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РОССИЙСКОЕ КАРДИОЛОГИЧЕСКОЕ ОБЩЕСТВО

# Effectiveness of legislative actions against tobacco smoking regarding the reduction of in-hospital morbidity of angina pectoris and myocardial infarction in Russia as a whole and 10 Russian constituent entities

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Russian anti-tobacco policy is aimed at reducing long-term morbidity and mortality from smoking-related diseases.

**Aim.** To assess the associations of tobacco control (TC) legislative measures with hospitalization rate for myocardial infarction (MI) and angina in Russia as a whole and in 10 Russian constituent entities, as well as to compare the effectiveness of anti-smoking measures in regions.

**Material and methods.** We analyzed data on hospitalizations of patients with angina (I20) and acute (I21) and subsequent (I22) MI, as well as chronic rheumatic heart diseases (I05-I09), for 2005-2019 in Russia as a whole and in 10 Russian constituent entities. We analyzed hospital admission rates for angina and MI to compare the periods before and after introduction of Federal TC law in 2013, adjusting for possible confounders and long-term trends. We used interrupted time-series design and Poisson regression model with calculation of rate ratio (RR) and 95% CI. Regions were compared by means of original TC law implementation scale (TCIS) developed based on the results of Russian TC policy evaluation survey in 10 Russian regions (n=11625). We analyzed the relationship between the TC law measures implementation scores and RR of hospital admissions reductions for angina and MI after the TC law by means of Spearman's rank correlation (coefficient with 95% CI) and linear regression models. Statistical package STATA 11.2 was used.

**Results.** The actual trend of hospital admission rates for angina after TC law introduction demonstrates the greatest slope change from the predicted trend (without the law) (p=0,004); less, but still significant slope change for MI (p=0,049), and no slope change for chronic rheumatic heart disease (p=0,332). Results showed a 16,6% decrease in hospital admission rates for angina (RR, 0,83; 95% CI, 074-0,93) and 3,5% – for MI (RR, 0,96; 95% CI, 0,96-0,97) after the TC law introduction in RF and effects of various magnitude in the regions. Regions with higher TCIS scores, i.e. better enforcement of full TC package had greater reduction in hospital admission rates for angina (rsp=-0,627; 95% CI, -1,05−-0,199; p=0,004); with better enforcement of smoke-free policies — grater reduction in hospitalization rates for MI (rsp=-0,793 95% CI, -1,08−-0,506, p<0,001). Reduction of hospital admission rates for angina and MI correlated with the higher scores for help to quit tobacco use (rsp=-0,555; 95% CI, -1,098−-0,01, p=0,045), (rsp=-0,736; 95% CI, -1,12−-0,357, p=0,027). Also, hospital admission rates for angina and MI were associated with the changes in smoking cessation prevalence in 2013-2018 in the regions (β=-0,345; 95% CI, -0,67−-0,02 p=0,041) and smoking prevalence in 2019 (β=2,964; 95% CI, 1,28-5,92, p=0,049), respectively.

**Conclusion.** TC legislation can lead not only to immediate reductions in hospital admission rates for angina and MI, but also to longer-term results. These effects may be due not only to the introduction of TC law, as such, but also to the enforcement of the law, as well as the direct results of TC measures — the decrease in smoking prevalence in the population.

**Keywords:** tobacco control policy, tobacco control legislation, evaluation of tobacco control policy, in-hospital morbidity, acute coronary events, angina, myocardial infarction, interrupted time series.

**Relationships and Activities:** none.

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Tobacco smoking, as well as exposure to environmental tobacco smoking, is the main modifiable factor in the development of noncommunicable diseases, including cancer, respiratory diseases, cardiovascular diseases (CVDs), with the largest contribution to premature mortality from these diseases.

The first Russian tobacco control (TC) law (Federal Law dated February 23, 2013 № 15-FL "On protecting the health of residents from secondhand tobacco smoke and consequences of tobacco consumption"), adopted as part of the ratification of the World Health Organization (WHO) Framework Convention on Tobacco Control (FCTC), is aimed not only at reducing the prevalence of smoking in the country, but also at reducing the morbidity and mortality of the population from smoking-related diseases. Articles of the TC law are aimed at protecting the population from secondhand tobacco smoke, prohibiting advertising and promotion of tobacco products, informing the population about the tobacco dangers, providing medical care to quit smoking and increasing taxes on tobacco products [1].

