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TOWARDS THE EFFICIENT USE OF PUBLIC HEALTHCARE RESOURCES IN CROATIA[1]

PRIJEDLOG ZA EFIKASNO KORIŠTENJE ZDRAVSTVENIH RESURSA U REPUBLICI HRVATSKOJ

ABSTRACT

Rational and efficient use of pubic resources is crucial in order to reduce the healthcare costs and consequently to decrease the problem of excessive indebtedness of public healthcare providers in Croatia. Given the growing prevalence of chronic disease (e.g. cancer), secondary prevention (screenings of risky population) has the potential for achieving significant savings in the health care system. Nowadays, many national health care systems are focusing on disease preventing activities. Pap test is proven to be the most cost-effective method of early detection of cervical cancer. Unfortunately, with the model of opportunistic screening a large percentage of women rarely undergo the Pap test, which points to a need for an organized screening program. One of the goals of such programs is to detect a larger population of women with pathological cell changes. The purpose of this paper is to analyze the justification for the implementation of organized screening for cervical cancer by examining the relationship between the number of Pap tests and number of pathological Pap test results as a share in abnormal Pap test results.

The estimation is carried out within vector autoregressive (VAR) model and Granger causality testing. Standard Granger causality analysis was helpful in establishing the direction of causal links between the variables of interest, while the signs of these relationships are examined by using impulse response function. Findings suggest that there is a unidirectional causality that

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runs from number of conducted Pap smears to the share of pathological in abnormal Pap results. Also, results indicate that Pap smears cause a positive response in the share of pathological in abnormal Pap results. This indicates that as the number of conducted Pap smears increases (which can only be done as part of organized screening programs) there will be more cases of an early detection of disease, which could result in healthier population and decrease in health care costs, resulting in less insolvency problems for individuals as well as for the public health care.

Keywords: *organized screening, Pap test, Granger causality, effectiveness, indebtedness*

SAŽETAK

Racionalno i efikasno korištenje zdravstvenih resursa ključno je za smanjivanje troškova javne zdravstvene zaštite te posljedično za rješavanje problema pretjerane zaduženosti pružatelja javnih zdravstvenih usluga u Republici Hrvatskoj. Obzirom na rastuću prevalenciju kroničnih bolesti (primjerice, karcinoma), sekundarnom prevencijom (probir rizične populacije) moguće je ostvariti značajne uštede u zdravstvenom sustavu. U sladu s time, mnogi se nacionalni zdravstveni sustavi okreću ka prevenciji bolesti i preventivnim aktivnostima. Papa test je dokazano troškovno efikasna metoda ranog otkrivanja bolesti, ali se uz oportunistički probir populacije veliki broj žene ne podvrgava pregledu, što upućuje na potrebu za organiziranim programima probira. Jedan od ciljeva ovakvih programa je otkriti populaciju žena s patološkim promjena stanica, a svrha ovog rada je analizirati opravdanost implementacije organiziranog probira ispitujući odnos između broja Papa testiranja i broja patoloških rezultata u ukupnom broju abnormalnih rezultata Papa testiranja.

Analiza je provedena koristeći model vektorske autoregresije (VAR) i Grangerov test kauzalnosti. Standardna Grangerova analiza kauzalnosti ukazala je na smjer kauzalne povezanosti između promatranih varijabli, dok su predznaci analizirani funkcijom impulsnog odaziva. Rezultati ukazuju na smjer povezanosti od broja provedenih Papa testiranja prema udjelu patoloških u abnormalnim rezultatima Papa testa. Također, rezultati ukazuju da porast broja Papa testiranja uzrokuje pozitivni odaziv udjela patoloških u abnormalnim rezultatima Papa testa. Sukladno rezultatima, može se zaključiti da kako se povećava broj provedenih Papa testiranja (što se može učiniti samo putem organiziranih programa probira) bit će više slučajeva rane detekcije bolesti, što u konačnici može rezultirati zdravijim stanovništvom i smanjenjem troškova zdravstvene zaštite, odnosno smanjivanjem problema insolventnosti kod stanovništva kao i zdravstvenog sustava u cijelosti.

