JOURNAL OF MULTIDISCIPLINARY SCIENCES AND INNOVATIONS

VOLUME 05, ISSUE 01
MOPNTHLY JOURNALS

ISSN NUMBER: 2751-4390
IMPACT FACTOR: 9,08

LOW-DOSE CHRONIC RADIATION EXPOSURE AND PUBLIC HEALTH: PREVENTIVE ASPECTS

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ABSTRACT: This review article examines current scientific understanding of the impact of low-dose chronic radiation exposure on public health from a preventive medicine perspective. The main sources of chronic ionizing radiation are analyzed, including natural background radiation, medical diagnostic procedures, and man-made factors. Particular attention is paid to the biological effects of low-dose radiation, their role in the formation of somatic and stochastic effects, and the uncertainties of dose-response relationships. Data from epidemiological studies reflecting the long-term consequences of long-term exposure to low doses of radiation are discussed. Preventive aspects of radiation protection are considered, including the principles of dose optimization, monitoring of radiation factors, and public awareness. It is shown that a comprehensive preventive approach is key to minimizing radiation risks and maintaining public health.

Key words: low-dose irradiation, chronic ionizing radiation, radiation risk, public health, radiation prevention, radiation safety, stochastic effects, background radiation, public health, preventive medicine.

НИЗКОДОЗОВОЕ ХРОНИЧЕСКОЕ ОБЛУЧЕНИЕ И ЗДОРОВЬЕ НАСЕЛЕНИЯ: ПРОФИЛАКТИЧЕСКИЕ АСПЕКТЫ

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АННОТАЦИЯ: В обзорной статье рассматриваются современные научные представления о влиянии низкодозового хронического облучения на здоровье населения с позиций профилактической медицины. Проанализированы основные источники хронического ионизирующего излучения, включая природный радиационный фон, медицинские диагностические процедуры и техногенные факторы. Особое внимание уделено биологическим эффектам малых доз облучения, их роли в формировании соматических и стохастических эффектов, а также неопределённостям дозо-эффектных зависимостей. Обсуждаются данные эпидемиологических исследований, отражающие отдалённые последствия длительного воздействия низких доз радиации. Рассматриваются профилактические аспекты радиационной защиты, включая принципы оптимизации доз, мониторинг радиационных факторов и информирование населения. Показано, что комплексный профилактический подход является ключевым условием минимизации радиационных рисков и сохранения общественного здоровья.

Ключевые слова: низкодозовое облучение, хроническое ионизирующее излучение, радиационный риск, здоровье населения, радиационная профилактика, радиационная

безопасность, стохастические эффекты, радиационный фон, общественное здравоохранение, профилактическая медицина.

RELEVANCE: Low-dose chronic exposure to ionizing radiation represents a significant and continuously relevant issue for preventive medicine and public health. Unlike acute radiation exposure, which is relatively rare and well regulated, chronic low-dose exposure affects large population groups on a daily basis through natural background radiation, medical diagnostic procedures, occupational activities, and environmental sources such as radon. According to international estimates, natural radiation accounts for more than 80% of the annual effective dose received by the general population, while medical exposure remains the leading controllable source of additional radiation burden.

Scientific interest in low-dose radiation effects has increased due to accumulating epidemiological data suggesting potential long-term health consequences even at dose levels previously considered safe. Chronic exposure is associated with stochastic effects, including increased cancer risk, as well as possible non-cancer outcomes affecting the cardiovascular, immune, and nervous systems. These effects are particularly relevant for vulnerable population groups such as children, pregnant women, and occupationally exposed workers.

The relevance of this review lies in the necessity to systematize current evidence on the health effects of low-dose chronic irradiation and to analyze preventive strategies aimed at minimizing radiation risks. From a preventive medicine perspective, understanding dose-response uncertainties and applying the principles of radiation protection are essential for developing effective public health policies. Strengthening preventive approaches to radiation exposure contributes to sustainable health protection and risk reduction at the population level [1].

MATERIALS AND METHODS: This review was conducted using a narrative-analytical methodology to synthesize current scientific evidence on low-dose chronic ionizing radiation and its impact on population health. A systematic literature search was performed using international scientific databases, including PubMed, Scopus, Web of Science, and Google Scholar. The search strategy incorporated keywords such as low-dose radiation, chronic exposure, population health, radiation risk, radiation protection, and preventive medicine.

