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Geographically selective assortment of cycles in pandemics: meta-analysis of data collected by Chizhevsky

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SUMMARY

In the incidence patterns of cholera, diphtheria and croup during the past when they were of epidemic proportions, we document a set of cycles (periods), one of which was reported and discussed by A. L. Chizhevsky in the same data with emphasis on the mirroring in human disease of the ~11-year sunspot cycle. The data in this study are based on Chizhevsky's book *The Terrestrial Echo of Solar Storms* and on records from the World Health Organization. For meta-analysis, we used the extended linear and nonlinear cosinor. We found a geographically selective assortment of various cycles characterizing the epidemiology of infections, which is the documented novel topic of this paper, complementing the earlier finding in the 21st century or shortly before, of a geographically selective assortment of cycles characterizing human sudden cardiac death. Solar effects, if any, interact with geophysical processes in contributing to this assortment.

Key words: Analysis of data, cholera, diphtheria, epidemics, outbreaks.

INTRODUCTION

A look into the history of chronobiology, the science of the study of biological rhythms, cannot ignore the pioneering work of Alexander Leonidovich Chizhevsky [1–3], who investigated the influence of the rhythms of solar activity on mass manifestations in human life: epidemics, wars, riots and other phenomena.

In particular, Chizhevsky analysed data on cholera and diphtheria in detail. Analyses of his data are not only very interesting from a historical point of view, as a reconsideration of periods found, but they remain relevant today. Despite impressive advances in the field of immunology, cholera has not disappeared from the face of the earth. According to the World Health Organization, an estimated 3·5 million cases of cholera and 100 000–120 000 cholera deaths are reported annually. Periodic outbreaks of cholera are reported in India [4–9], Africa [6–11] and Latin America [12–15].

Chizhevsky rightly pointed out that the disease has never disappeared from the face of the earth [3, p. 117], and what was true in his day holds good today. *Vibrio cholerae* is a natural inhabitant of estuarine environments in countries where cholera is epidemic or non-epidemic [16]. Of course, in regions of Asia, Africa, and South America, where public sanitation is poor, the disease is still endemic or epidemic. Vaccination is recommended for people living in those areas [17]. Complete protection against cholera, however, seems unlikely according to recent

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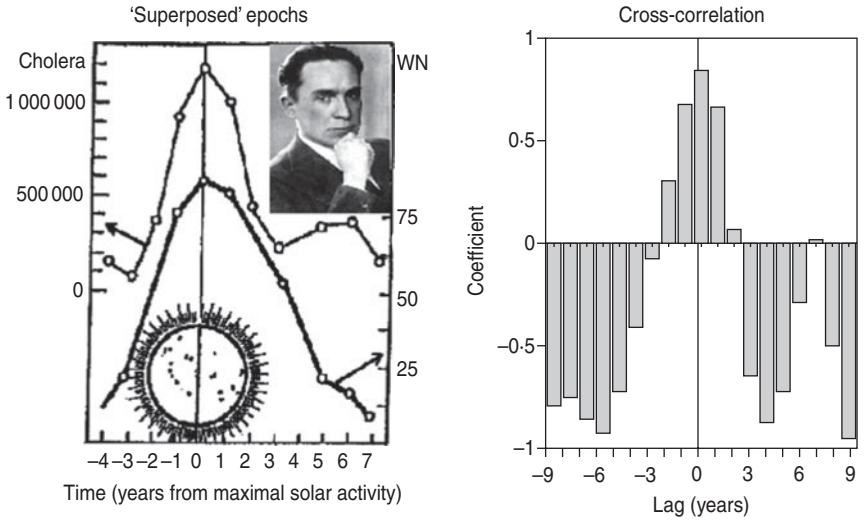

Fig. 1. Graph of A. L. Chizhevsky on cases of cholera recorded in Moscow between 1823 and 1923, published by Sigel [23]. In this graph, the original data are folded over the ~11-year solar activity cycle. The data show a peak incidence coinciding with maximal solar activity (left panel). Taking these folded data off the published graph, an analysis by cross-correlation of cholera incidence *vs*. Wolf numbers (WN) yields the largest correlation coefficient at a lag of zero (right) [33]. (© Halberg.)

research by epidemiologists, since, as in the case of influenza, the genome of cholera bacteria changes during certain cycles, perhaps in keeping also with a documented bacterial coperiodism [18]. Much as in the case of influenza viruses, cholera bacteria undergo a 'shift/drift cycle' over time, although the drift in *V. cholerae* is derived mainly from lateral gene transfer, most likely occurring in the natural environment in association with its plankton hosts [19, 20]. Thus, the issue of cholera pandemics returns to the issue of cycling. Chizhevsky, in his work, pointed out the connection between cycles of cholera outbreaks and outbreaks of solar activity. Indeed, among factors causing mutation, ionizing radiation from the sun is the most potent natural source [21].

Against this background, we meta-analysed Chizhevsky's summary first [22] and then turned from the graph we used for cross-correlation [23] (Fig. 1), to his actual tabulations. Modern inferential statistical methods are used [24–27], as is information obtained on other biospheric time series. However, an addition and subtraction, if not a remove and/or replace approach [28, 29], which is essential to examine causal relations, remains to be implemented at the periods detected.

