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“Changes in the system of country’s population health care depending on the level of providing affordable housing”

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CHANGES IN THE SYSTEM OF COUNTRY'S POPULATION HEALTH CARE DEPENDING ON THE LEVEL OF PROVIDING AFFORDABLE HOUSING

Abstract

This paper is devoted to providing affordable housing as a significant factor in public health management, inclusive growth, and SDG. The purpose is to empirically prove changes in the system of country's population health care depending on the level of providing affordable housing. The empirical base includes time series and panel data for 27 EU countries during 2011–2019. Due to correlation analysis (Shapiro-Wilk testing, Spearman or Pearson correlation, lags in time), regression analysis, and building a dynamic panel estimation model with Sargan testing in STATA, the study empirically confirmed and formalized the impact of affordable housing funding on changes in the system of country's population health care. In particular, the study found the dependence between overcrowding level and the share of homeowners with mortgages (a decrease of overcrowding level by an average of 0.61% with a time lag of 2 years due to an increase by 1%); the share of tenants on concessional terms/free (0.41% with a time lag of 3 years); and the share of public spending on housing development (0.25% with a time lag of 3 years). The direct relationship between the overcrowding and mortality from dangerous diseases (tuberculosis, AIDS, viral hepatitis, mental and behavioral disorders, diabetes, pneumonia) was also revealed. Public spending on housing under social protection programs (subsidies, etc.) proved to be the least effective. Preference should be given to the development of affordable mortgage lending (faster and greater effect). Generally, it impacts public management decisions in the health care system, social, and housing spheres.

Keywords aids, dangerous diseases, housing loan, human mortality, overcrowding, social housing

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INTRODUCTION

Today, improving public health is one of the priorities of public policy. However, despite understanding the importance and current unsatisfactory situation in the national public health model, the financial resources allocated to support this area and solve existing problems are limited and objectively insufficient. In this regard, it is important to reform the health care sector with an emphasis on social partnership and cooperation of crucial government actors, economic agents, and other stakeholders. This is vital to find adequate, timely, and effective mechanisms for implementing and improving the public health model, forms, methods, and tools for its practical implementation.

During the COVID-19 pandemic, governments and local authorities sought to strengthen existing networks and partnerships with communities to best meet people's needs (Mańka-Szulik & Krawczyk, 2022) while strengthening cross-sectoral cooperation (Sienkiewicz-

Małyjurek, 2022) and strong leadership in the health sector. At the same time, the World Health Organization emphasizes that governments would integrate health issues into national, regional, and urban planning policies and activities, including economic impact, benefit, and cost assessment (WHO, 2021b). Moreover, additional financial and organizational resources become available by involving other sectors, such as urban planning, infrastructure, and housing.

Therefore, one of the trends in sustainable development and inclusive growth is financing affordable housing as a factor of behavioral changes in the model of public health. The quality of housing and living conditions is a structural and social determinant of civil health. Housing is becoming increasingly significant for health in urban growth, population aging, and climate change. Housing overcrowding and housing insecurity in many countries necessitate a review of public policy and management to improve housing conditions in the context of public health reform. Moreover, infectious diseases such as malaria, COVID-19, tuberculosis, etc., are spreading rapidly, especially in poor and overcrowded environments, and are closely linked to unhealthy housing, poor sanitation, and poor waste management (WHO, 2021d). Accordingly, improving living conditions can save lives, prevent disease, and improve the quality of life in general (WHO, 2018), as the increased health burden caused by unhealthy living conditions (danger, overcrowding, cold, etc.) has a negative impact on educational and employment outcomes, social economic condition of the household and its members (WHO, 2021a, 2021c, 2011).

Thus, it is crucial to provide affordable and social housing as a significant factor in public health management, inclusive growth, and sustainable development. However, changes in the system of country's population health care depending on the level of providing affordable housing are not empirically proven enough, in particular, based on the impact assessment of social housing financing on housing overcrowding and, at the same time, the impact of housing overcrowding on human mortality from dangerous diseases.

1. LITERATURE REVIEW

The interconnection between housing conditions and civil health has been repeatedly raised by civil leaders, scientists, politicians, etc. As a result, certain aspects are reflected in the WHO recommendations (WHO, 2011, 2018, 2021a, 2021c). Moreover, this issue is one of the present directions of public policy and one of the potential possibilities to improve public health management in close relation to the social and financial policy of each country.

The bibliometric analysis based on the Scopus database tools shows that there are only 83 documents for 52 years from 1970 to 2021 according to the search request "public health management and social housing financing" (the search in titles, abstracts, and keywords in the publications indexed by the Scopus database) (Figure 1). Besides, more than 50% of the above publications were indexed in the last 15 years out of the 52 studied. Generally, the dynamics of scientific and publishing activity on the researched issue is positive, as evidenced by the trend shown in Figure 1.

The largest number of documents is affiliated with the USA, the United Kingdom, Canada, the Netherlands, Hong Kong, and Belgium. At the same time, the publications of authors from the USA, the United Kingdom, Canada, Australia, the Netherlands, Hong Kong, Singapore, and Sweden are the most cited as a result of the bibliometric analysis based on VosViewer software.

By conducting a bibliometric analysis using the VosViewer program, clusters of scientific research that are the most closely related to the key question of "public health management and social housing financing" were identified. The minimum number of keyword usages was set at 5, so 125 keywords were selected out of 1024 from the sample of publications. Then, for each of the 125 keywords, the total strength of the co-occurrence links with other keywords was calculated, and the keywords with the greatest total link strength were selected.

The four clusters of scientific research that are the most closely related to the key request of "public health management and social housing financing" are shown in Figure 2:

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Source: Authors' elaboration based on the Scopus database tools.

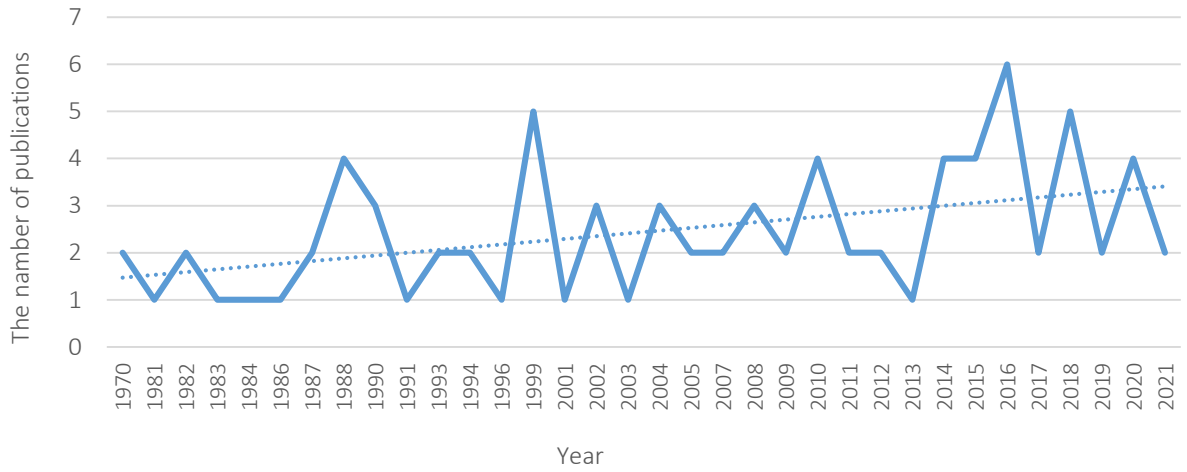

Figure 1. Bibliometric analysis of publications indexed by the Scopus database according to the search request "public health management and social housing financing" for 1970–2021

Source: Authors' elaboration based on the VosViewer software.

