THE MONTHLY VARIATIONS IN MORTALITY FROM THE CARDIOVASCULAR DISEASES IN TBILISI

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The meteorological and geophysical parameters, which sufficiently affect the human beings are the followings: air temperature and humidity, wind speed, atmospheric pressure, solar activity (Wolf's number), the geomagnetic fields, solar radiation, the cosmic rays, light ions, aerosols, ozone, other air toxic admixtures and others [1,2,5,7,10,12,13]. Generally, the human's health is primarily affected by the lifestyle (50-55%), then – by the environment (25-30%), and finally – by heritage and medical care [1]. In recent decades, in relation with intense growth of the anthropogenic environmental pollution and climate change, especially in the large cities, practically all above mentioned meteorological and geophysical parameters undergo significant change. Repeatability of extremely high air temperatures, anthropogenic levels of electromagnetic radiation (cell phones, computers, etc.), ground level ozone and aerosol concentrations and others has increased. This additional anthropogenic load on the biosphere increases the level of above mentioned risk - factors influencing on human health and life [1,2].

The effects of the action of environmental factors on human health have different scales - from minute, hour, day, decade and month to the seasonal and annual. For example, periodicity of 7 and 3, 5 day of mortality from the cardiovascular diseases (CVD) is established in the work [7]. Results of investigation of influence of monthly average values of air equivalent- effective temperature EET (combination of temperature, air relative humidity and wind speed) and monthly duration of magnetic storms D on the health of the population of Tbilisi city are represented in work [5]. It is obtained that the effect of indicated separate factors and their combinations on human health is various in different months of the year. The analysis of regression connections of mortality from the CVD with the EET and D showed that the contribution of each of the variables into changeability of mortality (in the limits of variation scope) is the following. In the range EET from – 5º to 4,6º: EET - 8,6%, D - 22,2%; in the range EET from 5,2º to 21,8º: T - 26,3%, D - is insignificant [5].

In work [1] is shown, that in smog days situation together with air pollution by ozone, the ozone forming gases and the aerosols under the conditions of Tbilisi (especially those suffering from cardiovascular diseases) an essential effect on human health have a variation in such factors as the thermal regime of air, atmospheric pressure, cosmic rays (in essence as the indicator of geomagnetic situation). Thus, increased surface ozone concentrations (and its accompanying harmful components of smog) on the average growth of annual mortality of the inhabitants of Tbilisi city by 1680 people. This is equal to 14.1% of entire average annual mortality of the population of Tbilisi city, which is approximately 3 times higher than the same indices for the advanced countries [1,2,9].

The thermal regime of the atmosphere is one of the most important factor influencing the human health. This factor acts on people everywhere, and especially in the large cities, where the inhomogeneities of the distribution of air temperature are clearly expressed. Very sensitive to the action of the thermal regime of the atmosphere appear those with cardiovascular, respiratory, cerebrovascular, etc. diseases. Therefore, the special attention is payed to studies of the influence of this factor on the appearance, the flow and the lethal outcome from the cardiovascular and other forms of catastrophes. A lot of works are devoted to similar studies.

In Europe and other countries higher mortality in winter than in summer, making it a public health issue [4,6,8,12,14-16]. Mortality from respiratory diseases exhibits a clear seasonal pattern that has been attributed to different infections including influenza [10,15,17]. The analogous seasonal effect is also observed for CVD mortality [4,6,8,14,16], probably due to seasonal changes in temperature [12], in cardiovascular risk factor levels [6,8,16,17] or to exacerbation by other conditions such as influenza [15].

The results [14] show that cold stress has a considerable impact on mortality in central Europe, representing a public health threat of an importance similar to heat waves. The elevated mortality risks in men aged 25-59 years may be related to occupational exposure of large numbers of men working outdoors in winter. The estimated excess mortality during the severe cold spells in January 1987 (+274 cardiovascular deaths) is comparable to that attributed to the most severe heat wave in this region in 1994. There is a striking association between the extreme cold temperatures and mortality from cancer, not previously reported, which is more remarkable in the elderly. These results could be explained by a harvesting effect in which the cold acts as a trigger of death in terminally ill patients at high risk of dying a few days or weeks later [12].