MATERIALS AND METHODS

We used the original statistical data from Chizhevsky's book [3] and official reports of the World Health Organization [5–9, 14] about cholera and diphtheria in Russia and in several European countries (Prussia, Switzerland, Scotland, England, Ireland, Denmark, Sweden) and in India during the span from 1823 to 1953 (details in Table 1). A combination of linear and nonlinear cosinor methods [24–27] served for temporally global analyses (of a time series as a whole). Plexograms, complemented by analyses of variance of the stacked data visualized signals detected by cosinor spectra [25–27].

RESULTS

Cholera in India

In considering cholera in Asia, Chizhevsky devoted considerable attention to this disease in India, tracing its history back to 1031 A.D., and noting that the first description of cholera was by Hindu writers. The description of all pandemics of cholera by Chizhevsky begins with India, but the digital statistical material presented in the book covers the span only from 1901 to 1924. We found similar statistics in the annual and consolidated reports of the WHO for the same span in a series continued up to 1961 (Fig. 2).

The above span allows a check of Chizhevsky's forecast of outbreaks of cholera:

> With regard to cholera, then, generally speaking, the latter is disappearing in countries with a high state of public sanitation and hygiene. Therefore, it is difficult to expect large epidemics in the countries of Europe or North America. From 1937–1939, 1948–1950, 1959–1960 and so on, however, an epidemic or local amplifications of cholera

Table 1. *Geographical differences in cycles with periods, τ values, in the range of 5–32 years* [*note τ values of ~17 years characterizing the incidence of infectious diseases* (*cholera, diphtheria, croup*]

Site	Span	Period, τ (years) (95% CI)	Amplitude (95% CI) (in thousands of cases)	A (percentage of MESOR)	*P* value†
		Cholera			
India	1901–1961*	11·668 (10·44–12·895)	70·016 (4·08; 135·95)	31	<0·05
Russia	1823–1926*	20·71 (18·55–22·88)	104·79 (5·69–203·89)	95	<0·001
		8·9 (8·36–9·54)	78·21 (28·2–128·23)	71	<0·05
		5·62 (5·45–5·79)	98·28 (0·74–197·3)	89	<0·005
		Diphteria			
Kherson province (Russia)	1874–1908*	19·38 (14·53–24·22)	31·93 (9·71–54·15)	46	<0·005
Kherson county (Russia)	1874–1908*	16·996 (13·83–20·16)	12·54 (3·42–21·67)	36	<0·001
Elizavetgrad county (Russia)	1874–1908*	20·53 (17·23–25·05)	27·74 (9·92–45·56)	65	<0·005
Denmark	1860–1910	31·78 (25·80–37·76)	43·91 (19·35–68·46)	66	<0·001
		11·99 (10·89–13·09)	35·77 (12·18–59·36)	54	<0·001
Switzerland	1876–1910*	16·98 (12·76–21·2)	13·04 (0·04–26·04)	36	<0·001
		12·01 (9·80–14·21)	8·52 (0·22–16·81)	23	<0·001
Scotland	1860–1910*	24·0 (23·29–24·73)	26·02 (20·13–31·9)	67	<0·001
		12·05 (11·71–12·43)	9·08 (0·46–17·69)	24	<0·001
Belgium	1870–1910*	20·6 (17·04–24·16)	8·02 (3·36–12·69)	14	<0·001
		8·25 (7·46–9·05)	5·55 (0·75–10·34)	10	<0·001
Holland	1875–1910*	27·63 (21·14–39·5)	10·21 (3·67–16·75)	38	<0·001
		9·41 (7·89–10·94)	6·46 (−0·9064 to 13·8223) (1·8598–11·0561) [1p]	26	<0·05
England and Wales	1860–1910	29·37 (23·15–35·59)	8·89 (4·06–13·73)	29	<0·001
		17·46 (14·66–20·26)	7·04 (1·32–12·76)	23	0·001
		12·58 (10·53–14·64)	5·10 (0·00–11·37)	17	<0·05
Ireland	1864–1910*	12·93 (11·37–15·11)	2·49 (−0·098 to 5·077) (0·865–4·114) [1p]	10	<0·05
Romania	1886–1910*	16·73 (12·66–20·80)	9·65 (2·86–16·45)	49	<0·001
Austria	1880–1910*	18·76 (15·52–20·0)	16·77 (7·22–26·33)	17	<0·001
Italy	1887–1910*	15·16 (12·63–18·4)	10·21 (1·74–18·69)	30	<0·001
Sweden	1861–1910	17·71 (15·45–19·98)	22·00 (8·72–35·28)	42	<0·001
		Relapsing fever			
Moscow	1883–1918	10·83 (9·67–12·43)	2·93 (0·56–5·3)	117 (overfit)	<0·001

CI, Confidence interval (conservative); when CI of amplitude overlaps zero, one-parameter [1p] limits are also listed.
* Linear trend removed.
† From zero-amplitude (no rhythm) test.

in the East can be expected. During these years, we should expect a sharp increase in the number of deaths from cholera in those of its foci, where it has or will occur, compared with all the intermediate years [3, p. 233].

In fact an outbreak of cholera occurred in India in 1938, with a particularly high number of deaths from cholera in 1943. Further outbreaks were reported in 1948, 1953 and 1957 (Fig. 2). Chizhevsky accurately predicted outbreaks of cholera in 1938 and 1948.

Spectral analysis revealed linearly a number of components with periods of ~30·5, ~19·4 and ~11·7 years (Fig. 3). However, the subsequent processing of these components by nonlinear least squares validated with statistical significance only the ~11·7-year period (τ), and then only after removing a linear trend. Estimates of the parameters are as follows: $\tau = 11{\cdot}67$ years, 95% confidence interval (CI) 10·64–13·11 years, amplitude $70{\cdot}02 \pm 20{\cdot}7$ (in thousands of cases), $P = 0{\cdot}024$ from one-way ANOVA after stacking data according to this period by plexogram (Fig. 4).

