REGISTRATION OF THE POPULATION LIVING AROUND THE SEMIPALATINSK TEST SITE: AN IMPORTANT TOOL FOR RESEARCH ON THE EFFECTS OF LOW DOSES OF IONIZING RADIATION

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Abstract

Introduction. A modern tool for long-term monitoring of public health, early detection and correction of pathological conditions is the database of the State Scientific Automated Medical Register of Persons Affected by Nuclear Weapons tests at the Semipalatinsk test site.

Materials and methods. Legal and medical documents are used to replenish the register's database. Methods used: study and copying of registration, dosimetric and medical information from primary documents, screening studies, population surveys. The register also serves as a mechanism for assessing individual radiation dose.

Results. Currently, the register has personal registration, medical and dosimetric data on 375,253 people, both those exposed to radiation and their descendants, who are represented by: 241,729 people who currently have the vital status of "alive", and 133,524 people with a mortality sub–register.

Conclusion. The register, which is maintained by the Research Institute of Radiation Medicine and Ecology of the NCJSC «Semey Medical University» is a unique database that includes information about all generations of the exposed population, allowing for scientific and clinical research of various fields, and is a valuable resource for further study of the effects of low doses and low levels of radiation on health.

Keywords: Kazakhstan, nuclear weapons tests, ionizing radiation, health effects, population register.

Резюме

РЕГИСТРАЦИЯ НАСЕЛЕНИЯ, ПРОЖИВАЮЩЕГО ВОКРУГ СЕМИПАЛАТИНСКОГО ИСПЫТАТЕЛЬНОГО ПОЛИГОНА: ВАЖНЫЙ ИНСТРУМЕНТ ДЛЯ ИССЛЕДОВАНИЙ ВОЗДЕЙСТВИЯ НИЗКИХ ДОЗ ИОНИЗИРУЮЩЕГО ИЗЛУЧЕНИЯ

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Введение. Современным инструментом для проведения долговременного мониторинга состояния здоровья населения, раннего выявления и коррекции патологических состояний является база данных Государственного научного автоматизированного медицинского регистра лиц, пострадавших при испытаниях ядерного оружия на Семипалатинском полигоне.

Материалы и методы. Для пополнения базы данных регистра используются юридические и медицинские документы. Используемые методы: изучение и выкопировка регистрационной, дозиметрической и медицинской информации из первичных документов, скрининговые исследования, опросы населения. Регистр также служит механизмом для оценки индивидуальной дозы облучения.

Результаты. В настоящее время регистр располагает персональными регистрационными, медицинскими и дозиметрическими данными на 375 253 человека, как подвергшихся радиационному воздействию, так и их потомков, которые представлены: лицами, имеющими в настоящее время жизненный статус «жив» – 241 729 человек, подрегистр смертности – 133 524 человека.

Заключение. Регистр, которым располагает НИИ РМиЭ НАО «МУС» – это уникальная база данных, включающая информацию обо всех поколениях облучавшегося населения, позволяющая проводить научные и клинические исследования разной направленности, представляющая ценный ресурс для дальнейшего изучения воздействия низких доз и низких уровней облучения на здоровье.

Ключевые слова: Казахстан, испытания ядерного оружия, ионизирующее излучение, влияние на здоровье, регистр населения.

Түйіндеме

СЕМЕЙ СЫНАҚ ПОЛИГОНЫНЫҢ АЙНАЛАСЫНДА ТҰРАТЫН ХАЛЫҚТЫ ТІРКЕУ: ИОНДАУШЫ СӘУЛЕЛЕНУДІҢ ТӨМЕН ДОЗАЛАРЫНЫҢ ӘСЕРІН ЗЕРТТЕУ ҮШІН МАҢЫЗДЫ ҚҰРАЛ

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Кіріспе. Семей полигонында ядролық қаруды сынау кезінде зардап шеккен адамдардың мемлекеттік ғылыми автоматтандырылған медициналық тіркелімінің деректер базасы халықтың денсаулық жағдайына ұзақ мерзімді мониторинг жүргізу, патологиялық жай-күйін ерте анықтау және түзету үшін заманауи құрал болып табылады.