In the works [6,8] is shown that the overall dependence of CVD mortality from EET in 15 hour is following - the decrease of mortality from the gradation of sharp cold to comfortable and warm with further increase to the hot. Studies on the seasonality of mortality by cause of death have focused on a separate or to the group of the adjacent country mainly [4,6,8,10,12,14]. However, recently extensive studies appeared covering countries located on different continents [16,17]. CVD mortality reveals a seasonal pattern. Some studies suggested several possible determinants of this pattern, including misclassification of causes of deaths. The authors aimed to assessing seasonality in overall, CVD, cancer and non-CVD/non-cancer mortality using data of 19 countries from different latitudes. In countries with seasonal variation, mortality from overall, CVD and non-CVD/non-cancer show a seasonal pattern being higher in winter than in summer. Conversely, cancer mortality shows no substantial seasonality [16]. In the Northern and Southern Hemispheres, cardiovascular risk factors levels tended to be higher in winter and lower in summer months [17].

Results of the detailed statistical analysis of the monthly average mortality on the reasons for cardiovascular diseases in Tbilisi into 1980-1992 and 2012-2013 are represented below. Together with this the scale of the levels of mortality is proposed.

Material and methods. In the work the data of the all Civil Registry Offices of Tbilisi city about the daily CVD mortality of the city population into the period from 1980 through 1992 and data of the National Statistics Office of Georgia “GEOSTAT” about the general annual mortality and monthly mortality in Tbilisi from diseases of the system of blood circulation, sharp myocardial infarction and stroke (CVD’) into the period from 1980 to 1992 and from 2012 through 2013 were used. The analysis of data with the aid of the methods of the correlation and regression analysis of stationary and non-stationary time-series of observations was conducted [8,10]. The following designations besides intelligible will be used below: M and M’ – mean monthly decade mortality from the CVD and CVD’ in Tbilisi for 1 million inhabitants in 1980-1992 and 2012-2013 accordingly; Range – variation scope (Max – Min); Range/Mean – relative variation scope (%), σ - standard deviation; σ_m - standard error (68% - confidence interval of mean values); C_v = 100·σ/Mean - coefficient of variation (%); A - coefficient of skewness; K - coefficient of kurtosis; R - coefficient of linear correlation; R^2 – coefficient of determination; R_s – Spearman’s rank correlation coefficient; R_k – Kendall’s rank correlation coefficient; R_a - autocorrelation coefficient; K_{DW} - Durbin-Watson statistic; 95%(+/-) - ±95% confidential interval; σ (R_a), C_v(R_a) and 95%(+/-, R_a) - values of σ, C_v and 95%(+/-) taking into account value of autocorrelation coefficient with a Lag = 1 month [9]; α - the two-sided level of significance; x – number of month (1,2...156, or 0, 0,52...81,16 radian). The variable curve (or trend) of M and M' changeability in time was determined by the optimum selection of the regression equation of the dependence of real data on time and the Durbin-Watson statistic value for the residuals (optimum combination values of R^2 and K_{DW}). It was assumed that the *variable* + *background* component = the values of real variable curve - minimum of the absolute value of residuals; *random components* = value of residuals + minimum absolute value of residuals. As a result: *Real data* = (*variable + background) + random components.*