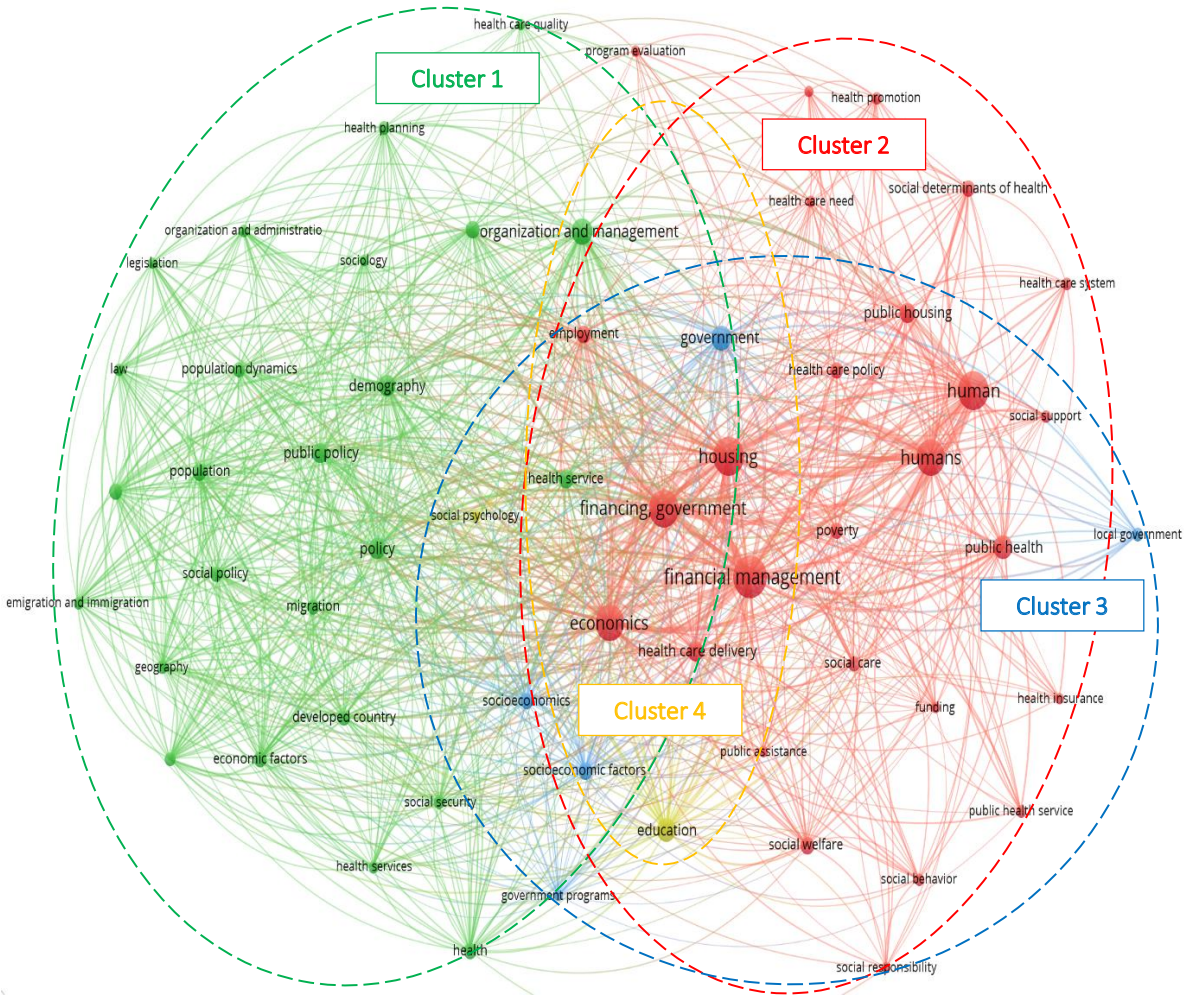

Figure 2. Clusters of scientific research that are the most closely related to the key request of "public health management and social housing financing"

- the 1st cluster – management, organization, and administration; public policy; social policy and security; public health service; health care planning and quality; legislation; demographic factors; sociology; migration; geographic factors;

- the 2nd cluster – financial management; government financing; program evaluation; economics; housing; public housing; public assistance; health care system and policy; health insurance and promotion; health status; public health; humans; poverty; employment; social behavior; social responsibility, support, and welfare;

- the 3rd cluster – government; local government; government programs; socioeconomics; socioeconomic factors;

- the 4th cluster – education; social psychology.

In the context of public health management and social housing financing, it is advisable to pay attention to separate areas of scientific development on this issue. Therefore, Habeeb (2021) investigated the public health model, focusing on population health, social security, and preventative.

Bagmet and Haponova (2018) focused on the influence of social institutions' quality on well-being and health. A public healthcare model based on social factors was also analyzed by Ansari et al. (2003). They paid attention to the challenge of reviewing links between modern directions of epidemiology and population health, factors of risk, sociological and ecological perspectives. Some factors that influence healthcare service were summarized by Shipko et al. (2020). Sardak et al. (2018) described the demographical situation, and Zhang et al. (2022) investigated the migration influence in this regard. Piven and Us (2022) and Yelnikova and Kwilinski (2020a, 2020b) analyzed approaches to the implementation of projects aimed at health care in Ukraine and foreign countries. Finally, some impact of COVID-2019 in this context was explained by Kolosok and Jakubowska (2020) and Smiianov et al. (2020).