Материалдар мен әдістер. Тіркелімнің дереккорын толтыру үшін заңдық және медициналық құжаттар пайдаланылады. Қолданылатын әдістер: бастапқы құжаттардан тіркеу, дозиметриялық және медициналық ақпаратты зерделеу және көшіру, скринингтік зерттеулер, халыққа сауалнама жүргізу. Тіркелім сонымен қатар сәулеленудің жеке дозасын бағалау механизмі ретінде қызмет етеді.

Нәтижелер. Қазіргі уақытта тіркелімде радиациялық әсерге ұшыраған 375 253 адамға және олардың ұрпақтарына жеке тіркеу, Медициналық және дозиметриялық деректер бар, олар: қазіргі уақытта "тірі" өмірлік мәртебесі бар адамдар – 241 729 адам, өлім – жітімнің кіші тіркелімі-133 524 адам.

Қорытынды. МУС КЕАҚ РМиЭ ҒЗИ бар тіркелім-сәулеленген халықтың барлық ұрпақтары туралы ақпаратты қамтитын, әртүрлі бағыттағы ғылыми және клиникалық зерттеулер жүргізуге мүмкіндік беретін, әсерді одан әрі зерттеу үшін құнды ресурс болып табылатын бірегей деректер базасы.

Түйінді сөздер: Қазақстан, ядролық қаруды сынау, иондаушы сәулелену, денсаулыққа әсері, халық тіркелімі.

Introduction

In the period from 1949 to 1962, 111 atmospheric tests were conducted at the Semipalatinsk Nuclear Test Site of the former Soviet Union [22,25], which led to significant radiation exposure of the territories adjacent to the test site [7]. The territories of the Abai region, East Kazakhstan, and partly the Pavlodar and Karaganda regions of Kazakhstan were exposed to radioactive contamination. In the period from 1963 to 1989, underground tests were conducted, which led to radiation exposure mainly on the territory of the nuclear test site, although radioactive traces were found outside it [12].

Long-term combined exposure to ionizing radiation makes a significant contribution to the formation of the health of the population living in the territories adjacent to the former Semipalatinsk test site. The problem of a comprehensive assessment of the medical consequences for the population of Kazakhstan during nuclear weapons testing, their prediction and determination of the causal relationship of various pathological conditions with radiation exposure is relevant due to the need for effective state rehabilitation and preventive measures to reduce public health losses caused by radiation exposure [19].

To do this, first of all, it is necessary to determine the numerical and age-sex composition of the victims, assess the health status of persons exposed to direct radiation and their descendants, and identify pathological processes that have a reliable relationship with exposure to the radiation risk factor. All subsequent medical and social activities depend on effective and successful work in these areas [16].

The problem of assessing the risk of prolonged exposure in small doses is quite complex. For a statistically significant determination of the dependence of the occurrence of long-term effects, epidemiological studies on large populations are required [20], and, accordingly, the availability of a sufficient database.

A modern tool for long-term monitoring of the health status of the population, early detection and correction of pathological conditions is the database of the State Scientific Automated Medical Register (SSAMR) of persons affected by nuclear weapons tests at the Semipalatinsk Nuclear Test Site.

The main tasks of the State Scientific Automated Medical Registry (SSAMR) include:
- creation and development of a unified radiation and epidemiological registration system for the Republic of Kazakhstan for persons affected by radiation exposure and exposed to radiation as a result of the activities of the Semipalatinsk Nuclear Test Site,
- ensuring long-term personal records of persons who were directly exposed to radiation and their subsequent generations,
- calculation of radiation doses,
- identification of priority measures aimed at protecting the health of citizens in this category.