about statistical structure of mean monthly decade mortality for reasons of cardiovascular diseases in Tbilisi in 1980-1992 are given. As follows from this table the values of M varies from 69,0 to 167,8; mean value is 106,1; median - 104,8; standard deviation - 19,0; coefficient of variation 17,9%; confidential interval – 3,0; the relative variation scope is 93,1%.Coefficient of skewness is 0,30 and coefficient of kurtosis is -0,29. The absolute values of the calculated coefficients of A and K are less than the trebled theoretical value of their standard deviations. Accordingly in general set of function of distribution of M should be close to normal. The intra-annual changeability of M in Tbilisi as in the works [6,8,10] has classical form – min. in summer and max. in winter. The non-randomness characteristic of time series of M in the right upper and lower parts of Table 1 are submitted. The value of autocorrelation coefficient with a Lag=1 month is 0,59. This two almost increases value of standard deviation and accordingly values of confidential interval and coefficient of variation of M (37,3; 5,9 and 35,2%) in comparison with calculations for the standard statistics (Table 1). The mean value of *variable +background* component of M is 72,6; the minimal value - 54,0; maximal - 91,2; standard deviation - 13,4. A share of the mean values of the component of *variable+background* from the mean value of real data of M constitute 68,4%. The mean value of *random* component of M is 33,5; the maximal -77,6; standard deviation - 13,4. The value of autocorrelation coefficient with a Lag=1 month is 0,36. This approximately to 46% increases values of standard deviation and coefficient of variation of random component of M accordingly (19,5 and 58,2%) in comparison with the calculations for the standard statistics (Table 1).

In Table 2 repetition of values of M at different months of year on the different levels of mortality are presented. The levels of mortality were established as follows: Moderate = mean±σ/2; Lowered = from mean – 3/2σ to mean - σ /2; Low = < mean – 3/2σ; Increased = from mean + σ /2 to mean + 3/2σ; High = from mean + 3/2σ to mean + 5/2σ; Extreme = >mean + 5/2σ. In comparison with the data of table 1 the following rounding's for the convenience are made: mean = 105 and σ = 20.

As it follows from Table 2 at different months of year the following levels of mortality are not observed: Low – from January to June and from October to December; Lowered – in February and March; Increased – from June to August; High – from April to November; Extreme - from February to December. In the warm half-year (April-September)

Table 1. The statistical structure of mean monthly decade mortality for reasons the cardiovascular diseases in Tbilisi in 1980-1992

Parameter	Value	Parameter	Value	Parameter	Value
The statistical analysis - (α) R_a<0,001					
Mean	106,1	σ	19,0	R with month	No sign.
Min	69,0	$σ_m$	1,5	R_k	No sign.
Max	167,8	A	0,30	R_s	No sign.
Range	98,8	K	-0,29	R_a, Lag 1	0,59
Median	104,8	Count	156	σ (R_a)	37,3
Mode	136,3	95%(+/-)	3,0	95%(+/-, R_a)	5,9
Range/Mean (%)	93,1	C_v, %	17,9	$C_v(R_a)$, %	35,2
Variable + background: M = 72,59+17,61·cos(x)+6,72·sin(x)					
R^2	0,50	Mean	72,6	Range/ Mean (%)	51,3
(α) R^2	0,001	Min	54,0	σ	13,4
K_{DW}	1,19	Max	91,2	C_v (%)	18,4
(α) K_{DW}	<0,01	Range	37,2	Share from real data (%)	68,4
Random components					
Mean	33,5	C_v (%)	40,1	$C_v(R_a)$, %	58,2
Max	77,6	R_a, Lag 1	0,36	Range/ Mean (%)	231,4
σ	13,4	σ (R_a)	19,5	Share from real data (%)	31,6

predominantly the tendency toward the reduction (24,36% with Moderate = 20,51% and Increased = 5,13% only), while into the cold (November-March) - to an increase in the mortality (25,64% with Moderate = 17,95% and Lowered = 6,41% only) is observed.