Krieger and Higgins (2002) claimed that housing availability and conditions are key determinants of good health. The study characterized both negative housing conditions and the necessity of affordable housing. Kashyap et al. (2020) studied respiratory health upshots due to the living environment, considering the absence of housing and its quality conditions, hygiene, sanitation, water, and waste treatment in investigated region. The significant housing and health role was also analyzed by Stein (1950), Marsh (1982), Hyndman (1998), Thomson et al. (2001), Jacobs et al. (2007), and Jacobs (2011). Moreover, Kraft (2021) showed the economic role of both individual and corporate health and the necessity of health promotion. The risk linked with loss of knowledge and information was investigated by Yarovenko et al. (2021). Furthermore, Rajan (2018) emphasized the perception of health hazards by medical and society in general.

The problem of inequality and poverty in access to housing was analyzed by Sanchez (2020). The question about business interest and ethic motives in financing social housing was set by Ianchuk (2021c). Didenko et al. (2020) identified the problem of financial inclusion in the context of behavioral and social factors. Polyakov et al. (2020) and Lyeonov et al. (2021) also studied this and other determinants in the national health model. One more critical aspect is private and public responsibility for unsatisfactory housing conditions. It was described by Burridge and Ormandy (2007). In this context, Yelnikova and Golochalova (2020) analyzed the issue of responsible investment and especially social bonds, Leonov et al. (2014) and Kolosok et al. (2018) determined potential opportunities for investors. At the same time, in the investment process, it is important to take into account macroeconomic indicators and the state of the financial sector, and its real opportunities, which was emphasized by Brychko et al. (2021), Shkolnyk et al. (2019), and Tiutiunyk et al. (2022).

Seliuchenko and Kosar (2016) and Zwerenz (2018) studied peculiarities in the development of the housing market, and Ianchuk (2021a, 2021b), in addition, studied fundamental tendencies in housing finance and its affordability in different countries, taking into account socioeconomic relationships. Also, the impact of financing affordable housing on the country's economic development was proved (Ianchuk et al., 2021). Finally, Lahouirich et al. (2022) focused on the interconnection between financial factors and sustainable development in general.

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However, the impact of overcrowding on civil health, on the one hand, and the impact of financing social and affordable housing and its mechanisms on the level of overcrowding in the context decision-making in public health management, on the other, have not been investigated enough, empirically confirmed, and formalized, taking into account modern situation and time evolution. This determines the timeliness and relevance of this study and forms its aim.

The study aims to empirically prove changes in the system of country's population health care depending on the level of providing affordable housing.

2. METHODS

The bibliometric analysis was conducted based on the Scopus database tools and VosViewer software program. Statistical and graphical analysis was used for trends visualization and comparison in the EU and Ukraine, connected with overcrowding and public health particularly mortality from dangerous diseases. The evaluation of statistical significance, strength, and nature of the influence of changes in overcrowding level on changes in mortality from a number of dangerous diseases and the effect of changes in affordable housing financing on changes in overcrowding level was performed on the basis of correlation analysis. Before direct calculating correlation coefficients, the Shapiro-Wilk test for the subordination of factor variable to the normal distribution law was made. As a result, certain correlation coefficient (Pearson or Spearman) was chosen. Furthermore, possible time lags from 0 to 3 years were taken into account to increase obtained values adequacy. These impacts were also formalized by regression analysis and building a dynamic panel-data estimation model (Arellano-Bond linear dynamic panel-data estimation and the Sargan test of overidentifying restrictions) (Stata, n.d.a, n.d.b). All calculations were made in the STATA software package.

The research information base is composed of statistical data from WHO, EU statistical office, the State Statistics Service of Ukraine, State Institution "Public Health Center of the Ministry of Health of Ukraine," State Institution "Center for Medical Statistics of the Ministry of Health of Ukraine" etc.

The empirical base includes time series and panel data for the 27 EU countries from 2011–2019. The limit 2019 is explained by the availability of necessary data on the open portal of the EU statistical office for all studied indicators at the time of the research: the dynamics of housing overcrowding, the mortality from tuberculosis in EU countries, AIDS mortality, mortality from viral hepatitis, mortality from mental and behavioral disorders, diabetes mortality, mortality from pneumonia, share of homeowners with outstanding mortgages/housing loans, share of tenants on preferential terms or free of charge, share of public spending on housing development, and share of public spending on housing as a direction of social protection.

3. RESULTS

To conduct the study, a sample of 27 EU countries was formed, the data for which are analyzed for the period from 2011 to 2019 (time constraints are due to the availability of published statistics on the open portal of the EU statistical office for all studied indicators). The first analyzed indicator was the dynamics of housing overcrowding in the EU for 2011–2019 (Eurostat, 2022d). The lowest levels of overcrowding are in Cyprus, Ireland, Malta, the Netherlands, Belgium, Spain, and Luxembourg. Instead, the highest – in Romania, Latvia, Bulgaria, Croatia, and others. The gap between countries is from about 2% to 46%.

Then TB mortality in the EU for 2011–2019 (Eurostat, 2022a) was studied for further comparison with the trend in overcrowding in the EU.

A comparative analysis of the EU countries, as well as Ukraine, in terms of housing overcrowding and tuberculosis mortality in 2019 is presented in Figure 3.

In Ukraine, the death rate from tuberculosis (3 418 deaths in 2019) is not only significantly higher than the average level of EU countries but also hundreds and even thousands of times higher than in some EU countries. Disappointing statistics on mortality in Ukraine relate to other socially dangerous diseases too.

Source: Authors' elaboration based on Eurostat (2022a, 2022d), State Statistics Service of Ukraine (2019), Kuzin et al. (2020).

