis will be finally evaluated by cosinor regression.

The level of statistical significance was set in all cases at α=0.05. In other words, the p values equal as or lower than 0.05 will be considered statistically significant.

Results

The cycling of the gravity and of the admissions during synodic lunar cycle is shown in Figure 2 a, b. For the gravity, only the semilunar rhythm is significant, with 33 % of the explained variance, while for salmonellosis the statistical significance relates to all 6 harmonics (90 % of the variance explained), with the dominance of the second one – the fortnight period. The most spectacular phenomenon are the two extreme down and up swings of the daily numbers of cases under the full and partly also new moon.

The yearly epidemiologic data from the whole Slovakia 1975–2008 are shown together with lunisolar gravitation (Fig. 3 a, b). The approximate reciprocal synchrony of both variables´ time series is obvious. For salmonellosis, a significantly ($p<0.001$) increasing trend was identified (+6.45 cases per year; 95 % confidence limits +5.53 and 7.37 cases) besides the significant ($p<0.001$) period of 18.6 years (amplitude is 55.65 cases; 95 % confidence includes values between 36.52 and 74.77 cases). There have been 78 % of the variance for gravity and 81 % for salmonellosis explained by the regression.

Discussion

The similarity of the behaviour of salmonellosis and other diarrheal infections during synodic lunar cycle two decades ago in Bratislava and Košice on one side and now in Bratislava on the other hand is striking. The most conspicuous phenomenon – the sudden depression followed immediately by high elevation under full and partly under new moon is similar as it has been in the past plexograms. These phenomena are now based altogether on 1427 cases registered during 10 years in Košice and 3 years in Bratislava, i.e.including almost 161 synodic lunar cycles. Accordingly, there can be little doubt about synodic lunar cycling of hospital admissions for salmonella and other acute diarrheal infections.

Surprisingly, a similarity in cycling of both variables – lunisolar gravitation and Slovakian salmonellosis incidence – seems to exist also for the period of 18.6 years which emerged from the cross-correlation calculation (Fig. 4). It is connected with nutation of the Moon (10, 11).

The time of peaking in gravity is associated roughly with the trough in salmonellosis secular data. This reciprocity might be conditioned by a reciprocity between gravitation and virulence of Salmonella. In the search for potential changes in microbial virulence associated wih spaceflight, an increased virulence of Salmonella enterica serovar Typhimurium was found in experi-

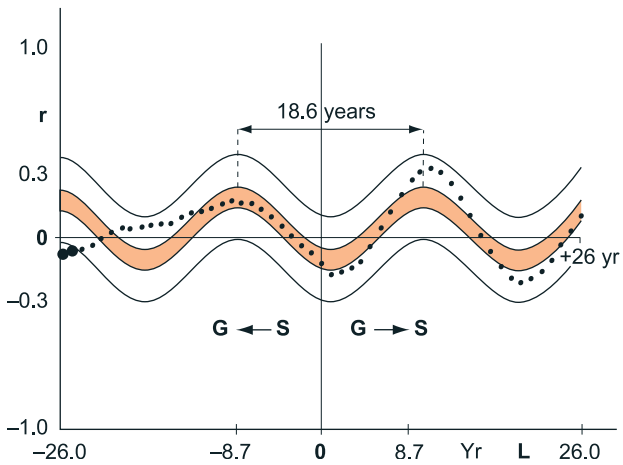

Fig. 4. The coefficient of correlation (r, vertical axis, light dots; two tolerance outliers by heavy dots) between lunisolar gravity (G) and Salmonellosis´ yearly incidence (S) as a function of the time lag (L, days), revealing significant ($p<0.001$) periodicity with the period length of 18.6 years.

mentally modeled microgravity (7; p. 3147, Abstract). It is suggested that the modeled microgravity belongs to "novel regulators of gene expression" (7; p.3151,left column).

We realize that incomplete three cycles do not convincingly document an existence of a permanent secular rhythmicity. Nevertheless, similar pattern was found so far also in Israel (6) and in Czech Republic (unpublished observation), thus increasing the number of the observed cycles to approximately eight.

Our "moon nutation" model offers for the sudden decrease, registered in the last decade worldwide, an explanation, which is principally different from the concept of a "reversal of trend" (6) by unknown causes: it could be understood as a descending arm of the last large wave which could be followed by new increase so that the linearly increasing trend, recognized so far by ourselves, would be upheld. Next 3–5 years should decide this dilemma: will the marked decrease be continuing as a new falling trend towards eradication of salmonellosis, or it will be replaced by repeated increase starting a new wave around the continuing old increasing trend?

References

1. Mikulecký M Jr, Ondrejka P. Acute diarrheal infectious disease and lunar cycle. 28–30. In: Marková E (Ed). Man in his terrestrial and cosmic environment. Proceedings. Úpice 1991.

2. Mikulecký M Jr, Ondrejka P. Moon cycle and acute diarrheal infections in Bratislava 1989. J Interdisc Cycle Res 1991; 22: 157–158.

3. Mikulecký M Jr, Ondrejka P. Moon cycle and acute diarrheal infections in Bratislava 1988–2000. 356–360. In: Gutenbrunner Ch, Hildebrandt G, Moog R (Eds). Chronobiology and Chronomedicine. Frankfurt – Berlin – Bern – New York – Paris – Wien: P. Lang, 1993.

4. Mikulecký M Sr, Schréter I. Incidence of acute infectious diarrhoeas during the lunar phases. Čas Lék Čes 1993; 132: 498–501.

5. Mikulecký M. Statistics with confidence and tolerance. EuroRehab 2001; 11: 42–51.

6. Weinberger M, Keller N. Recent trends in the epidemiology of nontyphoid Salmonella and antimicrobial resistance: the Israeli experience and worldwide review. Curr Opin Infect Dis 2005; 18: 513–521.

7. Nickerson CA, Ott CM, Mister SJ, Morrow BJ, Burns-Keliher L, Person DL. Microgravity as a novel environmental signal affecting Salmonella enterica serovar Typhimurium virulence. Infection Immunity 2000; 68: 3147–3152.

8. Weber E. Grundriss der biologischen Statistik. 127–156. VEB Gustav Fischer Verlag Jena 1967. 6. Auflage. 674 pp.

9. Neyman J. On a new class of "contagious" distributions, applicable in entomology and bacteriology. Ann Math Stat 1939; 10: 35–57.

10. Hill GW. Mr. G. W. Hill´s paper on the lunar theory. Monthly Notices of the Royal Astronomical Society 1884; 44: 194.

11. Brown EW. An introductory treatise on the lunar theory. Cambridge: Cambridge University Press, 1896.

12. Longman M. Formulas for computing the tidal acceleration due to the Moon and the Sun. J Geophys Res 1959; 64: 2351–2355.

13. Anonymous. Analysis of the epidemiologic situation in Slovak Republic. Regional Institute of Public Health. Banská Bystrica, Slovakia 2008.

14. Bingham Ch, Arbogast B, Cornélissen GG, Lee JK, Halberg F. Inferential statistical methods for estimating and comparing cosinor parameters. Chronobiologia 1982; 9: 397–439.

15. Bartlett MS. An introduction to stochastic processes with special reference to methods and applications. Cambridge: Cambridge University Press, 1953.

Received October 19, 2009.
Accepted June 26, 2010.