The nonlinearly validated cycle of ~11·7 years could correspond to the ~11-year periodicity in solar activity known as the Horrebow–Schwabe sunspot cycle. Note an additional ~19-year component and an ~35-year (paratridecadal) cycle known as the BEL cycle (after Brückner, Egeson and Lockyer). That the latter two could not be validated nonlinearly does not exclude their likely presence, notably since an ~35-year (BEL) cycle was also found for diphtheria and croup in Denmark.

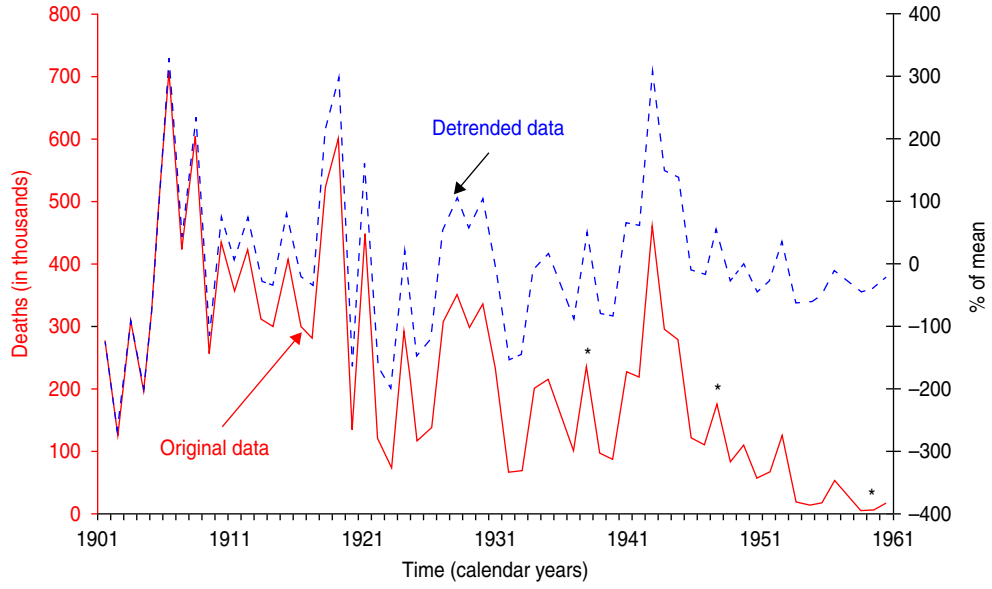

Fig. 2 [*colour online*]. Plot of yearly mortality data from cholera in India from 1901 to 1961, shown as original values (solid curve) and after removal of a linear trend (dashed curve). Data from Chizhevsky (1901–1924) and from WHO reports (1920–1961) during 1920–1924 are the same in both sources. * Prediction of outbreaks by Chizhevsky (two correct). (© Halberg.)

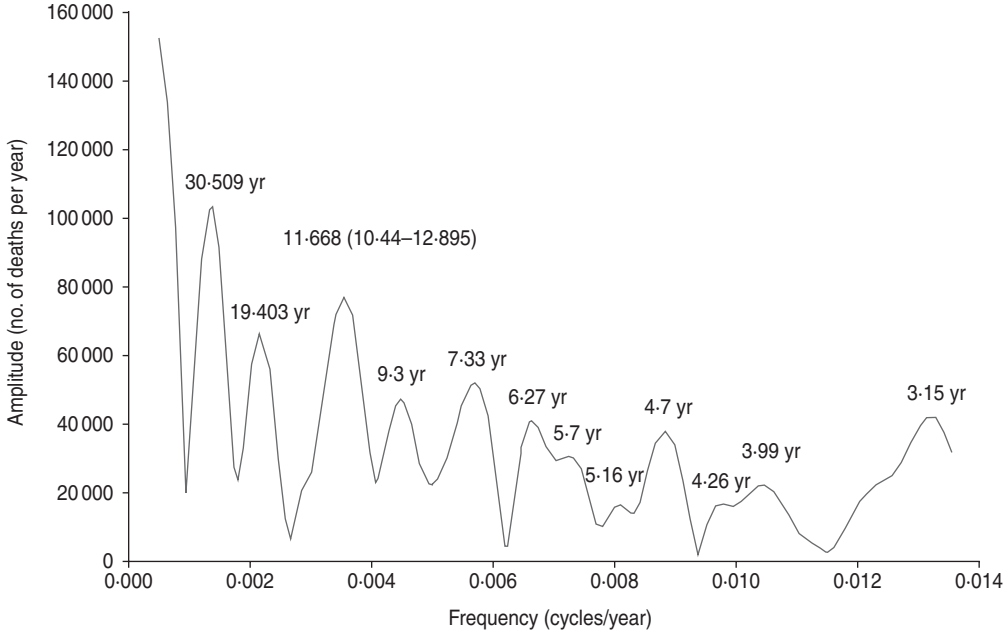

Fig. 3. Least squares spectrum of yearly detrended data on mortality from cholera in India during 1901–1961. The ~11·7-year cycle is detected with statistical significance and it is validated by nonlinear least squares, the period [and its confidence interval (CI)] being estimated as 11·668 (95% CI 10·44–12·895) years, similar to the ~11-year solar activity cycle, as suggested by Chizhevsky. (© Halberg.)