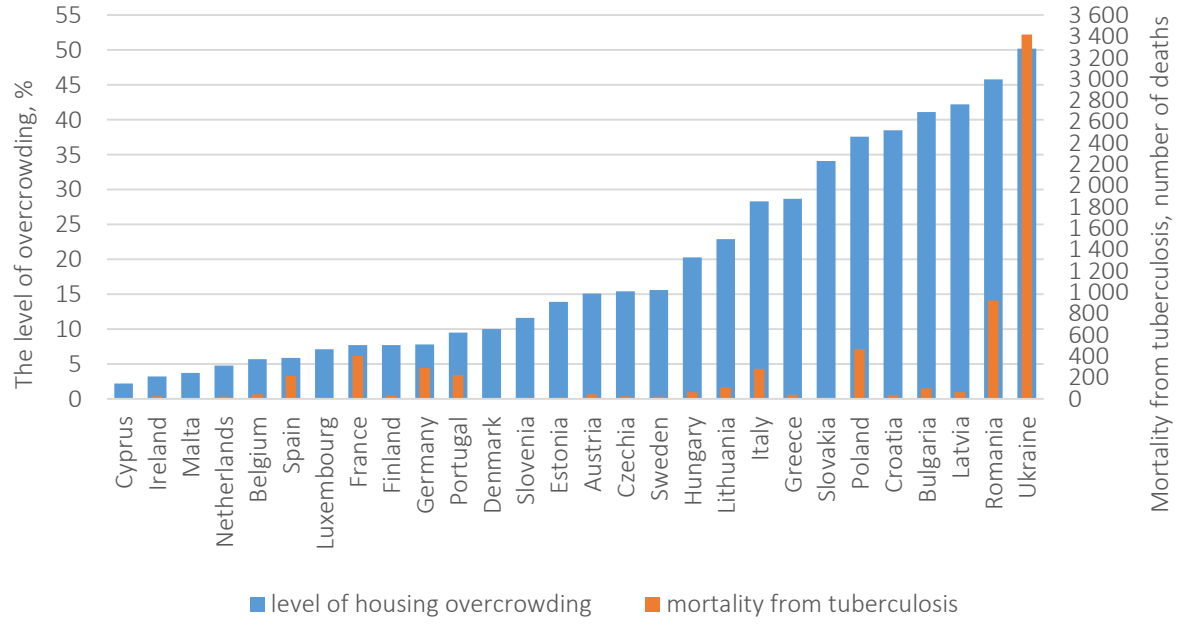

Figure 3. Comparative analysis of the EU countries and Ukraine in terms of overcrowding and mortality from tuberculosis in 2019

Figure 4 compares the EU countries and Ukraine in terms of housing overcrowding and AIDS mortality. In 2019, the number of AIDS deaths in Ukraine was 2 979.

The comparative analysis of the EU countries and Ukraine regarding the level of overcrowding and mortality from viral hepatitis and their consequences in 2019 are presented in Figure 5.

Source: Authors' elaboration based on Eurostat (2022a, 2022d), State Statistics Service of Ukraine (2019), Center for Public Health of the Ministry of Health of Ukraine (2019).

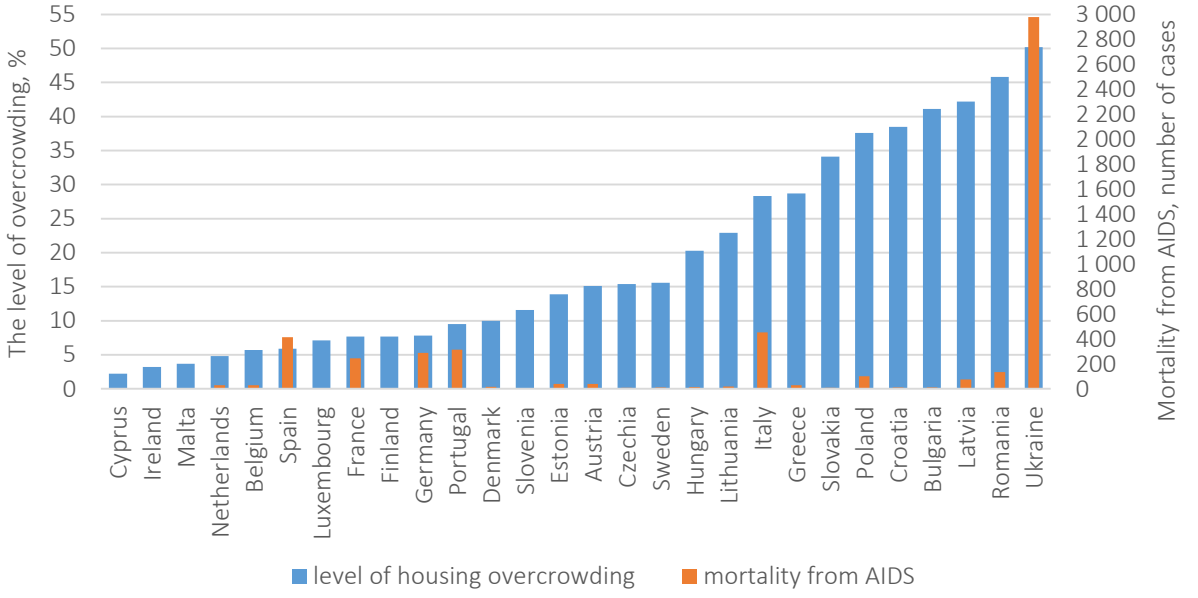

Figure 4. Comparative analysis of the EU countries and Ukraine in terms of housing overcrowding and AIDS mortality in 2019

http://dx.doi.org/10.21511/ppm.20(3).2022.18

Source: Authors' elaboration based on Eurostat (2022a, 2022d), State Statistics Service of Ukraine (2019), Database of the State Statistics Service of Ukraine (n.d.).

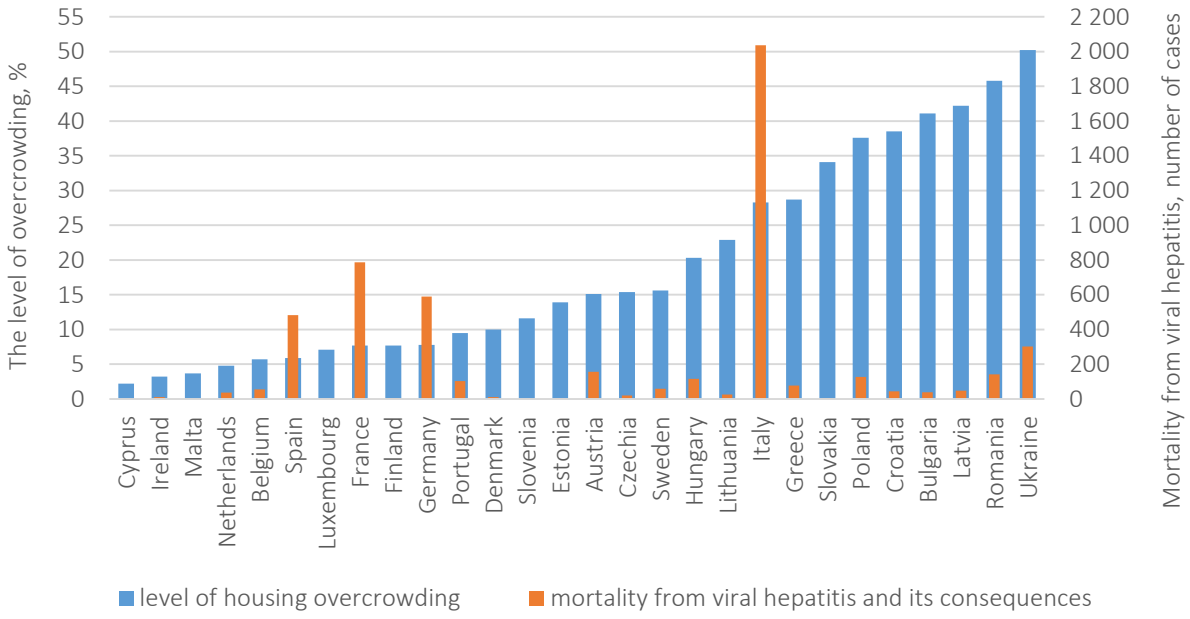

Figure 5. Comparative analysis of the EU countries and Ukraine in terms of housing overcrowding and mortality from viral hepatitis and their consequences in 2019

The highest rates are observed in Italy, France, and Germany.

