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# THE RELATIONSHIP OF THE BODY MASS INDEX AND THE RISK OF STROKE BY GENDER

## A case of Zhambyl Region, Kazakhstan

***Abstract***
*This paper analyses whether an increase in the body mass index has a greater risk of the mortality rate from stroke among men than among women on the case of Zhambyl Region, Kazakhstan during the first quarter of 2018 using Binary Logistic Regression Model. It concludes that an increase in the body mass index have a greater risk of mortality from stroke both among men and among women (i.e., irrespective of gender), as well as an increase in the age of the patient, an increase in the systolic blood pressure and an increase in the blood glucose level leads to a greater risk of the mortality from stroke.*
***Keywords:*** *stroke, body mass, gender, systolic blood pressure.*

## INTRODUCTION

This paper aims to investigate whether an increase in the body mass index has a greater risk of the mortality rate from stroke among men than among women. Finding an existence or a non-existence of the relationship between the body mass index and the gender of the patient on the mortality rate from stroke is important because this study might have clinical (e.g., the therapeutic decision making) and public health implications, as well as the implications in the epidemiologic studies. Furthermore, this study might help to have a higher longevity of the population, and the long-term surplus of the national economy. Also, the patients, the clinicians, and the policy-makers might benefit from this study, because stroke takes the second place among top ten causes of the disease-related deaths worldwide according to the World Health Organization. In 2015, 6.24 millions of deaths worldwide occurred only due to stroke incidents [1]. Therefore, this paper aims to find the most important factors for determining the mortality from stroke in developing countries by examining the relation between stroke-related mortality and variables which were cited as affecting the mortality from stroke in Literature Review Part, using the case of Zhambyl Region, Kazakhstan during the first quarter of 2018. The analysis finds that the age of the patient, an increase in the body mass index (i.e., irrespective of the gender of the patient), an increase in the systolic blood pressure and an increase in the blood glucose level raises the risk of death from stroke, while the gender of the patient and an increase in the blood cholesterol level of the patient do not affect the mortality rate from stroke at all. The similar results were obtained from other research papers, which can be seen in the Literature Review Part.

### Literature Review

Tobias Kurth, et al. (2002) did similar research on the relationship of the body mass index and the risk of stroke in men [2]. The participants were 21 414 US male physicians, who took part in the Physicians' Health Study. The results of this study showed that there were 747 strokes in total (631 ischemic, 104 hemorrhagic, 12 undefined) during 12.5 years of observation. Participants with BMI > 30.0 kg/m2 had an adjusted relative risk of 2.00 (95% CI, 1.39-2.72) for ischemic stroke, 2.25 (95% CI, 1.01-5.01) for hemorrhagic stroke. Furthermore, 1 unit increase in BMI caused 6% increase in the adjusted relative risks of a total (95% CI, 4%-8%), ischemic (95% CI, 3%-8%) and hemorrhagic stroke (95% CI, 1%-12%). An additional adjustment for hypertension, diabetes mellitus, hypercholesterolemia a little bit weakened the risks for total and ischemic stroke (relative risk: 4%; 95% CI, 2%-7%), while had no effect on hemorrhagic stroke. The study concludes that each one unit increase in BMI is strongly associated with an increase in the relative risk of total, ischemic and hemorrhagic stroke.

Kathryn M. Rexrode, et al. (1997) did another research on body mass index, weight change, and risk of stroke in women [3]. The participants were 116 759 women aged 30 to 55 years in 1976, who have not been diagnosed with coronary heart dis-

ease, stroke and cancer. The results showed that there were 866 stroke-related deaths during 16 years of follow-up (403 ischemic strokes and 269 hemorrhagic strokes). The results were adjusted for age, smoking, postmenopausal hormone use, and menopausal status, and showed that women with BMI of 27.0-28.9 kg/m2 had significantly increased risk of ischemic stroke, with relative risks of 1.75 (95% CI, 1.17-2.59), while women with BMI of 29.0-31.9 kg/m2 had relative risks of 1.90 (95% CI, 1.28-2.82), and women with BMI of 32 kg/m2 or more had relative risks of 2.37 (95% CI, 1.60-3.50), P < 0.001. Also, weight gain (from age of 18 years) of 11.0-19.9 kg increased the relative risks of acquiring ischemic stroke by 69% (95% CI, 1.26-2.29), while weight gain of 20.0 kg or more increased the relative risks of acquiring ischemic stroke by 152% (95% CI, 1.80-3.52) in comparison with women who maintained stable weight (i.e., loss or gain is less than 5 kg). The study concludes that both obesity and weight gain are important risk factors for ischemic and total stroke, but not for hemorrhagic stroke.

