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SOCIO-ECONOMIC SUBSTANTIATION OF EXPEDIENCY OF SEASONAL INFLUENZA VACCINE PROPHYLAXIS AMONG MEDICAL WORKERS

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Abstract. Socio-economic substantiation of expediency of seasonal influenza vaccine prophylaxis among medical workers. Kyi-Kokarieva V.G., Kriachkova L.V., Padalko L.I. *The purpose of this study is to determine the socio-economic effectiveness of seasonal influenza vaccine prophylaxis among health professionals based on the analysis of the morbidity with temporal disability (MTD) and the financial benefits of this preventive measure. The study included the collection and analysis of information on MTD and direct and indirect costs of influenza treatment compared to vaccine prophylaxis in "Dnipropetrovsk Regional Perinatal Center with Hospital" Dnipropetrovsk Regional Council" (ME "DRPC with Hospital" DRC") during 2017-2020 (3 epidemic seasons). To assess the consequences of vaccine prophylaxis, the analysis of MTD indicators was performed, and the index and coefficient of anti-epidemic effectiveness were used. The economic effect was determined on the basis of the cost-benefit method using the analysis algorithm in the form of a "decision tree". The information base for the analysis was the accounting and reporting and financial and economic documentation of the health care institution (HCI). The analysis of influenza MTD during the observation period revealed that all studied morbidity rates (number of cases per 100 employees; number of days per 100 employees; average case duration) were statistically significantly lower in vaccinated compared to unvaccinated ($p<0.001$). Precautionary number of cases of MTD for influenza in the last year of observation (2019-2020) was 11.07 (95% CI 6.68-15.46) per 100 employees; days – 96.23 (95% CI 81.86-110.60) per 100 employees. The index of anti-epidemic efficiency during the study increased by 2.37 (95% CI 1.95-2.79), the coefficient of anti-epidemic effectiveness – by 15.16% (95% CI 11.17-18.01). The economic efficiency of vaccination of 69.44% of employees for one epidemic season (2019-2020) amounted to a total of UAH 248,976 or UAH 494 (56%) benefits per employee. The study proved the high medical, social and economic effectiveness of vaccine prophylaxis in HCI. Medical efficiency consists in a significant reduction in the morbidity with temporary disability, high levels and a tendency to increase the indicators of anti-epidemic efficiency. The economic effect is defined as the available monetary benefit from the vaccine prophylaxis. The resulting savings are the basis for optimizing the use of resources of the medical institution, including labor.*

Реферат. Соціально-економічне обґрунтування доцільності вакцинопрофілактики сезонного грипу серед медичних працівників. Кий-Кокарєва В.Г., Крячкова Л.В., Падалко Л.І. *Метою цього дослідження є визначення соціально-економічної ефективності вакцинопрофілактики сезонного грипу серед медичних працівників на підставі аналізу захворюваності з тимчасовою втратою працездатності (ЗТВП) та фінансової вигоди цього профілактичного заходу. Дослідження включало збір й аналіз інформації щодо ЗТВП та прямих і непрямих витрат на лікування грипу порівняно з вакцинопрофілактикою в комунальному підприємстві «Дніпропетровський обласний перинатальний центр зі стаціонаром» Дніпропетровської обласної ради» (КП «ДОПЦ зі*