Cholera in Russia

Chizhevsky described the dynamics of cholera in Russia for a 100-year span: from 1823 to 1923, also indicating the number of sunspots, the Wolf numbers, during this span (Fig. 5). We were able to find data by Robert Pollitzer [5] on the European part of Russia in the records for the same span. Where these data overlap and can be checked, they are fully consistent with each other. Hence Pollitzer's data for 1925–1926 were added to Chizhevsky's data to obtain a series spanning 104 years. After 1926, we have no data of

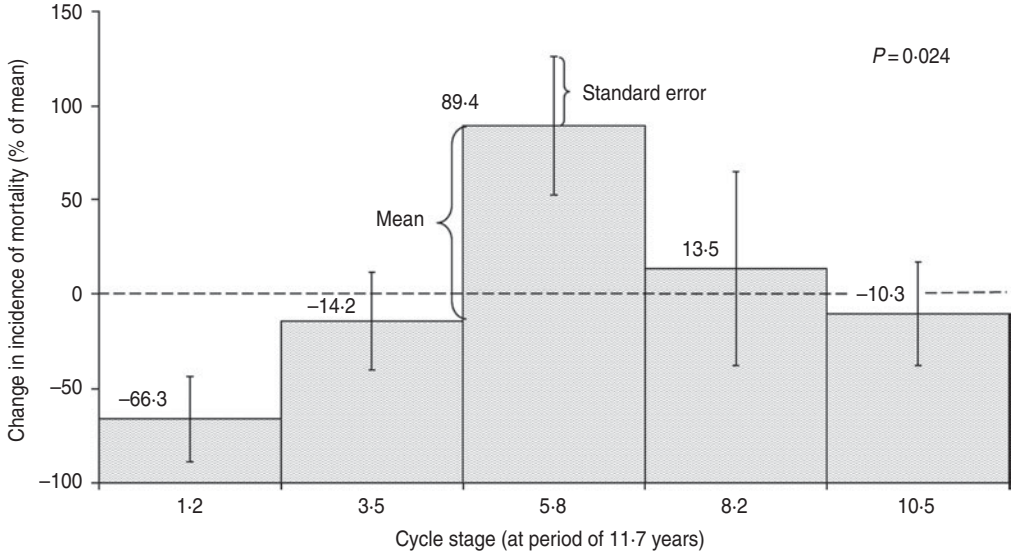

Fig. 4. In order to visualize the waveform of the ~11·7-year cycle characterizing mortality from cholera in India during 1901–1961, the yearly detrended data were stacked over an idealized 11·7-year scale (after removal of a linear trend), using five bins (classes). The ~11·7-year component was found to be statistically significant by one-way analysis of variance ($P = 0{\cdot}024$). Data from Chizhevsky (1901–1924) and from WHO reports (1920–1961) during 1920–1924 are the same in both sources. (© Halberg.)

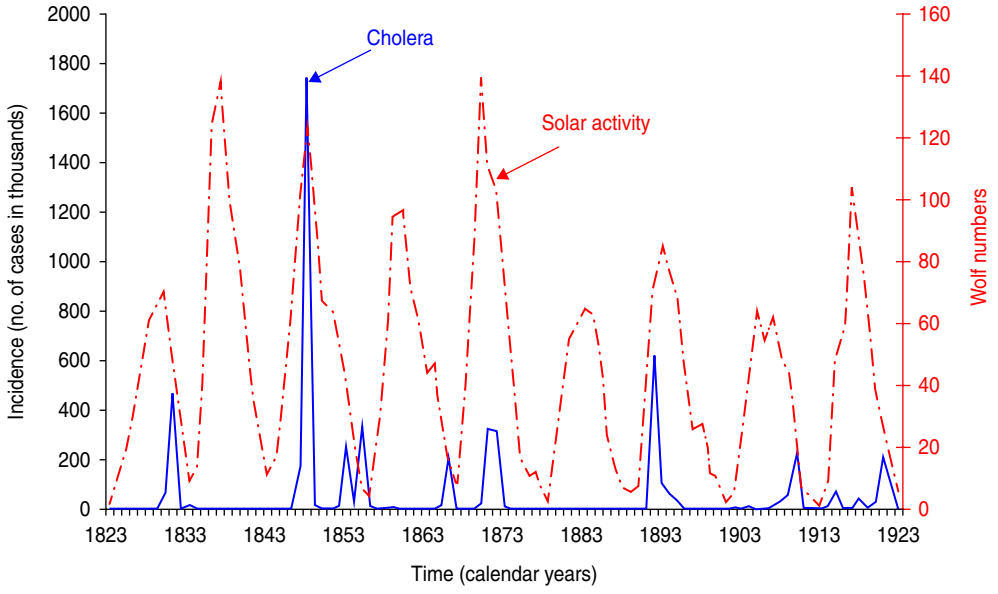

Fig. 5 [*colour online*]. Plot as a function of time of yearly data on mortality from cholera in Russia for 104 years (1823–1926) (solid curve), compared to changes in solar activity, gauged by Wolf numbers (dashed curve). Peaks in the incidence of cholera correspond to every other peak in solar activity, suggesting the presence of a ~22-year (Hale) cycle. Data from Chizhevsky [3]. (© Halberg.)

cholera in Russia available. Since the curve of incidence during epidemics covers a very large scale, from zero case in the good years to over 1 million deaths at the epidemic's peak, the data were transformed in order to reduce the extent of lack of fit by taking their square root prior to their linear-nonlinear analysis.

