



Ranking Dynamics of Economic Burden of Infectious Diseases as a Criterion of Effectiveness of Epidemiologic Control

Marina A. Mikheeva, Irina V. Mikheeva[✉]

Central Research Institute of Epidemiology, 111123, Moscow, Russia

Purpose: rank-based assessment of the economic impact of infectious diseases in the Russian Federation for the further analysis of effectiveness of their prevention and for prioritization of preventive measures.

Materials and Methods. The annual economic burden was estimated by using inflation-adjusted standard economic costs of one case of infectious disease in the Russian Federation. The data on the number of cases were obtained from the official statistical reports (Forms 1, 2) for 2009–2019. The annual burden of the specific disease was estimated by multiplying the standard cost of 1 case by the number of cases registered within a given year. The economic costs were assessed and ranked.

Results and discussion. In 2019, the greatest economic burden was exerted by acute respiratory infections, tuberculosis, acute gastrointestinal infections, chickenpox, HIV infection (newly diagnosed cases and deaths in 2019). The economic burden of rotavirus infection was assessed and ranked for the first time. The ranking analysis of the economic costs in 2009–2019 showed the largest decrease in the economic burden of influenza, rubella, acute and chronic hepatitis B. At the same time, the economic burden of measles, pertussis, hemorrhagic fevers and tick-borne borreliosis demonstrated an upward trend.

The possibility of using ranking dynamics of economic burden as a performance indicator of epidemiological control has been demonstrated. In response to limited public funding of healthcare, the offered method can be used in setting priorities in decision making in the field of epidemic control.

Keywords: economic burden; infectious diseases; Russian Federation; rank-based assessment; effectiveness of epidemiologic control.

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Динамика рейтинга экономического ущерба от инфекционных болезней как критерий эффективности эпидемиологического контроля

Михеева М.А., Михеева И.В.[✉]

ФБУН «Центральный научно-исследовательский институт эпидемиологии» Роспотребнадзора,
111123, Москва, Россия

Цель: рейтинговая оценка экономической значимости инфекционных болезней в Российской Федерации для анализа эффективности и выбора приоритетных направлений их профилактики.

Материалы и методы. Исходными данными для расчета ежегодного экономического ущерба послужили стандартные величины экономического ущерба от 1 случая инфекционной болезни в Российской Федерации, проиндексированные с учетом уровня инфляции. Сведения о числе случаев инфекционных заболеваний получены из официальной статистической отчетности (формы № 1, 2) за 2009–2019 гг. Ежегодный ущерб от конкретной болезни вычисляли путем умножения стандартной величины ущерба от 1 случая на число случаев, зарегистрированных в данном году. Стоимостные показатели ущерба подвергали рейтинговой оценке.

Результаты. В 2019 г. наибольший экономический ущерб нанесли острые респираторные вирусные инфекции, туберкулез, острые кишечные инфекции, ветряная оспа, ВИЧ-инфекция (впервые выявленные и летальные случаи в 2019 г.). Впервые был подсчитан экономический ущерб от ротавирусной инфекции,

который занял 6-е ранговое место. Рейтинговый анализ величин экономического ущерба в 2009–2019 гг. показал наибольшее снижение экономического ущерба от заболеваемости гриппом, краснухой, острым и хроническим вирусным гепатитом В. В то же время прослеживался рост экономического ущерба от кори, коклюша, геморрагических лихорадок и клещевого боррелиоза.

Обсуждение. Продемонстрирована возможность использования динамики рейтинга экономического ущерба в качестве показателя эффективности мер эпидемиологического контроля. Предложенная методика может быть использована в качестве инструмента для определения приоритетов при принятии управленческих решений в области эпидемиологического контроля в условиях ограниченных бюджетных ресурсов системы здравоохранения.

Ключевые слова: *экономический ущерб; инфекционные заболевания; Российская Федерация; рейтинговая оценка; эффективность эпидемиологического контроля.*

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Introduction

Amidst the healthcare reforms unfolding in Russia, the economic analysis comes to the fore, being instrumental in making managerial decisions aimed at achieving maximum effect in disease prevention with limited labor and money resources. The methods of economic analysis can be applied to any healthcare interventions, including prevention techniques, to assess their economic feasibility.

The epidemic control measures, which must be taken in full and on time to prevent any emergence and spread of infectious diseases, include sanitary measures within the Russian Federation, industrial control, restrictive measures (*quarantine*), isolation of patients with infectious diseases, *disinfection measures*, preventive vaccination, regular health exams, hygiene education and training, etc. Data resulting from socio-economic impact assessment of a nosological disease are traditionally used for selecting targets in prevention programs of different levels.