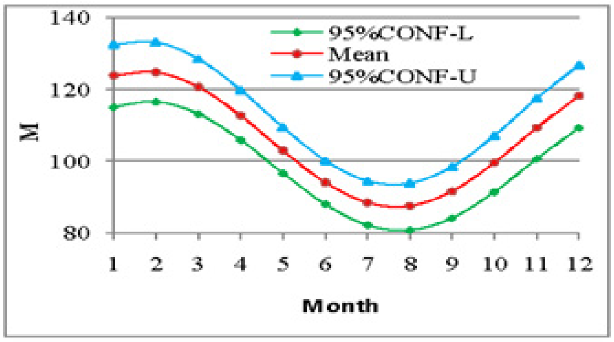

Fig. 1. Intra-annual changeability of mean monthly decade mortality from the cardiovascular diseases in Tbilisi into 1980-1992

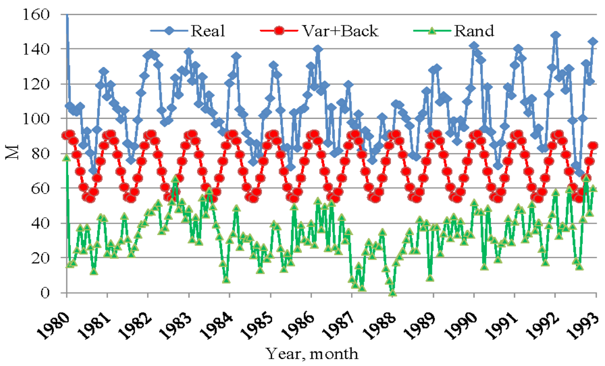

Fig. 2. Changeability of mean monthly decade mortality from the cardiovascular diseases in Tbilisi into 1980-1992

In Table 3 and Fig. 3 data about statistical structure of mean monthly decade mortality for reasons of CVD' in Tbilisi in 2012-2013 are given. As follows from this table the values of M' varies from 61,5 to 125,2; mean value is 82,3; median **-** 78,2; standard deviation - 16,1; coefficient of variation 19,5 %; confidential interval – 6,4; the relative variation scope is 77,4 %.Coefficient of skewness is 1,1 and coefficient of kurtosis is 0,9. The absolute values of the calculated coefficients of A and K are less than the trebled theoretical value of their standard deviations. Accordingly in general set of function of distribution of M should be close to normal. The intra-annual changeability of M' in Tbilisi as the M has min. in summer and max. in winter. The non-randomness characteristic of time series of M' in the right upper and lower parts of table 3 are submitted. The value of autocorrelation coefficient with a Lag=1 month is 0,71. This almost into two and one-half of time increases value of standard deviation and accordingly values of confidential interval and coefficient of variation of M' (39,1; 15,6 and 47,5 %) in comparison with calculations for the standard statistics (table 3). The mean value of *variable +background* component of M' is 60,5; the minimal value - 43,6; maximal - 77,3; standard deviation - 12,2. A share of the mean values of the component of *variable+background* from the mean value of real data of M' constitute 73,4%. The mean value of *random* component of M' is 21,9; the maximal -47,9; standard deviation - 10,4. The value of autocorrelation coefficient with a Lag = 1 month is 0,54. This approximately to 84% increases values of standard deviation and coefficient of variation of random component of M' accordingly (19,1 and 87,3%) in comparison with the calculations for the standard statistics (Table 3).

Table 2. Repetition of mean monthly decade mortality from the cardiovascular diseases in Tbilisi to 1 million inhabitants in different months of year on the different levels of mortality (%)

Month	**Low**	**Lowered**	**Moderate**	**Increased**	**High**	**Extreme**
	<75	**>75-95**	**>95-115**	**>115-135**	**>135-155**	**>155**
January	0	0,64	1,92	2,56	2,56	0,64
February	0	0	1,92	4,49	1,92	0
March	0	0	3,21	3,21	1,92	0
April	0	1,28	5,13	1,92	0	0
May	0	1,28	4,49	2,56	0	0
June	0	4,49	3,85	0	0	0
July	1,28	4,49	2,56	0	0	0
August	1,28	5,13	1,92	0	0	0
September	0,64	4,49	2,56	0,64	0	0
October	0	2,56	5,13	0,64	0	0
November	0	1,28	3,85	3,21	0	0
December	0	1,92	1,92	3,85	0,64	0
Warm period	3,21	21,15	20,51	5,13	0,00	0,00
Cold period	0,00	6,41	17,95	17,95	7,05	0,64
Year	3,21	27,56	38,46	23,08	7,05	0,64

