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Thesis paper

The effectiveness of screening program: The Case of Cardiovascular Diseases in Kazakhstan

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Abstract

Cardiovascular diseases (CVDs) are ones of the major death-causing issues in Kazakhstan which are needed to be solved. Different programs have been implemented in order to reduce the incidence of CVDs and the screening program is the one of them. The aim of this research is to identify the effectiveness of the screening program through assessing the hospitalization of the patients. After adjusting inclusion and exclusion criteria, the data obtained from polyclinic #5 of Astana contained medical records of 12 191 people in the age group of 41-59. Logit regression model analysis was used to find the significance of the independent variables and its effects. Additionally, average marginal effects were considered to represent the change in probability of outcomes. The results show that influence of the screening participation is not high enough to conclude that hospitalization depends on it. On the other hand, patients that participated twice in the program had lower chances of being hospitalized.

Keywords: screening program, cardiovascular disease, screening effectiveness

Introduction

Since the introduction of the first screening program, it has shown outstanding results in terms of early detection of diseases (Morabia & Zhang, 2004). Many lives were saved, which is crucial from ethical point of view. However, the effectiveness of the program is still debated by economists. Stout et al. (2006) suggest that the screening campaigns are too costly to implement. While Hackl et al. (2015) say that the screening programs bring even higher costs to the patients themselves in future. The defenders of the program talk about future savings that can be even greater than costs(Kones, 2011).

According to International Agency for Research on Cancer (WHO, 2005), four methods have been used to assess the effectiveness of screening:
(i) individual-based studies using case-control or cohort designs; (ii) correlating screening activity with changes in mortality or incidence rates across time, place or age group; (iii) modelling of screening policy and practice to estimate effectiveness; (iv) evaluation of operational parameters of screening. The latter includes screening performance indicators such as participation, quality and adequacy of follow-up of positive test results.

This research paper investigates the effectiveness of screening program on early detection and prevention of cardiovascular diseases corresponding to the 2nd method provided above through the prism of labor supply.

I expect that the screening program is effective in sustaining high level of labor supply. In Kazakhstan, every patient with cardiovascular disease is registered and given recommendations about their diet and physical activity. Since CVDs are the most common illnesses in the country (WHO, 2015), to combat the problem government guarantees full medical care for the patients. Consequently, citizens of Kazakhstan are given medicine drugs against various diseases (CVDs included) on a free basis (Ministry of Justice, 2009).

This investigation can bring a significant contribution to the development of the screening programs, as the research is done using unique data set. Even if the paper does not touch the topic of costs and benefits, it will mainly be focused on human behavior. The data allows me to identify the importance of health screening to the people and, as a result, constitute whether the use of screening programs is effective for labor supply attachment.

Literature Review

One of the researches related to my study is conducted by Hackl et al. (2015). In the research, they use data on Austrian mass screening program that was launched in 1974. The authors study the effect of screening program on health expenditures and health status. They state that participation in screening program increases the expenditures on healthcare for the next several years. Thus, they conclude that the implementation of screening programs is not favorable to recommend.

While the previous research is conducted on many types of diseases, some other teams, such as Cole et al. (2002) and Hardcastle et al. (1996), focus only on screening of colorectal cancer. After analyzing the data, they identify that the cancer is rarely found among people participating in the screening program.

In fact, Rosendaal et al. (2016) clearly states that CVD is the leading reason of the mortality worldwide, especially in low- and middle-income countries. Furthermore, it is concluded that CVDs alter the productivity of the workers. The authors suggest that primary and secondary medical care including screenings as well as antihypertensive treatments provided by different health care organizations may help to identify and reduce the illness at the early stages. By doing the analysis, they find out that the screening programs are effective tool to identify the disease in Nigeria, though, only when it is provided to patients on the free basis.

Screening programs are the effective tools to identify CVDs to reduce the mortality caused by these diseases. It is found out that approximately 10% of men diagnosed with CVDs are associated with 25-30% of overall mortality rate (Grndal et al., 2015). Moreover, 50% of these men have the arterial hypertension. The authors suggest that the early detection of health problems related to CVDs will help to organize prophylactic actions such as drug therapies and the control of blood pressure. The study is evaluating the attendance and detection rates of screening programs for CVDs. As a result of the study, it is concluded that the distance to the screening location influences significantly on the attendance and decision to participate.

