

Correlation between the mortality from cancer of the breast, prostate, lung, colon and pancreas and *pro capite* food consumption in Serbia, 1991-2010

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Summary. *Aim:* The purpose of this study was to investigate the association between *pro capite* food consumption and mortality rates of the five commonest cancers in Serbia. *Materials and methods:* The correlation between the age-adjusted mortality rates of breast, prostate, lung, colon and pancreatic cancer and *pro capite* food consumption was calculated by Pearson's correlation coefficient. *Results:* The coefficients of correlation indicate that *pro capite* consumption of animal fat ($r=-0.67$), beef ($r=-0.80$), milk ($r=-0.47$), wine ($r=-0.72$) and hard drinks ($r=-0.81$) were significantly negatively correlated with female breast cancer mortality rates, while consumption of poultry ($r=0.61$), dried and processed meat ($r=0.57$), fish ($r=0.53$), eggs ($r=0.71$), and yogurt ($r=0.66$) were positively correlated. A positive correlation was apparent in the four cancers (prostate, lung, colon and pancreatic cancer) mortality rates with *pro capite* consumption of vegetable oil, poultry, dried and processed meat, fish, eggs, yogurt and other dairy products, and coffee. Consumption of beer was correlated only with pancreatic cancer mortality rates ($r=0.52$). *Conclusions:* Striking changes in mortality rates of breast, prostate, lung, colon and pancreatic cancers have been shown, which may be at least in part attributable to the concurrent nutrition transition.

Key words: mortality, cancer, *pro capite* food consumption, correlation

«CORRELAZIONE TRA LA MORTALITÀ PER CANCRO DEL SENO, DELLA PROSTATA, DEL POLMONE, DEL COLON E DEL PANCREAS E CONSUMO ALIMENTARE *PRO CAPITE* IN SERBIA, 1991-2010»

Riassunto. *Scopo:* Lo scopo di questo studio era di valutare l'associazione tra il consumo *pro capite* di cibo e i tassi di mortalità dei cinque tumori più comuni in Serbia. *Materiali e metodi:* La correlazione tra i tassi aggiustati per età e mortalità per cancro del seno, della prostata, del polmone, del colon e del pancreas e il consumo alimentare *pro capite* è stata misurata mediante l'indice di correlazione di Pearson. *Risultati:* I coefficienti di correlazione indicano che il consumo *pro capite* di grassi animali ($r=-0,67$), carne bovina ($r=-0,80$), latte ($r=-0,47$), vino ($r=-0,72$) e superalcolici ($r=-0,81$) erano in modo significativo correlati negativamente con i tassi di mortalità per cancro al seno femminile, mentre il consumo di pollame ($r=0,61$), salumi e insaccati ($r=0,57$), pesce ($r=0,53$), uova ($r=0,71$), e yogurt ($r=0,66$) erano correlati positivamente. Una correlazione positiva si è resa evidente per i tassi di mortalità nei quattro tipi di cancro (prostata, polmone, colon e pancreas) con il consumo *pro capite* di olio vegetale, pollame, salumi e insaccati, pesce, uova, yogurt e altri pro-

dotti caseari, e caffè. Il consumo di birra è correlato soltanto con tassi di mortalità per cancro al pancreas ($r=0,52$). *Conclusioni:* Ci sono stati cambiamenti notevoli nei tassi di mortalità per cancro del seno, della prostata, tumori del polmone, del colon e del pancreas, che possono essere almeno in parte attribuibili alla contemporanea transizione nutrizionale.

Parole chiave: mortalità, cancro, consumo *pro capite* di cibo, correlazione

Introduction

The Serbian population shows higher mortality rates of some cancers compared to the developed countries and other Southern European countries (1-3). The most common anatomical sites of cancer mortality were female breast, lung, prostate, colon and pancreas. In recent decades, cancer mortality has increased in Serbia (4, 5), but the reasons for such an increase have not been fully recognized.

Rather than using genetic factors, the large international differences in cancer mortality may be at least partially explained by differences in certain “lifestyle” variables, such as smoking, obesity, food consumption, and use of alcohol (2, 3, 6). The “westernized” diet has been proposed as a causative factor for many cancers in developing countries (7, 8).

A number of studies have found high correlations between cancers and food consumption (9-11). The most significant positive correlations were noticed between mortality from breast, prostate and colorectal cancer and red meat intake, particularly processed meat or beef (7, 12-14). Fewer studies with less consistent associations have been reported for pancreatic (15, 16) and lung cancers (17, 18). Dairy products such as butter, cheese and yogurt have been postulated to increase the risk of developing prostate and colorectal cancer (19-22). The most significant correlations with prostate cancer mortality rates included the non-fat portion of milk (20, 23). Egg consumption was associated with an increased risk of colon and rectal cancers (24). However, some international comparisons of epidemiological data cannot strongly support a link between cancer and diets (25, 26).

