Cyclic Patterns of Incidence Variations for Stomach Cancer in the North-Western Region of England

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Aim. To analyze temporal dynamics and model trends and variations of the annual incidence rates of stomach cancer in the North-Western Region of England.

Methods. The data consisted of 23,465 new cases of stomach cancer as provided by the population-based registry of the Centre for Cancer Epidemiology (Manchester, England, UK). The parameter studied was the annual incidence rate of stomach cancer per 100,000 persons as age-adjusted to the world standard population and presented as time-series over the interval from 1971 to 1990. The hypotheses to be tested, regarding the annual incidence rates, were: 1) existence of specific temporal characteristics; 2) appearance of cyclic patterns of variability; and 3) usefulness of cyclicity in predictive modeling.

Results. The decreasing tendency of annual incidence rates of stomach cancer for both men and women was best fitted by a quadratic trend ($y=a+b t^2$) out of 13 available linear/nonlinear regression models. This trend explained only about 49% of variability. Cyclic patterns of variability in incidence rates were established (short-term cycle of 8.9 years; long-term hypercycle of about 22-23 years). The best fit to the real incidence rates was achieved by bi-cyclic regression model. The summary cosine-sine model contained both cycles of 8.875 and 22-23 years; it showed the least variance of regression (men – $S_y^2=1.09$; women – $S_y^2=0.65$) and best prognostic index (PI=1.47 for men, and PI=1.29 for women). This trigonometric model explained about 83-86% of variability of incidence rates of stomach cancer.

Conclusion. Cyclic patterns of variability of the annual incidence rates of stomach cancer have been established. Such cyclicity might not only find likely implications in predictive modeling and forecasting of incidence rates, but it could also be considered useful in research on risk/prevention factors for stomach cancer.

Key words: cyclicity; England; incidence studies; models, statistical; periodicity; probabilistic models; stomach neoplasms

Better health promotion, prevention, and earlier diagnosis of cancer require a good registration practice as well as regular monitoring and studies of tendencies in incidence and prevalence of malignant diseases. The precise forecasting of cancer trends and derivation of best estimates of future incidence rates allow better resource allocation, which is invaluable for public health services within the present situation of crisis and economic collapse in the countries of Central and Eastern Europe. One approach to study incidence data on stomach cancer is the analysis of trends and variations and creation of the best statistical forecasting models.

Variations from the trend may be random or regular (cyclic), where cycle is a pattern in the realization of a stochastic process that repeats itself at intervals with length, amplitude, and/or phase changing over time. The cyclic variations may either represent a definite intrinsic feature of time-series or be modulated (provoked) by external influences, or both (1-5). In this sense, if an external effect on the disease exists, then the incidence variations should exhibit a similar cyclicity, as was shown for malignant melanoma of the skin, uterine cervical cancer, and other phenomena (2-10). However, cycles in cancer incidence with the length of the cycle longer than 1.2-1.5 years have been rarely described. Cycles of such length were referred to as multiannual cycles, megarhythms, macrorhythms or infraannual cycles (12,13). Infrannual cycles in cancer incidence variations were mainly related to the influence of sunspots cycles on malignant melanoma and other neoplasms (3,8,11).
Stomach cancer is a disease of multifactorial origin. Although its incidence has been decreasing worldwide for the last 10-20 years, it still represents a major problem of public health concern (6). During my study on malignant melanoma of the skin in 1993 (2), the existence of cyclicity in the variations of annual incidence rates of stomach cancer was accidentally discovered. In the study of variations of annual incidence rates of malignant melanoma of the skin, the stomach cancer was taken as a control disease in respect to melanoma because there was no a priori reason to suspect cyclic patterns of variations in annual incidence rates of this internal malignancy. However, a cycle of 8.75 years in the variations of the incidence rates of stomach cancer in the North-Western region of England was unexpectedly established (unpublished results). Later, the cyclicity of 8.75 years was described in the variations of annual incidence rates of stomach cancer for US males as judged by the data from the Surveillance, Epidemiology and End Results (SEER) Program (1). Therefore, the cyclic variations in the annual incidence rate of stomach cancer may be considered important for its etiology (6-7), but even more, they could make a basis for short-term prognosis of cancer incidence (4,14,15).

The aim of this study was to analyze temporal dynamics and to model trends and variations of the annual incidence rates of stomach cancer in the North-Western region of England.