It was also the systematization of data on mortality from mental and behavioral disorders, diabetes mortality, and mortality from pneumonia in the EU for 2011–2019 for further stage of research (Eurostat, 2022a). A comparative analysis of Ukraine and EU countries in terms of mortality rates from the above deadly diseases in 2019 is presented in Figure 6.

Source: Authors' elaboration based on Eurostat (2022a), State Statistics Service of Ukraine (2019).

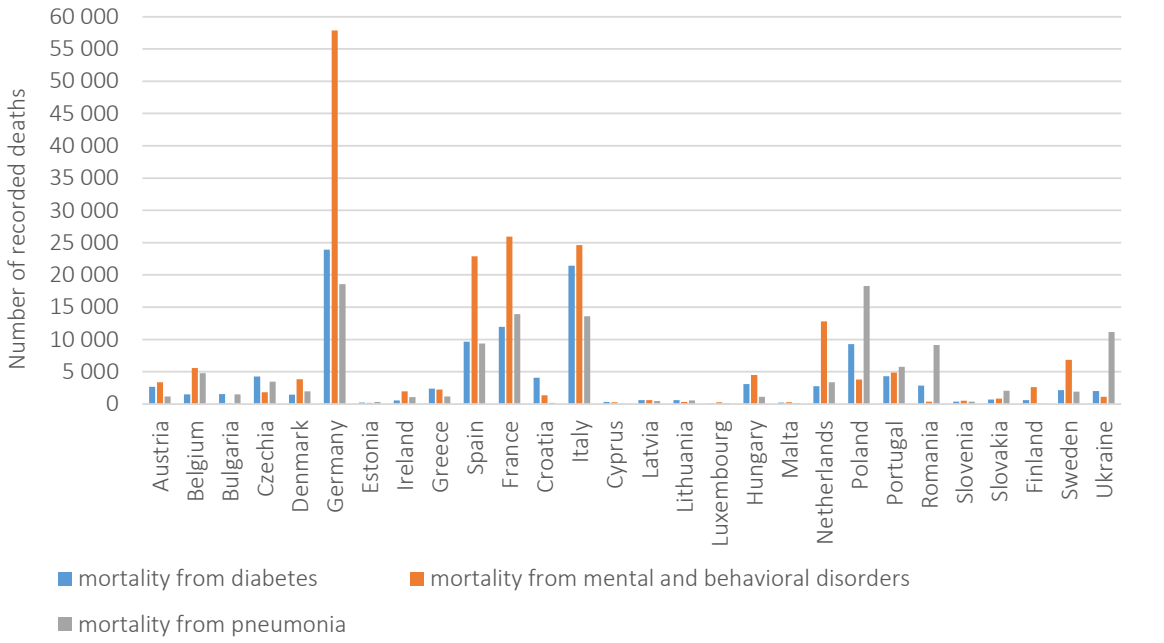

Figure 6. Comparative analysis of the EU countries and Ukraine by mortality rates from some dangerous diseases in 2019

Mortality from mental and behavioral disorders is very high in Germany, Spain, France, and Italy compared to other EU countries. In the same countries, there are significant mortality rates from diabetes. Pneumonia is also a common cause of death in many countries (as in Ukraine).

A correlation analysis was performed based on the above data to test the positive impact of reducing overcrowding on the level of mortality from a number of deadly diseases. Before the direct calculation of the correlation coefficients, the Shapiro-Wilk test for the subordination of the factor variable to the law of normal distribution (Shapiro & Wilk, 1965) was made in the STATA software package. According to the results, the method of calculating the correlation coefficient – Pearson (Prob > z more than 0.05) (Pearson, 1896) or Spearman Prob > z less than 0.05) (Spearman, 1904) was chosen. In addition, to increase the adequacy of the obtained values, possible time lags from 0 to 3 years were taken into account. Summary results of the assessment of statistical significance, nature, and strength of the impact of changes in housing overcrowding on changes in mortality from a number of dangerous diseases based on a sample of 27 EU countries for 2011-2019 are shown in Appendix A, Table A1.

The results of the correlation analysis show the mostly direct dependence between reducing the overcrowding of housing and reducing mortality from:

- tuberculosis (in 14 of the 27 sample countries, the direct nature of the impact was confirmed, as evidenced by a positive sign of the correlation coefficient). There is a high (correlation coefficient of more than 0.5) or very high (correlation coefficient of more than 0.9) strength of the relationship in 26 of the 27 sample countries, which is most often without time lag or with a lag of 3 years;

- AIDS (direct nature of the impact is in 16 of the 27 countries; high or very high strength of the relationship is in 24 of the 27 sample countries, most often with a time lag of 3 years);

- viral hepatitis (direct nature of exposure is in 16 of 26 countries; high or very high strength of the relationship is in 21 of 26 sample countries, often without time lag, while in Lithuania, this effect is not statistically significant (correlation coefficient less than 0.3);

- mental and behavioral disorders (direct nature of the impact is in 14 of the 27 countries; high or very high strength of the relationship is in 26 of the 27 sample countries, often without a time lag);

- diabetes (direct nature of the impact is in 14 of the 27 countries; high or very high strength of the relationship is in 22 of the 27 sample countries, usually with a time lag of 2 years);

- pneumonia (direct impact is in 16 of the 26 countries; high or very high strength of the relationship is in 21 of the 26 sample countries, often with a time lag of 3 years (in Croatia, this effect is not statistically significant).

One of the priority measures to reduce the overcrowding of housing is the financing of social housing. So, for the next research stage, the data on the following indicators were generalized: the share of homeowners with outstanding mortgages/housing loans, the share of tenants on preferential terms or free of charge, the share of public spending on housing development, the share of public spending on housing as a direction of social protection in the EU countries in 2011–2019 (Eurostat, 2022b, 2022c).

To confirm or reject the hypothesis about the positive impact of the growth of the above indicators of social housing financing on the level of overcrowding, a correlation analysis was performed with preliminary verification of factor variables for compliance with the law of normal distribution by the Shapiro-Wilk test. Summary results of the assessment of statistical significance, nature, and strength of the impact of changes in social housing financing on changes in housing overcrowding based on a sample of 27 EU countries for 2011–2019 are shown in Appendix A, Table A2.

The results of the correlation analysis confirm the dependence between an increase in the financing of social housing and a decrease in the level of overcrowding, as evidenced by the predominant

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Table 1. Impact of changes in the share of homeowners with mortgage/housing loan on changes in the level of overcrowding

Source: Authors' elaboration in the STATA software package.