Zou et al. (2007) conduct the study that evaluates diagnostic tests via a non-parametric method of analysis, known as Receiver-operating model. The authors highlight the main issues that may arise while evaluating the effectiveness of the diagnostic programs. They include verification bias and measurement error. Verification bias may occur when those patients who were already known to have the disease are included into the analysis. Measurement error may occur, when patients that are imperfectly matched the desired characteristics are included into the analysis (Zou et al., 2007).

In my work, I do not have data on individual expenditures. The reason is that I suppose people not spending money on healthcare, because government is already supplying medicine and drugs on a free basis (medicine is given with prescription only). I focus my attention on CVDs, which are known to be ones of the most widespread diseases in Kazakhstan leading to more than 50% of deaths per year (WHO, 2014). As the health care in Kazakhstan is provided on the free basis, I suppose that the effect of the screening programs would be negative (decrease probability of labor supply loss) in Kazakhstan. In this study I will include the patients that are registered in particular polyclinics near their houses. Moreover, polyclinics are widely using mobile laboratories to access the patients on their workplaces. Therefore, I expect that the attendance of patients will be high and I will be able to receive more accurate results without many missing data. I will try to escape the errors shown above by excluding those patients that already have CVDs prior the screening process as well as including to the analysis only those patients that highly match the desired characteristics. The perfect match is a patient of ages 41-59, not registered as CVD positive.

Background information

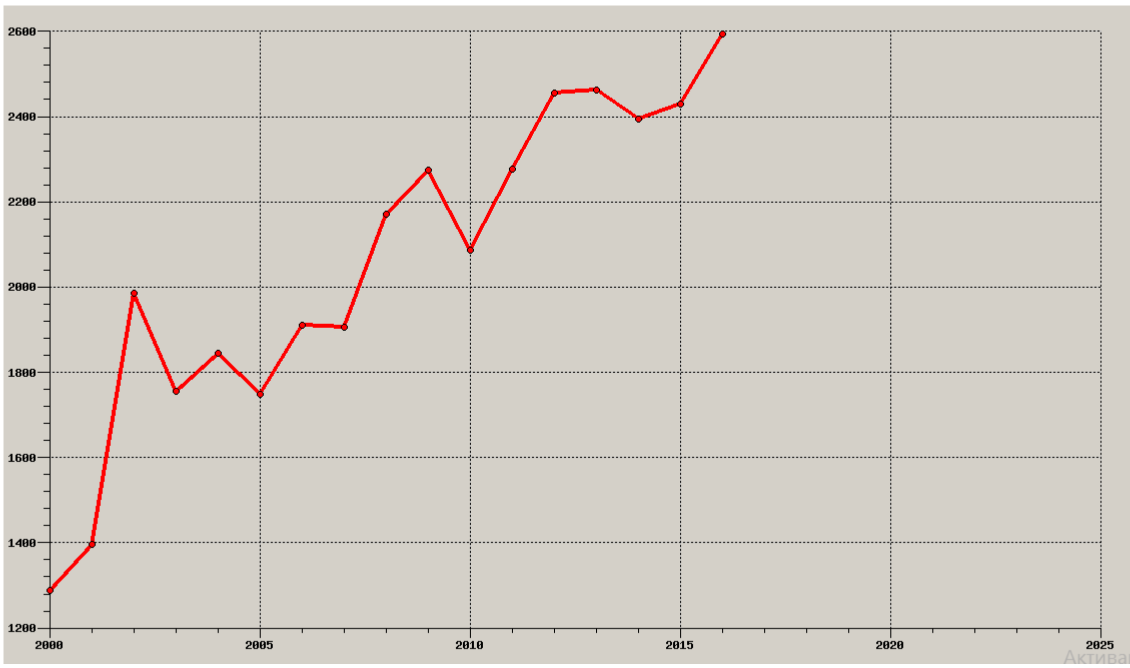
A well-developed healthcare system is essential to improve the quality of life in country. During the Soviet time, healthcare in Kazakhstan was based on Semashko model that was focused on provision of high numbers of hospital beds and doctors, instead of provision of good facilities and achieving positive outcomes. Therefore, there was centralized planning of the medical care (MacLehose, 2002). For instance, every citizen was provided with same free medical care. However, the main emphasis of this model was not on prevention, but on tertiary health care. According to WHO, in order to establish good health system, well-maintained facilities and policies should be organized (Health systems, n.d.).