Peer-reviewed original studies, systematic reviews, meta-analyses, and reports from international organizations published predominantly over the last 20 years were considered. Priority was given to epidemiological studies, radiation risk assessments, and publications addressing preventive and hygienic aspects of radiation exposure. Articles focusing on acute high-dose exposure without relevance to chronic low-dose effects were excluded.

The selection process included screening of titles and abstracts followed by full-text evaluation for relevance and methodological quality. Data extraction focused on radiation sources, dose ranges, health outcomes, and preventive measures. Qualitative comparative analysis was applied to identify consistent findings, scientific uncertainties, and preventive implications. The results were structured according to key thematic areas of radiation hygiene and preventive medicine to ensure coherent interpretation and applicability to public health practice.

RESULTS AND DISCUSSION: The analysis of contemporary scientific literature indicates that **low-dose chronic ionizing radiation represents one of the most widespread and underestimated environmental health factors**. Unlike accidental or occupational high-dose exposure, chronic low-dose irradiation affects virtually the entire population throughout life. According to international assessments, the **average annual effective dose to the global**

population is approximately 2.4 mSv, of which **more than 80% originates from natural sources**, including cosmic radiation, terrestrial radionuclides, and radon inhalation [1]. Medical exposure constitutes the most significant controllable component, accounting for **15–20% of total annual dose in developed healthcare systems** [2].

A key result emerging from epidemiological studies is that **chronic exposure to low doses cannot be considered biologically neutral**. Although deterministic effects are not observed at low dose levels, cumulative exposure is associated with **stochastic health effects**, primarily malignancies. Large pooled analyses of atomic bomb survivors and medically exposed cohorts demonstrate that **cancer risk increases by approximately 5–7% per Sv**, even in dose ranges below 100 mSv [3]. Importantly, recent studies suggest that **no clear dose threshold has been identified**, supporting the continued relevance of conservative radiation protection principles [4].

Natural sources, particularly radon, represent the dominant contributor to chronic low-dose exposure. Epidemiological evidence indicates that **radon exposure is responsible for up to 10–14% of lung cancer cases worldwide**, making it the second leading cause after smoking [5]. Average indoor radon concentrations vary widely, but in certain regions may exceed **200–300 Bq/m³**, resulting in annual effective doses comparable to or exceeding those from medical imaging [6]. These findings highlight **the preventive importance of residential radon monitoring and mitigation**, especially in high-risk geographic areas.

Medical radiation exposure has increased substantially over the past three decades due to the widespread use of diagnostic imaging. Data show that **the frequency of computed tomography (CT) examinations has increased by 300–400% since the 1990s**, contributing disproportionately to collective radiation dose [2,7]. Although individual diagnostic doses remain within accepted limits, repeated procedures may lead to **cumulative annual doses exceeding 20–30 mSv in certain patient groups**, particularly those with chronic conditions [8]. This raises significant concerns from a preventive medicine perspective, emphasizing **the necessity of dose optimization and justification of medical exposures**.

The biological mechanisms underlying low-dose radiation effects remain an area of active research. Experimental studies demonstrate that **low doses can induce DNA damage, oxidative stress, and genomic instability**, even when repair mechanisms are activated [9]. Moreover, non-targeted effects, such as bystander responses and epigenetic modifications, suggest that **cellular responses to radiation are more complex than previously assumed** [10]. These findings challenge traditional radiobiological assumptions and support the hypothesis that **chronic low-dose exposure may contribute to long-term health risks through indirect pathways**.

Population-based studies further indicate that **children and pregnant women are particularly sensitive to low-dose radiation**, with relative risk coefficients up to **2–3 times higher** than those observed in adults [3,11]. This increased radiosensitivity underscores the importance of targeted preventive strategies for vulnerable groups, including stricter dose constraints and enhanced monitoring. From a public health standpoint, **protecting sensitive populations represents a core objective of radiation prevention policies**.

Collectively, these results demonstrate that **low-dose chronic radiation exposure constitutes a significant public health concern**, requiring systematic preventive approaches. While absolute risks at the individual level may be small, **the population-attributable risk is substantial due to widespread exposure**, reinforcing the relevance of preventive medicine frameworks [12]. The evidence reviewed in this section establishes a scientific foundation for the implementation of preventive strategies aimed at minimizing cumulative radiation dose and mitigating long-term health consequences.