LnO	Coef.	Std. Err.	z	P >|z|	[95% Conf. Interval]
LnO L1	.5022425	.0989557	5.08	0.000	.3082929 .6961921
LnL L0	–.0216965	.1771576	–0.12	0.903	–.368919 .3255259
L1	.3350288	.3212045	1.04	0.297	–.2945205 .964578
L2	–.6072635	.2518789	–2.41	0.016	–1.100937 –.11359
Const.	2.110072	.5017508	4.21	0.000	1.126659 3.093486
Wald chi2(11) = 46.63 Prob > chi2 = 0.0000					

Note: O – the level of overcrowding; L – share of homeowners with mortgage/loan; L0-L2 – time lags 0-2 years, respectively; Coef. – coefficient estimates; Std. Err. – standard deviations of estimates; P – level of significance; z – z-criterion; Conf. Interval – confidence interval; Const. – constant.

inverse nature of the impact of indicators (negative correlation coefficient). In particular, the following will help to reduce the level of overcrowding:

- increase in the share of homeowners with mortgage/housing loan (reverse impact is in 21 of the 27 countries; high or very high interconnectedness is in 23 of the 27 sample countries, most often with a time lag of 1 year);
- increase in the share of tenants on preferential terms/free of charge (reverse impact is in 14 out of 26 countries; high or very high interconnectedness is in 23 out of 26 sample countries (in Slovenia, this impact is not statistically significant), which is most often manifested in time lag 3 years);
- increase in the share of public spending on housing development (reverse impact is in 15 of 26 countries; high or very high interconnectedness is in 21 of 26 sample countries (in Croatia, this impact is not statistically significant), which is most often manifested with a time lag 3 years);
- increase in the share of public spending on housing as a direction of social protection (reverse impact is in 11 out of 22 countries; high or very high interconnectedness is in 19 out of 22 sample countries (in 5 sample countries, the impact of this indicator is not detected due to consistency in the dynamics of the study period), which is most often manifested with a time lag of 1 or 3 years).

This impact was formalized by regression analysis and building a dynamic panel-data estimation model (Arellano-Bond linear dynamic panel-data estimation) based on a sample of 27 EU countries. This model allows taking into account the evolution of economic phenomena through the introduction of lag variables, in particular the existing impact of past values of housing overcrowding on current values of the studied indicators, as well as endogenous factor variable (one or another indicator of social housing) and the impact of its past values. Furthermore, to improve the quality of the model, the study pre-generated variables in the form of natural logarithms of the studied indicators based on their different dimensions. The results of the impact of changes in the share of homeowners with a mortgage on the change in the level of overcrowding are presented in Table 1.

The coefficients LnO (with a time lag of 1 year) and LnL (with a time lag of 2 years) are statistically significant (P > | z | does not exceed 0.05). Prob > chi2 = 0.00 does not exceed 0.05 and indicates the adequacy of the constructed model, which is also confirmed by the results of the Sargan test (Sargan test of overidentifying restrictions). A negative LnL coefficient characterizes the inverse relationship between the studied indicators.

The constructed dynamic model for estimating the impact of changes in the share of homeowners with mortgage/housing loan on the change in the level of overcrowding is as follows:

$$LnO = 2.11 + 0.5LnO_{i,\,t-1} - 0.61LnL_{i,\,t-2}. \quad (1)$$

It is empirically confirmed that the level of overcrowding can decrease by an average of 0.61% with a time lag of 2 years due to an increase in the share of homeowners with mortgages/housing loans by 1%.

Table 2. Impact of changes in the share of tenants on preferential terms/free of charge on changes in the level of overcrowding

Source: Authors' elaboration in the STATA software package.

LnO	Coef.	Std. Err.	z	P >|z|	[95% Conf. Interval]
LnO L1	.5018998	.0984923	5.10	0.000	.3088585 .6949411
LnR L0	.1444758	.1254414	1.15	0.249	–.1599574 .6888602
L1	.2644514	.2165391	1.22	0.222	–.2873663 .3886737
L2	.0506537	.1724624	0.29	0.769	–.7124624 –.1120051
L3	–.4122338	.1531807	–2.69	0.007	–.1013849 .3903364
Const.	1.139092	.4211207	2.70	0.007	.3137102 1.964473
Wald chi2(11) = 44.14 Prob > chi2 = 0.0000					

Note: O – the level of overcrowding; R – the share of tenants on preferential terms / free; L0-L3 – time lags 0-3 years, respectively; Coef. – coefficient estimates; Std. Err. – standard deviations of estimates; P – level of significance; z – z-criterion; Conf. Interval – confidence interval; Const. – constant.

The results of the assessment of the impact of changes in the share of tenants on preferential terms/free of charge on changes in the level of overcrowding are presented in Table 2.

The coefficients LnO (with a time lag of 1 year) and LnR (with a time lag of 3 years) are statistically significant (P > | z | does not exceed 0.05). Prob > chi2 = 0.00 does not exceed 0.05 and indicates the adequacy of the constructed model, which is also confirmed by the results of the Sargan test of overidentifying restrictions. The negative LnR coefficient characterizes the inverse relationship between the studied indicators.

The constructed dynamic model for estimating the impact of changes in the share of tenants on preferential terms / free of charge on changes in the level of overcrowding is as follows:

$$LnO = 1.14 + 0.5LnO_{i,\,t-1} - 0.41LnL_{i,\,t-3}. \quad (2)$$

It is empirically confirmed that the level of overcrowding can decrease by an average of 0.41% with a time lag of 3 years due to an increase in the share of tenants on preferential terms/free of charge by 1%.

The assessment results of the impact of changes in the share of government spending on housing development and housing as a direction of social protection on the change in the level of housing overcrowding are presented in Table 3.

The coefficients LnO (with a time lag of 1 year), LnGE_d (without time lag and with a time lag of 3 years) are statistically significant (P > | z | does not exceed 0.05). The value of the coefficient LnGE_sh is not statistically significant in the estimated interval, considering time lags from 0 to 3 years. Prob > chi2 = 0.00 does not exceed 0.05 and indicates the adequacy of the constructed model, which is confirmed by the Sargan test results of overidentifying restrictions (Prob > chi2 = 0.0634). A positive coefficient LnGE_d without time lag characterizes the direct relationship between the studied indicators; instead, a negative sign of the same coefficient for a time lag 3 years allows us to say the inverse relationship, which occurs with a lag of 3 years.

Based on the above, the built dynamic model for assessing the impact of changes in the share of public spending on housing development and housing as a direction of social protection on changing the level of overcrowding is as follows:

$$LnO = 0.33 + 0.45LnO_{i,\,t-1} + \\ +0.14LnGE\_sh_{t\,t} - 0.25LnGE\_d_{,\,-3}. \quad (3)$$

It is empirically confirmed that an increase in the share of public spending on housing development by 1% can help to reduce the level of overcrowding by an average of 0.25% with a time lag of 3 years.