Table 3. The statistical structure of mean monthly decade mortality for reasons the CVD' in Tbilisi in 2012-2013

Parameter	Value	Parameter	Value	Parameter	Value
The statistical analysis - (α) R_a <0,001					
Mean	82,3	σ	16,1	R with month	-0,63
Min	61,5	σ_m	3,3	R_k	-0,42
Max	125,2	A	1,1	R_s	-0,57
Range	63,8	K	0,9	R_a, Lag 1	0,71
Median	78,2	Count	24	σ (R_a)	39,1
Mode	90,6	95%(+/-)	6,4	95%(+/-, R_a)	15,6
Range/Mean (%)	77,4	C_v, %	19,5	$C_v(R_a)$, %	47,5
Variable + background: M = 82,35+ 13,78·cos(x)+ 9,83·sin(x)					
R^2	0,58	Mean	60,5	Range/ Mean (%)	55,7
(α) R^2	0,001	Min	43,6	σ	12,2
K_{DW}	0,80	Max	77,3	C_v (%)	20,2
(α) K_{DW}	<0,01	Range	33,7	Share from real data (%)	73,4
Random components					
Mean	21,9	C_v (%)	47,7	$C_v(R_a)$, %	87,3
Max	47,9	R_a, Lag 1	0,54	Range/ Mean (%)	218,8
σ	10,4	σ (R_a)	19,1	Share from real data (%)	26,6

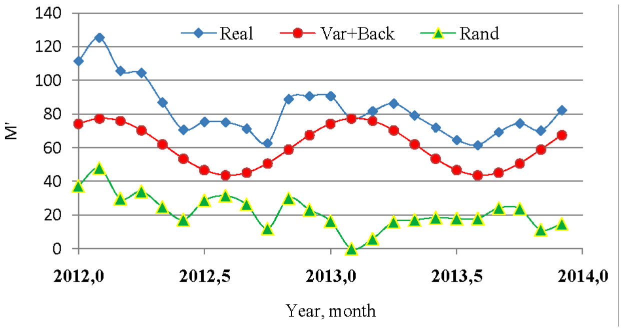

Fig. 3 Changeability of mean monthly decade mortality from the CVD' in Tbilisi into 2012-2013

As it follows from Tables 2 and 3 average annual decade mortality M' in 2012-2013 (82,3) is lower than the values M (106,1) in 1980-1992. However, the general average annual decade mortality for 1 million inhabitants in Tbilisi in 2012-2013 in comparison with 1980-1992 grew by 25,3% (297 and 237 respectively). This can be explained by the imperfection of the statistical information of the last years. Nevertheless, the general nature of the monthly changeability of mortality into both periods of time is sufficiently similar. In particular, variable components of values M and M ' are described by similar trigonometric equation. A share of the average values of variable + background components into both periods of time differs little from each other (68,4% and 73,4% respectively into 1980-1992 and 2012-2013). This is the index of that, the contribution of random meteorological and geophysical factors to the changeability of mortality into both periods of time remained approximately identical. If one assumes that the real values M' into 2012-2013 increased proportional to the general mortality (by 25,3%), then during this period of time its value must compose 133, which in the correspondence with table 2 falls into the range "Increased".