The method based on "standard" economic costs of 1 case was offered and adapted to Russia by I.L. Shakhanina [1–4] for assessment of economic impact of infectious illnesses. Weighted averages of economic burden inflicted by one infectious disease case are quite informative and can serve the purposes of healthcare management [4].

Economic impact is estimated in accordance with GOST R 57525-2017¹, where "the cost of illness includes all the costs related to treatment of patients with a particular disease, both during a particular stage (period of time) and during all stages of medical care, as

well as to disability and premature death". Economic impact of diseases is estimated as burden inflicted on the economy and is measured in rubles.

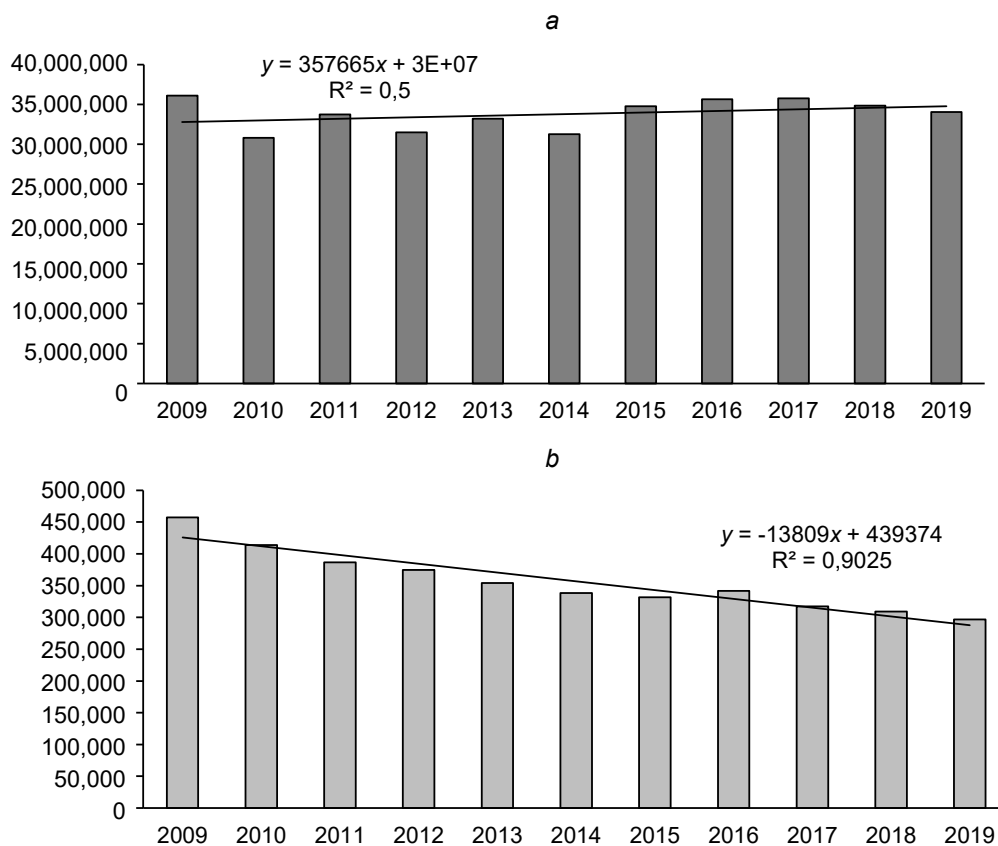
In the meantime, numerous objective and subjective factors that affect economic costs of each disease, including inflation inputs, make it impossible to provide accurate estimates required for comparative assessment of the economic costs of different diseases in their dynamics. Difficulties associated with the assessment of economic impact of diseases impede the possibility to choose the relevant and most efficient preventive programs to channel the available limited resources.

The purpose of this study is to perform rank-based assessment of the economic impact of infectious diseases in the Russian Federation for the further analysis of effectiveness of their prevention and for prioritization of preventive measures.

Materials and Methods

Standard economic costs of one infectious disease case in Russia were used as inputs for estimation of annual economic burden. Most of the standard economic costs per 1 weighted average case of infectious disease are given in publications of I.L. Shakhanina [2, 4]. The economic cost of one disease case was calculated as the sum of direct and indirect costs. The direct costs included the cost of pharmaceuticals, inpatient and outpatient care. The estimation took into account clinical forms broken down by severity. Indirect economic burden was assessed as the gross domestic product unproduced because of labor time (days and years) lost due to an employee's illness or due to the illness of an employee's (acting as a parent or guardian) child. The economic costs of a tuberculosis [5] and *HIV infection* [6] case were obtained from available publications; costs

¹ GOST R 57525-2017 Clinical and Economic Studies. General Requirements. Effective date 2018-06-01.