The results of studies carried out in different years in foreign countries show that TC legislative measures, for example, a banning smoking in public places, can help reduce the incidence of acute cardiovascular events among the population [2-5].

Different studies have shown varying degrees of TC legislation effectiveness in reducing cardiovascular morbidity. The effect varied in the range from 0 to 70%, and the differences were explained by variations in the sample, observation duration, differences in the prevalence of active and passive smoking in the studied populations, and methodological aspects [5-7]. Similar differences in the effectiveness of TC measures in relation to hospitalization for myocardial infarction (MI) and angina between different Russian regions have been described in recent studies [8]. Interestingly, all of the above studies analyzed the impact of public smoking bans on hospital admissions for acute CVDs.

The abovementioned Russian TC law came into force simultaneously throughout the Russia territory, and therefore the assessment of TC law effectiveness involves evaluation of the entire range of measures. Despite the fact that the implementation of TC norms is equally mandatory throughout the Russia territory, there are certain differences in the completeness of the implementation of individual law measures between the regions, as was shown in our studies conducted in the following 10 Russian regions: Chuvash Republic, Krasnodar Krai, Primorsky Krai, Arkhangelsk, Astrakhan, Belgorod, Novosibirsk, Orenburg, Samara and Tyumen Oblasts [9].

Accordingly, the prevalence of tobacco consumption and its changes over the period of TC law implementation also differed in these subjects, depending on the completeness of the implementation of legislative measures [10].

The aim of the study was to assess the associations of TC legislative measures with hospitalization rate for MI and angina in Russia as a whole and in 10 Russian constituent entities, as well as to compare the effectiveness of TC measures in regions.

## Material and methods

**Data used in the analysis.** We analyzed data on hospitalizations of patients with angina (I20) and acute (I21) and subsequent (I22) MI, as well as chronic rheumatic heart diseases (I05-I09), for 2005-2019 in Russia as a whole and in 10 Russian constituent entities. Information provided by the ederal Research Institute for Health Organization and Informatics (Moscow). In this work, we analyzed the changes of hospitalization rate per 100 thousand population for the above diseases among the adult population aged ⩾18 years in Russia as a whole and the following 10 Russian regions: Chuvash Republic, Krasnodar Krai, Primorsky Krai, Arkhangelsk, Astrakhan, Belgorod, Novosibirsk, Orenburg, Samara and Tyumen Oblasts.

Population data disaggregated by age groups (0-17 years and ⩾18 years old), as well as data on population per hospital bed, were taken from official statistics — database of the Federal State Statistics Service (Rosstat) [11].

The data on the prevalence of tobacco use were obtained from a sample survey of behavioral factors affecting the population health for 2013 and 2018, conducted by Rosstat in 2013 and 2018 [12], and a sample survey of Rosstat on the state of population health in 2019 [13].

**Scale for assessing TC law implementation.** To compare the hospitalization rate changes of acute coronary events in the periods before and after the TC law adoption in different regions, we used the original scale. The scale was developed by us based on representative survey of the adult population on the implementation of TC measures in 10 Russian constituent entities in 2017 and 2018, and is presented in earlier works [9]. The scale allows to assess the completeness of the implementation of the whole complex of TC legislative measures indicated by WHO MPOWER (the following six cost-effective and high impact measures: monitoring tobacco use and prevention policies; protecting people from tobacco smoke; offering help to quit tobacco use; warning about the dangers of tobacco; enforcing bans on tobacco advertising, promotion and sponsorship; raising taxes on tobacco)), as well as certain measures: protection of tobacco smoke, smoking cessation assistance, information policy measures including warnings on cigarette packs, tobacco advertising bans and tax and price measures. The scores characterizing the completeness of each of these measures are used as independent variables in correlation and linear regression analysis [9].

**Statistical analysis.** Data on cases of hospitalizations for diagnoses of MI and angina were analyzed for the periods before and after TC law implementation. The Interrupted time series (ITS) design was applied to analyze the impact of TC law implementation on the hospitalization rate for these conditions. ITS is a robust quasi-experimental design for evaluating the effects of interventions in population-based studies without the ability to conduct randomized controlled trials [18]. A generalized linear Poisson regression was used, which is the one of most frequently used models for ITS [2, 7, 14-17].