The regression analysis results of the impact of government spending on housing (as a direction of social protection) on the level of housing overcrowding are not statistically significant in the sample (although correlation analysis found inverse dependence and high interconnectedness in about half of the sample countries).

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Table 3. Impact of changes in the share of government spending on housing development and housing as a direction of social protection on changes in the level of overcrowding

Source: Authors' elaboration in the STATA software package.

LnO	Coef.	Std. Err.	z	P >|z|	[95% Conf. Interval]
LnO L1	.3252281	.116812	2.78	0.005	.0962808 .5541754
LnGE_sh L0	.1429262	.0853244	1.68	0.094*	–.0243066 .3101589
L1	.0833433	.0721897	1.15	0.248	–.058146 .2248326
L2	.0598885	.0682107	0.88	0.380	–.073802 .1935789
L3	.0132546	.0639551	0.21	0.836	–.1120952 .1386043
LnGE_d L0	.3353129	.0943647	3.55	0.000	.1503615 .5202644
L1	.1411504	.1281097	1.10	0.271	–.10994 .3922408
L2	.1108561	.1512078	0.73	0.463	–.1855057 .407218
L3	–.2473181	.1402924	–1.76	0.018	–.5222861 .0276499
Const.	1.934112	.3500791	5.52	0.000	1.24797 2.620255
Wald chi2(11) = 55.92 Prob > chi2 = 0.0000					

Note: O – the level of overcrowding; GE_d – the share of government spending on housing development; GE_sh – the share of public spending on housing as a direction of social protection; L0 - L3 – time lags 0-3 years, respectively; Coef. – coefficient estimates; Std. Err. – standard deviations of estimates; P – level of significance; z – z-criterion; Conf. Interval – confidence interval; Const. – constant; * – the value of the coefficient is not statistically significant in the estimated interval, taking into account time lags from 0 to 3 years.

4. DISCUSSION

Maqboo et al. (2015) made similar conclusions about understanding housing as a determinant of health. However, conclusions were not based on empirical evidence of cross-country analysis as in the case of this study. Garland et al. (2013) investigated the impact of social housing, especially on asthma, using the methods of questionnaires, observations, and testing, and this study is based on economic-mathematical modeling. However, the study did not pay attention to the problem of financing affordable housing and the according possibilities in decision-making in public management.

This paper strongly agrees that quite often, health professionals are not involved in the direct public decision-making. This can lead to a loss of opportunities to ensure and improve public health (Robert Wood Johnson Foundation & The Pew Charitable Trusts, 2016) and, in particular, taking into account housing affordability as its important determinant.

Rolfe et al. (2020) used a realist research approach, longitudinal study of tenants, and staff interviews to determine connections between tenants' experience of housing and their health. Meltzer and Schwartz (2016) proved the relationship between health and housing affordability due to building multivariate regression models. But the authors used the data only for New York, and the proposed models include some dummy indicators. Finally, Rahman (2007) proposed a case of the impact of housing finance on socio-economic uplift, but only for Bangladesh.

That is why this study, based on empirical evidence of 27 countries for 9 years and economic-mathematic modeling, objectively proves the dependence between an increasing the direction and volume of financing social housing and reducing the overcrowding of both own and rented housing and, accordingly, and an influence on the quality of living conditions (sanitary conditions, environmental factors, etc.). Moreover, it can have a positive impact not only on physical but also mental health and behavior of citizens (reduction of mental and behavioral disorders due to unbearable financial burden because of housing problems) and help free up financial resources of households to improve healthy eating, pay for medical supplies and medical services in the field of health care, which will eventually reduce mortality from a number of dangerous diseases: tuberculosis, AIDS, viral hepatitis, mental and behavioral disorders, pneumonia, diabetes.

Of course, the proved effect is not instantaneous and quantitatively significant, delayed in time, as evidenced by the defined time lags and low coefficient values in the regression equations. However, public management focused on improving health

care system and provision of affordable housing is justified in the medium and long term. The above results have a great potential both in future research on investigated issues and decision-making in public management in health care system, social and financial fields on cross-countries, national and local levels of decisions making. Further research can be aimed at evaluating the effectiveness of the implementation of various mechanisms for the financial provision of social housing and detailing the forms and methods of its organization and management of this process.

CONCLUSIONS

The study empirically confirmed and formalized changes in the system of country's population health care depending on the level of providing affordable housing based on correlation-regression analysis and modeling the impact assessment of social housing financing on housing overcrowding and, at the same time, the impact of housing overcrowding on mortality from dangerous diseases (sample from 27 EU countries for 2011–2019).

It was found the dependence between the level of overcrowding and financing affordable housing. The level of overcrowding can decrease by an average of 0.61% with a time lag of 2 years due to an increase in the share of homeowners with mortgages/housing loans by 1%; it can decrease by an average of 0.41% with a time lag of 3 years due to an increase in the share of tenants on concessional terms/free by 1%; it can decrease by an average of 0.25% with a time lag of 3 years due to an increase in the share of public spending on housing development by 1%. Accordingly, it has been confirmed the direct dependence between reducing overcrowding and reducing mortality from tuberculosis (mostly without time lag or with a lag of 3 years), AIDS (mostly with a time lag of 3 years), viral hepatitis (mostly without time lag), mental and behavioral disorders (mostly without a time lag), diabetes (mostly with a time lag of 2 years), and pneumonia (mostly with a time lag of 3 years).

These issues affect public management decisions in the system of country's population health care, social, and housing spheres. The governments of the EU countries and especially in Ukraine (where the overcrowding rate is more than 50%) should pay particular attention to the impact of affordable housing providing as an essential factor in public health. When choosing directions/mechanisms of financing affordable housing, preference should be given to the development of affordable mortgage lending (faster and greater effect) compared to providing rental housing on concessional terms or free and public financing of housing development costs. At the same time, public spending on housing under social protection programs (subsidies, etc.) proved to be the least effective in addressing the problem of overcrowding and, consequently, improving public health.

AUTHOR CONTRIBUTIONS

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APPENDIX A

Table A1. Statistical significance, nature, and strength of the impact of changes in the level of overcrowding on changes in mortality from a number of dangerous diseases (a sample from 27 EU countries for 2011–2019)

Source: Calculated by the authors in the STATA software package.

