

## Original Article

### Self-Violence and Suicide among Different Ages in Iraqi Society

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#### Abstract

**Background:** Self-harm and suicide represent significant public health challenges globally.

**Objectives:** This study examines the distribution and characteristics of self-harm and suicide cases in Iraq, to inform targeted interventions and mental health strategies.

**Methods:** This study analyzes the distribution and characteristics of self-harm cases in 2023, focusing on age, gender, regional demographics, educational levels, methods of injury, and underlying reasons. Data were examined using chi-square tests to identify statistical differences and calculate percentages for distribution patterns.

**Results:** Findings reveal that the age group 25–34 had the highest self-harm rates (33.3%), followed by 15–24 (22.2%), indicating vulnerability among young adults. Peaks in self-harm occurrences were noted in August and September, suggesting seasonal influences on mental health. Males, particularly in the 25–34 age bracket, exhibited higher rates with a significant gender difference ( $p < 0.05$ ). Geographically, Baghdad, Ninawa, and Basra reported the highest case incidences ( $p < 0.05$ ), linked to regional socioeconomic conditions. Individuals with primary and middle school education had higher self-harm rates, though no significant educational differences were found ( $p = 0.506$ ). Poisoning was the most common method, especially among females, while males predominantly used hanging ( $p < 0.05$ ). Family issues were the leading reason for self-harm (66.1%), followed by psychological issues (29.7), with notable gender differences ( $p = 0.0005$ ).

**Conclusion:** The study identifies critical patterns of self-harm and suicide in Iraq, particularly among young males in socioeconomically challenged regions. This highlights the need for targeted, culturally sensitive mental health interventions and further research into underlying socio-cultural factors.

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#### Introduction

Self-violence, including self-injury and suicide attempts, is increasingly prevalent in Iraq, reflecting deep psychological disorders often exacerbated by societal, economic, and political stressors.<sup>1,2</sup>



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It frequently serves as a coping mechanism for individuals facing intense emotional distress, trauma, or undiagnosed mental health issues, particularly among young people who lack social support and mental health resources.<sup>1-3</sup>

Key factors contributing to self-violence in Iraq include prolonged exposure to conflict and displacement, leading to high levels of trauma and post-traumatic stress disorder (PTSD). Research shows that those affected by conflict or displacement have a heightened risk of self-violence due to the psychological implications of violence and instability.<sup>2-3</sup>

Economic pressures and unemployment amplify feelings of hopelessness, particularly among young adults who see no viable future. Self-harming behaviors, which may include cutting or self-immolation, often arise from a desire to relieve emotional pain in the absence of healthy coping mechanisms.<sup>4</sup>

Gender dynamics also play a role in self-violence patterns. Women tend to engage in non-fatal self-harm due to relational pressures, while men are more likely to die by suicide, often influenced by cultural norms discouraging emotional expressivity.<sup>5</sup>

Additionally, the cultural stigma surrounding mental health issues further complicates self-violence in Iraq, limiting community conversations and support systems that could facilitate early intervention. Organizations like the WHO and UNDP advocate for culturally sensitive mental health services to address these challenges.<sup>6-7</sup>

The rise in suicide rates in Iraq mirrors a global trend, attributed to ongoing socio-political conflicts, economic hardships, and stigma against mental health.<sup>8-9</sup>

Notably, youth represent a significant portion of suicides, with methods influenced by cultural factors and availability, such as self-immolation and firearms. The COVID-19 pandemic has intensified mental health issues, particularly among economically vulnerable groups, highlighting the need for community-based interventions.<sup>4,7-9</sup>

In response, the Iraqi government has initiated a national action plan to enhance mental health care and reduce suicides.<sup>10</sup>

## Methods

This cross-sectional study investigates the prevalence, characteristics, and factors associated with self-violence and suicide among different age groups in Iraqi society. Utilizing both quantitative and qualitative methods, the study collects data through surveys, semi-structured interviews (self-developed tools), and analyses of medical records from healthcare facilities across Iraq's urban and rural areas.

The target population consists of Iraqi citizens categorized into four age cohorts: children (10–17 years), young adults (18–35 years), middle-aged adults (36–55 years), and older adults (56 years and above). A stratified random sampling method ensures representative sampling from each age group, aligning with demographic data provided by the Iraqi Ministry of Planning.