The regression model is as follows:

$Y_t = \beta_0 + \beta_1 T + \beta_2 X_t + \beta_3 T X_t$

where $Y_t$ — result measured at each time point t; T — time from the start of the study, with an interval representing the observation frequency (year); $X_t$ — dummy variable denoting the period before the intervention ($X_t$=0) or the period after the intervention ($X_t$=1); $\beta_0$ — the initial level of the studied variable at T=0; $\beta_1$ — the original trend of the outcome variable before the intervention; $\beta_2$ — change in the level after the intervention, which indicates whether there was a change in the level of the studied variable immediately after the introduction of intervention; $\beta_3$ — change in the slope or trajectory of the result after the intervention [18]. A detailed description of this methodology and its application was presented earlier [19].

The models are based on case time series of annual hospitalizations with MI and angina for the period before the implementation of TC law measures (from 2005 to 2013) and after it (from 2014 to 2019) in Russia as a whole and in 10 Russian regions indicated above. The analysis used absolute values of hospitalizations corresponding to the Poisson distribution, which were subsequently transformed into relative values of hospitalization rates by their ratio to population data. The trajectories of changes in hospitalization levels for angina and MI before the entry into force of the TC law, changes immediately after it, as well as the sequential dynamics in the period after the introduction of TC law were assessed, which makes it possible to assess the long-term trends in hospitalization rate with these conditions.

In the model, the scaling was adjusted using the Pearson $\chi^2$-statistic to prevent possible overdispersion and misinterpretation of standard errors. The model was also tested for autocorrelation.

Despite the fact that the use of the ITS methodology assumes that external variables do not affect the outcome, we took into account the fact that the long-term trends in hospitalization rate for angina and MI could differ between 10 Russian regions due to the influence of factors that change over time. For example, to take into account that changes in angina and MI incidence may reflect general trends in hospital care accessibility, the model for population per hospital bed was adjusted in regional comparisons.

In addition, the data were analyzed for possible confounder — the introduction of another regulatory document (Standard for healthcare provision for non- and ST segment elevation acute coronary syndrome (ACS)), adopted in 2012 and potentially having an impact on hospitalization rate for angina and, in particular, MI, which, along with the TC law, was included in the analysis model as a second factor of intervention. The results were calculated as rate ratio (RR) — ratio of hospitalization probability before and after the intervention, with a 95% confidence interval (CI).

Additionally, as a control, the same analysis was carried out for the same time periods in relation to chronic rheumatic heart diseases, which should not depend directly on changes in TC legislation.

To assess the potential associations between changes in hospitalization rates for angina and MI and the completeness of TC law implementation in the regions, interregional comparisons were carried out by analyzing the associations between the relative dynamics of hospitalization rate after the introduction of TC law (in %) in each region, as dependent variables, and indicators of the implementation of 6 TC measures in the regions, as independent variables.

