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

Dnipro State Medical University¹
V. Vernadsky str., 9, Dnipro, 49044, Ukraine
e-mail: 302@dmu.edu.ua
МЕ «Dnipropetrovsk regional perinatal center with a hospital» DRC» ²
Kosmichna str., 17, Dnipro, 49010, Ukraine
e-mail: padalko.dopc@ukr.net
Dniprovskyi derzhavnyi medychnyi universitet¹
vul. V. Verhnyksoho, 9, Dnipro, 49044, Ukraina
КП «Дніпропетровський обласний перинатальний центр зі стаціонаром» ДОП «²
vul. Kosmichnaya, 17, Dnipro, 49010, Ukraine

Key words: vaccine prophylaxis, influenza, vaccination, able-bodied population, effectiveness, cost-benefit analysis (CBA)

Abstract. Socio-economic substantiation of expediency of seasonal influenza vaccine prophylaxis among medical workers. Kyi-Kokarieva V.G., Kriaichkova 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 temporary 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 (HCl). 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 effectiveness. 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.
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. Groshkopf [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 HCl, 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]:

$$IE = \frac{B}{A}$$

$$KE = 100 \times \frac{(B - A)}{B},$$

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.
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     |

Table 1

| 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)

| Indicator                                                   | Total    | Vaccinated | Unvaccinated | p level   |
|-------------------------------------------------------------|----------|------------|--------------|-----------|
| Total                                                       | 9.0 (8.71-9.29) | 7.0 (6.71-7.29) | 11.0 (10.71-11.30) | <0.001   |
| Vaccinated                                                 | 7.0 (6.71-7.29) | 6.0 (5.73-6.27)  | 9.0 (8.73-9.27)  | <0.001   |
| Unvaccinated                                               | 11.0 (10.71-11.30) | 5.0 (4.76-5.24)  | 8.0 (7.76-8.24)  | <0.001   |

The average number of days of MTD prevented by vaccination

| Indicator                                                  | IE, M (95% CI) | CE (%), M (95% CI) |
|-----------------------------------------------------------|----------------|-------------------|
| Total                                                     | 4.0 (3.68-4.32) | 2.94 (1.39-3.79)  |
| Vaccinated                                                | 3.0 (2.67-3.33) | 3.60 (1.25-4.95)  |
| Unvaccinated                                              | 3.0 (2.68-3.32) | 5.31 (3.96-7.06)  |
| The average number of days of MTD prevented by vaccination | 4.0 (3.68-4.32) | 2.94 (1.39-3.79)  |
| CE (%), M (95% CI)                                        | 66.0 (55.61-68.39) | 66.0 (55.61-68.39) |

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, $C_{vac}$          | 250         |
| 2. Cost of antiviral chemoprophylaxis, $C_{avch}$ | 100         |
| 3. Cost of outpatient treatment, $C_{out}$ | 1235        |
| 4. Cost of hospitalization of the vaccinated, $C_{hos1}$ | 3375        |
| 5. Cost of hospitalization of the unvaccinated, $C_{hos2}$ | 4902        |
| Indirect                                   |             |
| 6. Payments on sick leave, $C_{sl}$        | 365         |
| 7. Production losses, $C_{prod}$           | 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].

Not hospitalized

$P = 0.995 \sum = C_{vac} + C_{hos2} + 8 \times C_{sl} + 5 \times C_{prod} = 9605 \text{ UAH}$

Hospitalized

$P = 0.005 \sum = C_{vac} + C_{hos1} + 8 \times C_{sl} + 6 \times C_{prod} = 10982 \text{ UAH}$

Did not get ill

$P = 0.974 \sum = 250 \text{ UAH}$

Fell ill

$P = 0.026 \sum = 5879 \text{ UAH}$

Medical Worker

Vaccinated

$P = 0.694 \sum = 396 \text{ UAH}$

Unvaccinated

$P = 0.306 \sum = 890 \text{ UAH}$

Did not get ill

$P = 0.864 \sum = 100 \text{ UAH}$

Fell ill

$P = 0.136 \sum = 5910 \text{ UAH}$

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

| 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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