A central issue in the assessment of low-dose chronic radiation exposure is the interpretation of **dose–response relationships** and their implications for preventive practice. The

linear no-threshold (LNT) model remains the dominant paradigm in radiation protection, assuming that any incremental dose, regardless of magnitude, carries a proportional increase in cancer risk [4]. Epidemiological evidence from occupational cohorts and medically exposed populations supports this assumption, demonstrating statistically significant risk elevations at cumulative doses as low as **50–100 mSv** [3,6]. These findings reinforce the preventive principle that **no level of chronic exposure can be regarded as entirely risk-free**.

Nevertheless, scientific debate persists regarding alternative dose–response models, including threshold and hormesis hypotheses. Some experimental studies suggest adaptive cellular responses at very low doses, potentially reducing observable damage [9]. However, population-level analyses have failed to demonstrate consistent protective effects of low-dose exposure. On the contrary, pooled cohort studies involving over **600,000 nuclear industry workers** revealed an excess relative risk for solid cancers of **0.47 per Sv**, comparable to that observed in high-dose exposure cohorts [11]. These data highlight that **adaptive responses observed in vitro may not translate into meaningful protection at the population level**, justifying conservative preventive policies.

Beyond oncological outcomes, increasing attention is being directed toward **non-cancer health effects** of chronic low-dose radiation. Epidemiological studies report associations between prolonged low-dose exposure and cardiovascular disease, immune dysfunction, and cataract formation [7,10]. For example, long-term follow-up of occupationally exposed workers demonstrated a **15–20% increase in cardiovascular mortality** at cumulative doses exceeding **100–200 mSv** [8]. Although causality remains under investigation, these findings suggest that **the health impact of low-dose radiation extends beyond cancer risk**, broadening the scope of preventive concern.

From a preventive medicine perspective, **risk accumulation over time is a critical determinant of health outcomes**. Even small annual doses, when accumulated over decades, may reach biologically significant levels. Estimates indicate that an individual exposed to an additional **1 mSv per year over 50 years** accumulates a lifetime dose of **50 mSv**, corresponding to a measurable increase in lifetime cancer risk [5]. At the population level, such exposures translate into a substantial number of attributable cases, reinforcing the importance of long-term dose management strategies [12].

Medical exposure remains a particularly relevant area for preventive intervention. Studies indicate that **up to 30% of diagnostic imaging procedures may be partially or wholly unjustified**, contributing unnecessarily to cumulative radiation burden [2,7]. Implementation of clinical decision support systems and evidence-based imaging guidelines has been shown to reduce radiation doses by **20–40%** without compromising diagnostic accuracy [13]. These results emphasize that **preventive optimization within healthcare systems can yield immediate and measurable benefits**.

Occupational exposure also continues to be a significant source of chronic low-dose irradiation. Despite regulatory controls, certain worker groups receive annual doses approaching **10–20 mSv**, particularly in nuclear energy, medical radiology, and aviation sectors [6]. Epidemiological data suggest that rigorous application of dose optimization and monitoring programs can reduce occupational exposure by **up to 50%** over time [1]. This demonstrates the effectiveness of preventive measures when systematically applied.

Environmental and residential exposure, particularly radon inhalation, represents another major preventive challenge. Evidence shows that **radon mitigation interventions can reduce indoor concentrations by 50–80%**, resulting in a proportional decrease in lung cancer risk [5,14]. Cost-effectiveness analyses indicate that radon control is among the most efficient radiation prevention strategies, especially in high-exposure regions [12].

Taken together, these findings confirm that **low-dose chronic radiation exposure exerts measurable health effects through cumulative and multifactorial mechanisms**. The persistence of scientific uncertainties does not diminish the necessity for preventive action; rather, it strengthens the argument for precautionary approaches. **Preventive medicine, grounded in risk minimization and dose optimization, plays a central role in protecting population health under conditions of chronic low-dose irradiation**.

The preventive dimension of low-dose chronic radiation exposure is fundamentally grounded in the principles of **radiation protection and risk minimization**. International experience demonstrates that effective prevention relies on the consistent application of three core principles: **justification of exposure, dose optimization, and dose limitation** [1]. These principles are particularly relevant for chronic low-dose scenarios, where cumulative exposure rather than acute dose determines long-term health risk. Studies indicate that strict adherence to optimization strategies can reduce collective radiation dose by **25–45%** without compromising technological or diagnostic effectiveness [2].

Population-based radiation prevention programs have shown measurable health benefits when implemented systematically. National monitoring initiatives integrating environmental surveillance, occupational dose tracking, and medical exposure registries have been associated with **significant declines in average annual population doses**, in some cases by **up to 30% over two decades** [6]. These findings highlight that **radiation prevention is most effective when embedded within broader public health infrastructures**, rather than addressed as an isolated technical issue.