Ključne riječi: *organizirani probir, Papa test, Granger kauzalnost, efektivnost, zaduženost*

1. Introduction

With regular screening tests and follow-ups, cervical cancer is the easiest gynecologic cancer to prevent (Arbyn et al. 2010) and Pap test is still the best and cost-effective morphological test for cell abnormality due to its simple use for physicians, acceptability for patients and high test sensitivity (NCI, http://seer.cancer.gov/statfacts/html/cervix.html). The Pap test (or Pap smear) looks for cell changes on the cervix that might become cervical cancer if they are not treated appropriately. Its purpose is to prevent cervical cancer and identify women with CIN II and more severe lesions (CIN II+).

The number of provided annual Pap tests in Croatia varies around 230,000, but many women never took the Pap test and cervical cancer still causes the deaths of more than 100 women

annually (National program for early detection of cervical cancer, 2010). This is in accordance with many middle-income developing countries where opportunistic cervical screening programs tend to be ineffective, as adequate coverage does not extend to the majority of women with high risk (WHO, 2002; Anttila et al. 2004).

A well-organized screening is proved (Nieminen et al. 1999; Madlensky et al. 2003) to be more efficient than opportunistic (spontaneous) screening (it is more effective, costs less, and results in less harm than the spontaneous one), partly because screened women tend to be in high risk for the disease. The goal of organized cervical cancer screening (in its first phase) is to detect as many women with pathological cells change in early stage of the disease, which could improve the probability of cure and decrease costs of invasive cervical cancer. After certain time since the introduction of screening program, it is expected that effective screening (attendance rate of target population grater than 80 percent) would lead to increase in the number of Pap test diagnosis that does not imply pathological cells change (second phase). It is estimated that 80-91 percent cases of invasive cervical cancer could be prevented with screening interval of every three years (National program for early detection of cervical cancer, 2010).

Considering the above stated findings, the purpose of this paper is to analyze the need for an organized program of cervical cancer screening which in the long run should result in positive epidemiological and sociological implications, along with cost savings within public health care system. Empirical investigation was conducted using data on monthly basis from 2007 to 2012 by examining the relationship between the number of Pap smears and pathological Pap results as a share in overall abnormal Pap results. As the goal of organized cervical cancer screening is to include women who avoid Pap screening but are in the group with pathological Pap results (CIN II and CIN II+), justification for the introduction of screening program can be found in positive relationship between the number of performed Pap smears and number of pathological Pap results as a share in overall abnormal Pap results. If this relationship was negative it would mean that current opportunistic cervical cancer screening is already accomplishing the long term goal of organized screening and it would be more prudent to allocate resources in other purposes.

2. Economic implications of cervical cancer screening

Poor health and chronic illness can affect the economy through spending and savings (capital formation), as well as the level of education (Suhrcke et al. 2006). Reduced (due to illness) household consumption and the level of education have a negative impact on gross domestic product, while at the same time expenditures for chronic diseases across Europe are taking an increasingly large share in the government and private consumption. Empirical research at the micro level shows that chronic diseases reduce wages, earnings, labour force participation and productivity while, also, affecting early retirement, disability benefits and high rate of employee turnover (Busse et al. 2010). Therefore, it is necessary to redesign the public health system towards a model of integrated care (Pelletier et al., 2009) with a focus on chronic disease management (McKee & Nolte, 2004) and to ensure greater sensitivity to patients' needs and preferences, consequently increasing the efficiency of the provision of public healthcare.