Yun-Mi Song, Joohon Sung, George Davey Smith and Shah Ebrahim (2004) also investigated the relation between body mass index and ischemic and hemorrhagic stroke [4]. 234 863 Korean men aged 40 to 64 years were participated in this research and have been divided into 8 categories according to their BMI and have been observed between 1991 and 2000 for fatal and nonfatal stroke accidents. The study showed that 1 kg/m2 increase in BMI leads to 11% increase in the occurrence of ischemic stroke (95% CI, 1.09-1.12), while people with BMI greater than 22-23 kg/m2 had an increased risk of getting hemorrhagic stroke. The adjustment for variables such as blood pressure, blood glucose level and blood cholesterol level slightly weakened the results only for those people with BMI greater than the reference category (i.e., 22-23 kg/m2). The research concludes that BMI is a strong positive predictor of occurrence of both ischemic and hemorrhagic stroke, but shows different relationships with ischemic stroke and with hemorrhagic stroke.

Another study was conducted on the abdominal obesity and the risk of ischemic stroke between July 1993 and June 1997 in northern Manhattan, New York by Seung-Han Suk, et al (2003). 576 cases of first ischemic stroke were categorized by age, sex and race-ethnicity, and compared to the stroke-free community of 1142 people [5]. The results show that a greater waist-to-hip ratio had an increased risk of stroke both among men and women, as well as among all race-ethnic groups. The impact of gender-specific medians of waist-to-hip ratio (WHR) on the risk of acquiring an ischemic stroke adjusted for hypertension, diabetes mellitus, any cardiac disease, current smoking status, no physical activity, moderate alcohol drinking, level of LDL cholesterol, level of HDL cholesterol, education and BMI showed that the risk among men (OR, 3.8; 95% CI, 1.8 to 5.0) was greater (z = 2.9, P < 0.0038) than among women (OR, 2.5; 95% CI, 1.6 to 4.0). The study concludes that the prevention of obesity and the weight reduction should be emphasized to prevent the stroke-related mortality rate of the population.

Maigeng Zhou, et al. (2008) conducted another study on the body mass index, the blood pressure and the mortality from stroke [6]. This was a prospective study of 212 000 Chinese men, aged 40 to 79, and without known cardiovascular diseases between 1990 and 1991 who were observed for 10 years. The results of this study show that the mean systolic blood pressure (SBP) and the mean body mass index (BMI) were 124 mmHg and 21.7 kg/m2, respectively, and that 5766 stroke-related deaths occured during ten years of follow-up. There was also strong, positive relations between the systolic blood pressure and the stroke-related mortality, showing that only 3 mmHg increase in the systolic blood pressure causes 5.6% increase in the stroke-related mortality (95% CI, 5.3% to 6.0%; P < 0.00001). There was a nonlinear association between BMI and the stroke-related mortality, showing that the risk of mortality increases only when BMI > 25.0 kg/m2 (P < 0.001 for nonlinearity). The study concludes that high BMI was strongly associated with an increase in the stroke-related mortality among men who were overweight or obese.

These papers are similar to this research, however most of these studies consider the effect of body mass index on the risk of stroke irrespective of gender, so Tobias Kurth, et al. (2002), Yun-Mi Song, et al. (2004), Maigeng Zhou, et al. (2008) investigated the impact of the body mass index on the risk of stroke only among men, while Kathryn M. Rexrode, et al. (1997) did similar research using the case of women. Furthermore, Seung-Han Suk, et al. (2003) searched for the determinants for the risk of stroke according to the age, the gender and the race-ethnicity of people, but this research gave controversial results in comparison with this research paper.

**DATA AND METHODOLOGY**

The data used in this work is from the statistics division of the medical organization "City Hospital

No.1" of town Taraz, Zhambyl Region, Kazakhstan for the first quarter (January 1 - March 31) of 2018. It includes information on 310 patients who had either pre-stroke condition or stroke, from which 50 deaths and 260 recoveries of the patients took place.

To calculate the marginal effects of different factors on the mortality from stroke, the binary logistic regression model was used. The model was specified as follows:

MRS = ß0 + δ0×male + ß1×BMI + δ1×male×BMI + ß2×age + ß3×SBP + ß4×BC + ß5×BGL + ε,

For females: male = 0,

MRS = ß0 + ß1×BMI + ß2×age + ß3×SBP + ß4×BC + ß5×BGL + ε

For males: male = 1,

MRS = (ß0 + δ0) + (ß1 + δ1)×BMI + ß2×age + ß3×SBP + ß4×BC + ß5×BGL + ε

where MRS is a dichotomous variable for the mortality rate from stroke (0 = alive, 1 = dead); male - a dichotomous variable for the gender of the patient (0 = female, 1 = male); BMI - a ratio variable for the body mass index[1] (kg/m2); male×BMI - the interaction term for the gender and the body mass index of the patient, age - a ratio variable for the age of the patient (years), SBP - a ratio variable for the systolic blood pressure of the patient (mmHg), BC - a ratio variable for the blood cholesterol level (mg/dL (milligrams per deciliter)); BGL - a ratio variable for the blood glucose level (mmol/L).