стаціонаром» ДОР») протягом 2017-2020 років (3 епідсезони). Для оцінки наслідків вакцинопрофілактики проводився аналіз показників ЗТВП, використовувалися індекс та коефіцієнт протиепідемічної ефективності. Економічний ефект визначався на підставі методу витрати – вигода із застосуванням алгоритму аналізу у вигляді «дерева рішень». Інформаційною базою для аналізу слугувала обліково-звітна й фінансово-економічна документація закладу охорони здоров'я (ЗОЗ). При аналізі ЗТВП на грип за період спостереження виявлено, що всі досліджені показники захворюваності (число випадків на 100 працюючих; число днів на 100 працюючих; середня тривалість випадка) були статистично значущо меншими в щеплених порівняно з невакцинованими (p<0,001). Відвернена кількість випадків ЗТВП на грип за останній рік спостереження (2019-2020 рр.) становила 11,07 (95% ДІ 6,68-15,46) на 100 працюючих; днів – 96,23 (95% ДІ 81,86-110,60) на 100 працюючих. Індекс протиепідемічної ефективності за час дослідження зріс на 2,37 (95% ДІ 1,95-2,79), коефіцієнт протиепідемічної ефективності – на 15,16% (95% ДІ 11,17-18,01). Економічна ефективність вакцинації 69,44% працюючих за один епідемічний сезон (2019-2020 рр.) становила загалом 248 976 грн або 494 грн (56%) вигоди на одного працівника. У результаті дослідження була доведена висока медико-соціальна та економічна ефективність вакцинопрофілактики в ЗОЗ. Медична ефективність полягає в суттєвому зниженні показників захворюваності з тимчасовою втратою працездатності, високих рівнях і тенденції до зростання показників протиепідемічної ефективності. Економічний ефект визначається як наявна грошова вигода від проведеної вакцинопрофілактики. Отримана економія є підґрунтям для оптимізації використання ресурсів медичного закладу, зокрема й трудових.

According to the World Health Organization, approximately 3 to 5 million cases of severe diseases caused by the seasonal influenza virus are reported each year, including 290,000 to 650,000 deaths [10]. In 2015, the total economic burden of influenza was estimated at $ 11.2 billion, of which $ 3.2 billion was related to direct medical costs and $ 8.0 billion to indirect costs [13]. According to US researchers, all-cause mortality among hospitalized patients with influenza was 5.1% during hospital stay and 9.2% within 30 days after diagnosis [9].

The most vulnerable groups to the flu are the elderly, pregnant women, children, people with comorbidities and health workers. Influenza vaccines are safe and effective in reducing the serious effects of influenza infections, but for them to be effective at the population level, a high level of vaccination must be achieved [16].

Many studies have shown the positive effects of vaccination on improving the health of the population, economic growth and the effectiveness of health systems, as it is one of the most cost-effective measures to improve the efficiency of the industry [14, 15].

Currently, the situation is complicated by the COVID-19 pandemic, which can have both positive and negative consequences for the general vaccination and influenza vaccination program. Adverse effects include an increased risk of an outbreak of infectious diseases due to delayed or discontinued compulsory vaccination programs, among the positives is the increased likelihood that the generally accepted need for coronavirus vaccination may increase adherence to vaccines in general, leading to improved post-pandemic vaccination rates [8].

According to the recommendations of the Advisory Committee on Immunization Practices, USA annual influenza vaccination should not be stopped during a pandemic, it is recommended for all persons over 6 months of age who have no contraindications and is especially important for people with advanced the risk of serious diseases and complications of influenza, health care workers who have contact with potential infection, etc. [12].

According to the Public Health Center, during the epidemic season of 2019-2020 in Ukraine, 12.9% of the population became ill with seasonal flu and acute respiratory viral infections (ARI), 0.6% of the population was vaccinated, including 12.8 % of medical staff, 71 people died, none of the dead were vaccinated against influenza [2].

Issues related to influenza vaccination are considered in their works as foreign authors L. Grohskopf [12], H. Zaraketa [16], W. Putri [13], S. Bolge [9], C. Rodrigues [14], and Ukrainian researcher A. Mironenko [5]. However, there are not enough publications in the country that would consider the socio-economic consequences of influenza prevention at the level of HCI, which has led to the relevance of the study.

The purpose of this article is to determine the socio-economic effectiveness of seasonal influenza vaccine prophylaxis among health care workers based on the analysis of the morbidity with temporal disability and the financial benefits of this preventive measure.