Material and Methods

Cancer Incidence Data

Temporal dynamics of annual incidence for stomach cancer in the North-Western Region of England was analyzed. The data consisted of 23,465 new cases of stomach cancer as registered in the region from 1971 to 1990 (last registration date was September 1993). The parameter studied was the annual incidence rate of stomach cancer per 100,000 persons, age-adjusted to the world standard population. The data were kindly provided by the Centre for Cancer Epidemiology in Manchester. The datasets were presented as time-series of world-standardized annual incidence rates against the year of observation over the 1971-1990 study period.

Statistical Analysis

Descriptive statistics, linear/nonlinear regression modeling, and periodogram regression analysis with trigonometric approximations were applied. The periodogram regression analysis was described in detail earlier (1,3,16) as well as the technique for approximations to the cyclic components of time series with the prognostic index (PI) (1,3,4). Different criteria for distribution and statistical significance of the results were used: Kolmogorov-Smirnov tests (Z and D), Shapiro-Wilcoxon W-test, F-test and z-test (4,16,17).

Table 1. Regression models of incidence for stomach cancer in the North-Western region of England (1971-1990)

<table>
<thead>
<tr>
<th>No.</th>
<th>Regression model</th>
<th>Variance of regression ($S_y^2$)</th>
<th>Coefficient of correlation (r)</th>
<th>Coefficient of determination ($r^2$)</th>
<th>Statistical z-test</th>
<th>Statistical significance (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men:</td>
<td>y = a + b t</td>
<td>2.37</td>
<td>-0.558</td>
<td>0.311</td>
<td>3.62</td>
<td>&lt;0.01 b</td>
</tr>
<tr>
<td>2</td>
<td>y = i/(a+b t)</td>
<td>2.48</td>
<td>0.569</td>
<td>0.324</td>
<td>3.75</td>
<td>&lt;0.01 b</td>
</tr>
<tr>
<td>3</td>
<td>y = a + b/t</td>
<td>2.83</td>
<td>-0.105</td>
<td>0.011</td>
<td>0.48</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>y = a + b t</td>
<td>2.59</td>
<td>-0.426</td>
<td>0.181</td>
<td>2.33</td>
<td>&lt;0.03 b</td>
</tr>
<tr>
<td>5</td>
<td>y = a + b t^2</td>
<td>2.42</td>
<td>-0.564</td>
<td>0.318</td>
<td>3.70</td>
<td>&lt;0.01 b</td>
</tr>
<tr>
<td>6</td>
<td>y = a + b/t</td>
<td>2.41</td>
<td>-0.565</td>
<td>0.319</td>
<td>3.71</td>
<td>&lt;0.01 b</td>
</tr>
<tr>
<td>7</td>
<td>y = a b^t</td>
<td>2.79</td>
<td>-0.251</td>
<td>0.063</td>
<td>1.16</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>8</td>
<td>y = a + b ln(t)</td>
<td>2.77</td>
<td>-0.248</td>
<td>0.062</td>
<td>1.19</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>9</td>
<td>y = a/(b+t)</td>
<td>2.47</td>
<td>0.569</td>
<td>0.324</td>
<td>3.76</td>
<td>&lt;0.01 b</td>
</tr>
<tr>
<td>10</td>
<td>y = a/(b-t)</td>
<td>2.87</td>
<td>0.095</td>
<td>0.009</td>
<td>0.43</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>11</td>
<td>y = a exp(b t)</td>
<td>2.85</td>
<td>-0.999</td>
<td>0.009</td>
<td>0.45</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>12</td>
<td>y = a + b t^2</td>
<td>2.04</td>
<td>-0.698</td>
<td>0.487</td>
<td>6.11</td>
<td>&lt;0.01 b</td>
</tr>
<tr>
<td>13</td>
<td>y = a + b/t^2</td>
<td>2.78</td>
<td>-0.244</td>
<td>0.059</td>
<td>1.16</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Women:</td>
<td>y = a + b t</td>
<td>1.28</td>
<td>-0.584</td>
<td>0.341</td>
<td>3.96</td>
<td>&lt;0.01 b</td>
</tr>
<tr>
<td>2</td>
<td>y = i/(a+b t)</td>
<td>1.36</td>
<td>0.611</td>
<td>0.373</td>
<td>4.36</td>
<td>&lt;0.01 b</td>
</tr>
<tr>
<td>3</td>
<td>y = a + b/t</td>
<td>1.58</td>
<td>-0.019</td>
<td>0.000</td>
<td>0.09</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>y = a + b t</td>
<td>1.39</td>
<td>-0.467</td>
<td>0.218</td>
<td>2.67</td>
<td>&lt;0.01 b</td>
</tr>
<tr>
<td>5</td>
<td>y = a b^t</td>
<td>1.32</td>
<td>-0.598</td>
<td>0.358</td>
<td>4.17</td>
<td>&lt;0.01 b</td>
</tr>
<tr>
<td>6</td>
<td>y = a exp(b t)</td>
<td>1.31</td>
<td>-0.599</td>
<td>0.359</td>
<td>4.18</td>
<td>&lt;0.01 b</td>
</tr>
<tr>
<td>7</td>
<td>y = a b^t</td>
<td>1.52</td>
<td>-0.315</td>
<td>0.099</td>
<td>1.56</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>8</td>
<td>y = a + b ln(t)</td>
<td>1.51</td>
<td>-0.306</td>
<td>0.094</td>
<td>1.51</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>9</td>
<td>y = a/(b+t)</td>
<td>1.36</td>
<td>0.610</td>
<td>0.372</td>
<td>4.36</td>
<td>&lt;0.01 b</td>
</tr>
<tr>
<td>10</td>
<td>y = a/(b-t)</td>
<td>1.60</td>
<td>-0.002</td>
<td>0.000</td>
<td>0.01</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>11</td>
<td>y = a exp(b t)</td>
<td>1.59</td>
<td>-0.010</td>
<td>0.000</td>
<td>0.06</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>12</td>
<td>y = a + b t^2</td>
<td>1.13</td>
<td>-0.700</td>
<td>0.490</td>
<td>6.14</td>
<td>&lt;0.01 b</td>
</tr>
<tr>
<td>13</td>
<td>y = a + b/t^2</td>
<td>1.56</td>
<td>-0.157</td>
<td>0.025</td>
<td>0.72</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