The prevention of chronic diseases that reduces morbidity and disability has a significant part in integrated medicine and there is a growing interest towards the prevention (Clarke, 2010). Given that in times of crisis the burden of chronic disease is increasing, preventive interventions are becoming more important as they affect the maintenance and improvement of the population's health, therefore reducing government spending on the sick leave and disability benefits (Wei-Hua et al., 2010; Sassi & Hurst, 2008). Also, the effective use of the prevention helps to reduce

the need for curative care and the associated high costs of medical treatment (Wei-Hua et al., 2010; Sassi & Hurst, 2008) which is of great importance nowadays. According to National Social Marketing Centre (2010) in Great Britain, every improvement by one percent in quality of health due to health preventive program leads to costs savings in public health in GBP 190 mills. Moreover, investment in prevention is not only in the interest of the government but also in the interest of the employers (Pelletier et al., 2009), who can save 2-3 dollars on average in costs associated with the loss of productivity due to employee illness only by spending a dollar on medical/pharmaceutical costs.

The effectiveness of cervical screening programs has been demonstrated in several countries (Advisory Committee on Cancer Prevention, 2000), and Pap smears are considered to be the successful method of prevention and early detection of cervical cancer. Apart from the reduction of medical costs, screening implies significant benefits for families, business and broader society (Brow, Lipscomb & Snyder, 2001). Compared to other disease preventive interventions and accepted baseline cost-effectiveness ratio, cervical cancer screening is highly cost-effective (Eichler et al., 2004) with relative costs and benefits of screening varying upon the age of target populating and the interval of screening (Goldie, 2006). Moreover, organized screening program with active invitation activities could improve participation and equity of access to the preventive health care thus allowing educational (Espinas et al. 2011) and socioeconomic (Segnan, 1997) gap to narrow.

In Croatia the cost of treating one patient with cervical cancer varies around HRK 100,000. This means that annual medical costs of treating around 350 women in the age of 25 to 69 goes beyond HRK 35 mills. If incidence of cervical cancer were to decrease by 60 present, annual medical costs could decrease by HRK 20-30 mills, leaving behind much healthier population. Only the funds that could have been saved on the sick leaves of women treated for invasive cancer would be enough to cover the costs of acquisition and maintenance of technical equipment along with education of public health care providers.

3. Data and methodology

There is agreement that cytology indicative of high-grade lesions (CIN II-III or moderate and savere dysplasia plus carcinoma *in situ* or (acording to Bethesda system) HSIL - high-grade squamous intraepithelial lesion) should be followed by immediate referral for colposcopy. On the other hand as the large majority of low-grade lesions (LSIL - low-grade squamous intraepithelial lesion or ASCUS - atypical squamous cells of undetermined significance) resolve spontaneously (WHO, 2002), women can be followed with regular cytology and only referred for colposcopy if repeat smears at 6-month intervals show evidence of cytological progression (Miller et al. 2000).

Considering above-mentioned, in examining the interactions between variables, the following vectors of time series are examined. One observed variable was the share of Pap results that indicated pathological cell change (or high-grade lesions) in overall number of abnormal Pap results (both low-grade and high-grade lesions). The second variable was the number of Pap smears that were taken by gynecologist in primary health care which was expressed in natural logarithms in order to stabilize its variance. Time series consist of monthly data in period 1M2007 – 12M2013. The data were obtained from cytology laboratory of the Clinical Hospital Centre Rijeka and encompassed the Pap smears taken by gynecologists in primary health care from Primorje-Gorski Kotar County. The analyzed data are not publicly available, making this research unique.

Since we opted for time series approach, based on diagnostic testing we choose a vector autoregression analysis as appropriate time series technique. Vector autoregression (VAR) has emerged as an important tool in the empirical analysis of time series in the early 1980s (Cooley, Dwyer, 1998). There are two basic applications of VAR methodology: testing theories and analysis of the dynamics phenomena between variables. The key property in the VAR model is the stationarity[2] of all variables included in the model. To examine the stationarity of variables, it is necessary to apply well known unit root tests such as Augmented Dickey-Fuller test (ADF) and Phillips-Peron test (PP). In this sense, if variables are not stationary they have to be transformed to become stationary and as such, included in VAR models.

Also, VAR methodology cover an analysis of causal variables in the model (Granger causality), innovative analysis, which is a common term for the analysis of the impulse response function (IRF - Impulse Response Function) and analysis of variance decomposition (DVC - Decomposition of Variance). Results of innovative analysis provide the same information, but presented in a form suitable for interpretation and conclusions (Bahovec and Erjavec, 2009).