MATERIALS AND METHODS OF RESEARCH

To study the epidemiological and socio-economic effectiveness of influenza vaccine prophylaxis of medical workers, a study of the staff of the municipal enterprise ME "DRPC with Hospital" DRC" was conducted.

The study included the collection and analytical processing of information on the results of influenza

vaccine prophylaxis, which was conducted during 2017-2020 (three epidemic seasons 2017-2018, 2018-2019, 2019-2020) in ME "DRPC with Hospital" DRC". Vaccination was carried out in October of the corresponding year. To assess the anti-epidemic effectiveness of vaccine prophylaxis, we used the index (IE) and the coefficient (CE, %) of anti-epidemic effectiveness, which were calculated according to the formulas [3]:

IE=B/A and KE=100×(B-A)/B,

where A – the incidence rate among the vaccinated;
B – the incidence rate among the unvaccinated.

Morbidity rates from temporary disability were calculated according to standard formulas. On the basis of current medical and technological documents for the standardization of medical care for influenza, the total cost of influenza management in health care workers was estimated [4].

The assessment of the economic efficiency of vaccine prophylaxis was performed by the cost-benefit analysis (CBA) on the basis of comparisons of total costs and benefits from the implementation of different alternatives [11]. To do this, an analytical model was developed using the data analysis tool "decision tree" [7]. The creation of the model was based on the description of the course of influenza in health care workers on the background of vaccine prophylaxis and without it, depending on the possible variants of the disease. It should be noted that severe complications, fatalities from influenza during the study period were not observed and they were not taken into account in the analysis model.

The cost of vaccination, production losses and hospital payments were calculated on the basis of accounting and reporting and financial and economic documentation of the health care institution, taking into account indicators in the industry. Medical expenses were determined according to the unified clinical protocol of medical care for influenza, approved by the Order of the Ministry of Health of Ukraine No. 499 [4].

Statistical analysis, which included descriptive (calculation of arithmetic means with 95% confidence intervals – 95% CI) and analytical statistics (assessment of the significance of discrepancies according to Student and Mann-Whitney criteria depending on the nature of the distribution of variables using Holm corrections in multiple comparisons) was carried out using STATISTICA 6.1 (StatSoftInc., serial No. AGAR909E415822FA). The critical level of statistical significance was taken at the level of $p<0.05$ (5%) [1].

RESULTS AND DISCUSSION

The effectiveness of vaccine prophylaxis (medical, economic and social) is achieved through the implementation of an appropriate measure aimed at a specific result, which is accompanied by no adverse effects or minimal side effects [3]. The medical and social effectiveness of influenza vaccine prophylaxis is characterized by the degree of impact on health. In our case, it is manifested in a decrease in the morbidity with temporary disability (MTD) for influenza vaccinated in the staff of the studied health care institution (Table 1).

The level of vaccination coverage of the team for three years was about 70%. The incidence of MTD per 100 employees during the three years of the study decreased statistically insignificantly ($p>0.05$), both among vaccinated and unvaccinated, while the number of cases of MTD for influenza increased from 9.98 in three years (95% CI 4.98-14.99) to 11.07 (95% CI 6.68-15.46) per 100 employees ($p>0.05$). This suggests that the reduction in morbidity occurred both through vaccination and by creating an immune layer.

The rate of MTD days per 100 employees also decreased in the dynamics in both comparison groups ($p>0.05$). Each year, the rates of both cases and days of MTD per 100 employees were statistically significantly lower among vaccinated health workers compared to unvaccinated ($p<0.001$). Due to vaccination against seasonal flu in 2019-2020 it was possible to avoid 96.23 (95% CI 81.86-110.6) days of incapacity for work in the medical staff, which averaged 3.0 per employee (95% CI 2.68-3.32) days. The average duration of influenza among vaccinated was significantly lower than among unvaccinated ($p<0.001$).