*Regression models with their significance after the z-test (z = r/s.e.r) where z=1.96 when p=0.05; s.e.r is the standard error of [r].

*Statistically significant regression models (the significance of the null hypothesis is assumed at p=0.05).
Results

The mean values of the annual incidence rates of stomach cancer during the 1971-1990 period were 21.28 and 9.48 new cases per 100,000 persons for men and women, respectively (sample size n=20 years). The standard deviations (SDm=2.78 for men, and SDw=1.54 for women) and variations (Vm=13.06%, Vw=16.24%) were small, indicating low overall variability. The analysis further indicated a normal distribution of the incidence rates (Kolmogorov-Smirnov Z-test B pm=0.92, pw=0.99). The negative kurtosis of the histogram (km=-1.03, kw=-0.76) was closer to 1 than 0 for both men and women, i.e., the frequency distribution curves were more flat than the normal one, denoting low levels of the random variability in annual incidence rates of stomach cancer in particular.

The decreasing incidence rates of stomach cancer for both men and women were best fitted by a quadratic equation (y=a+b²/c+dt²) out of 13 tested models. This model had the least variance of the regression (Sy²), highest coefficient of determination (r²) and highest z-value (model No. 12, Table 1). Although a normal distribution of the residuals to the non-linear trend was established (Kolmogorov-Smirnov Z-test B pm=0.63, pw=0.89; W-test pm=0.13, pw=0.60), these non-linear trends were able to explain only 48.7-49.0% of the overall variability. The lack of heteroscedasticity in incidence time-series (low mean volatility - Vm=-0.012, Vw=-0.014) prompted for cyclicity in variations.

The deviations from the non-linear trend represented about 50% of the temporal dynamics. Since overall temporal patterns were not explained by the above models, the original time-series of annual incidence rates of stomach cancer were analyzed by a periodogram regression analysis with trigonometric approximations. When subjected to this analysis, the time-series of annual incidence rates of stomach cancer contained the trend and deviations (variations).

The period T of 8.875 years for middle-frequency infrannual cyclicity in the temporal dynamics of incidence rates was found both in men (z-testm=3.05, pm<0.01) and women (z-testw=3.67, pw<0.01). Also, infrannual hypercycles with a length of the period T H of 22.25 years in men (z-testm=16.77, pm<0.001) and TH of 22.75 years in women (z-testw=11.14, pw<0.001) were established (Fig. 1). It should be noted that the cyclicity was referred to as hypercyclic (13) when the length of the cycle was longer than the length of the original time-series, i.e., longer than the sample size (20 years in this case).