Table 1.

**SUMMARY STATISTICS**

| Indicator | | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Age of The Patient | 310 | 25 | 96 | 65.78 | 13.028 |
| Dead or Alive | 310 | 0 | 1 | .16 | .368 |
| Male or Female | 310 | 0 | 1 | .50 | .501 |
| Body Mass Index | 310 | 19.92 | 46.88 | 25.8965 | 2.85335 |
| Systolic Blood Pressure | 310 | 110 | 230 | 169.77 | 20.514 |
| Blood Cholesterol | 310 | 4.0 | 10.0 | 6.144 | .7032 |
| Blood Glucose | 310 | 3.0 | 12.0 | 5.449 | 1.5476 |
| Alcohol Consumption | 310 | 0 | 300 | 31.52 | 44.670 |
| Smoking | 310 | .00 | 30.00 | 4.3452 | 7.56334 |
| Interaction Term | 310 | .00 | 35.43 | 13.1876 | 13.31654 |
| Valid N (listwise) | 310 | | | | |

## RESULTS

The first issue to resolve is the proper level of alpha that should be set. Since here, the Type II error is more damaging than the Type I error, i.e. detecting causes of mortality from stroke is more important compared to the alternatives, a high level of α = 15% was chosen. The null was in the form of δ0 = 0 and δ1 = 0, and the alternative was one-sided.

The regression results can be seen in Table 2. From these results, it follows that the age of the patient, the gender, the body mass index, the interaction of the gender and the body mass index, the systolic blood pressure, and the blood glucose level are significant factors in predicting the outcome for a patient's mortality from stroke. Furthermore, the multicollinearity does not exist (VIF < 3.0 for all variables).

[1] **The body mass index (BMI)** *or Quetelet index is a value derived from the mass (weight) and height of an individual. The BMI is defined as the body mass divided by the square of the body height, and is universally expressed in units of kg/m2, resulting from mass in kilograms and height in metres. Commonly accepted BMI ranges are underweight: under 18.5 kg/m², normal weight: 18.5 kg/m² to 25 kg/m², overweight: 25 kg/m² to 30 kg/m², obese: over 30 kg/m². (The definition was taken from the Wikipedia. https://en.wikipedia.org/wiki/Body_mass_index)*

Table 2

**REGRESSION TABLE**

| Explanatory Variable | Coefficient [Exp(B)] |
|---|---|
| Gender (*male*) | 0.002* (2.085) |
| Body Mass Index (*BMI*) | 0.858** (2.925) |
| The Interaction Term (*male*×*BMI*) | 1.287* (2.574) |
| Age (*age*) | 1.136**** (22.524) |
| Systolic Blood Pressure (*SBP*) | 1.154**** (45.987) |
| Blood Cholesterol (*BC*) | 0.766<br>(0.371) |
| Blood Glucose Level (*BGL*) | 1.679**** (9.013) |
| Intercept | 0.000**** (34.394) |

the Wald statistics (i.e., t2 statistics, with df = 1) in parentheses

* p < 0.15, ** p < 0.10, *** p < 0.05, **** p < 0.01.

So, this study investigates the impact of the body mass index on the mortality rate from stroke by gender of the patient. Consequently, the findings of this study might have an impact on clinical and public health issues, as well as on the epidemiologic studies. It might also affect the well-being and the longevity of the population, thus leading to higher productivity of workers (i.e., the population) and to the long-term surplus of the national economy.

**ROBUSTNESS CHECK**

This section examines the behavior of regression coefficient estimates of the model used in this paper when other specifications of this model are used. The several variables of secondary importance, such as Alcohol Consumption (AC) and Smoking (SM) were included into the model. Consequently, some variables such as Gender (male), Body Mass Index (BMI) and The Interaction Term (male×BMI) have been a little bit attenuated, while the coefficients and significance levels of other variables such as Age (age), Systolic Blood Pressure (SBP), Blood Cholesterol (BC), Blood Glucose Level (BGL) stayed the same. The multicollinearity does not exist (VIF < 3.0 for all variables).