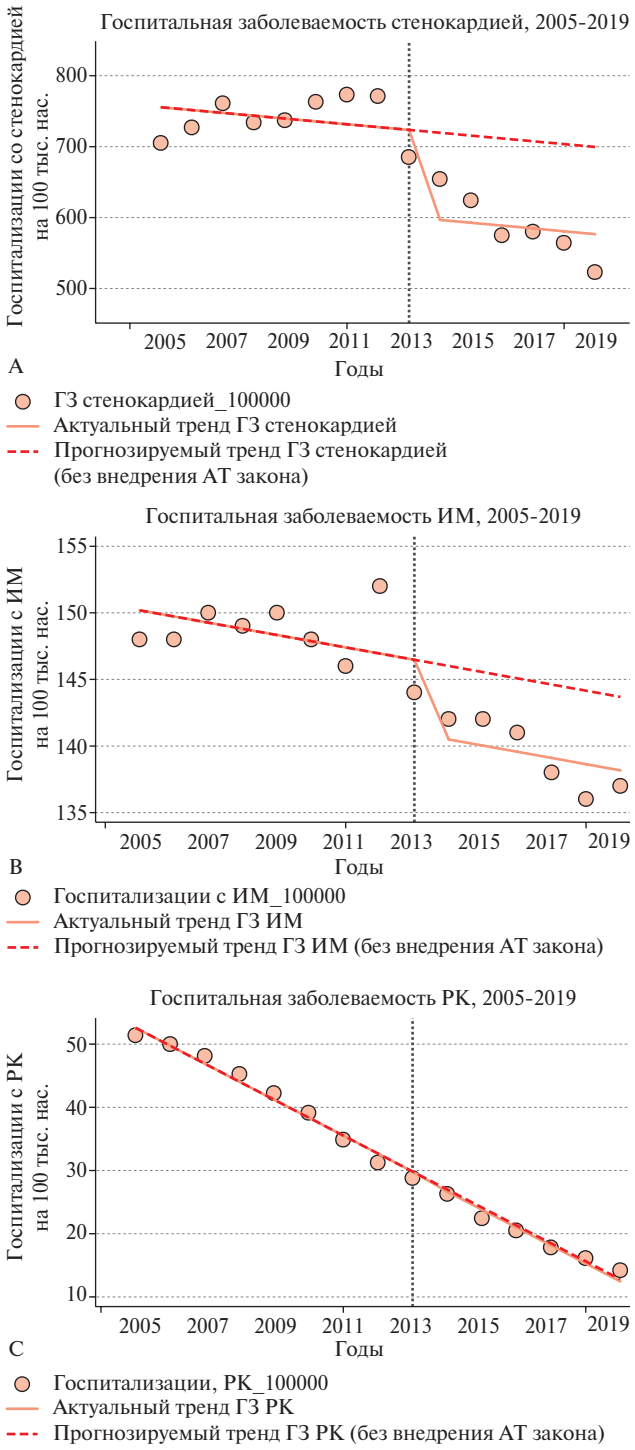


*Figure 1.* Hospitalization rate for angina (*A*), MI (*B*) и chronic rheumatic heart diseases (*C*) from 2005 to 2019 — before and after the implementation of TC law measures in Russia

Note: TC — tobacco control, MI — myocardial infarction, RHD — rheumatic heart disease.

For this, Spearman's rank correlation analysis was used. In addition, linear regression analysis was carried out to identify associations between smoking prevalence in 2018 and 2019 and the relative dynamics of hospitalization rate in the period after TC law was introduced throughout the follow-up period (%) (dependent variables).

**Table 1**

Hospitalization rate for angina and MI: RR (95% CI)
after the TC law implementation compared to the period before adoption
in Russia as a whole and 10 regions (data adjusted for Standard for healthcare provision for ACS in 2012)

| | Angina | | MI | |
|---|---|---|---|---|
| Russian regions | RR (95% CI)* | RR (%)** | RR (95% CI) | RR (%) |
| Russia | 0,83 (0,74-0,93) | -16,6 | 0,95 (0,92-0,98) | -3,5 |
| Chuvash Republic | 0,85 (0,78-0,93) | -15,1 | 0,9 (0,74-1,08) | -12,1 |
| Krasnodar Krai | 0,86 (0,74-0,98) | -12,4 | 0,98 (0,91-1,1) | -1,4 |
| Primorsky Krai | 0,96 (0,77-1,18) | 0,7 | 1,22 (0,98-1,52) | 27,2 |
| Arkhangelsk Oblast | 0,94 (0,56-1,55) | -8,9 | 0,95 (0,88-1,02) | -1,5 |
| Astrakhan Oblast | 0,77 (0,58-1,02) | -24,7 | 0,76 (0,64-0,91) | -24,6 |
| Belgorod Oblast | 0,88 (0,78-0,99) | -10,6 | 0,91 (0,97-1,03) | -9,3 |
| Novosibirsk Oblast | 0,89 (0,74-1,07) | -12,2 | 0,9 (0,82-0,99) | -9,8 |
| Orenburg Oblast | 0,69 (0,49-0,96) | -30,7 | 0,95 (0,87-1,04) | -0,7 |
| Samara Oblast | 0,82 (0,72-0,92) | -16,4 | 0,86 (0,81-0,91) | -12,2 |
| Tyumen Oblast | 0,93 (0,73-1,2) | -4,9 | 0,87 (0,79-0,97) | -13,3 |

Note: * — RR after the TC law implementation compared to the period before its adoption, ** — relative dynamics of RR after the TC law implementation compared to the period before its adoption (%). Significant results are highlighted in bold — p<0,05.