Country's name (code)	Tuberculosis		AIDS		Viral hepatitis		Mental and behavioral disorders		Diabetes		Pneumonia	
	r	*t*	*r*	*t*	*r*	*t*	*r*	*t*	*r*	*t*	*r*	*t*
AT	–0.90	3	–0.77	3	0.64	0	0.77	3	0.71	1	0.82	3
BE	–0.66	0	–0.74	1	–0.84	0	0.67	0	–0.57	0	0.87	0
BG	0.98	2	0.40	3	–0.81	2	–0.47	0	–0.40	2	0.42	3
CZ	0.83	2	0.69	3	0.81	2	–0.96	0	–0.91	3	–0.96	0
DK	–0.73	0	0.60	3	–0.93	2	0.91	0	0.88	2	0.73	3
DE	–0.76	0	–0.95	1	–0.94	1	0.92	0	0.62	2	0.33	2
EE	0.93	3	0.81	1	0.53	1	–0.88	1	–0.75	1	0.54	0
IE	–0.86	1	–0.34	3	0.46	1	0.67	3	0.87	3	0.60	1
EL	–0.79	1	0.60	0	–0.79	2	0.99	2	0.98	1	0.82	0
ES	0.86	1	0.77	1	0.58	3	–0.87	2	–0.45	2	–0.61	3
FR	0.83	3	0.76	3	0.63	0	–0.81	2	–0.64	2	–0.67	2
HR	0.65	0	–0.57	2	0.39	3	–0.53	0	–0.94	2	–0.21*	0
IT	0.51	2	–0.91	3	–0.77	3	0.94	3	0.61	2	0.88	3
CY	0.35	1	0.77	3	0.45	3	–0.78	3	0.57	3	0.50	3
LV	–0.86	3	–0.80	0	–0.74	3	0.57	0	0.63	0	0.79	2
LT	–0.54	3	0.87	3	0.55	0	0.62	3	0.34	3	0.64	3
LU	–0.63	3	–0.70	2	–0.28*	3	0.74	1	0.41	3	0.76	2
HU	0.89	1	0.46	2	0.93	2	–0.94	3	–0.94	2	–0.37	1
MT	0.83	2	0.74	3	0.52	1	–0.97	2	–0.83	3	–0.70	3
NL	–0.90	3	–0.84	1	–0.71	0	0.98	1	–0.66	2	0.73	3
PL	0.85	0	0.74	0	0.95	3	–0.93	1	–0.93	0	–0.93	1
PT	–0.54	1	0.75	0	0.69	1	–0.73	1	0.54	2	0.65	2
RO	0.95	0	0.78	3	–0.99	0	–0.78	0	–0.96	2	–0.99	1
SI	0.51	2	0.76	2	0.48	0	–0.97	3	–0.48	3	0.90	3
SK	0.55	3	–0.90	3	0.83	1	0.54	3	0.66	1	–0.76	3
FI	–0.51	0	0.53	2	0.34	0	0.65	0	0.66	3	–0.48	0
SE	–0.65	0	–0.58	3	–0.65	1	0.78	0	0.70	1	–0.30	1

Note: * means the value of the correlation coefficient is not statistically significant for the studied period; r is the correlation coefficient; t is the time lag (from 0 to 3 years), at which the value of the correlation coefficient is the maximum for the studied period; AT – Austria; BE – Belgium; BG – Bulgaria; CZ – Czechia; DK – Denmark; DE – Germany; EE – Estonia; IE – Ireland; EL – Greece; ES – Spain; FR – France; HR – Croatia; IT – Italy; CY – Cyprus; LV – Latvia; LT – Lithuania; LU – Luxembourg; HU – Hungary; MT – Malta; NL – Netherlands; PL – Poland; PT – Portugal; RO – Romania; SI – Slovenia; SK – Slovakia; FI – Finland; SE – Sweden.

Table A2. Statistical significance, nature, and strength of the impact of changes in social housing financing on changes in the level of overcrowding (sample from 27 EU countries for 2011–2019)

Source: Calculated by the authors in the STATA software package.

Country's name (code)	Share of homeowners with outstanding mortgage/loan terms		Share of tenants on preferential terms/ free of charge		Share of government spending on housing development		Share of public spending on housing as a direction of social protection	
	r	*t*	*r*	*t*	*r*	*t*	*r*	*t*
AT	0.75	1	–0.47	2	0.74	1	0.66	3
BE	–0.39	3	0.83	3	–0.66	3	0.73	1
BG	–0.88	1	–0.86	1	–0.62	2	–0.49	0
CZ	–0.99	0	–0.70	3	0.68	2	–0.87	3
DK	–0.86	1	0.90	3	–0.45	0	0.80	3
DE	–0.94	1	0.86	0	–0.97	3	–0.70	1
EE	–0.86	2	–0.82	2	0.60	1	–	–
IE	0.61	1	0.66	1	–0.67	3	–0.44	1
EL	–0.72	3	0.96	0	0.73	3	–0.48	1
ES	–0.32	2	0.67	3	–0.32	3	–0.65	1
FR	–0.45	1	–0.71	0	–0.82	3	0.66	1
HR	–0.96	0	0.57	0	0.22*	0	–	–
IT	–0.41	2	0.72	0	–0.75	2	–	–
CY	–0.55	0	0.33	2	0.34	0	–0.74	3
LV	0.74	3	0.80	2	–0.76	1	–0.81	2
LT	–0.81	2	–0.51	3	–0.88	2	0.90	2
LU	0.52	3	–0.74	3	–0.77	3	0.81	3
HU	0.84	2	–0.90	3	0.49	2	0.90	3
MT	–0.86	0	–0.46	0	0.33	1	–0.89	1
NL	0.69	1	–0.82	0	–0.82	0	0.88	1
PL	–0.96	3	–0.99	3	0.98	0	0.83	2
PT	–0.84	3	–0.83	1	–0.52	2	0.66	3
RO	–0.85	1	–0.62	3	–0.77	3	–	–
SI	–0.99	2	0.22*	3	0.62	0	–0.70	0
SK	–0.97	0	–0.80	3	0.76	2	–	–
FI	–0.76	3	0.73	3	–0.51	1	0.71	3
SE	–0.83	2	0.86	0	0.80	0	–0.65	0

Note: * means the value of the correlation coefficient is not statistically significant for the studied period; – means the connection is not established, based on constant data in the dynamics of the studied indicator; r is the correlation coefficient; t – time lag, at which the value of the correlation coefficient is the maximum for the studied period (from 0 to 3 years); AT – Austria; BE – Belgium; BG – Bulgaria; CZ – Czechia; DK – Denmark; DE – Germany; EE – Estonia; IE – Ireland; EL – Greece; ES – Spain; FR – France; HR – Croatia; IT – Italy; CY – Cyprus; LV – Latvia; LT – Lithuania; LU – Luxembourg; HU – Hungary; MT – Malta; NL – the Netherlands; PL – Poland; PT – Portugal; RO – Romania; SI – Slovenia; SK – Slovakia, FI – Finland; SE – Sweden.

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