The obtained results are confirmed by the indicators of anti-epidemic efficiency, which increased during the three years of observation. Thus, the index of anti-epidemic effectiveness of IE increased from 2.94 (95% CI 1.39-3.79) to 5.31 (95% CI 3.96-7.06), so it increased by 2.37 (95% CI 1.95-2.79); coefficient of anti-epidemic efficiency – from 66.0% (95% CI 55.61-68.39) to 81.16% (95% CI 69.05-95.27), an increase of 15.16% (95% CI 11.17-18.01), the differences became statistically significant ($p<0.001$).

Given the limited resources of health care facilities, the economic efficiency of vaccine prophylaxis plays an important role, which in terms of cost shows the results of the practical implementation of the measure. The price of the vaccine during the three observation periods was 140, 170 and 250 hryvnias, respectively.

Table 1

Indicators of the effectiveness of vaccination against seasonal influenza of employees of ME "DRPC with Hospital" DRC" in 2017-2020

Indicators	Epidemic Season, years		
	2017-2018	2018-2019	2019-2020
Number of employees, persons, from them:	522	496	504
Vaccinated	350	350	350
Unvaccinated	172	146	154
Vaccination coverage level, %	67.05	70.56	69.44
Indicator of cases of MTD per 100 employees, M (95 % CI)			
Total	8.43 (6.3-13.96)	7.06 (5.31-13.07)	5.95 (4.57-11.64)
Vaccinated	5.14 (2.83-7.45)	4.00 (1.94-6.06)	2.57 (0.90-4.24)
Unvaccinated	15.12 (9.77-20.47)	14.38 (8.68-20.08)	13.64 (8.23-19.05)
p level	*<0.001*	*<0.001*	*<0.001*
Cases of MTD prevented by vaccination	9.98 (4.98-14.99)	10.38 (5.50-15.26)	11.07 (6.68-15.46)
Indicator of MTD days per 100 employees, M (95 % CI)			
Total	78.93 (42.28-115.58)	55.04 (21.33-98.75)	42.26 (12.14-82.38)
Vaccinated	36.0 (11.57-60.43)	24.0 (15.14-53.14)	12.86 (5.89-41.61)
Unvaccinated	166.28 (154.06-178.50)	129.45 (114.88-144.02)	109.09 (94.72-123.46)
p level	*<0.001*	*<0.001*	*<0.001*
Days of MTD prevented by vaccination	130.28 (118.06-142.5)	105.45 (90.88-120.02)	96.23 (81.86-110.60)
The average duration of the case of MTD in days, M (95 % CI)			
Total	9.0 (8.71-9.29)	8.0 (7.63-8.37)	7.0 (6.75-7.25)
Vaccinated	7.0 (6.71-7.29)	6.0 (5.73-6.27)	5.0 (4.76-5.24)
Unvaccinated	11.0 (10.71-11.30)	9.0 (8.73-9.27)	8.0 (7.76-8.24)
p level	*<0.001*	*<0.001*	*<0.001*
The average number of days of MTD prevented by vaccination	4.0 (3.68-4.32)	3.0 (2.67-3.33)	3.0 (2.68-3.32)
IE, M (95% CI)	2.94 (1.39-3.79)	3.60 (1.25-4.95)	5.31 (3.96-7.06)
CE (%), M (95% CI)	66.0 (55.61-68.39)	72.18 (60.03-84.33)	81.16 (69.05-95.27)

Note: p level of statistical significance of the difference between vaccinated and non-vaccinated.

To analyze the cost-effectiveness of the measures, we evaluated the costs and potential benefits of seasonal influenza vaccination for healthcare professionals. All costs, according to standard approaches, were divided into direct and indirect. The direct ones included the cost of vaccination, outpatient treatment and hospitalization, and the indirect ones included payments for sick leaves and losses at work (Table 2).