**Table 2**

Correlation of hospitalization rate dynamics (RR, %)
for angina and MI before and after the TC law introduction
and the smoking prevalence in 2018 and 2019 (rsp and 95% CI)

| | Angina | MI | Rheumatic heart disease |
|---|---|---|---|
| Legislative measures | rsp* (95% CI) | rsp (95% CI) | rsp (95% CI) |
| Whole complex of legislative measures | -0,627 (-1,055; -0,20) | -0,09 (-0,855; 0,672) | -0,064 (-0,615; 0,487) |
| p | 0,004 | 0,816 | 0,821 |
| Taxes and prices | -0,077 (-0,735; 0,580) | -0,073 (-0,863; 0,717) | -0,318 (-0,928; 0,29 |
| p | 0,817 | 0,856 | 0,305 |
| Protection from tobacco smoke | 0,014 (-0,655; 0,683) | -0,793 (-1,08; -0,506) | -0,205 (-0,885; 0,475) |
| p | 0,968 | 0,000 | 0,555 |
| Information policy | -0,319 (-0,911; 0,273) | -0,046 (-0,768; 0,676) | 1,777 (-0,504; 0,859) |
| p | 0,291 | 0,902 | 0,609 |
| Prohibition of advertising | -0,132 (-0,757; 0,493) | -0,498 (-1,15; 0,154) | -0,08 (-0,73; 0,566) |
| p | 0,678 | 0,134 | 0,804 |
| Warnings on cigarette packs | 0,126 (-0,454; 0,706) | 0,322 (-0,247; 0,891) | 0,471 (-0,155; 1,1) |
| p | 0,671 | 0,268 | 0,141 |
| Medical assistence | -0,554 (-1,09; -0,02) | -0,736 (-1,12; -0,357) | -0,273 (-0,98; 0,44) |
| p | 0,042 | 0,000 | 0,452 |
| Smoking prevalence | | | |
| Smoking prevalence in 2018 | 0,727 (0,316; 1,138) | 0,209 (-0,567; 0,982) | 0,055 (-0,6; 0,709) |
| p | 0,001 | 0,596 | |
| Smoking prevalence in 2019 | 0,672 (0,213; 1,133) | 0,582 (0,07; 1,09) | 0,172 (-0,432; 0,778) |
| p | 0,004 | 0,027 | 0,576 |
| Smoking prevalence dynamics in 2013-2018 | -0,818 (-1,09; -0,546) | -0,2 (0,862; 0,461) | -0,109 (-0,763; 0,544) |
| p | 0,000 | 0,554 | 0,744 |

Note: * — Spearman rank correlation coefficient; significant results are highlighted in bold (p<0,05).

Statistical processing and data analysis were carried out using the STATA 11.2 package.

## Results

The data on hospitalization rate per 100 thousand population for angina, MI and chronic rheumatic heart diseases from 2005 to 2019 in Russia are shown in dot diagrams in Figure 1. The dynamics of annual hospitalization rate for angina (1A), MI (1B) and chronic rheumatic heart diseases (1B) in Russia from 2005 to 2019 before and after the implementation of TC law are presented. The trend of hospitalization rate dynamics after TC law implementation (solid line) in comparison with the

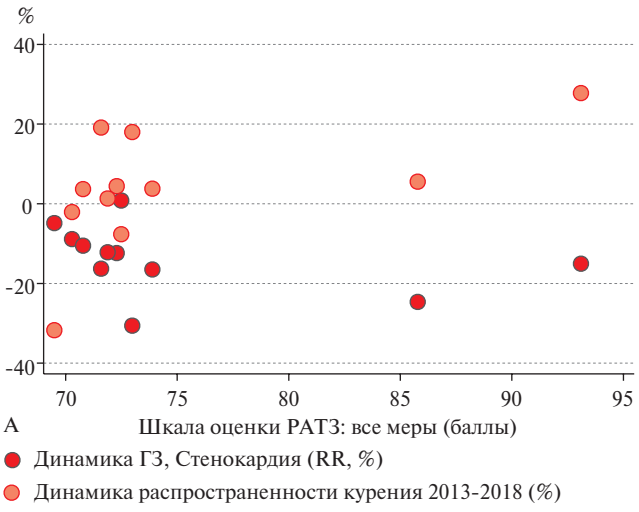


*Figure 2 A.* Correlation between the total score (all measures) (1), the relative dynamics of smoking prevalence in 2013-2018 (2), the dynamics of hospitalization rate for angina (3) in 10 Russian subjects.