To achieve statistical significance at a 95% confidence level, a sample size of 1,200 participants was calculated based on estimated prevalence rates of suicide and self-harm from prior studies.

The data collection employed several methods to comprehensively cover factors related to self-violence and suicide.

**Questionnaires:** Self-administered questionnaires were distributed, addressing demographics, mental health history, socio-economic status, trauma exposure, family background, and substance use. The questionnaires were created in Arabic, ensuring cultural relevance.

**Semi-Structured Interviews:** Interviews were conducted with a subset of 100 participants across all age cohorts, allowing an in-depth exploration of personal experiences related to self-violence and suicidal behavior. The interviews focused on psychological distress, familial dynamics, coping strategies, and perceptions of mental health resources.

Data on self-violence incidents and suicide attempts were extracted from medical records across five major hospitals and mental health clinics in Iraq, capturing patient demographics, diagnoses, self-harm types, and treatment outcomes.

The data analysis was conducted in two phases:

quantitative and qualitative.

Survey data and medical records were statistically analyzed using SPSS software. Descriptive statistics summarized demographic variables, while logistic regression models assessed associations between age, gender, socio-economic factors, and self-violence or suicide rates. Chi-square tests explored significant differences among age groups.

Thematic analysis of interview transcripts identified patterns related to mental health stigma, family dynamics, trauma histories, and access to mental health resources.

**Ethical Considerations:** Ethical considerations adhered to the Declaration of Helsinki guidelines. Ethics Committee approval was obtained from [University/Hospital], ensuring confidentiality and voluntary participation. Written informed consent was collected from adult participants, while minors aged 10–17 provided assent with parental consent. Participants in distress were referred to counseling services offered by partner organizations.

Limitations include potential response bias given the sensitive nature of the topics, as some might withhold personal information due to stigma. Additionally, reliance on self-reported data could limit the accuracy of findings. To address these limitations, the study

combines self-reported data with objective medical records and employs a culturally sensitive approach to enhance participant comfort.

The study design ensures sufficient statistical power to draw meaningful conclusions across age groups. Anonymized data from medical records are available upon request for replication under ethical compliance.

## Results

**Distribution of Self-Harm and Suicide Cases by Age Group (2023):** This pie chart illustrates the distribution of self-harm and suicide cases across various age groups in Iraq in 2023. The age group 25–34 constitutes the largest portion (33.3%) of incidents, suggesting that young adults are more vulnerable to self-violence. The 15–24 age group also has a significant share (22.2%), highlighting a concerning trend among adolescents and young adults. Such data can be useful for targeting age-specific prevention and intervention programs.

**Monthly Self-Harm and Suicide Incidents in 2023:** This bar chart shows the monthly trend of self-harm and suicide cases throughout the year. Peaks are noticeable in August and September, possibly due to seasonal factors, societal stressors, or cultural events that may impact mental health. Understanding the

**Table 1:** Distribution according to Iraqi's governorates:

Region	Male Injured (Count & %)	Male Death (Count & %)	Female Injured (Count & %)	Female Death (Count & %)	Total Cases
Baghdad	135 (19.81%)	2 (0.29%)	551 (80.88%)	7 (1.03%)	695
Kerbala	37 (24.83%)	21 (14.09%)	95 (63.76%)	8 (5.37%)	161
Kirkuk	38 (25.17%)	11 (7.28%)	72 (47.68%)	19 (12.58%)	140
Najaf	13 (13.27%)	13 (13.27%)	46 (46.94%)	9 (9.18%)	98
Basra	98 (25.13%)	39 (10.00%)	211 (54.08%)	22 (5.64%)	370
Diyala	7 (13.73%)	14 (27.45%)	23 (45.10%)	15 (29.41%)	59
Ninawa	37 (10.58%)	72 (20.58%)	111 (31.75%)	175 (50.00%)	395
Diwania	11 (19.30%)	19 (33.33%)	7 (12.28%)	20 (35.09%)	57
Misan	4 (10.81%)	18 (48.65%)	3 (8.11%)	11 (29.73%)	37
Thiqr	1 (2.63%)	24 (63.16%)	0 (0.00%)	17 (44.74%)	42
Wasit	5 (9.62%)	18 (34.62%)	21 (40.38%)	19 (36.54%)	63
Babil	2 (7.41%)	18 (66.67%)	0 (0.00%)	13 (48.15%)	33
Muthana	3 (10.71%)	10 (35.71%)	17 (60.71%)	11 (39.29%)	41
Sala-Din	1 (10.00%)	0 (0.00%)	4 (40.00%)	6 (60.00%)	10
Total	392	289	821	346	1848