To our knowledge, no other correlation study of the relationship between the nutritional intake and cancer mortality in the Serbian population is present.

The purpose of this study was to investigate the association between *pro capite* food consumption and mortality rates of the five commonest cancers in Serbia.

Materials and methods

The mortality rates are calculated from data collected by the Statistical Office of the Republic of Serbia, which receives death certificates and compiles mortality data by gender, age, year, and cause of death. We used the International Classification of Diseases, 9th and 10th Revision, to classify codes of deaths. The research included the entire population of the Republic of Serbia, during the period 1991 to 2010, excluding the Autonomous Province of Kosovo and Metohia for which data are unavailable from the year 1998 (27). Population size and composition by age and gender were obtained from the 1991 and 2002 censuses; for inter-census years, estimates published by the Statistical Office of the Republic of Serbia were used. Age-adjusted mortality rates were calculated by direct standardization, using the world standard population (28). Cases were grouped by gender into 10-year age groups at diagnosis. A linear trend model was used to examine trends of mortality from observed cancers.

Food consumption *pro capite* in the Republic of Serbia was obtained through the Survey on Households Consumption, which was carried out by the Statistical Office of the Republic of Serbia (29). The Survey covered the whole territory of the Republic of Serbia. From total number of households which predicted for surveying (4800 for the Republic of Serbia), the survey covered at least 90% of planned households in every year. The Survey on Households

Consumption was harmonized with the international standards and recommendations of Eurostat and United Nations, which provide international comparison of data.

The unit of observation in the survey is every household selected according to the sampling plan. The Survey used a two-stage, stratified, rotating sample, with enumeration areas as the primary and households as the secondary units of selection. Sample selection was performed by choosing the first-stage units (enumeration areas) proportionally to the number of households within them, while the second-stage units (households) were chosen with equal chances (randomly). The Survey used a diary method (a household keeps a diary of food consumption per fifteen or sixteen days) to record the amount of food and drink consumed, and oral examination method (interview method) of the selected household, where the reference period was twelve months. This data served as a basis to determine the *pro capite* food consumption in a household.

The dietary components chosen for analysis are primarily those linked to observed cancers in other studies, such as fat, meat, fish, eggs, milk, and drinks. Since the literature suggests that meat and milk play

an important rôle in the etiology of cancer, the various components of meat and milk were separately treated.

The correlation among the five cancers mortality rates and *pro capite* food consumption was calculated by Pearson's correlation coefficient. Correlation coefficients were calculated while comparing food consumption rates to cancer mortality rates for the same year. Two-sided *P* values are reported and are considered to indicate statistical significance when they are less than 0.05. All statistical analyses were carried out using the Statistical Package for Social Sciences software (SPSS Inc., version 19.0, Chicago, IL).

Results

Over the 20-year observation period, a significant increase in five cancer mortality rates in the Republic of Serbia (without Autonomous Province Kosovo and Metohia) was observed (Figure 1). The increase for all observed cancer mortality rates was significant for: female breast cancer ($y=0.14x + 18.83, p=0.000, R^2=0.65$), prostate cancer ($y=0.23x + 7.55, p=0.000, R^2=0.77$), lung cancer ($y=0.59x + 24.07, p=0.000, R^2=0.95$), colon cancer ($y=0.15x + 5.46, p=0.000, R^2=0.89$), and pancreatic cancer ($y=0.11x + 4.54, p=0.000, R^2=0.87$).