Note: Spearman rank correlation coefficient (rsp): (1,2) rsp=0,627 (p<0,05), (1,3) rsp=-0,636 (p<0,005), (2,3) rsp=-0,809 (p<0,001), RR — Rate Ratio.

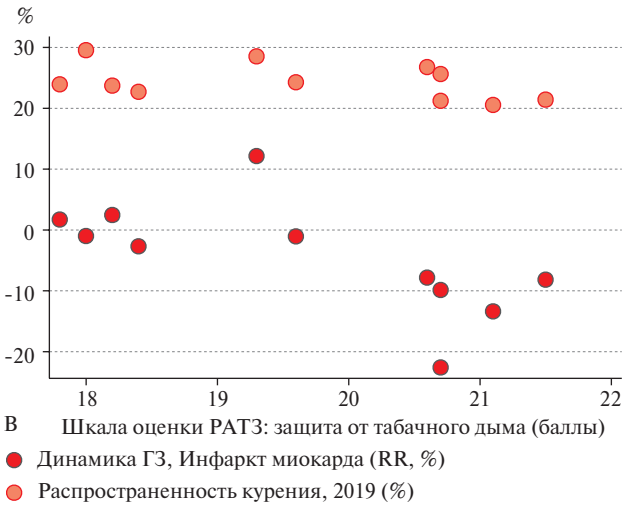


*Figure 2 B.* Correlation between the score for protection from tobacco smoke (1), smoking prevalence in 2019 (2) and the dynamics of hospitalization rate for MI (3) in 10 Russian regions.

Note: Spearman rank correlation coefficient (rsp): (1,2) rsp=-0,492 (p=0,07), (1,3) rsp=-0,793 (p<0,001), (2,3) rsp=0,581 (p<0,05). RR — Rate Ratio.

predicted trend and without TC measures (dashed line) (Figure 1) is shown.

Obviously, to the greatest extent, the hospitalization rate trend after TC law introduction deviates from the predicted trend for angina. This deviation is less pronounced, but significant for MI. In both cases, the difference between the actual and predicted trends remains for the entire period after TC law introduction, which indicates the effect persistence throughout the entire observation period. The difference between the trend lines before and after the TC law implementation is practically absent in chronic rheumatic heart disease, which indicates that the decrease in hospitalization rate for chronic rheumatic heart disease, possibly associated with a number of factors (for example, the higher effectiveness of antibiotic therapy, outpatient treatment), is not associated with TC legislative measures.

The results of Poisson regression analysis on the level of age-adjusted hospitalizations (per 100 thousand population) with angina and MI in relation to the time period of TC law implementation in Russia as a whole and 10 regions are demonstrated (Table 1). The analysis takes into account changes in hospitalization rate for these diseases associated with adoption of "Standard for healthcare provision for non- and ST segment elevation ACS" (2012) [20].

Table 1 shows that after the TC law introduction in Russia, there was a significant decrease in hospitalization rate of angina by 16,6% (RR=0,83 (95% CI: 0,741-0,927)) and in MI — by 3,5% (RR=0,953 (95% CI: 0,923-0,984)). The analysis showed the persistence of TC law effect for the entire follow-up period after the introduction regarding hospitalizations for angina (p=0,004), MI (p=0,049), but not regarding chronic rheumatic heart diseases (p=0,332), which is also illustrated in Figures 1 A, B, C.

The hospitalization rate dynamics for angina and myocardial infarction after the introduction of legislative measures is uneven across 10 Russian regions. However, in almost all regions, to a greater or lesser extent, there is a tendency towards a decrease in hospitalization rate for angina and MI after TC law introduction (Table 1).

We analyzed how the indicator of hospitalization rate dynamics (RR, %) after the introduction of TC law in the Russian constituent entities correlates with the completeness of the implementation of legislative measures and the prevalence of smoking in these regions (Table 2).

A significant correlation was found between the decrease in the hospitalization rate for angina and the total score characterizing the TC law implementation by the above scale: rsp=-0,627, 95% CI: from -1,055 to -0,12 (p=0,004) and a score characterizing the completeness of smoking cessation assistance: rsp= -0,554, 95% CI: -1,09 to -0,02 (p=0,042).