After the collapse of Soviet Union, when Kazakhstan had faced the issues with the system of healthcare, new health system was aimed to be investigated. This time, the model targeted on prevention rather than on treatment was used as a base. Kazakhstan-2030 program was established in 1997 and one of the targets was to improve quality and productivity of labor force via investing in health care (Utegenova, 2015). After 1997, the program was modified and thus the healthcare in Kazakhstan moved to the next stage of development.

Programs such as Salamatty Kazakhstan or Densaulyk 2016-2019 were introduced. One of such programs is a screening program which was presented in 2008. The main goal of it was to identify the most life-threatening diseases at early stages and lower their effects on human health. The program targeted the most widespread diseases such as arterial hypertension, breast cancer and cervical cancer. In 2011, the program was expanded to cover some other diseases such as glaucoma, stomach cancer, diabetes and etc.

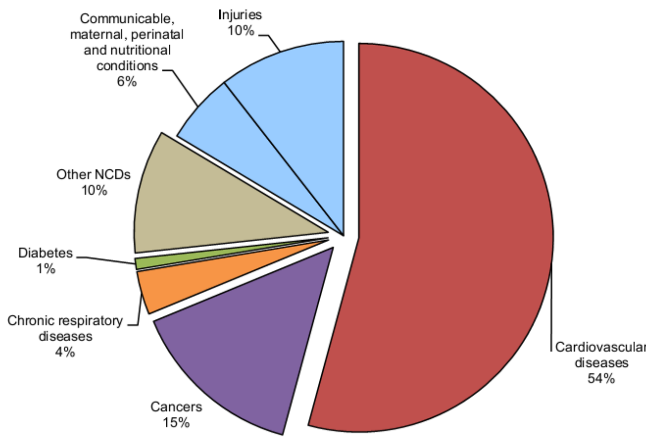
As cardiovascular diseases (CVDs) cause more than half of the fatalities in Kazakhstan (Townsend et. al, 2016), it is crucial to identify the disease at the early stages. One of the most common CVDs is arterial hypertension. According to Shinbolatova et. al (2014), the prevalence of this disease

Figure 1. New cases of of diseases of the circulatory system per 100 000 population Source: Data Presentation System Kazakhstan



was 24.1%. The number of explored cases associated with circulatory system steadily increases every year (Figure 1). Moreover, the mortality rate associated with CVDs has increased as shown in Figure 2. Approximately 40% of the deaths are found out to occur during active working age. Therefore, the screening age for cardiovascular diseases was set to between 34 and 64 years. However, as the level of detection was low, the range was later shortened to 40-64 years in 2009 (Ministry of Justice). Also the 64% of all deaths due to CVDs are among male population.

Figure 2. Deaths by cause in Kazakhstan. Source: World Health Organization



To deal with these issues, the State Health System of Kazakhstan came out with the screening program that aimed on early detection of CVDs and its risk factors. These screening programs were established in 2008 and the patients had an opportunity to take the screening tests on a free basis as well as get free treatment therapies. However, even after establishment of these programs the epidemiology did not change significantly. The possible reasons of that were the lack of response by population or not taking the disease seriously by population (Shinbolatova et al., 2014).

Data

In Kazakhstan, any citizen has a freedom to choose primary healthcare organization that will be providing healthcare services. However, after being registered in one of the organizations, other organizations do not provide any services, except emergency cases. In order to get the treatment, the patient needs to sign out of the previous medical organization and register again in the new one (Ministry of Justice, 2015). Consequently, the primary healthcare organizations have the lists of screening participants that are registered to them. In Astana, there are 12 polyclinics and 7 health centers that are responsible for primary healthcare. In this study, I used the data from Polyclinic 5 only as the rest of the data is restricted. The panel data contains medical records of 68 596 people on gender, age, screening participation and

Table 1: Summary statistics of the data set

Variable	Year	Treated	Not treated	Total mean
Hospitalization	2012	.0229787	.0289362	.0281355
	2013	.0392927	.0255403	
	2014	.0241449	.028169	
	2015	.0363973	.0277606	
Age	2012	49.20851	48.78894	49.0228
	2013	50.06876	48.65324	
	2014	48.57867	49.17062	
	2015	50.00802	48.7261	
Male	2012	.4034043	.452766	.4444262
	2013	.4238703	.456778	
	2014	.4676056	.4430584	
	2015	.4324491	.4441703	

CVD morbidity. The data for gender, age and screening participation were easily available, while the data on visits to the doctors and emergency calls related to the CVD morbidity were digitized manually. Moreover, because the attached population is changing almost every day (due to migration), I use only the participants who have been attached to the polyclinic 5 for the whole time period in my research.