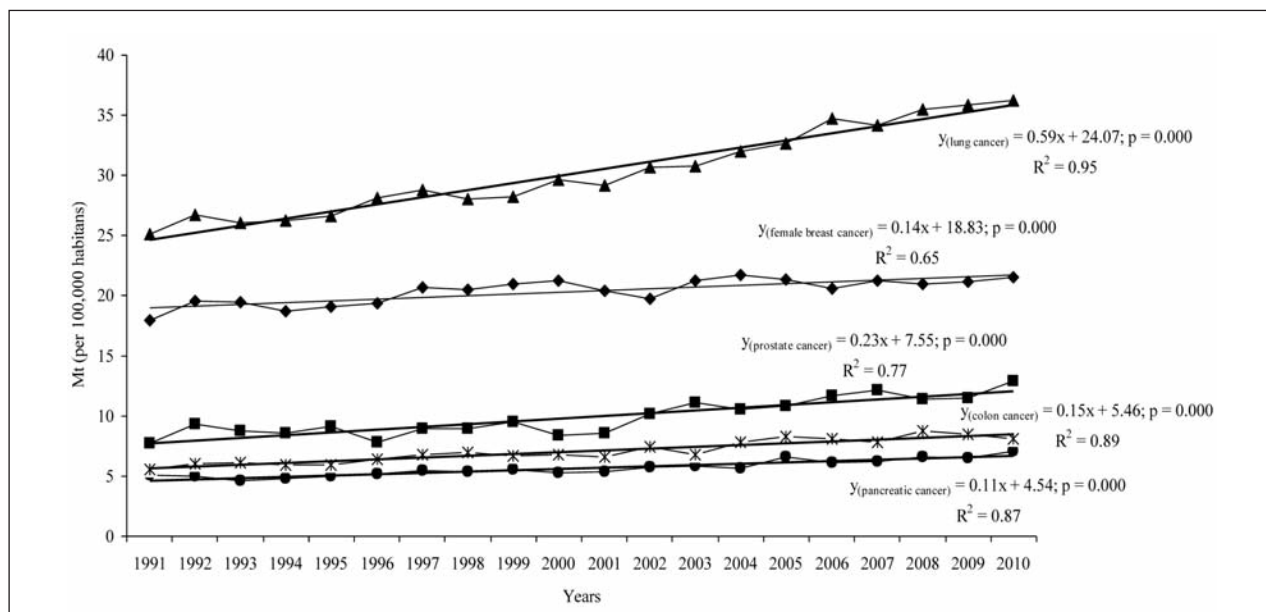


Figure 1. Cancer mortality rates age-adjusted to the World standard population per 100,000 inhabitants in the Republic of Serbia (without Autonomous Province Kosovo and Metohia), 1991-2010.

$R^2=0.95$), colon cancer ($y=0.15x + 5.46$, $p=0.000$, $R^2=0.89$), and pancreatic cancer ($y=0.11x + 4.54$, $p=0.000$, $R^2=0.87$).

Intertumor correlation shows that all five malignant tumors observed had a high statistically significant positive correlation (Table 1).

Pearson's correlation coefficients among five cancer mortality rates and *pro capite* food consumption are presented in Table 2. The coefficients of correlation indicate that *pro capite* consumption of animal fat ($r=-0.67$), beef ($r=-0.80$), milk ($r=-0.47$), wine ($r=-0.72$) and hard drinks ($r=-0.81$) were significantly negatively

Table 1. Pearson's correlation coefficients between cancer mortality rates age-adjusted to the World standard population per 100.000 habitants in Republic of Serbia (without Autonomous Province Kosovo and Metohia), 1991-2010.

	Breast	Prostate	Lung	Colon	Pancreas
Breast		0.68*	0.75**	0.77**	0.72**
Prostate			0.90**	0.83**	0.87**
Lung				0.96**	0.94**
Colon					0.91**
Pancreas					

* $p<0.01$; ** $p<0.001$

Table 2. Pearson's correlation coefficients between *pro capite* food consumption and cancer mortality rates age-adjusted to the World standard population per 100.000 habitants in Republic of Serbia (without Autonomous Province Kosovo and Metohia), 1991-2010.

	Breast	Prostate	Lung	Colon	Pancreas
Fat					
- Animal	-0.67**	-0.90**	-0.89**	-0.87**	-0.86**
- Vegetable	0.33	0.75**	0.75**	0.64**	0.76**
- Total fat	-0.55*	-0.11	-0.34	-0.45*	-0.29
Meat					
- Red meat	-0.58**	-0.11	-0.16	-0.27	-0.14
- Beef	-0.80**	-0.55*	-0.69**	-0.73**	-0.61**
- Pork	-0.21	0.23	0.26	0.15	0.23
- Poultry	0.61**	0.83**	0.92**	0.84**	0.88**
- Total meat	0.07	0.52*	0.55*	0.43	0.54*
- Dried and processed	0.57*	0.91**	0.93**	0.89**	0.93**
Fish	0.53*	0.85**	0.89**	0.86**	0.90**
Eggs	0.71**	0.80**	0.86**	0.82**	0.82**
Milk and dairy products					
- Milk	-0.47*	-0.81**	-0.74**	-0.68**	-0.64**
- Cheese	0.01	0.32	0.15	0.03	0.14
- Yogurt	0.66**	0.91**	0.90**	0.85**	0.90**
- Other	0.38	0.81**	0.80**	0.72**	0.82**
Cofee	0.28	0.68**	0.59*	0.53*	0.58*
Alcohol beverages					
- Beer	0.35	0.41	0.47	0.46	0.52*
- Wine	-0.72**	-0.31	-0.52*	-0.55*	-0.47
- Hard drinks	-0.81**	-0.87**	-0.96**	-0.96**	-0.91**
- Total	-0.29	-0.15	-0.34	-0.22	-0.11

* $0.01<p<0.05$; ** $p<0.01$.

correlated with female breast cancer mortality rates, while consumption of poultry ($r=0.61$), dried and processed meat ($r=0.57$), fish ($r=0.53$), eggs ($r=0.71$), and yogurt ($r=0.66$) were positively correlated.