Figure 5 shows that the cholera outbreaks do not accompany each cycle of solar activity, and seem to correspond to each second peak of solar activity, with a period of ~22 years, the Hale sunspot bipolarity cycle [30]. By spectral analysis, the largest peak corresponds to an ~20·8-year period, with additional

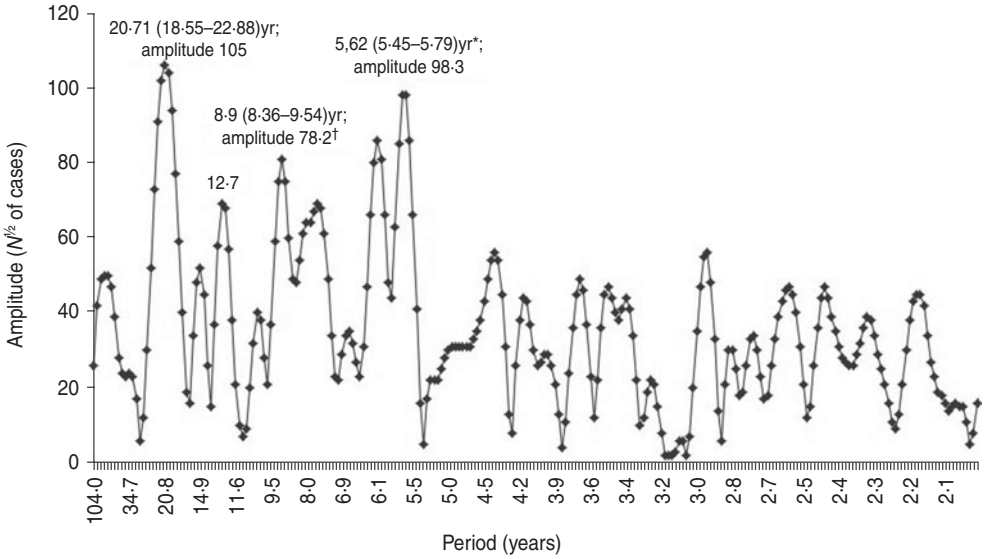

Fig. 6. Least squares spectrum of yearly data on mortality from cholera in Russia (1823–1926), revealing the presence of several peaks corresponding to components with periods of ~21, 9, and 5·6 years. Whereas the ~9-year cycle only reaches borderline statistical significance by nonlinear analysis, the other two components are validated with statistical significance. Period estimates and their CIs (given in parentheses) are listed above their respective spectral peaks. Nonlinear result and 95% confidence interval (CI); for 1823–1924, Chizhevsky's data [3] were used and compared with the data of Pollitzer [5] and added for 1924–1926. * Found for Chizhevsky originally by Vladimir Shostakovich. † Borderline significance (non-overlap of zero by CI of amplitude only with one-parameter CI). (© Halberg.)

components of gradually lesser prominence having periods of ~5·6, ~9·0 and ~12·7 years (Fig. 6).

Nonlinear analyses confirmed the statistical significance of these spectral components characterizing cholera in Russia. Figure 6 shows a cycle with a period of 20·71 (95% CI 18·55–22·88) years, with an amplitude of 104·8 (95% CI 5·7–203·9) and a MESOR (midline estimating statistic of rhythm) of 108 (95% CI 38–178). Chizhevsky noted that the period of 5·5 years was calculated by Vladimir Boleslavovich Shostakovich, a Russian geophysicist [3]. Chizhevsky considers this period as half an 11-year (Schwabe) cycle. According to our calculations, the period is of 5·6 years (95% CI 5·5–5·8) with an amplitude of 98·3 (95% CI 13–183). The 8·95-year (95% CI 8·36–9·54) cycle is detected with statistical significance: its amplitude is 78·2 (95% CI 28·2–128·2; one-parameter limits†, as the 'conservative' CI slightly overlaps zero). An 11-year cycle is not statistically significant in the dynamics of cholera in Russia during 1823–1926, even when using the already too liberal approach of Marquardt's one-parameter approach†.

Plexograms (Fig. 7*a–c*) and corresponding one-way ANOVAs confirmed the statistical significance of all three components ($P<0·05$) in the statistics of deaths from cholera in Russia during 1823–1826, respectively.

Diphtheria and croup

Chizhevsky also reported on other infectious diseases, notably diphtheria and croup. Here, we show the presence of several cycles that may correspond to the ~11-year (Horrebow–Schwabe), the ~22-year (Hale) and the ~35-year (BEL) cycles, among others. Such correspondence can only prompt a subtraction-addition approach [28, 29]. The use of special computer programs allows us to more accurately estimate the periods. A paradecadal cycle of 8·25–12·93 years was found in Denmark, Belgium, Switzerland, Scotland, England (and Wales) and Ireland, whereas in Austria, Italy, Romania and Sweden, the period length of the most prominent cycle was between 15 and 18·8 years (Table 1). In the dynamics of diphtheria

† Marquardt's algorithm [24] provides three measures of uncertainty of the period estimate and of the other parameters of the fitted model. One is an equivalent of the usual standard error and is called the 'one-parameter' approach. Another is called 'conservative' in the sense that the corresponding confidence intervals are slightly wider than the 'true' or 'nonlinear' 95% limits. The nonlinear limits, a third measure, are more complex, but generally do not differ much from the more easily derived 'conservative' approximation. In view of the non-stationarities of the biological data analysed, the approach called 'conservative' by Marquardt is actually too liberal and is used in the want of a more appropriate method that accounts for non-stationarities.