Dynamics of the absolute number of cases of infectious (a) and parasitic (b) diseases in Russia in 2009–2019.

of rotavirus infection [7], pertussis [8], chickenpox and shingles [9] were calculated during our own studies.

All standard economic costs were adjusted for inflation by using data published by the Russian Federal Statistics Service for the studied time period. The data on the number of cases of infectious diseases were obtained from the publicly available statistical reports (Forms 1 and 2 of the Federal Statistical Monitoring of Infectious Morbidity in the Russian Federation) for 2009–2019.

The annual cost of a single infectious disease was calculated by multiplying the standard economic cost of 1 case of the given disease by the number of cases registered in a particular year. Further on, the economic costs of infectious diseases were ranked in descending order and assessed.

This method was used for the first time by the authors of the article for the State Report on Sanitary and Epidemiologic Well-Being in 2014, and, later on, it was regularly used for state reports of Federal Service for Surveillance on Consumer Rights Protection and Human Well-Being in 2015–2018.

This article analyzes the dynamics of economic cost rankings for specific diseases in 2009–2019.

Results

In 2019, Russia demonstrated a 2.4% decrease in the total number of infectious and parasitic diseases

as compared to 2018: The number of registered cases was 34,338,157 cases against 35,166,730 cases in 2018. The growth trend in the incidence of infectious diseases was not pronounced, while the incidence of parasitic diseases declined significantly (Figure). The last 3 years were characterized by a steady downward trend in the incidence of infectious and parasitic diseases.

The performed calculations show that the economic burden resulting from as few as 36 infectious diseases exceeded RUB 646 billion (Table 1). The economic burden prevented due to decreased incidence of some infectious diseases amounted to around RUB 3.56 billion as compared to 2018. In the meantime, due to the increased number of cases of some nosological diseases, the economic burden increased by more than RUB 7 billion. The absolute economic costs of infectious diseases increased by 1.4% in 2019 as compared to the previous year. When adjusted for the inflation, which, as reported by the Russian Federal Statistics Service², reached 3% in 2019, the total cost of infectious diseases went down by 1.6%.

Following the trend started in 2014, the most severe economic burden in 2019 was inflicted by acute respiratory infections, tuberculosis, acute gastrointestinal infections, chickenpox, HIV infection (newly diagnosed

Russian Federal Statistics Service. URL: <https://www.gks.ru>

Table 1. Economic burden of infectious diseases in the Russian Federation in 2019

Infectious diseases	Economic burden, thousand rubles
Acute upper respiratory tract infections of multiple and unspecified sites	518 428 786,5
Tuberculosis (newly diagnosed cases), active forms	32 562 991,4
Chickenpox	28 999 139,7
Acute gastrointestinal infections caused by unidentified pathogens, foodborne toxin-mediated infections of unknown etiology	15 858 048,5
Human immunodeficiency virus (HIV) disease and asymptomatic HIV infection status (newly diagnosed cases)	10 562 626,4
Rotavirus infection	8 431 262,1
Acute gastrointestinal infections caused by identified bacterial and viral pathogens as well as foodborne toxin-mediated infections of known etiology	8 242 993,7
Exposure to infected animal bites, saliva and scratches	4 163 413,7
Infectious mononucleosis	4 144 779,7
Salmonellosis	2 502 405,5
Pediculosis	1 932 728,5
Arthropod-borne viral fevers and viral hemorrhagic fevers	1 829 268,6
Chronic hepatitis C (newly diagnosed cases)	1 792 327,7
Influenza	1 600 608,5
Lyme disease	1 092 414,9
Pertussis, parapertussis	859 826,0
Scarlet fever	742 375,4
Hepatitis A	576 216,2
Bacillary dysentery (shigellosis)	470 647,6
HBV carrier state (newly diagnosed cases)	464 971,5
Meningococcal disease	372 485,2
Measles	284 766,7
Acute hepatitis C	255 266,5
Acute hepatitis B	198 896,9
Brucellosis, new cases	128 338,7
Epidemic parotitis (mumps)	32 307,6
Pseudotuberculosis	32 289,5
Leptospirosis	12 860,7
Tularemia	8 097,2
Tetanus	2 011,1
Typhoid fever	1 978,0
Rubella	1 280,3
Diphtheria	1 277,6
Paratyphoid fevers A, B, C and unspecified	329,7
Typhoid and paratyphoid bacteria carriers	329,7
Carriers of diphtheria toxigenic strains	305,8
Total	646 590 653,3

cases and deaths in 2019). For the first time, rotavirus infection was separated out of the group of gastrointestinal infections with identified pathogen, and its economic burden was estimated as ranking sixth. The nosologies characterized by the highest economic burden in 2019 included exposures to animal bites and saliva, infectious mononucleosis, salmonellosis and pediculosis.