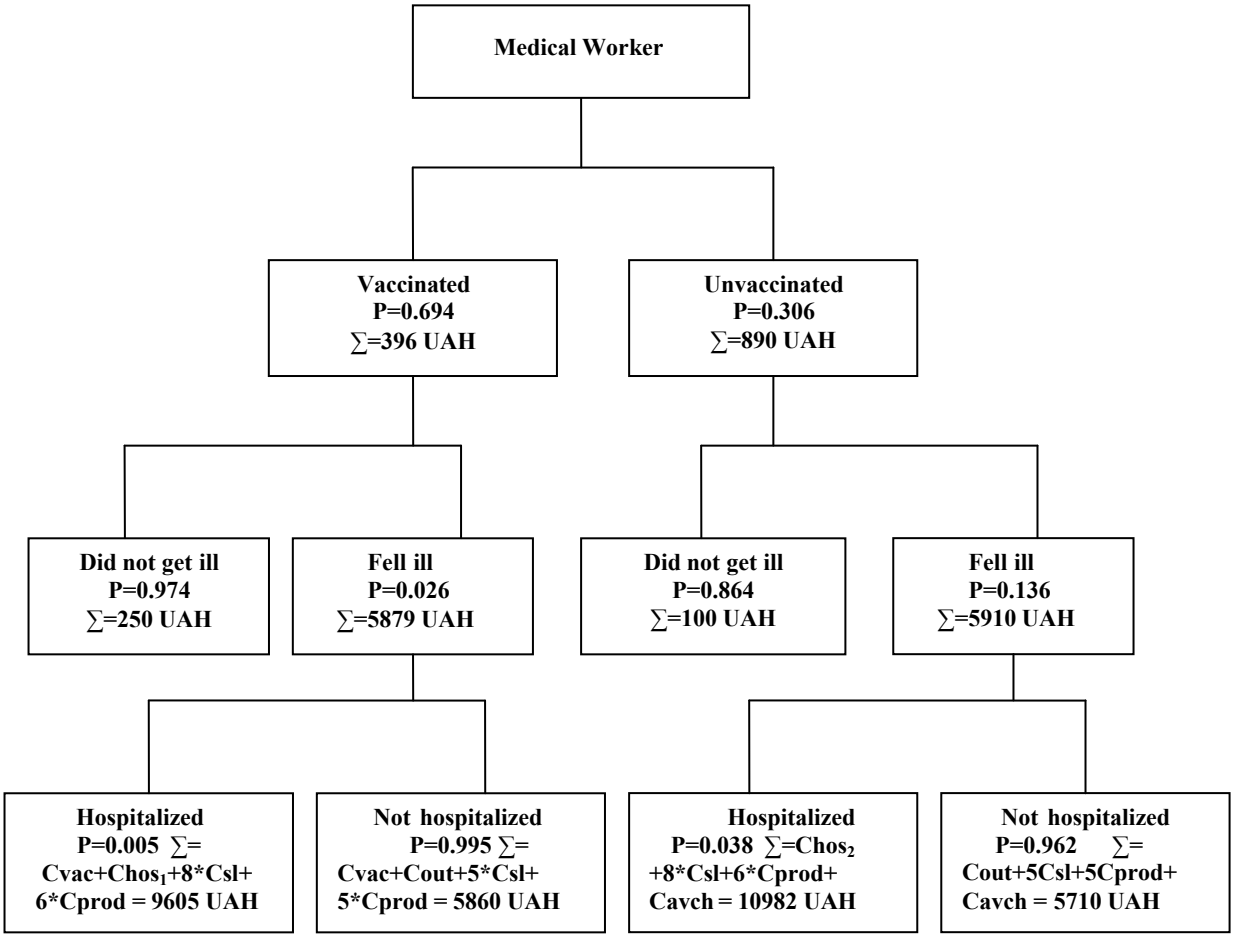
During the economic evaluation, an analytical model was developed using the data analysis tool "decision tree" (Fig.). The construction of the model was based on the identification of alternative approaches in the course of the disease and the treatment of a patient with influenza and the assessment of possible outcomes of the disease.