**Note:** Chi-square statistic: 965.37, p-value:  $3.93 \times 10^{-1773.93} \times 10^{-177}$ ,

**Table 2:** Distribution according to educational level:

Educational Level	Male Count	Male %	Female Count	Female %
Primary	210	31.34%	494	33.86%
Middle School	224	33.43%	465	31.87%
High School	106	15.82%	237	16.24%
Institute	5	0.75%	9	0.62%
Bachelor's Degree	13	1.94%	30	2.06%
Illiterate	12	1.79%	41	2.81%
Unknown	100	14.93%	183	12.54%
<b>Total</b>	<b>670</b>	<b>100%</b>	<b>1459</b>	<b>100%</b>

Note: Chi-Square Statistic: 5.30, p-value: 0.506

**Table 3:** Distribution according to the types of harm:

Method of Injury	Male Count	% Male	Female Count	% Female	Total Count	% Total
Hanging	58	46.03%	27	26.21%	85	37.12%
Poisoning	49	38.89%	50	48.54%	99	43.23%
Gunshot	6	4.76%	1	0.97%	7	3.06%
Self-immolation	9	7.14%	24	23.30%	33	14.41%
Stabbing	3	2.38%	1	0.97%	4	1.75%
Jumping from height	1	0.79%	0	0.00%	1	0.44%
<b>Total</b>	<b>126</b>	<b>100%</b>	<b>103</b>	<b>100%</b>	<b>229</b>	<b>100%</b>

Note: The p-value is approximately 0.00062

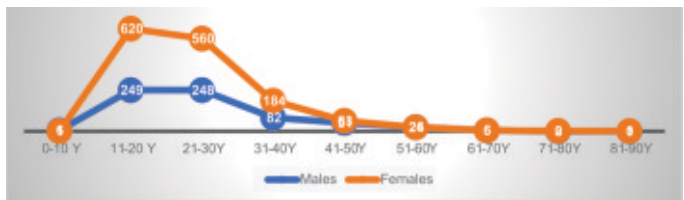
**Table 4:** Distribution according to reasons of self-harm:

Reason for Self-Harm	Male Count	Percentage Male	Female Count	Percentage Female	Total Count	Percentage Total
Family Issues	374	61.17%	907	69.43%	1281	66.14%
Psychological Issues	198	32.39%	375	28.72%	573	29.69%
Work Issues	1	0.16%	0	0.00%	1	0.05%
Domestic Violence	83	13.58%	139	10.63%	222	11.64%
Economic Issues	5	0.82%	0	0.00%	5	0.26%
Unknown	3	0.49%	0	0.00%	3	0.15%
<b>Total</b>	<b>611</b>	<b>100%</b>	<b>1307</b>	<b>100%</b>	<b>1918</b>	<b>100%</b>

p-value is approximately 0.0005

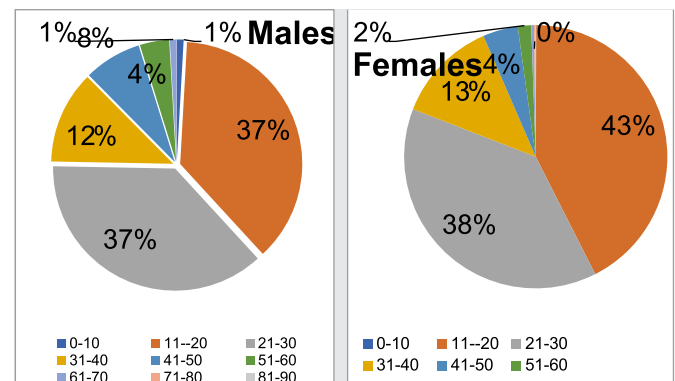
fluctuations across the months may assist public health officials in preparing resources and support mechanisms during high-risk periods.