The ranking analysis of the economic costs of infectious diseases in 2009–2019 (**Table 2**) demonstrated the largest decrease in the economic burden resulting from influenza (the ranking changed from the 2nd to the 11th ranking position), rubella (from the 25th to the 30th position), acute hepatitis B (from the 17th to the 21st position) and HBV carrier state (actually, chronic hepatitis B) (from the 12th to the 17th position) as well as acute hepatitis A (from ranking 11th to ranking 15th) and shigellosis (from ranking 13th to ranking 16th).

At the same time, the economic burden resulting from measles (down from the 29th position to the 19th position) and pertussis (from ranking 22nd to ranking 13th) showed an upward trend. The upward trend was also observed in the economic impact of *hemorrhagic fevers* (from ranking 14th to ranking 9th) and *Lyme disease* (from ranking 16th to ranking 12th).

As compared to 2018, the ranking results for 2019 showed a decrease in the economic burden of acute and chronic hepatitis C (by 1 and 2 points, respectively), scarlet fever, *Lyme disease*, *diphtheria*, tularemia (by 1 point). The economic burden of the following diseases moved up the ranks: *hemorrhagic fevers* (by 3 points), measles (by 2 points), *pertussis* (by 1 point).

Discussion

The offered method of ranking costs associated with economic burden gave the possibility to compare not only economic losses caused by different diseases, but also to cross-reference the burden imposed by each nosology within 10 years. The analysis of changes in the rankings of infectious diseases made it possible to assess the effectiveness of ten-year-long control measures taken to fight a particular disease. As expected, the largest reduction of economic burden was achieved in vaccine-controllable infectious diseases — influenza (from 2nd to 11th position), rubella (moved down by 5 points), hepatitis B and A (moved down the ranks by 4 points). This fact proves another time that vaccination is the most economically efficient method of epidemic control, in general, and for rubella [10] and hepatitis A [11] and B [12], in particular. As for influenza, the reduction can be also explained by changes in the approaches to case registration — only laboratory-confirmed influenza cases were taken into account during certain time periods [13].

If a disease moves up the ranks in the economic burden ranking list, it may be indicative of existing problems encountered by control measures targeted at a particular infection. For example, the increased eco-

nomical burden of measles (up from the 29th to the 19th ranking position) results from the recurrence of *endemic circulation* of measles virus and the increased number of unvaccinated people who contribute to the growing number of infection sites³.

The higher ranking positions for the economic burden of pertussis (moving up from the 22nd to the 13th position) can be explained by the improved accuracy of infection diagnosis through using more sensitive laboratory techniques and by the increased participation of preschool and school-aged children in spreading of pertussis, thus requiring that the booster vaccination against this infection should be included in the National Immunization Schedule [14, 15].

The increased economic impact of *hemorrhagic fevers* (up from the 14th to the 9th ranking position) and *Lyme disease* (up from the 16th to the 12th position) suggests not only the improved accuracy laboratory diagnostic techniques used for the above diseases, but also signifies the need to strengthen the measures aimed at prevention of transmissible infectious diseases amid changing climate conditions, expanding business activities within natural focal spots and decreasing scope of *disinfection* measures [16].

The "standard" weighted average economic costs of 1 disease case can be later revised and corrected, taking into account regional specific features, among other things. While previously a number of parameters were estimated for a group of diseases, for example, for acute *gastrointestinal infections of known etiology*, further estimations will give more accurate profiles for individual infections of the given group. For example, we estimated the burden of 1 case of rotavirus infection [7]. Thus, the burden resulting from this disease was singled out of the combined economic losses caused by the group of *acute gastrointestinal infections* with the identified pathogen.

Although the burden estimation based on "standard" weighted average economic costs of 1 disease case is clearly not accurate and very rough, it is highly important for planning and prioritizing preventive and anti-epidemic measures targeted at diseases ranking high in economic burden.

The invariably high ranking of the burden caused by chickenpox (ranking 2nd – 3rd among 33 nosologies in Table 2) emphasizes the urgent need to optimize the infection control, to use the potential of scheduled and emergency preventive vaccination for efficient epidemic control.

Conclusions

1. The ranking dynamics economic burden caused by infectious diseases can serve as an *epidemiological control* performance indicator.

³ The National Scientific and Methodological Center for Supervision over Measles and Rubella.