Also, the decrease in angina hospitalization rate for the period after TC law introduction correlates with the prevalence of smoking in 2018 (rsp=0,727, 95% CI: from 0,316 to 1,138 (p<0,001)), in 2019 (rsp=0,672, 95% CI: with 0,213 to 1,33 (p=0,004)) and correlates with the smoking prevalence dynamics from 2013 to 2018 (rsp=-0,818, 95% CI: from -1,09 to -0,546 (p<0,001)). Figure 2 demonstrates the correlations between the completeness of TC law implementation, the dynamics of smoking prevalence from 2013-2018 and the

**Table 3**

Associations of hospitalization rate dynamics for acute coronary events before and after the TC law introduction with the dynamics of smoking prevalence in 2013-2018 and smoking prevalence in 2019 according to linear regression

| | Dynamics of smoking prevalence in 2013-2018 | | Smoking prevalence in 2019 | |
|---|---|---|---|---|
| | β | 95% CI | β | 95% CI |
| | Hospitalization rate dynamics | | | |
| Angina | -0,345 | (-0,67; -0,02) | 1,73 | (-0,16; 3,62) |
| p | 0,041 | | 0,068 | |
| Myocardial infarction | -0,16 | (-0,85; 0,53) | 2,964 | (0,01; 5,92) |
| p | 0,612 | | 0,049 | |

Note: β — regression coefficient; significant results are highlighted in bold (p<0,05).

dynamics of angina hospitalization rate (Figure 2 A), the completeness of protecting people from tobacco smoke, the prevalence of smoking in 2019 and the dynamics of MI hospitalization rate (Figure 2 B).

Similar correlations were found between the decrease in MI hospitalization rate and the score characterizing smoking bans in public places (rsp=-0,793, 95% CI: from -1,08 to -0,506 (p<0,001) (Figure 2B)), as well as a score characterizing the completeness of smoking cessation assistance: rsp=-0,736, 95% CI: from -1,12 to -0,357 (p=0,027). A significant correlation was also revealed between the MI dynamics after the TC law introduction with the prevalence of smoking in 2019: rsp=0,582, 95% CI: from 0,07 to 1,09 (p=0,027) (Figure 2 B). It should be noted that the dynamics of smoking prevalence during the TC law implementation and the prevalence of smoking in 2019 also reliably correlate with the completeness of the implementation of legislative measures (Figure 2).

At the same time, no significant correlations were found between a decrease in hospitalization rate for chronic rheumatic heart diseases either with the completeness of the implementation of TC legislative measures, or with the prevalence of smoking in Russian constituent entities.

The above correlations are confirmed by linear regression analysis, which revealed significant associations of a decrease in MI hospitalization rate with the implementation of smoking bans in public places (β=-4,26, 95% CI: from -8,02 to -0,47; p=0,031) and smoking cessation assistance (β=-3,21, 95% CI: -6,23 to -0,2; p=0,039).

Also, according to linear regression analysis, significant associations were found between a decrease in hospitalization rate for angina and MI with smoking prevalence dynamics from 2013 to 2018 and smoking prevalence in 2019, respectively (Table 3).

## Discussion

For the first time, we analyzed long-term trends in annual hospitalizations (over 15 years) for acute coronary events, including ~18 million hospitalizations: >14680 thousand for angina, >3 million for MI in Russia as a whole and 10 Russian constituent entities. In all prior works analyzing the changes in hospitalization rates for different diseases in relation to TC law adoption, the time series of monthly hospitalizations was studied, thereby narrowing the time range of studied trends to several years [5, 8, 19].

The results obtained are comparable with the data of colleagues from other countries [5-7]. For example, Barone-Adesi, et al. revealed a 4% reduction in MI hospitalization rate immediately after the introduction of public smoking bans in Italy [5]. In the present study, a significant decrease in hospitalization rate for angina and MI (but not rheumatic heart disease, taken as a control) was obtained not only immediately after TC law adoption, but also throughout the studied period after the law introduction, in contrast, from the results of Italian colleagues [5]. This made it possible to compare the results obtained with the completeness of TC legislative measures, as well as with other results of TC law implementation.

This study analyzes for the first time the sequential effect of hospitalization rate reduction for acute coronary events after the introduction of tobacco control measures and the completeness of implementation of these measures. The results obtained allow to assume that the completeness of TC law implementation in the regions from the first years corresponded to its implementation in 2017-2018, on the one hand, and that the degree of enforcement of these measures could affect the dynamics of hospitalization rate for angina and MI, on the other. Well-known studies mainly discuss the effectiveness of TC measures by protecting the population from tobacco smoke [7, 21]. Most studies indicate that TC law norms, and especially public smoking bans, in most cases, are well enforced [22, 23]. However, not a single study demonstrates the relationship between the degree of hospitalization rate decrease and the completeness of compliance with TC laws.