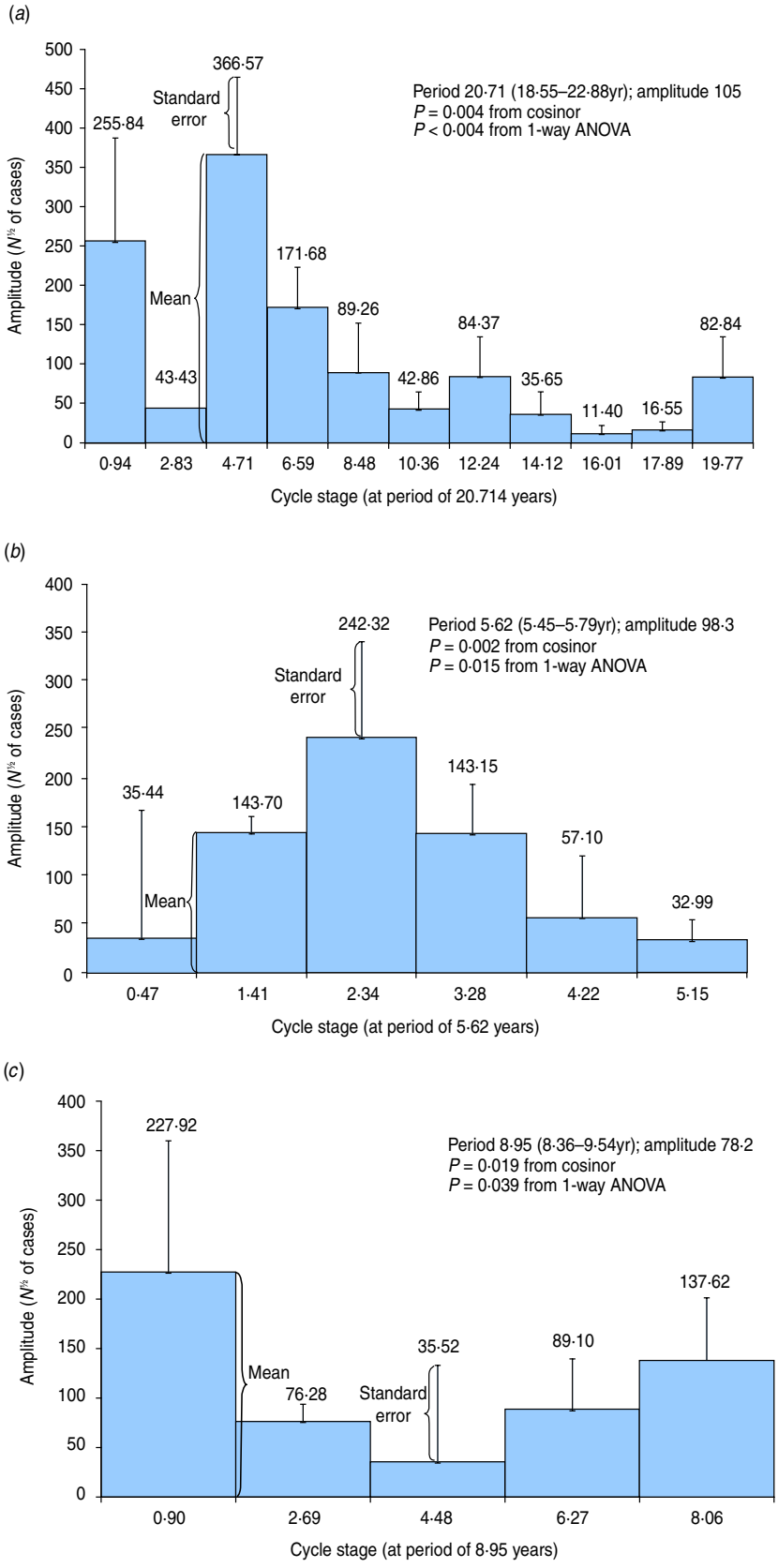

Fig. 7. For legend see next page.

in Kherson province (then South Russia, now Ukraine), statistically significant periodicities include a point estimate of 17 years, with others of 19·4 and 21 years, but with very wide overlapping CIs so that the periods cannot be separated. In Russia, only relapsing fever in Moscow had a prominent ~10-year period [Table 1 (bottom)], a detail qualifying even a genius like Chizhevsky. If not an 'echo' only to the sun, the biosphere and the noosphere it created are resonators to both the sun and the earth, among others, and the various environmental influences compete (wrangle) with one or the other dominating in different geographical regions at the same time.