It the paper, we used general unrestricted VAR model (Sims, 1980) that assumes no constraints on the parameters of the model, i.e. there should not be any a priori distinction between endogenous and exogenous variables.

Granger causality test (Granger, 1969) was used for determining the direction of causality between the number of Pap smears and the share of pathological in overall abnormal Pap results. Granger's test is a convenient and very general approach for detecting the presence of a causal relationship between two variables. A time series X is said to Granger-cause another time series Y if the predication error of current Y declines by using past values of X in addition to past values of Y. The application of the standard Granger's causality test requires that the series of variables to be stationary. If this is not the case, then two variables have to be first transformed to covariance stationary processes. This is usually done by taking their first differences. The Augmented Dickey-Fuller and Phillips-Perron test are used in examining the unit roots and stationary property of two variables. To test for Granger's causality between number of Pap smears (LPAPA) and the share of pathological in overall abnormal Pap results (PAT_ABN), two bivariate models are specified, one of Pap smears and another for the share of pathological Pap results. If two variables are stationary, the standard form of the Granger's causality test used in this paper can be specified accordingly as follows:

$$\Delta PAT\_ABN_t = \alpha_{11} + \sum_{i=1}^{n} \beta_{11i} \Delta LPAPA_{t-i} + \nu_{11t} \quad (1)$$

$$\Delta LPAPA_t = \alpha_{21} + \sum_{i=1}^{m} \beta_{21i} \Delta PAT\_ABN_{t-i} + \nu_{21t} \quad (2)$$

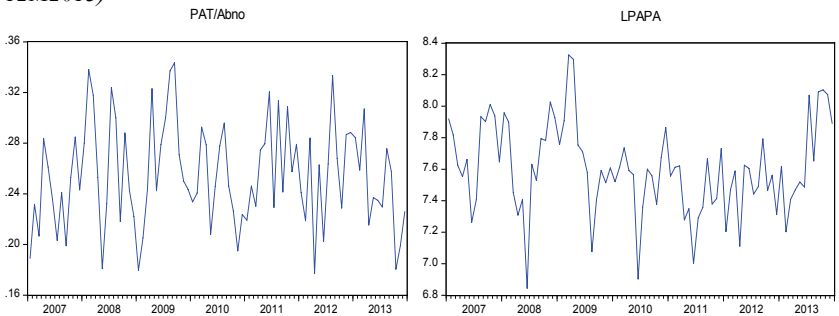
Also, the innovation analysis is used to obtain information concerning the interaction among the variables. It is possible to analyze the dynamics of the share of pathological in the overall abnormal Pap results in terms of the relative contribution of endogenous shocks and their transmission effects (Cooley, Dwyer, 1998). As we are interested in the analysis of impact of conducted Pap smears, the variance decomposition is performed on the share of pathological in abnormal Pap results.

[2] Mean and variance of underlying variable do not change over time, meaning that the series has no drift and is homoscedastic.

4. Empirical results (Unit root tests and VAR and Granger causality)

The initial step in the analysis is to determine the order of integration of the variables included in the analysis. The graph 1 presents time series variables in levels. Based on the graphical representation it can be assumed that the variables in levels are stationary, which can be confirmed by using the unit root tests.

Graph 1 *Share of pathological in abnormal Pap results and Pap smears in levels (1M2007 – 12M2013)*



Source: Authors calculation

Unit root tests are used to test for the existence of unit roots and identify the order of integration for each variable. Augmented Dickey-Fuller test (ADF) and Phillips-Perron test (PP) unit root tests are performed allowing for an intercept and a time trend. The optimal lag length for the VAR model was determined by using the sequential modified LR test statistic model selection criteria which indicated that the optimal lag is five. Unit root test for levels of Pap smears and share of pathological in abnormal Pap results in the period 2007-2013 are presented in table 1.