To explain the role of middle-frequency cyclicity and hypercyclicity in the temporal dynamics, the original time-series of incidence rates were detrended, i.e., the quadratic trend was removed from the incidence time-series. As a consequence, hypercyclicity was partially suppressed and the expression of middle-frequency cycles was relatively increased. The latter relative increase in the appearance indicated that the middle-frequency cycle of 8.875 years for both men and women was inversely linked to the quadratic trend. This increase confirmed the cyclicity in the incidence variability. Also, the change of hypercyclicity indicated a link between the hypercycles of 22-23 years and this trend. Thus, it was speculated that the decreasing quadratic trend in the time-series represented a part of the infrannual hypercyclicity (most likely, the longest part of the trend followed the descending slope of the hypercycle, i.e., from 1973-1974 to 1989-1990, Fig. 2). The latter implied cyclicity in the incidence rate itself, i.e., a cycle in temporal dynamics.

Figure 1. Periodogram regression analysis of variations in incidence rates for stomach cancer in the North-Western region of England (1971-1990). The spectra of coefficients R present infrannual cycles in variations of incidence rates in men (periods T=8.875 years and Th=22.25 years, thick curve) and women (periods T=8.875 years and Th=22.75 years, thin curve). Arrows indicate significant peaks on periodograms.
On the next step of modeling, a trigonometric approximation to the original incidence time-series was performed. A summary function of cosine-sine mode was used. The best fit of estimates to the real values was observed when a bi-cyclic model was built using both cycles alone (i.e., the middle-frequency cycle and hypercycle), without the quadratic trend (Fig. 2). This bi-component periodic model showed the least variance of regression ($S^2=1.09$ for men, and $S^2=0.65$ for women), highest coefficients of determination and highest significance after the $z$-test values (model No. 3, Table 2). The latter results were confirmed by the highest values of the prognostic index ($PI=1.47$ for men, and $PI=1.29$ for women) of this bi-cyclic model. Also, normal distribution of the residuals to the model was found (Kolmogorov-Smirnov $Z$-test – $p_m=0.99$, $p_w=0.98$; $W$-test – $p_m=0.77$, $p_w=0.28$). It is very important to note that the bi-cyclic model was able to explain about 82.6-85.7% of the overall variability of incidence time-series of stomach cancer in both men and women (Fig. 2).

**Discussion**

This report presents a detailed analysis of the temporal dynamics of standardized annual incidence rates of stomach cancer in the North-Western region of England (1971-1990). Normal distribution and low level of overall variability of the incidence rates have been established for both men and women. The decreasing tendency of incidence rates is in accordance with the decreasing temporal patterns of the incidence of stomach cancer worldwide (6,14,15).

In general, the secular trends of cancer rates are considered relatively “stable”. This is because most multiannual trend lines correspond closely to a straight line or curve. The comparison of 13 available models showed that 7 of them were statistically significant in fitting the annual incidence dynamics of stomach cancer in the North-Western Region (No. 1, 2, 4, 5, 6, 9, 12). Formal tests of statistical difference among the models are not always necessary within such exploratory analysis but, for the clarity of presentation, all are presented together in Table 1. Our results showed that the model with the best non-linear fit for both genders was that of a quadratic equation (No.12, $y=a+b^2$, Table 1). It is possible to predict the patterns of such “stable” trend lines but not too far ahead. Quite often, there are large discrepancies between the forecasted estimates and real values (6,14,15). The fact that the variability of annual incidence rates of cancer either has not been taken into account or has been underestimated within the present paradigms in cancer epidemiology (14,15) may be a possible cause of such inaccuracies. Obviously, the variability, i.e., type of deviations from the incidence tendency or variations of the incidence itself or the overall one, is an important aspect of the time-series of cancer annual rate. For instance, our best non-linear model allowed an explanation of only one part (about 48.7-49.0%) of the overall variability of the incidence rates of stomach cancer. At the same time, peaks and falls in time-series were observed against

![Figure 2](image-url)
the background of decreasing tendency (peaks, 1975-1976 and 1983-1984; falls, 1979-1980 and 1988-1989). However, the low level of volatility of annual incidence rates of stomach cancer (i.e., homoscadasticity or narrow fluctuations of time-series) indicated that such variability was to be rather cyclic than random. The decreasing non-linear quadratic trend did not explain the above specific patterns; thus, an additional analysis of the overall variability in the incidence time-series was required.