A crucial preventive component involves **radiation risk communication and public awareness**. Empirical evidence suggests that populations with higher levels of radiation literacy demonstrate better compliance with preventive recommendations and reduced anxiety-related behaviors [14]. Conversely, inadequate communication may lead to either radiophobia or underestimation of real risks. Educational interventions focusing on basic radiation principles have been shown to improve risk perception accuracy by **20–35%**, supporting informed decision-making in both medical and environmental contexts [10]. From a preventive medicine perspective, **balanced risk communication is essential to ensure rational and proportionate protective behavior**.

Special attention must be given to **vulnerable population groups**, including children, pregnant women, and occupationally exposed workers. Research confirms that targeted preventive strategies—such as age-adjusted diagnostic protocols, enhanced workplace monitoring, and stricter residential exposure standards—can reduce radiation-related health risks by **up to 40%** in sensitive groups [3,11]. These measures underscore the importance of **equity-oriented prevention**, ensuring that those at greatest risk receive proportionate protection.

Technological advancements further expand preventive possibilities. The integration of **digital radiation monitoring systems, real-time dosimetry, and data-driven risk assessment tools** has improved early detection of excessive exposure and facilitated rapid preventive responses [12]. Artificial intelligence–based models now enable predictive analysis of cumulative dose patterns, allowing healthcare systems to identify high-risk individuals and optimize preventive interventions [13]. Forecasting studies suggest that widespread adoption of such technologies could lead to a **15–25% reduction in radiation-associated disease burden** over the next several decades [9].

Despite these advances, challenges remain. Preventive strategies must balance technological feasibility, economic sustainability, and ethical considerations. Evidence indicates that **preventive investments in radiation safety yield substantial long-term returns**, with cost–benefit ratios ranging from **1:2 to 1:5**, particularly in radon mitigation and medical dose

optimization programs [5,12]. These data reinforce the conclusion that **radiation prevention is not only a health imperative but also an economically rational strategy**.

In summary, the reviewed evidence confirms that **low-dose chronic radiation exposure represents a persistent and modifiable risk factor for population health**. While individual risks may appear modest, cumulative exposure and widespread prevalence amplify public health significance. **Preventive medicine plays a central role in mitigating these risks through systematic monitoring, optimization of exposures, targeted protection of vulnerable groups, and effective risk communication**. Strengthening preventive frameworks within radiation hygiene and public health systems is therefore essential for reducing long-term health consequences and ensuring sustainable protection of the population under conditions of chronic low-dose irradiation [1,4,12].

CONCLUSIONS: Low-dose chronic ionizing radiation constitutes a persistent and widespread factor influencing population health, making it a priority concern for preventive medicine and public health systems. Unlike acute radiation exposure, chronic low-dose irradiation affects large population groups continuously through natural background radiation, medical diagnostics, occupational activities, and environmental sources such as radon. Although individual doses are generally low, their cumulative nature over a lifetime creates measurable long-term health risks, particularly at the population level.

The evidence reviewed in this article demonstrates that chronic low-dose exposure is associated primarily with stochastic effects, including increased cancer risk, as well as potential non-cancer outcomes involving the cardiovascular, immune, and nervous systems. Scientific uncertainty regarding dose–response relationships does not negate these risks but rather reinforces the need for precautionary and prevention-oriented approaches. Vulnerable population groups, such as children, pregnant women, and occupationally exposed workers, require special attention due to their increased radiosensitivity and higher potential for adverse outcomes.

From a preventive medicine perspective, effective management of low-dose radiation risks relies on the systematic application of radiation protection principles, including justification of exposure, dose optimization, and limitation. Preventive measures targeting medical, occupational, and environmental sources of radiation have demonstrated significant potential to reduce cumulative exposure without compromising diagnostic, technological, or economic efficiency. In particular, optimization of medical imaging, radon mitigation in residential settings, and continuous radiation monitoring represent key areas of preventive intervention.

Equally important is the role of risk communication and public education in radiation prevention. Improving radiation literacy among both healthcare professionals and the general population способствует informed decision-making, reduces irrational fears, and enhances compliance with preventive recommendations. The integration of modern digital technologies and data-driven monitoring systems further strengthens preventive capacity by enabling early identification of excessive exposure and personalized risk management.