Materials and Methods

The basis for the creation of the SSAMR is the Law of the Republic of Kazakhstan dated December 18, 1992 No. 1787 – XII «On Social protection of citizens affected by nuclear tests at the Semipalatinsk Nuclear Test Site». The register was established in 2003 on the basis of the

Research Institute of Radiation Medicine and Ecology (RI RME) of the Non-Commercial Joint-Stock Company «Semey Medical University» in collaboration with Japanese colleagues from the Radiation Effect Research Foundation (RERF) [14] and with the support of the Ministry of Health of the Republic of Kazakhstan (MH RK).

The creation of the register and the formation of its database was a rather long process: similar registers were studied abroad (Russia, Japan, Belarus, Ukraine), the institute's specialists completed an internship at the Institute for the Study of Radiation Effects (Hiroshima, Japan), a computer program was developed with the participation of Japanese colleagues, a server for data storage was installed, and a collection mechanism was developed, methodological support for operators and administrators has been developed.

The SSAMR database was developed using the database used in the RERF, as well as using the experience of creating the Kazakh «historical cohort» [6, 11]. Since 2007, the register has been constantly updated, taking into account demographic and medical information [7, 34].

SSAMR is registered in the Register of the Committee of Intellectual Property Rights of the Ministry of Justice of the Republic of Kazakhstan (Certificate of State Registration No. 253 dated March 19, 2010). By Order No. 327 dated April 12, 2010, SSAMR was registered by the Ministry of Communications and Information of the Republic of Kazakhstan as an intellectual property object of the Research Institute of Radiation Medicine and Ecology (RI RME) for № KZ-B-10-0000003. The execution of the Order of the Ministry of Health of the Republic of Kazakhstan of 2012 No. 522 «On personal registration of persons affected by nuclear tests at the Semipalatinsk test site ...» has improved the quality and quantity of information entered into SSAMR, the Register has been tested for compliance with international standards, SSAMR has been integrated into the European low-dose radiation research platform MELODI.

Various sources of information are used to replenish the register's database:
- legal documents: household books, materials from the archives of cities and regional centers, certificates of causes of death from the Registry Office archives;
- medical documentation: medical histories, results of screening, outpatient and inpatient examinations of the population;
- interviewing residents by making house-to-house visits with verification of documents confirming the fact of residence in the territory.

Information is collected to replenish the SSAMR database according to the scheme shown in Figure 1.

Methods and forms of scientific and practical work used:
• Study and copy registration, dosimetric and medical information from specialized paper primary documents.
• Screening studies (in order to obtain missing data on morbidity and mortality in the studied settlements of East Kazakhstan region).
• The method of population survey by filling in developed screening maps (in order to obtain more reliable socio-economic data).