As I am interested only in the effectiveness of the screening program which has spillover effects on labor supply, I focus on the age group 41-59. I omit those people that already had cardiovascular diseases before the time scale of my research. As a result, after analyzing inclusion and exclusion criteria, the records on 12 191 people were selected, of whom: 5 418 men and 6 773 women; 343 of them were served by medical organization in 2015-2016 with CVD diagnoses and 11 848 did not.

One important note to make is that if a patient visits medical organization without being on the list, he is not counted as screened. This point again prooves the randomness of the data.

One of the main variables that could have great importance in the model is income level. I expect that people with higher income are less exposed to CVDs due to better diet and lower level of stress. On the other hand, since all the medical needs are supplied for free, it is possible that income level would play a major role in hospitalization occurrence. However, due to unavailability of this information in open access data, I omit it in my model.

The research might have information biases that could bring measurement errors. For example, it might be that medical personnel could make a mistake while registering the patients in the digital database. Another reason could lie in handwritten journals. Sometimes it happens that a name was misspelled or the diagnosis was written incorrectly. In addition, the data error could be in the screening results.

Model

To analyze the effect of screening program I use logit regression model. The logit model is used in statistics when the regression is run on the dependent variable that has only 2 values. Specifically, the logit regression shows the probability that an observation with particular set of characteristics will have one of the values (Freedman, 2009).

Since I do not have data for labor supply, I use the data on hospitalization as a proxy for it. I assume that labor supply decreases every time the patient is visiting the hospital. Therefore, my dependent variable is the hospitalization data. The data account for the visits in hospital that lasted more than 3 days (up to one month). The hospitalization data is shown as a binary variable, where 1 means that the patient visited the hospital or called emergency services within a year and 0 otherwise.

The independent variables in my research are age, gender and screening participation. Both gender and screening participation data are dummy variables that equal to 1 if the patient is male and participated in the screening program, respectively. The age data vary between 41 and 59 years. Since the data on screening differ for every year, I use dummies to differentiate them.

A simple linear regression model would be:

$$pr[hosp = 1|x] = x\beta,$$

where: - the dependent variable, indicating whether the patient was hospitalized within a surveyed year or not; - the set of independent variables: age of the patients and dummies for gender and screening participation. However, this model does not restrict probabilities between values 0 and 1. Consequently, the results of the regression are not considered as reliable.

The logit regression model is as follows:

$$pr[hosp = 1|x] = F(x\beta) = \frac{e^{x\beta}}{1 - e^{x\beta}},$$

where $F(x\beta)$ is the CDF of logistic distribution. Using this model, we can find the significance of the independent variables and their effects (positive/negative). However, to find their magnitudes I use the average marginal effects, which represent the change in probability of outcome being equal to 1 when an independent variable is changed by one unit.

Results

The overall results can be seen from the Table 2 below. The column (1) shows the overall logit regression. The last 4 regressions show separate logit regression for ages 41-45 (2), 46-50 (3), 51-55 (4), 56-59 (5).

The regression analysis shows negative and non-significant effect of screening participation on hospitalization outcome. Overall, the age variable shows high significance to the hospitalization. The sign of the coefficients assumes that as people get older, the probability of hospitalization increases. The variable depicting the gender of the patients, male, showed high significance only in the older ages. It assumes that men have higher chances of getting hospitalized than women. Overall, however, the gender variable is not significant.

Table 3 shows the average marginal effects in each case. The following coefficients show how 1 unit increase of a variable affect the probability of hospitalization.

The most significant result was found in the importance of age. It was found out that age variable is positively related to hospitalization.

In case of gender differences, the probability of males getting hospitalized is higher by 4.43% between ages 56-59, meaning significant difference with females. In other regressions, the coefficient for gender is not enough to make sense.

Among variables representing screening programs, scrn2013 showed positive relationship with hospitalization. This means that patients that participated in screening program in the year 2013 had more chances of getting hospitalized. This is particularly true for the patients aged 51-55. On the other hand, the scrn2014 in the regression of ages 39-45, vice versa, has negative relationship with hospitalization.