Table 1 *Unit root test results for share of pathological in abnormal Pap results and Pap smears (in levels)*

Variable	**ADF value, Constant incl.**	**ADF value, Constant and trend included**	**Phillips-Perron t, Constant incl.**	**Phillips-Perron t, Constant and trend included**
PA	-5.219 (0.000)	-5.183 (0.000)	-5.382 (0.000)	-5.358 (0.000)
ABN	-7.024 (0.000)	-6.982 (0.000)	-6.973 (0.000)	-6.926 (0.000)

Notes: Δ is the difference operator. MacKinnon (1996) critical values are used for the rejection of the hypothesis of a unit root (p-values in brackets).

ADF and PP test have the null hypothesis of non-stationarity, i.e. the underlying variable has a unit root. Based on the obtained results, at 1% significance, we can reject the presence of a unit root in levels for both variables and conclude that both series are stationary and a VAR model can be employed.

Validity of the chosen number of lags and stability of the VAR model can be tested by calculating the roots of the characteristic polynomial. VAR model is stable if all characteristic roots lie outside the unit circle.

Table 2 *Roots of characteristic polynomial*

Root	Modules
0.829380 - 0.335138i	0.894533
0.829380 + 0.335138i	0.894533
-0.254296 - 0.711901i	0.755956
-0.254296 + 0.711901i	0.755956
-0.680046 - 0.172654i	0.701621
-0.680046 + 0.172654i	0.701621
0.227537 - 0.656346i	0.694668
0.227537 + 0.656346i	0.694668
0.200502 - 0.186347i	0.273726
0.200502 + 0.186347i	0.273726

Source: Authors calculation

Since no roots lie outside the unit circle it can be concluded that VAR model satisfies the stability condition. VAR model (Table 3) has been evaluated and the results indicate that there is significant positive relationship, at 5th lag, between the number of Pap smears and share of pathological in abnormal Pap results. It means that an increase in the number of conducted Pap smears in the period t-5 raises the share of pathological in abnormal Pap results in the period t.

Table 3 *Results of the VAR model*

ıdent variable	**PAT_ABNO**
ABNO(-1)	0.2796 (0.1137) **[2.4572]**
'A(-5)	0.0561 (0.0181) **[3.094]**
ıared	0.257
R-squared	0.147
sq. resids	0.097
equation	0.038
istic	2.348
ikelihood	152.66
te AIC	-3.586
arz SC	-3.256
dependent	0.256
dependent	0.0409

Standard errors in parentheses and t-statistics in brackets
Source: Authors calculation

Since correlation does not signify causality, we are interested in the existence and the possible direction of causality between the two analysed variables. We proceed with the standard pairwise Granger causality test (1969) which is used to determine the existence and the direction of causality between the variables.

Table 4 *Results of the pairwise granger causality test between the share of pathological in abnormal Pap results and Pap smears*

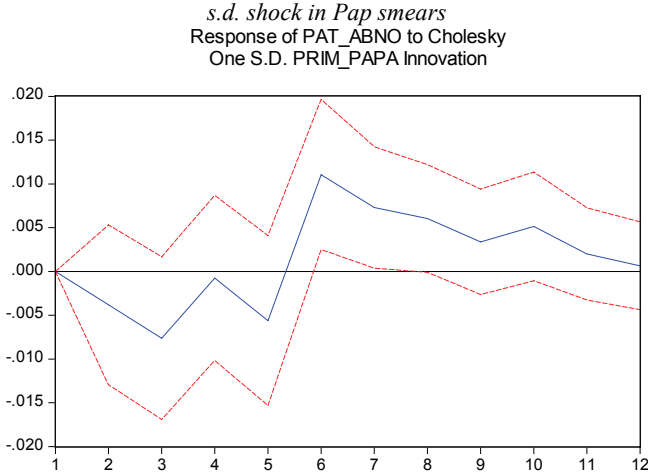
Null Hypothesis:	Obs	F - Statistic	Probability
ABN does not Granger Cause LPAPA	79	1.30099	0.2739
A does not Granger Cause PAT_ABN		**3.02753**	**0.0159**