Gender-Based Distribution of Self-Harm and Suicide Cases by Age Group (2023), this line graph compares the incidence of self-harm and suicide between males and females across age groups. Generally, males exhibit higher numbers across most age groups, particularly in the 25-34 age group, indicating a higher risk for men within this demographic. Female cases are relatively lower but still significant. This information emphasizes the need for gender-sensitive approaches in mental health interventions.

**Figure-1:** Selfharm according to age

Differences by Sex, Chi-square statistic, 75.01, p-value:  $4.69 \times 10^{-184.69} \times 10^{-18}$ , Interpretation: The very low p-value suggests a significant difference in the distribution of injury and death cases between males and females.

Differences Between Injury and Death Outcomes, Chi-square statistic: 0.0, p-value, 1.0, Interpretation: The p-value of 1.0 indicates no significant difference between the injury and death outcome distribution when aggregated across all categories

**Figure-2:** Distribution of the cases according sex and age.



## Discussion

This study highlights critical insights into self-harm and suicide patterns in Iraq in 2023, considering demographic, temporal, and regional factors. The findings show statistically significant differences in self-harm incidents across governorates, gender, age groups, educational levels, and methods of injury.

**Age-Based Vulnerability:** The data indicates that young adults, particularly those aged 25–34, constitute the largest percentage of self-harm cases (33.3%), followed by individuals aged 15–24 (22.2%). This pattern aligns with global research suggesting that young adults are at heightened risk for mental health challenges and self-destructive behaviors.<sup>9,10</sup>

**Temporal Trends:** Peaks in August and September: The observed increase in self-harm and suicide cases in August and September could be attributed to seasonal or cultural factors. Previous studies suggest that mental health may fluctuate with environmental and social changes; for instance, the end of summer and return to routine life can increase stress, potentially explaining the spike in cases.<sup>10-11</sup>

**Gender Differences in Self-Harm and Suicide Cases:** The analysis indicates significant gender differences in self-harm and suicide rates, with males generally showing higher rates of self-harm across most age groups, particularly among those aged 25–34 Years. This aligns with previous findings, where males often engage in more fatal forms of self-harm, such as hanging and gunshot, compared to females, who are more likely to use methods like poisoning. The significant p-value in gender-based differences ( $p < 0.05$ ) suggests a need for gender-sensitive mental health interventions.<sup>12-14</sup>

**Regional Variations in Self-Harm and Suicide Rates:** The chi-square analysis demonstrated substantial variation in self-harm cases across different governorates ( $p < 0.05$ ). For instance, Baghdad, Ninawa, and Basra had the highest number of cases, which could be due to population density, socio-economic disparities, or varying levels of mental health service availability.<sup>15-16</sup>

Regions like Baghdad, the capital, often face high-stress levels due to urbanization, while areas like Ninawa have experienced significant conflict and instability, potentially contributing to higher mental health challenges.<sup>17</sup>

Addressing regional disparities in mental health resources is crucial for comprehensive public health

strategies. Investing in community-based mental health services and crisis intervention programs, especially in high-incidence areas, may reduce these disparities.<sup>18</sup>

**Educational Level and Self-Harm Risk:** Educational attainment appears to influence self-harm and suicide rates, with individuals holding only primary or middle school education showing higher incident rates.<sup>19</sup> This association could be due to socio-economic challenges faced by individuals with lower education levels, such as limited job opportunities and increased stress due to financial insecurity.<sup>20</sup> Educational attainment is often linked with awareness of and access to mental health resources, suggesting that targeted outreach for less-educated populations might help bridge this gap. Interventions could include workplace mental health programs and social services to support low-income families.<sup>21</sup>

**Methods of Self-Harm: A Call for Intervention:** The distribution of self-harm methods also differs significantly by gender ( $p < 0.05$ ), with males predominantly using hanging, and females more likely to choose poisoning.<sup>22</sup>

These findings align with global research suggesting that males often select more lethal methods.<sup>23</sup>

The choice of method is an essential factor in intervention planning, as it affects the potential for successful intervention and the type of support required. For example, restricting access to means (such as firearms and toxins) and increasing awareness about safe coping strategies could be effective. Further, training for emergency responders to recognize and respond to high-risk behaviors related to specific methods of self-harm may enhance survival rates.<sup>24</sup>