Overall, the main variables in my research showed in most of the regressions negative sign. However, due to high variation around zero I assume that the effect is not meaningful.

In addition, I also checked whether participation in screening 2 times plays role in this model. Here, var1214 show that the patient participated in screening in 2012 but did not in 2014; var1412 show that the patient participated in screening in 2014 but did not in 2012; and var12141 shows that the patient participated in both screenings. The same is with var1315, var1513 and var13151. However, in this amalysis I omit var1513 due to perfect failure, which means that it is not playing any role in the analysis.

This model shows the same results for the age and gender variables. One of the findings of this model is that the coefficients for var1214 and var1315 are greater than for var12141 and var13151 respectively. This means that patients passing the screening twice have lower chances of hospitalization occurrence.

For better interpretation of the results I use average marginal effects in Table 5. There you can see the magnitudes of the relationship between the dependent and independent variables. A patient passing the screening in both 2012 and 2014 have approximately 1.5% lower probability of hospitalization than a patient passing screening only in 2012. In addition, he/she has 1.3% lower chances than 2015 screening participant. A patient passing the screening in both 2013 and 2015 have approximately 0.8% lower probability of hospitalization than a patient passing screening only in 2013.

Table 2. Logit regression model

	Ages 41-59 hosp	Ages 41-45 hosp	Ages 46-50 hosp	Ages 51-55 hosp	Ages 56-59 hosp
hosp					
male	0.192	-0.517	0.174	-0.0227	0.952***
	(1.74)	(-1.70)	(0.72)	(-0.13)	(4.14)
age	0.637**				
	(2.76)				
age2	-0.00535*				
	(-2.35)				
scrn2012	-0.173	0.260	-0.427	-0.0826	-0.0787
	(-0.81)	(0.41)	(-1.03)	(-0.22)	(-0.20)
scrn2013	0.496*	0.293	0.320	0.740*	0.00778
	(2.14)	(0.44)	(0.47)	(2.42)	(0.01)
scrn2014	-0.00794	-1.090*	0.243	0.104	0.0448
	(-0.05)	(-1.98)	(0.88)	(0.38)	(0.16)
scrn2015	-0.277	0.0221	-0.241	-0.386	-0.0347
	(-1.09)	(0.03)	(-0.32)	(-1.16)	(-0.06)
_cons	-22.05***	-4.057***	-3.956***	-3.249***	-3.474***
	(-3.79)	(-20.60)	(-19.80)	(-22.14)	(-16.91)
N	12191	3894	3376	3124	1797

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3. Average Marginal Effects

	Ages 41-59 hosp	Ages 41-45 hosp	Ages 46-50 hosp	Ages 51-55 hosp	Ages 56-59 hosp
hosp					
male	0.05	-0.0067	0.0036	-0.0009	0.0443***
	(1.74)	(-1.66)	(0.72)	(-0.13)	(3.91)
age	0.017**				
	(2.73)				
age2	-0.000145*				
	(-2.34)				
scrn2012	-0.005	0.0034	-0.0088	-0.0033	-0.0037
	(-0.81)	(0.41)	(-1.02)	(-0.22)	(-0.20)
scrn2013	0.013*	0.0038	0.0066	0.0299*	0.00036
	(2.13)	(0.44)	(0.47)	(2.38)	(0.01)
scrn2014	-0.00022	-0.014*	0.005	0.042	0.0021
	(-0.05)	(-1.91)	(0.87)	(0.38)	(0.16)
scrn2015	-0.007	0.00029	-0.005	-0.0156	-0.0016
	(-1.09)	(0.03)	(-0.32)	(-1.15)	(-0.06)
N	12191	3894	3376	3124	1797

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4. Logit regression model with several cases