Conclusions. Mean monthly mortality from the cardiovascular diseases in Tbilisi as in other cities of different countries has clearly expressed seasonal behavior, described by trigonometric equation. Together with this in the changeability of mortality besides the air temperature variations of the random components of those depending on the action of different meteorological, social and other factors of irregular or quasi-regular nature play significant role. Subsequently we plan to conduct the analogous analysis of the statistic structure of decade and daily cardiovascular mortality, which will make possible more correct estimations of the contribution of different indicated environmental factors on her changeability with different scales of averaging. The indicated studies have retrospective nature however they will be highly useful for conducting the comparative analysis with the contemporary reasons for the changeability of cardiovascular mortality.

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SUMMARY

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Results of the detailed statistical analysis of the monthly average decade mortality on the reasons for cardiovascular diseases in Tbilisi into 1980-1992 and 2012-2013 are represented. Variable +background and random component of time-series of mortality are determined. A share of the mean values of the component of variable +background from the mean value of real data of mortality constitute 68,4 % in 1980-1992 and 73,4 % in 2012-2013. Variations of the random component and their contribution to the real values of mortality (31,6 % in 1980-1992 and 26,6 % in 2012-2013) besides the air temperature can depend on many others meteorological, geophysical, social and so forth of factors. The scale of the six levels of cardiovascular mortality is proposed. In different months of year the indicated levels of mortality are various.

Keywords: health security, cardiovascular mortality, statistical models of monthly cardiovascular mortality.

РЕЗЮМЕ

МЕСЯЧНЫЕ ВАРИАЦИИ СМЕРТНОСТИ ОТ СЕРДЕЧНО-СОСУДИСТЫХ ЗАБОЛЕВАНИЙ В ТБИЛИСИ

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Представлены результаты детального статистического анализа среднемесячной декадной смертности по причинам сердечно-сосудистых заболеваний в Тбилиси за 1980-1992 и 2012-2013 гг. Определены переменная+фон и случайная компоненты временных рядов смертности. Доля среднего значения компоненты переменная+фон от средней величины реальных данных о смертности составляет 68,4% в 1980-1992 гг. и 73,4% - в 2012-2013 гг. Изменения случайной компоненты и ее вклада в реальные значения смертности (31,6% в 1980-1992 гг. и 26,6 % в 2012-2013 гг.) помимо температуры воздуха могут зависеть от многих других метеорологических, геофизических и социальных и факторов. Предложена шкала сердечно-сосудистой смертности, состоящая из шести уровней. В различные месяцы года указанные уровни смертности различные.

რეზიუმე

გულ-სისხლძარღვთა დაავადებით სიკვდილიანობის ყოველთვიური ვარიაციები თბილისში

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ნაშრომში წარმოდგენილია ქ. თბილისში გულ-სისხლძარღვთა დაავადებით საშუალო ყოველ-თვიური სიკვდილიანობის სტატისტიკური ანალიზის შედეგები 1980-1992 და 2012-2013 წლებში. განსაზღვრულია ცვლადი+ფონი და სიკვდილიანობის დროითი რიგის შემთხვევითი კომპონენტები. ცვლადი+ფონი კომპონენტის საშუალო მნიშვნელობის წილი სიკვდილიანობის მაჩვენებელში შეადგენს 68,4% (1980-1992 წწ.) და 73,4% (2012-2013 წწ.); შემთხვევითი კომპონენტის ცვლილება და მისი წვლილი სიკვდილიანობის რეალურ მნიშვნელობაში - 31,6% (1980-1992 წწ.), 26,6% (2012-2013 წწ.), ჰაერის ტემპერატურის გარდა შეიძლება დამოკიდებული იყოს მრავალ მეტეოროლოგიურ, გეოფიზიკურ, სოციალურ და სხვა ფაქტორზე. შემოთავაზებულია გულ-სისხლძარღვთა დაავადებით სიკვდილიანობის სკალა, რომელიც შედგება ექვსი დონისგან. წელიწადის სხვადასხვა თვისთვის სიკვდილიანობის აღნიშნული დონეები განსხვავებულია.