**Reasons for Self-Harm: Family and Psychological Issues as Key Factors:** Among the identified reasons for self-harm, family issues and psychological problems were the most common, accounting for 66.1% and 29.7% of cases, respectively. This finding aligns with broader literature indicating that familial and psychological stressors are often underlying factors in self-harm. Family issues may involve conflicts, domestic violence, or financial stress, all of which can exacerbate mental health challenges.<sup>25</sup>

Future efforts should prioritize expanding mental health services, especially in high-risk regions, and addressing the socio-cultural factors underlying self-harm behaviors. Moreover, continued research on

these trends is essential for adapting interventions to meet the evolving needs of the population.

## Conclusion

This study provides a comprehensive understanding of self-harm and suicide cases in Iraq, highlighting the need for age, gender, and region-specific interventions. Addressing these differences can optimize resource allocation, enhance preventive strategies, and improve mental health outcomes.

**Ethical Approval:** The Medical Research Bioethical Committee of University of Kerbala College of Medicine has approved the study vide letter No. 24-23.

**Conflict of Interest:** None

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**Authors' Contribution:**

**AAS:** Conception & design, acquisition of data, drafting of article

**FAB:** Drafting of article

**ISGMH:** Critically revision for important intellectual content

**MHB:** Drafting of article, critically revision for important intellectual content, final approval of the version

## References

1. Predescu E, Sipos R. Self-Harm Behaviors, Suicide Attempts, and Suicidal Ideation in a Clinical Sample of Children and Adolescents with Psychiatric Disorders. *Children (Basel)*. 2023 14;10(4):725. doi: 10.3390/children10040725.
2. Younis MS, Lafta RK. Suicide and suicidality in Iraq: a systematic review. *Med Confl Surviv*. 2023;39(1):48-62. doi: 10.1080/13623699.2023.-2170580.
3. Taha PH, Taib NI, Sulaiman HM. Posttraumatic stress disorder correlates among internally displaced Yazidi population following Islamic state of Iraq and Syria attacks in Iraq. *BMC Psychiatry*. 2021 3;21(1):290. doi: 10.1186/s12888-021-03299-8.
4. Mathieu S, Treloar A, Hawgood J, Ross V, Kölves K. The Role of Unemployment, Financial Hardship, and Economic Recession on Suicidal Behaviors and Interventions to Mitigate Their Impact: A Review. *Front Public Health*. 2022 6;10:907052. doi: 10.3389/fpubh.2022.907052.
5. Lutz NM, Neufeld SAS, Hook RW, Jones PB, Bullmore ET, Goodyer IM, et al. Why Is Non-suicidal Self-injury More Common in Women? Mediation and Moderation Analyses of Psychological Distress, Emotion Dysregulation, and Impulsivity. *Arch Suicide Res*. 2023;27(3):905-21. doi: 10.1080/13811118.2022.2084004.
6. Younis MS, Anwer AH, Hussain HY. Stigmatising attitude and reflections towards mental illness at community setting, population-based approach, Baghdad City 2020. *Int J Soc Psychiatry*. 2021;67(5):461-66. doi: 10.1177/002076402-0961797.
7. Al-Imam A, Motyka MA, Hoffmann B, Basil S, Al-Hemiary N. Suicidal Ideation in Iraqi Medical Students Based on Research Using PHQ-9 and SSI-C. *Int J Environ Res Public Health*. 2023 18;20(3):1795. doi: 10.3390/ijerph20031795.
8. World Health Organization. "Mental health and suicide prevention in Iraq." [Available]: <https://www.emro.who.int/iraq/news/an-increasing-number-of-suicide-cases-in-iraq-worries-public-health-experts-amid-covid-19-pandemic.html>. [Cited on, 21.11.2024]
9. Xiao Y, Cerel J, Mann JJ. Temporal Trends in Suicidal Ideation and Attempts Among US Adolescents by Sex and Race/Ethnicity, 1991-2019. *JAMA Netw Open*. 2021;4(6):2113513. doi: 10.1001/jamanetworkopen.2021.13513.
10. Saied AA, Metwally AA, Ahmed SA, Omar RM, Abdulqadir SO. National suicide prevention strategy in Iraq. *Asian J Psychiatr*. 2023;82: 103486. Doi:10.1016/j.ajp.2023.103486.
11. Too LS, Shin S, Mavoa S, Law PCF, Clapperton A, Roberts L, et al. High-Risk Suicide Locations in Australia. *JAMA Netw Open*. 2024;7(6):2417770. doi: 10.1001/jamanetworkopen.2024.17770.
12. Lantos T, McNally RJQ, Nyári TA. Patterns of suicide deaths in Hungary between 1995 and 2017. *SSM Popul Health*. 2021;16:100958. doi: 10.1016/j.ssmph.2021.100958.
13. Roman-Lazarte V, Moncada-Mapelli E, Huarcaya-Victoria J. Evolution and differences of suicide rates in Peru by gender and department, 2017-2019. *Rev Colomb Psiquiatr (Engl Ed)*. 2023;52(3):185-92. English, Spanish. doi: 10.1016/j.rcpeng.2023.10.001
14. Balt E, Mérelle S, van Bergen D, Gilissen R, van der Post P, Looijmans M, et al. Gender differences in suicide-related communication of young suicide victims. *PLoS One*. 2021 21;16(5):0252028. doi: 10.1371/journal.pone.0252028.