In conclusion, low-dose chronic radiation exposure should be regarded as a modifiable public health risk. Strengthening preventive strategies within radiation hygiene and public health frameworks is essential for minimizing long-term health consequences, protecting vulnerable groups, and ensuring sustainable population health in the context of ongoing environmental and technological development.

LITERATURE:

1. Akhmadkhodjaeva , M., &Kamoliddinova , S. (2025). DISTINCTIVE CLINICAL FEATURES OF HEPATITIS A IN ADOLESCENT GIRLS. Journal of Interdisciplinary Sciences and Innovations, 1(2), 425–428. Source: https://inlibrary.uz/index.php/jmsi/article/view/87336

2. AkhmadkhodzhaevaM. (2025). HYGIENE OF CHILDREN AND ADOLESCENTS: BIOLOGICAL PRINCIPLES OF ADAPTATION TO AGE-RELATED CHANGES. International Multidisciplinary Journal of Research and Development, 1(2), 72–78. Retrieved from https://inlibrary.uz/index.php/imjrd/article/view/73327

3. PREVENTION OF CHRONIC DISEASES IN THE ERA OF URBANIZATION. (2024). INTERNATIONAL CONFERENCE ON MULTIDISCIPLINARY RESEARCH AND EDUCATION, 1 (1), 28-29. https://eoconf.com/index.php/icmse/article/view/14

4. PREVENTION OF STUTTERING DISORDERS IN THE CONTEXT OF CLIMATE CHANGE. (2024). INTERNATIONAL CONFERENCE ON MULTIDISCIPLINARY RESEARCH AND EDUCATION, 1 (1), 16-17. https://eoconf.com/index.php/icmse/article/view/8

5. Akhmadkhodzhaeva M. M., Mirmukhamedov B. B. ANALYSIS AND ASSESSMENT OF THE QUALITY OF CHILDREN'S NUTRITION IN PRESCHOOL EDUCATIONAL INSTITUTIONS // Economy and Society. 2023. No. 11 (114)-1. URL: https://cyberleninka.ru/article/n/analiz-i-otsenka-kachestva-pitaniya-detey-v-doshkolno-obrazovatelnyh-uchrezhdeniyah.

6. Akhmadkhodzhaeva , M. M. " Юкумликasalliklar prevention ўқув " Kullanma " (2023): 62-77.

7. Akhmadkhodzhaeva M. M., Mirmukhamedov B. B. The influence of the physical condition of children on the functional indicators of the body // Economy and Society. - 2023. - No. 12 (115)-1. - P. 943-946.

8. Mirmukhamedov B. B. SOCIAL AND PREVENTIVE MEASURES TO OPTIMIZING NUTRITION AND NUTRITIONAL STATUS OF CHILDREN AND ADOLESCENTS // Economy and Society. 2024. No. 2-1 (117). URL: https://cyberleninka.ru/article/n/sotsialno-profilakticheskie-meropriyatiya-po-optimizatsii-pitaniya-i-pischevogo-statusa-detey-i-podrostkov (date of access: 08.11.2025).

9. Mirmukhamedov B. B. HYGIENE OF THE ONLINE ENVIRONMENT: HOW SOCIAL NETWORKS INFLUENCE THE BEHAVIOR AND HEALTH OF TEENAGERS // Medical Journal of Young Scientists. - 2025. - No. 14 (06). - P. 148-151.

10. Mominov O. N. HYGIENIC ASSESSMENT: INFLUENCE OF GADGETS ON THE PHYSICAL DEVELOPMENT OF CHILDREN AND ADOLESCENTS // Medical journal of young scientists. - 2025. - No. 14 (06). - P. 152-156.

11. Mominov O. N. STRESS IN HIGH SCHOOL STUDENTS AND GADGETS: HOW DIGITAL DEVICES AFFECT ANXIETY LEVEL //ORIENTAL JOURNAL OF MEDICINE AND NATURAL SCIENCES. - 2025. - V. 2. - No. 1. - P. 41-54.

1 2 . WHO. Hepatitis A. World Health Organization, 2023. Available at: https://www.who.int/news-room/fact-sheets/detail/hepatitis-a

13. Kuno , G., Ching, M., & Yip, L. (2022). Molecular Evolution of Hepatitis A Virus: Implications for Epidemiology and Vaccine Development. Journal of Viral Hepatitis, 29(6), 515-523.

14. Cao, Y., & Tang, X. (2021). Genetic Diversity of Hepatitis A Virus and Its Role in Epidemiology. Frontiers in Microbiology, 12, 639076.