Source: Authors calculation

Results shown in table 4 indicate that there is a unidirectional causality relationship between Pap smears and share of pathological in abnormal Pap results. The results show that number of Pap smears Granger causes the share of pathological in abnormal Pap results. These findings are expected due to the fact that organized screening program in Croatia was introduced in 2013 and it is in its first phase, with attendance rate of target population being only around 10 percent. Even more importantly, the results justify the introduction of an organized screening program. As increase in Pap smears causes increase in the share of pathological cell formations detected in the population, it means that women with high risk of cervical cancer are being detected as the number of conducted Pap smears in population increases. Within the organized screening in Croatia women who did not take the Pap test in last tree years are being invited for the Pap smear. Given this results, it can also be expected that increase in the attendance rate of target population of the screening program could enhance the early detection of cervical cancer.

Since analysis of Granger causality may not provide a full picture of the dynamic interactions between underlying variables, impulse response function based on orthogonal residuals and decomposition of variance was also performed.

Graph 2 *Impulse response function of the share of pathological in abnormal Pap results to one s.d. shock in Pap smears*



Source: Authors calculation

Impulse response function indicates the response of the share of pathological in abnormal Pap results (defined to be the response variable in the application of linear causality analysis at the 5% significance level) to a one s.d. (i.e. standard deviation) shock in Pap smears (defined to be the causal factor in the linear causality analysis). A one s.d. shock from Pap smears causes a positive response in the share of pathological in abnormal Pap results after five months (the

highest positive response was reported in 6 month). This probably can be explained by the fact that it usually takes tree to six month to get the cytology results for Pap smears.

Further analysis of the relationships between variables, can be explained by using the variance decomposition of the share of pathological in abnormal Pap results. Table 5 shows how the underlying variable responds to the shocks in a number of conducted Pap smears. As expected, the share of pathological in abnormal Pap results is largely explained by its own lagged shocks. However, the proportion of variance explained by the number of Pap smears is not negligible and during the one year period (12 months) time span, it reaches almost 16,5%.

Table 5 *Variance decomposition of share of pathological in abnormal Pap results*

I	S.E.	AT_ABNO	LPAPA
1	0.037767	100.0000	0.000000
2	0.039511	98.43041	1.569588
3	0.040073	95.72263	4.277370
4	0.040460	95.73045	4.269552
5	0.041029	93.39407	6.605930
6	0.042285	88.00247	11.99753
7	0.042743	86.13169	13.86831
8	0.043197	84.60049	15.39951
9	0.043431	84.35234	15.64766
10	0.043769	83.53195	16.46805
11	0.043808	83.51390	16.48610
12	0.043816	83.51531	16.48469
Cholesky Ordering: PAT_ABNO LPAPA			

Source: Authors calculation

In assessing the robustness of the estimated VAR model we conducted several residual tests. Based on the LM test statistics, none of the test statistics could reject the null of no serial correlation and heteroscedasticity in the residuals. The results of residual testing suggest that the estimated VAR model is unbiased and efficient. The residual normality test is computed using the Jarque–Berra statistic with Cholesky (Urzua) orthogonalization and shows that residuals for the VAR model can be viewed as being multivariate normally distributed. Overall, diagnostic statistics indicate that a model is adequately specified, therefore, we can conclude that the model is statistically sound.

5. Conclusion

The goal of organized cervical cancer screening (in its first stage) is to detect as many women with pathological cells change in early stage of the disease, which could improve the probability of cure and decrease costs of invasive cervical cancer. Therefore, it is argued in this paper that justification for the introduction of organized screening programs can be found in positive relationship between the number of performed Pap smears and number of pathological Pap results as a share in overall abnormal Pap results. Empirical results indicate that increase in Pap smears causes increase in the share of pathological cell formations detected in the population and therefore justify the introduction of an organized screening program. Also, it means that more women with high risk of cervical cancer can be detected as women (who do not take the Pap test regularly) are invited for the screening, respectively the increase in the attendance rate of target

population of the organized screening program could enhance the early detection of cervical cancer.

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