15. Zulkipli SH, Rosliza AM. Application of socio-ecological model in developing preventive strategies against suicidal ideation and suicidal attempt among youth in low and middle-income countries: A scoping review. *Med J Malaysia*. 2022;77(6):755-63. PMID: 36448396.
16. Stack S. Media coverage as a risk factor in suicide. *J Epidemiol Community Health*. 2003;57(4):238-40. doi: 10.1136/jech.57.4.238.
17. Jaycox LH, Murphy ER, Zehr JL, Pearson JL, Avenevoli S. Social media and Suicide Risk in Youth. *JAMA Netw Open*. 2024;7(10):2441499. doi: 10.1001/jamanetworkopen.
18. Galera C, Collet O, Orri M, Navarro M, Castel L, Galesne C, et al. Prospective associations between ADHD symptoms and physical conditions from early childhood to adolescence: a population-based longitudinal study. *Lancet Child Adolesc Health*. 2023;7(12):863-74. doi: 10.1016/S2352-4642(23)00226-2.
19. Hawkins D, Patel J. Suicide mortality according to occupation and method of suicide, Massachusetts, 2010-2019. *Am J Ind Med*. 2024;67(7):624-35. doi: 10.1002/ajim.23593.
20. Wu Y, Lu Y, Kong L, Xie Y, Liu W, Yang A et al. Gender differences in plasma S100B levels of patients with major depressive disorder. *BMC Psychiatry*. 2024;24(1):387. doi: 10.1186/s12888-024-05852-7.
21. Merkulova YV, Stahl-Herz J. Complex (Multimodality) Suicides in New York City: 2008-2017. *Am J Forensic Med Pathol*. 2022 ;43(3):225-30. doi: 10.1097/PAF.0000000000000778.
22. Al-Imam A, Motyka MA, Hoffmann B, Basil S, Al-Hemary N. Suicidal Ideation in Iraqi Medical Students Based on Research Using PHQ-9 and SSI-C. *Int J Environ Res Public Health*. 2023;20(3):1795. doi: 10.3390/ijerph20031795.
23. McMorrow C, Nerney D, Cullen N, Kielty J, VanLaar A, Davoren M, et al. Psychiatric and psychosocial characteristics of suicide completers: A 13-year comprehensive evaluation of psychiatric case records and postmortem findings. *Eur Psychiatry*. 2022;65(1):e14. doi: 10.1192/j.eurpsy.2021.2264.
24. Mann JJ, Michel CA, Auerbach RP. Improving Suicide Prevention Through Evidence-Based Strategies: A Systematic Review. *Am J Psychiatry*. 2021;178 (7):611-24. doi: 10.1176/appi.ajp.-2020.20060864.
25. Beghi M, Butera E, Cerri CG, Cornaggia CM, Febbo F, Mollica A, et al. Suicidal behaviour in older age: A systematic review of risk factors associated to suicide attempts and completed suicides. *Neurosci Biobehav Rev*. 2021;127:193-11. doi: 10.1016/j.neubiorev.-2021.04.011.