A positive correlation was apparent in the four cancers (prostate, lung, colon and pancreatic cancer) mortality rates with *pro capite* consumption of vegetable oil, poultry, dried and processed meat, fish, eggs, yogurt and other dairy products, and coffee. The lung and colon cancer mortality rates were negatively correlated with consumption of animal fat, beef, milk, wine and hard drinks. Animal fat, beef, milk and hard drinks consumption showed a highly significant negative relationship with the prostate and pancreatic cancer mortality rates.

Pro capite consumption of pork and cheese was not correlated with any cancer mortality rates. Consumption of beer was correlated only with pancreatic cancer mortality rates ($r=0.52$).

Discussion

This descriptive epidemiological study presents an assessment of diet influence on mortality from 5 selected malignant tumors in Serbia.

A remarkable increase in mortality rates of breast, prostate, lung, colon and pancreatic cancers have been observed in Serbia (without Autonomous Province Kosovo and Metohia) during the 20-year observation period. Our data on cancer mortality are similar to data from developing countries, in contrast to data from developed countries where last years recorded a downward trend in mortality from malignant tumors (1-5). An increasing trend of the mortality of five cancers in Serbia may be partially explained by the difficult conditions of functioning of health care system, especially during the economic sanctions against Serbia, during the war and the 1999 NATO bombing of the FR Yugoslavia, and due to the larger number of internally displaced persons and refugees (4, 5). In support of this, in the observed period there have been significant changes in the living standard of the population, which could have contributed to some changes in the consumption structure in Serbia. International differences in mortality from the observed

cancers could partially be explained by the differences in quality of death certificate data between individual countries (3-5). The proportion of cases with uncertain death cause (revision 9 codes 780-799 and revision 10 codes R00-R99) in the period observed was on an average of 6.8% with non-significant decreasing trend ($p=0.137$) (5).

A significant positive correlation between observed cancer mortality rates may indicate their reciprocal etiology. In the period observed, the increasing trend of mortality rates of all common cancers was significantly positively correlated with *pro capite* consumption of dried meat and processed meat products, poultry, fish, eggs and dairy products. In contrast, the use of animal fat in the preparation of food, beef, milk and the use of hard drinks decreased cancer mortality. This findings support the associations reported in the correlation studies in southern Mediterranean countries (30), China (31), Japan (32), Brazil (33), Iran (34), and some East Asian countries (7). Our results stand in contrast to the pattern seen in developed countries, such as some comparisons in United States and most Western European countries (10, 16, 35-37).

Some potential explanations for these apparent differences among the countries may lie in discrepancies in quality of food consumption data, primarily due to differences in data collection methodology. Also, the changes in the patterns of smoking and alcohol use in recent decades, obesity, lifestyle and other factors, such as diet, have been attributed to changes in cancer mortality (2, 3). Also, studies of migrants suggest that cancer mortality trend is positively associated with a Western-style diet (38).

Strengths and limitations of the study

Our study could potentially be more informative than international correlation study because that composition of the population and national food data likely vary less than at the international level. Our results are based on the statistical cancer mortality data and food consumption data in Serbia, which in turn enabled us to exclude the differences in international correlation studies stemming from the differences in medical procedures and methods of providing data on the food consumption in various countries.

Our study, like all correlation studies, carries a number of limitations. The primary limitation is the ecological nature of the study. Namely, the correlation analysis implies that different nutritional components may be independently observed, even though the usual food consumption is combined. In addition, confounding factors cannot be controlled. However, since correlation studies observe the average exposure to influences of individual factors, it must be observed that the existence of a link on the group level does not necessarily mean it exists on the individual one.

According to the International Agency for Research on Cancer (39), tobacco is causally related to cancer of lung and pancreas, while link with cancer of the colon and prostate is considered as secondary, and with breast cancer is inconsistently associated. Unfortunately, Serbia not having data about cigarettes *pro capite* consumption in the whole observed period (only since 2006), so that correlation analyses with cancer mortality data were not carried out. World Health Organization convention on tobacco control was entry into force in Serbia since 2006, the positive effects of which may be expected in the future.

Significant increase in mortality from cancers in Serbia in period 1991–2010 underlines the importance of implementing preventive measures that have proved effective in other countries. Unfavorable mortality trend from breast and colon cancers might be due the lack of implementation screening activities. A screening program for breast, colon and cervical cancers will start in 2013, and national coverage is planned for the near future.

Correlation studies represent the first step in investigating causal relationships (help formulate a hypothesis), and help determine high-risk populations, time frames or geographical areas for future studies. Analytical epidemiological studies could determine which nutritional factors have a causal rôle in the occurrence of cancers.

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