DISCUSSION

In different countries, and even in neighbouring regions that were then part of Russia, point estimates of different periods are statistically significant for the cases of the infectious diseases examined here. The criteria to be considered, however, are the CIs that in the case of diphtheria in Russia are so wide as to fail to support any difference in period. CIs are indispensable, their limitations that call for their improvement notwithstanding, since judgements based only on point estimates ignore the stochastic nature of environmental and biological variables. Better CIs that also account for the aeolian nature of time structures in and around us remain to be developed. It seems possible that ruling congruence in or out by the conservative limits of Marquardt's algorithm [24] may not strictly apply, but in the want of better CIs, the latter offer a compromise with practicability. With this qualification, results of currently prevailing non-communicable diseases were presented earlier [22]. By the non-overlap of the CIs of the periods, the cycle lengths differ for the same disease, sudden cardiac death in different geographical regions (Table 2). Existing geographical differences among countries differing relatively little in latitude are thus noted for both communicable and non-communicable diseases. Geomagnetic, interplanetary and solar influences may all interact ('wrangle') differentially in different geographical locations. We cannot speculate without further study beyond Sir Edward Appleton:

> There are simple and fundamental reasons why collaborative effort is necessary in studying the influence of the sun's emanations on our own planet. First of all, the earth is round, and not flat. The result is that solar radiations do not impinge with equal effect on all regions of the earth's surface. The second reason is that the earth is constantly rotating; and, since interesting solar features may occur at any time, it is necessary to have observers at different terrestrial longitudes, in order that none of these interesting events may be missed. The third important fact is that the earth itself is a great magnet, and, because of this magnetic influence, electrified particles of solar origin are constrained to travel, not in straight lines, but along curved tracks. Sometimes the curvature of these tracks is so great that such charged particles impinge on the side of the earth's atmosphere which is further from the sun. In other words, we get solar effects at night. Moreover such effects occur with unequal intensity at different terrestrial latitudes because of the earth's magnetic qualities [31].

We can add, however, that in the language of frequencies, there are both similarities and differences among signatures of the solar wind's speed and of the antipodal index aa in the spectral region between 2 and 0·3 years (Table 3) [32, 33].

For the general reader, an annotated bibliography by John T. Burns [34] surveys alleged cosmic influence on influenza pandemics (p. 3), among other conditions such as Down syndrome (p. 2), suicide (p. 2), hip fractures (p. 3), myocardial infarctions (p. 5), poliomyelitis (p. 6), fetal growth (p. 7), births (p. 9) and affective disorders (p. 9). References to inferentially statistically assessed studies are also available in [33, 35].

Fig. 7 [*colour online*]. (*a*) In order to visualize the waveform of the ~20·7-year cycle characterizing mortality from cholera in Russia during 1823–1926, the yearly data were stacked over an idealized 20·714-year scale, using 11 bins (classes). This component is validated with statistical significance both by cosinor ($P=0·004$) and by one-way analysis of variance ($P<0·001$). This component corresponds to a spectral peak and is validated nonlinearly, based on the 'conservative' CI (see earlier footnote for explanation of conservative CI). (*b*) In order to visualize the waveform of the ~5·6-year cycle characterizing mortality from cholera in Russia during 1823–1926, the yearly data were stacked over an idealized 5·62-year scale, using six bins (classes). This component is validated with statistical significance both by cosinor ($P=0·002$) and by one-way analysis of variance ($P=0·015$). This component corresponds to a spectral peak and is validated nonlinearly, based on the 'conservative' CI (see earlier footnote for explanation of conservative CI). (*c*) In order to visualize the waveform of the ~9-year cycle characterizing mortality from cholera in Russia during 1823–1926, the yearly data were stacked over an idealized 8·95-year scale, using five bins (classes). This component is validated with statistical significance both by cosinor ($P=0·019$) and by one-way analysis of variance ($P=0·039$). This component only reached borderline statistical significance by nonlinear analysis. For 1823–1923 data from Chizhevsky [3] were compared with data from Pollitzer [5] and added for 1924–1926. (© Halberg.)

Table 2. *Geomagnetic/geographical differences among cycles with periods in the range of 0·8–2·0 years, characterizing the incidence of myocardial infarction (MI) and sudden cardiac death**†*

Site	Span	T, $\triangle t$, N	MI (N)	Period (years) (95% CI)	Amplitude (95% CI)	A (percentage of MESOR)	P value‡
MI: dominating calendar year and near- and far-transyear							
Czech Republic	1999–2003	5y, 1d, 1826	52 598	1·014 (0·989–1·038)	2·85 (2·22–3·48)	9·88	<0·001
				1·354 (TY) (1·252–1·456)	1·35 (0·69–2·02)	4·68	<0·001
	1994–2003	10y, 1d, 3652	115 520	0·998 (0·988–1·009)	3·03 (2·47–3·60)	9·58	<0·001
				1·453 (TY) (1·417–1·489)	1·91 (1·34–2·49)	6·04	<0·001
				1·15 (TY) (1·116–1·184)	1·23 (0·64–1·82)	3·88	<0·001
Site	Span	T, $\triangle t$, N	SCD (N)	Period (years) (95% CI)	Amplitude (95% CI)	A (percentage of MESOR)	P value‡
Sudden cardiac death (SCD)†							
Only calendar-year component; candidate transyear not detected							
North Carolina	1999–2003	5y, 1d, 1826	752	0·929 (0·834–1·023)	0·069 (0·00–0·14)	16·9	0·007
Tbilisi, Georgia	Nov. 1999–2003	4·1y, 1d, 1505	130	0·988 (0·862–1·114)	0·035 (0·00–0·07)	40·7	0·007
Hong Kong	2001–2003	3y, 1 m, 36	52	0·843 (0·651–1·036)	n.s.	44·9	0·077
Transyear (TY) or candidate transyear (cTY) component							
Minnesota	1999–2003	5y, 1d, 1826	343	1·392 (TY) (1·173–1·611)	0·042 (0·00–0·09)	22·0	0·014
Tokyo, Japan	1998–2005	8y, 1 m, 96	221	1·391 (TY) (1·250–1·533)	0·430 (0–0·860)	42·9	0·009
Coexisting calendar-year and far-transyear							
Arkansas	1999–2003	5y, 1d, 1826	273	1·095 (0·939–1·251)	0·032 (0·00–0·07)	21·1	0·040
				1·686 (cTY) (1·293–2·071)	0·031 (0·00–0·07)	20·7	0·044
Czech Republic	1999–2003	5y, 1d, 1826	1006	0·974 (0·856–1·091)	0·078 (0·00–0·16)	14·2	0·007
				1·759 (cTY) (1·408–2·110)	0·077 (0·00–0·15)	13·9	0·01
	1994–2003	10y, 1d, 3652	1792	1·726 (TY) (1·605–1·848)	0·074 (0·02–0·13)	15·1	<0·001
				1 (0·944–1·056)	0·052 (0·00–0·10)	10·6	0·01