URL: <http://www.gabrich.ru/measles-center.html>

Table 2. Ranking dynamics of economic burden of infectious diseases (exclusive of tuberculosis and HIV infection) in Russia in 2009–2019

Nosological forms	Ranking (maximum burden = 1, minimum burden = 33)										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Acute respiratory infections	1	1	1	1	1	1	1	1	1	1	1
Acute gastrointestinal infections of unknown etiology	3	2	2	2	2	2	2	2	2	3	3
Chickenpox	4	3	3	3	3	3	3	3	3	2	2
Acute gastrointestinal infections of known etiology	5	4	5	4	4	4	4	4	4	4	4
Animal bites	6	5	6	5	5	5	5	5	5	6	5
Salmonellosis	7	6	7	6	6	7	7	8	7	7	7
Infectious mononucleosis	9	8	8	7	7	6	6	6	6	5	6
Pediculosis	8	9	9	8	9	8	8	9	9	9	8
Chronic hepatitis C	10	10	10	9	10	9	9	10	8	8	10
Hepatitis A	11	11	15	12	12	10	13	11	11	15	15
Hemorrhagic fevers	14	17	16	15	11	11	11	12	12	12	9
Scarlet fever	15	14	13	14	15	12	15	16	14	13	14
HBV carrier state	12	13	12	11	16	13	14	15	15	17	17
Lyme disease	16	15	11	10	14	14	12	13	13	11	12
Dysentery (shigelloses)	13	12	14	13	13	15	16	14	16	16	16
Hepatitis B	17	16	17	17	17	16	17	17	18	20	21
Hepatitis C	19	19	19	19	19	17	18	18	17	19	20
Influenza	2	7	4	16	8	18	10	7	10	10	11
Meningococcal disease	18	18	18	18	18	19	21	20	19	18	18
Measles	29	29	24	22	22	20	24	27	24	21	19
Pertussis, paraptussis	22	21	20	20	21	21	20	19	20	14	13
Yersiniosis	21	20	21	21	23	22	21	21	23	23	22
Brucellosis	23	23	22	23	24	23	22	22	22	22	23
Pseudotuberculosis	20	22	23	24	25	24	23	23	25	25	25
Leptospirosis	24	24	25	26	27	25	26	26	27	27	26
Tularemia	28	25	29	27	20	26	25	25	26	26	27
Epidemic parotitis	26	28	28	28	28	27	28	24	21	24	24
Typhoid and paratyphoid diseases	27	27	26	29	26	28	27	28	28	28	28
Rubella	25	26	27	25	29	29	30	30	31	32	30
Tetanus	31	30	32	30	30	30	29	29	29	29	29
Diphtheria carrier state	32	31	30	31	31	31	31	31	30	31	32
Diphtheria	30	32	31	32	32	32	32	32	32	30	31
Brill-Zinsser disease	33	33	33	33	33	33	33	33	33	33	33

Note. Color codes for rankings: — 1–5; — 6–10; — 11–15; — 16–20; — 21–33.

2. In response to limited public funding of health-care, the offered method can be used in setting priorities for preventive and epidemic control measures.

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Information about the authors:

Marina A. Mikheeva — junior researcher, Laboratory of immunoprophylaxis, Central Research Institute of Epidemiology, 111123, Moscow, Russia.
ORCID ID: <https://orcid.org/0000-0003-0290-388X>.
E-mail: mma17211@gmail.com

Irina V. Mikheeva — D. Sci. (Med.), Prof., Head, Laboratory of immunoprophylaxis, Central Research Institute of Epidemiology; Head, Scientific and Methodological Center of Immunoprophylaxis of Rospotrebnadzor, 111123, Moscow, Russia.
ORCID ID: <http://orcid.org/0000-0001-8736-4007>.
E-mail: irina_mikheeva@mail.ru

Contribution: the authors contributed equally to this article.

Информация об авторах:

Михеева Марина Андреевна — м.н.с. лаб. иммунопрофилактики ФБУН «ЦНИИ Эпидемиологии» Роспотребнадзора, 111123, Москва, Россия.
ORCID ID: <https://orcid.org/0000-0003-0290-388X>.
E-mail: mma17211@gmail.com

Михеева Ирина Викторовна — д.м.н., проф., зав. лаб. иммунопрофилактики ФБУН «ЦНИИ Эпидемиологии» Роспотребнадзора; руководитель Научно-методического центра иммунопрофилактики Роспотребнадзора, 111123, Москва, Россия.
ORCID ID: <http://orcid.org/0000-0001-8736-4007>.
E-mail: irina_mikheeva@mail.ru

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