Table 2

Expenditures in case of influenza of an employee of ME "DRPC with Hospital" DRC", 2019-2020

	Costs	Amount, UAH
Direct	1. Cost of vaccination, Cvac	250
	2. Cost of antiviral chemoprophylaxis, Cavch	100
	3. Cost of outpatient treatment, Cout	1235
	4. Cost of hospitalization of the vaccinated, $Chos_1$	3375
	5. Cost of hospitalization of the unvaccinated, $Chos_2$	4902
Indirect	6. Payments on sick leave, Csl	365
	7. Production losses, Cprod	510

The developed analytical model allowed to analyze the costs of prevention and treatment of influenza by two alternatives and to choose the most effective, from an economic point of view, strategy. The first option considers the situation when vaccination of medical workers is carried out as a preventive measure. The second option is based on the analysis of the use of antiviral chemoprophylaxis by employees. At the same time costs depending on a kind of treatment of sick employees are analyzed. Direct (preventive and medical) costs, such as the average cost and duration of treatment, and indirect costs associated with labor losses (payment of sick leaves, loss of productivity) are taken into account [6].



Notes: P – the probability of occurrence of the event in fractions of a unit; the definition of the types of costs corresponds to those specified in table 2.

Analytical model of economic evaluation of influenza vaccination among employees of ME "DRPC with Hospital" DRC", 2019-2020

The proposed model allows to obtain the final indicators taking into account the probabilities of events. The final indicators for each of the options were the average total cost per person. The benefit was calculated as the difference between them. The final results of the comparative analysis are given in Table 3.

The overall savings for the three observation seasons ranged from UAH 489 to UAH 546 per able-bodied person or 54-57% of total costs. In general, the socio-economic effect for the epidemic season of 2019-2020 amounted to UAH 248.976. Over three years, the savings due to the reduction in the duration of morbidity and, accordingly, the reduction in hospital payments amounted to UAH 62.780, and the loss of labor productivity decreased by UAH 87.720.

Table 3

Evaluation of the effectiveness of vaccine prophylaxis of employees of ME "DRPC with Hospital" DRC" against influenza for 2017-2020

Indicators	Average total costs per person, UAH		
	epidemic season 2017-2018	epidemic season 2018-2019	epidemic season 2019-2020
Without vaccination	904	965	890
With vaccination	415	419	396
Benefit	489	546	494
Benefit, %	54	57	56

As can be seen from the information provided, for society as a whole, as well as for individual health care, vaccination of health workers against seasonal influenza can reduce both medical and non-medical (indirect) treatment costs in case of illness and ultimately has a significant economic effect.

CONCLUSIONS

1. Based on the study, it can be stated that the constant vaccination of the staff of the health care institution against influenza can achieve a significant ($p<0.001$) reduction in all morbidity with temporal disability (number of cases per 100 employees; number of days per 100 employees; average duration of the case disease).
2. The available positive effects are confirmed by the increase ($p<0.001$) of indicators of anti-epidemic efficiency: the index of anti-epidemic efficiency by 2.37 (95% CI 1.95-2.79), the coefficient of anti-epidemic efficiency by 15.16% (95% CI 11.17-18.01).
3. Determined by the cost-benefit method, the economic efficiency of influenza vaccination in medical workers of ME "DRPC with Hospital" DRC" for one epidemic season (2019-2020) amounted to a total of 248,976 UAH, which is 56% and 494 UAH benefits per employee.
4. According to the study, the strategy to combat influenza in health care workers who belong to the group of occupational high risk of morbidity and mortality should include vaccination of at least 70% of HCI staff to benefit from this preventive measure. In this case, it will significantly reduce morbidity and mortality during the epidemic and reduce the socio-economic losses from influenza.

Conflict of interests. The authors declare no conflict of interest.

Prospects for further research are to study the factors influencing the decisions of health professionals regarding influenza vaccination.

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