T, Length of data series (y = years); $\triangle t$, sampling interval (d = day, m = month); N, number of data (including 0 s); n.s., not significant.

Period and 95% confidence interval (CI) estimated by nonlinear least squares. In longer (10-year) series, a near-transyear (cycle with a period between 1·0 and 1·2 years) is detected for MIs in addition to a far-transyear. Brevity of series and lack of ordering statistical significance qualify results from Hong Kong. Note that transyears are found in 3/6 locations ($P<0·05$ by linear least-squares) with a relative amplitude >12 (% of MESOR).

* With focus on transyears, with periods longer than 1·0 year (underlined; double underline for near-transyear).

† International Classification of Diseases (ICD-10), code I46·1, excluding MI and sudden death of unknown or unspecified cause (except before 1999).

‡ From linear least-squares analyses, not corrected for multiple testing. Amplitude expressed as N/day.

Table 3. *Congruent* periods of helio-geomagnetics* (*columns 1 and 2*), *the estimation of 1-minute by a healthy man over 3·5 decades* (*column 3*)

Period (years) (95% confidence interval)								
Solar wind (SW)	aa	1-min time estimation (1MTE)		SW/ aa	SW/ 1MTE	aa/ 1MTE	SW/aa/ 1MTE	None
15·6 (15·2–16·0)								x
	10·85 (10·78–10·92)							x
9·54 (9·38–9·70)								x
		8·71 (8·52–8·90)						x
	5·31 (5·38–5·35)							x
		4·11 (4·06–4·16)						x
3·56 (3·52–3·60)								x
		2·81 (2·76–2·84)						x
2·17 (2·15–2·19)								x
	1·92 (1·89–1·95)*	1·98 (1·94–2·01)*	E			x		
		1·85 (1·82–1·88)*						x
1·69 (1·67–1·72)*	**1·71 (1·69–1·74)***	**1·71 (1·68–1·74)***	**SE**				x	
1·60 (1·58–1·62)*								x
1·52 (1·50–1·54)*		**1·54 (1·52–1·56)***	**S**		x			
1·39 (1·37–1·41)*	**1·39 (1·37–1·41)***			x				
1·32 (1·31–1·34)*								x
1·24 (1·23–1·26)*		1·26 (1·25–1·27)*	S		x			
		1·16 (1·15–1·18)*						x
1·06 (1·05–1·07)*	**1·06 (1·04–1·07)**	**1·06 (1·05–1·07)***	**SE**				x	
	0·99 (0·98–1·01)*	**0·99 (0·98–1·01)***	**SE**			x		
0·91 (0·90–0·92)*								x
0·83 (0·82–0·84)*		**0·82 (0·81–0·83)***	**S**		x			
0·72 (0·71–0·73)*	**0·72 (0·71–0·73)***	**0·713 (0·708–0·719)**	**SE**				x	
	0·599 (0·598–0·600)							x
0·559 (0·557–0·561)		0·561 (0·558–0·564)	S		x			
	0·548 (0·547–0·549)							x
0·524 (0·522–0·526)								x
0·500 (0·499–0·501)	0·500 (0·499–0·501)			x				
	0·437 (0·436–0·438)	0·440 (0·438–0·442)	E			x		
0·485 (0·483–0·487)								x
0·425 (0·423–0·427)								x
0·409 (0·407–0·411)								x
0·355 (0·354–0·356)								x
	0·341 (0·340–0·342)	0·339 (0·338–0·340)	E			x		

SW, Solar wind, aa, antipodal index.

* Based on weekly measurements; otherwise on daily measurements. Congruence defined by overlying or overlapping 95% confidence intervals given in parentheses. Congruence in the last column is designated as pertaining to the sun (S) or earth (E).

Solar wind/aa: 2/34 (5·882%); solar wind/1MTE: 5/34 (14·706%); aa/1MTE: 4/34 (11·765%); solar wind, aa and 1MTE all congruent: 3/34 (8·824%); No congruence: 19/34 (55·882%).

CONCLUSION

We detected cycles of different length in different geographical locations in the incidence patterns of cholera in India and Russia and of diphtheria and croup in various regions of Europe. A geographically selective assortment is thus documented for infectious diseases in the past, in keeping with such a selective assortment found earlier in recent years for sudden cardiac death. This selective assortment among decadal and multidecadal periods is also found among different variables of the same population and among

and within individuals' physiology, organ systems such as blood circulation, among variables and even among circadian characteristics such as MESOR *vs.* amplitude of the same variable of the same person [33]. We may be dealing with genetically coded periods in the biosphere that could be driven off and on but are not consistently synchronized by competing space and earth weather, notably magnetism.

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DECLARATION OF INTEREST

None.

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