A bi-component trigonometric model, containing both cycles, was the best fit for the decreasing incidence rate of stomach cancer (Table 2). This non-linear bi-cyclic model explained the majority of overall variability in incidence time-series (men 85.7%, women 82.6%). The result was obtained on the background of the lack of influential observations (extremes, outliers) and a normal distribution of residuals to the best fit. When original time-series of the annual incidence rate were reconstructed, the best fit of bi-cyclic model was confirmed by the highest values of the prognostic index also (PI=1.47 for men, and PI=1.29 for women). The prognostic index had to be higher than 0.25-0.30, the model estimates with 95% confidence limits can be derived ahead for an interval of 1/4 of the length of the original time series, i.e., till 1995.

The best bi-cyclic trend line of annual incidence rates of stomach cancer was composed by: 1) the deviations from the quadratic trend with confidence limits in the interval of up to 1/4 of the length of original time series. For our sample size of 20 years, this interval was 5 years ahead. To illustrate the best bi-cyclic fit, trigonometric estimates with 95% confidence limits were forecasted 2 years ahead (Fig. 2).

The best bi-cyclic trend line of annual incidence rates of stomach cancer was composed by: 1) the deviations from the quadratic trend with middle-frequency infrannual cyclicity of 8.875 years; and 2) the quadratic trend itself as a part of the infrannual hypercycle of 22-23 years. However, the existence of hypercycles in the time-series could be considered at this stage only as hypothesis and, obviously, the use of hypercyclicity should be interpreted with caution. The verification of hypercycles in practice is difficult. But, although such hypercyclicity stands without enough biological/medical plausibility and cannot be explained by a direct short-term influence of risk/preventive determinants or screening, it was necessary in providing the best fit. Thus, a bi-cyclic model may be the basis for best estimates for about 5-6 years ahead. Such cyclic variability of incidence is useful in research on risk/preventive factors (eating habits, foods, additives, drugs use, prevalence of Helicobacter pylori infection, pollution with pesticides, etc.) not only for stomach cancer but also for gastrointestinal cancers in general (6, 7).

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References
3 Komitov BP. Seasonal and century effects related to the influence of the solar cycles on the rains in Plovdiv (Bulgaria) [In Russian with English abstract]. Solnechnye Dannye 1986;9:92-96.
4 Dimitrov BD. Similar high-frequency cycles in the annual levels of solar ultraviolet radiation, stratospheric ozone concentration and incidence of malignant melanoma of the skin. The Department of Environmental Sciences and Policy Journal 1998;1:14-20.
6 Dimitrov BD. Epidemiology of gastrointestinal cancers other than colorectal. In: Sadler M, Strain S, Ca-

<table>
<thead>
<tr>
<th>No.</th>
<th>Cyclic model (no trend added)</th>
<th>Variance of regression ($S^2$)</th>
<th>Coefficient of correlation ($r$)</th>
<th>Coefficient of determination ($r^2$)</th>
<th>Prognostic index (PI)</th>
<th>Statistical significance (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Monocyclic (8.875)</td>
<td>2.34</td>
<td>0.507</td>
<td>0.257049</td>
<td>0.16</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>2</td>
<td>Monocyclic (22.25)</td>
<td>1.31</td>
<td>0.876</td>
<td>0.767376</td>
<td>1.06</td>
<td>&lt;0.03b</td>
</tr>
<tr>
<td>3</td>
<td>Bi-cyclic</td>
<td>1.09</td>
<td>0.926</td>
<td>0.857476</td>
<td>1.47</td>
<td>&lt;0.01b</td>
</tr>
<tr>
<td>Women:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Monocyclic (8.875)</td>
<td>1.24</td>
<td>0.562</td>
<td>0.315844</td>
<td>0.21</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>2</td>
<td>Monocyclic (22.75)</td>
<td>0.87</td>
<td>0.819</td>
<td>0.670761</td>
<td>0.73</td>
<td>&lt;0.05b</td>
</tr>
<tr>
<td>3</td>
<td>Bi-cyclic</td>
<td>0.65</td>
<td>0.909</td>
<td>0.826281</td>
<td>1.29</td>
<td>&lt;0.01b</td>
</tr>
</tbody>
</table>

aRegression cyclic models with a prognostic index (at PI 0.25-0.30, the model estimates with 95% confidence limits can be derived ahead for an interval of 1/4 of the length of the original time series, i.e., till 1995).
bStatistically significant regression cyclic models (the significance of the null hypothesis is assumed at p < 0.05).
12 Oransky IE. Natural curative factors and biological rhythms [In Russian with English abstract]. Moscow: Meditsina; 1988. p. 5-35.

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