	Ages 41-59	Ages 41-45	Ages 46-50	Ages 51-55	Ages 56-59
	hosp	hosp	hosp	hosp	hosp
hosp					
male	0.191	-0.510	0.173	-0.0283	0.946***
	(1.73)	(-1.68)	(0.72)	(-0.16)	(4.11)
age	0.633**				
	(2.74)				
age2	-0.00531*				
	(-2.33)				
var1214	0.0871	0.364	-0.713	0.409	0.249
	(0.32)	(0.49)	(-0.98)	(0.93)	(0.51)
var1412	0.0761	-1.022	0.189	0.287	0.163
	(0.47)	(-1.69)	(0.63)	(1.00)	(0.53)
var12141	-0.403	-0.991	-0.0683	-0.497	-0.370
	(-1.34)	(-0.97)	(-0.14)	(-0.83)	(-0.61)
var1315	0.517*	0.607	0.218	0.747*	-0.0543
	(2.18)	(0.99)	(0.30)	(2.37)	(-0.09)
var13151	0.234	0.225	0.0934	0.399	0.0215
	(1.54)	(0.57)	(0.23)	(1.78)	(0.07)
_cons	-21.95***	-4.065***	-3.940***	-3.282***	-3.497***
	(-3.77)	(-20.43)	(-19.59)	(-21.95)	(-16.83)
N	12191	3894	3376	3124	1797

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5. Average Marginal Effects

	Ages 41-59 hosp	Ages 41-45 hosp	Ages 46-50 hosp	Ages 51-55 hosp	Ages 56-59 hosp
hosp					
male	0.0052	-0.0066	0.0036	-0.0011	0.0441***
	(1.73)	(-1.64)	(0.72)	(-0.16)	(3.89)
age	0.0172**				
	(2.71)				
age2	-0.0001*				
	(-2.32)				
var1214	0.0024	0.00469	-0.0147	0.0165	0.0116
	(0.32)	(0.49)	(-0.97)	(0.93)	(0.51)
var1412	0.0021	-0.013	0.0039	0.0116	0.0076
	(0.47)	(-1.65)	(0.63)	(1.00)	(0.53)
var12141	-0.0109	-0.0128	-0.0014	-0.0201	-0.0172
	(-1.33)	(-0.97)	(-0.14)	(-0.83)	(-0.61)
var1315	0.014*	0.0078	0.0045	0.03*	-0.0025
	(2.17)	(0.99)	(0.30)	(2.34)	(-0.09)
var13151	0.0063	0.0029	0.0019	0.0161	0.001
	(1.53)	(0.57)	(0.23)	(1.77)	(0.07)
N	12191	3894	3365	3111	1791

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Discussion

In this study, I expected that the screening program with its so many advantages will have significant effect in decreasing hospitalization outcome. In addition, I assumed that as people get older the chances of unexpected health issues increase, too. In case of gender, the national statistics on mortality rates have made me to believe that males are much less aware of own health. Consequently, they are getting to hospital more often.

The results, however, did not meet my expectations fully. It was found that screening program participation did not play significant role in decreasing hospitalization frequency among the observed population. I suppose that patients participating in the screening program failed to control own diet or use opportunities provided by government on a free basis such as medicine and healthcare services. The incidence of hospitalization among both groups was almost the same. The age variable showed high significance for hospitalization. It was found that as people get older, the chances of being hospitalized increase, even though the rate of increase is declining. The gender variable, on its turn, was not significant factor up to the age group of 56-59. In this case, males have higher chances of hospitalization than women.

The outcomes of the analysis have several implications. Firstly, insignificance of the variable representing screening participation can be used in reevaluation of the government funding in the program. One of the recommendations I can make is to decrease the funding of medicine drugs to registered patients. In addition, I suggest medical organizations to increase awareness of the male population regarding self-care.

One of the limitations of this study is that I do not have data on the severeness of the diseases that are found among the population. One could find out about own CVD on the latest stages, when only stationary healthcare is effective. However, since the program was launched in 2008 and it screens up to 50% of population of selected ages, the chances of revealing patients with severe CVD is very low. On the other hand, the medical personnel do not have rights to force people to pass screening.

Another limitation is that my study was made only on cardiovascular diseases, which is only one out of 9 screening procedures that are made in the program. Consequently, the results do not fully show the effectiveness of the program that is highly respected internationally.

Regarding future studies, I suggest to add more variables, for instance the severeness of the disease or data on other screening procedures. In addition, this study can be implemented in all hospitals to assess the effectiveness of the screening program on whole Astana population.

Conclusion

This paper investigated the effectiveness of the screening program on labor supply on example of cardiovascular diseases in one of the city policlinics. Study was conducted among men and women aged 41-59. The data was analyzed using logit regression. It was revealed that the effectiveness of the screening program is low, meaning that the participation does not influence on probability of hospitalization. On the other hand, the analysis showed that repeated screening lowers the chances of hospitalization. Moreover, possible sources of error and limitations were identified as well as future directions were suggested.

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