Since the present work studied annual rather than monthly hospitalizations, there was no need to adjust

the model for seasonality. However, this study tried to take into account the potential impact of all possible factors that can both potentiate and reduce the impact of tobacco control measures, which is especially important when comparing regions. Model adjustments in relation to the hospital beds provision of population did not change the results of interregional comparisons. But the improvement of diagnostics and healthcare for patients with ACS, in connection with the introduction of new ACS Standard in 2012, could cause an increase in hospitalization rate for acute MI and, thereby, distort hospitalization rate dynamics related to the implementation of TC measures. A similar opinion that the change in diagnostic criteria for acute MI by the European Society of Cardiology and the American College of Cardiology in 2000 could be the reason for subsequent apparent increase in hospital admissions has already been stated by European colleagues [24, 25]. Other studies have shown that the effect of novel diagnostic criteria on the growth of morbidity, for example, in Italy was lower than in other countries [25]. In the present study, it was also shown that there was an increase in MI hospitalization rate due to the adoption of new Standard for care of patients with ACS, which, nevertheless, was less than the effect of TC legislative measures in Russia. In different constituent entities of Russia, this effect varied, and in some places exceeded the effect of TC measures.

TC laws are aimed both at protecting the population from secondhand smoke, and at reducing the prevalence of active smoking, and, ultimately, at reducing morbidity and mortality from smoking-related diseases. Palmieri L, et al. showed that a decrease in the prevalence of active smoking in Italy from 31,7 to 21,8% from 1980 to 2000 led to a 3,7% reduction in mortality from coronary artery disease, which is comparable to the effect of medical treatment for MI, hypertensive drugs and statins [26]. Interestingly, the results obtained in this study on "three-dimensional" links between the successful implementation of TC measures, the prevalence of smoking and hospitalization rate for acute coronary events. The Russian TC law is aimed at protecting the population from tobacco smoke, reducing the prevalence of smoking and protecting the population from its consequences. This study shows that the results of TC law implementation, for example, such as the dynamics of smoking prevalence during the period of TC law implementation and the low prevalence of smoking at the end of study period, can also be associated with the consistent dynamics of hospitalization rate for ACS. In particular, the identified associations between the completeness of TC law implementation, as well as the dynamics of smoking prevalence from 2013-2018 and the prevalence of smoking in 2019 with a decrease in hospitalization rate for angina UK and MI in the subsequent period after TC law adoption, can serve as confirmation of this hypothesis. The more complete the TC law implementation, the more pronounced the decrease in smoking prevalence from 2013 to 2018, and the more pronounced the decrease in hospitalization rate for angina, which indicates the long-term effects of TC legislative measures.

**Study limitations.** This natural-experiment population-based study allows only making assumptions about the causal relationship between TC law adoption and the decrease in hospitalization rate for smoking-related diseases. However, our findings are consistent with the results of many international studies using ITS design to assess the effects of interventions in population studies, and indicate changes in morbidity trends associated with the application of legislative measures.

Comparative analysis of hospitalization rate changes after the TC law introduction in regions is complicated by the limited number of regions TC measures was assessed, which may affect the study power and the assessment of correlations and associations. Nevertheless, significant associations were obtained, which allow to confirm the connections between these events.

## Conclusion

The results of this study, including a long-term follow-up period, show that, during the period of C law implementation, there is a significant decrease in hospitalization rate for angina (by 16,6%) and MI (by 3,5%) compared to the period before its adoption. This effect persists throughout the follow-up period until 2019. These results suggest that TC policy laws can contribute not only to short-term reductions in hospitalization rate for angina and MI immediately after adoption, but to longer-term results. The results also showed an uneven decrease in hospitalization rate for angina and MI in different regions, which may be due not only to the introduction of TC legislative measures, as such, but also to the completeness of their implementation, as well as the direct results of these measures — a decrease in smoking prevalence among population. Research findings that are significant for public health can be used to reasonably improve legislative practices regarding the protection of population from tobacco smoke exposure and the consequences of tobacco consumption, as well as programs for CVD prevention.

**Relationships and Activities:** none.

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