Table 3

**ROBUSTNESS CHECK, REGRESSION TABLE**

| Explanatory Variable | Coefficient [Exp(B)] | Coefficient [Exp(B)] |
|---|---|---|
| Gender (*male*) | 0.002* (2.085) | 0.004<br>(1.503) |
| Body Mass Index (*BMI*) | 0.858** (2.925) | 0.859* (2.669) |
| The Interaction Term (*male*×*BMI*) | 1.287* (2.574) | 1.222<br>(1.421) |
| Age (*age*) | 1.136**** (22.524) | 1.129**** (19.739) |
| Systolic Blood Pressure (*SBP*) | 1.154**** (45.987) | 1.149**** (41.935) |
| Blood Cholesterol (*BC*) | 0.766<br>(0.371) | 0.761<br>(0.390) |
| Blood Glucose Level (*BGL*) | 1.679**** (9.013) | 1.874**** (10.370) |
| Alcohol Consumption (*AC*) | | 0.988* (2.385) |
| Smoking (*SM*) | | 1.132**** (6.913) |
| Intercept | 0.000**** (34.394) | 0.000**** (29.534) |

the Wald statistics (i.e., t2 statistics, with df = 1) in parentheses

* p < 0.15, ** p < 0.10, *** p < 0.05, **** p < 0.01.

According to the Robustness Check Table:

It seems that 1 unit increase in BMI will 0.859 times increase the risk of mortality from stroke among the

patients who had either stroke or pre-stroke condition. Furthermore, 1 year increase in the age of the patient will 1.129 times increase the risk of mortality from stroke, while 1 unit increase in the systolic blood pressure of the patient will 1.149 times raise the mortality rate from stroke. Also, 1 unit increase in the blood glucose level of the patients will raise the risk of mortality from stroke by 1.874 times.

Alcohol Consumption and Smoking also affects the mortality rate from stroke positively, such that one unit increase in each of these factors will raise the stroke-related mortality risk by 0.988 and 1.132 times respectively.

**CONCLUSION**

In the analysis conducted in this paper, the data from the statistics division of the medical organization "City Hospital No.1" of town Taraz, Zhambyl Region, Kazakhstan was used in order to investigate the impact of the body mass index of the patient on the mortality rate from stroke according to the gender of the patient, and to identify other physiological and habitual factors of the patients that are most significant in determining the mortality from stroke. The analysis found that the body mass index of the patient is a significant factor in determining the mortality from stroke irrespective of the gender of the patient. Furthermore, the age of the patient, the systolic blood pressure and the blood glucose level are significant factors in predicting the outcome for a patient's mortality from stroke. These factors are all statistically significant at 1% (i.e., not including the body mass index, which is statistically significant at 15%). However, the gender and the blood cholesterol level of the patient do not affect the mortality from stroke at all. These results may have important policy implications for all countries, since most of the factors contributing to the mortality from stroke are preventable. Hence, reducing the high systolic blood pressure and the high blood glucose level of patients will lead to higher survival rates of the population.

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## ВЗАИМОСВЯЗЬ ИНДЕКСА МАССЫ ТЕЛА И РИСКА ИНСУЛЬТА В ГЕНДЕРНОМ РАЗЛИЧИИ

### На примере Жамбылской области, Казахстан


**Аннотация**

В этой статье анализируется, имеет ли увеличение индекса массы тела больший риск смертности от инсульта среди мужчин, чем среди женщин, на примере Жамбылской области (Казахстан), по итогам первого квартала 2018 года с использованием бинарной модели логистической регрессии. Делается

вывод о том, что увеличение индекса массы тела имеет больший риск смертности от инсульта как среди мужчин, так и среди женщин (т.е. независимо от пола), а также увеличение возраста пациента, увеличение систолического давления крови и повышение уровня глюкозы в крови приводит к большему риску смертности от инсульта.

**Ключевые слова:** инсульт, масса тела, пол, систолическое артериальное давление.

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# ГЕНДЕРЛІК ӨЗГЕШЕЛІКТЕРДЕГІ ИНСУЛЬТТЫҢ ТӘУЕКЕЛІ МЕН ДЕНЕ МАССАСЫ ИНДЕКСІНІҢ ӨЗАРА БАЙЛАНЫСЫ

## Жамбыл облысы мысалында, Қазақстан

**Аңдатпа**

Бұл мақалада дене массасы индексінің жоғарылауына байланысты әйел адамдарға қарағанда ер адамдар арасындағы инсульттан болатын өлім тәуекелінің артуы талданған. Зерттеу Жамбыл облысының (Қазақстан) 2018 жылғы бірінші тоқсан қорытындысы бойынша логистикалық регрессия бинарлық моделін қолдану арқылы жүргізілген. Дене массасы индексінің жоғарылауы әйел адамдар арасында да, ер адамдар арасында да (яғни жынысына тәуелсіз) инсульттан болатын өлім тәуекелін арттыратындығы, сонымен қатар пациенттің жасының ұлғаюы, систоликалық қан қысымының жоғарылауы, қан құрамындағы глюкоза деңгейінің артуы де инсульттан болатын өлімнің жоғары тәуекеліне алып келетіндігі жөнінде қорытынды жасалынған.

**Негізгі сөздер:** инсульт, дене массасы, жыныс, систолалық қан қысымы