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SSAMR also serves as a mechanism for assessing the individual radiation dose received by a person while living (staying) in the territories adjacent to the landfill in the period from 1949 to 1990. The assessment of individual doses is carried out by calculation method through an automatic program embedded in the register structure, based on Methodological Recommendations approved and recommended for publication by the Republican Center for Innovative Technologies of Medical Education and Science of the Ministry of Health of the Republic of Kazakhstan, Protocol No. 12 dated 19.11.2010.
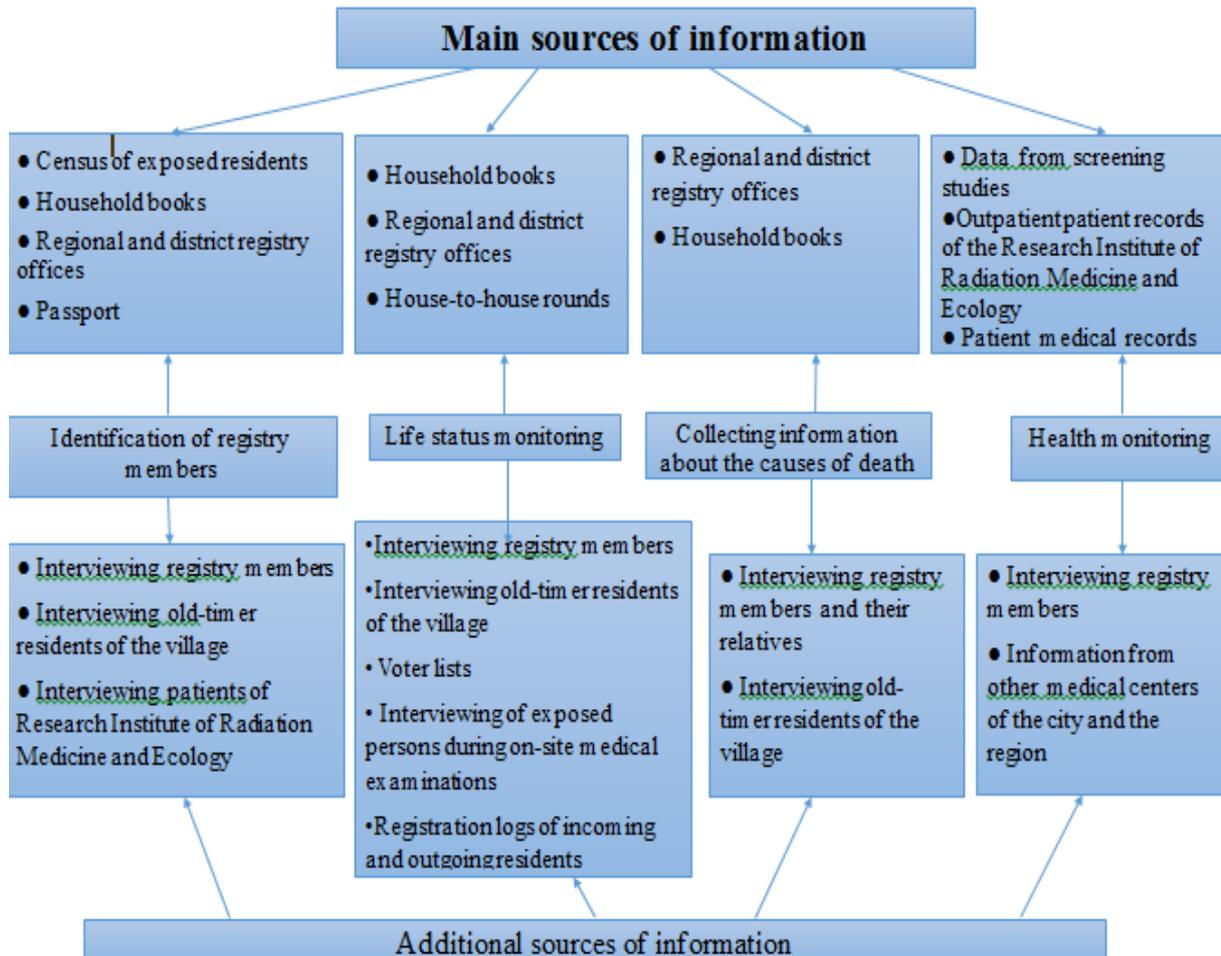

Figure 1. The algorithm for collecting information to replenish the SSAMR database.

Results

The register database contains the following information:
- passport data,
- nationality,
- radiation route,
- education, profession,
- availability and numbers of official documents,
- medical information based on the results of a comprehensive examination conducted by the staff of the Institute,
- the cause of death, if the person died,
- the received radiation dose,
- results of the Human Radiation Spectrometer (HRS) study,
- information on the availability of biomaterials (blood, DNA, tissues).

The register also contains information about the descendants of people who were directly exposed to radiation – their children, grandchildren and great-grandchildren.

Each person included in the register's database is assigned an identification number that allows access to all information available on that person.

The software upgrade makes it possible to generate automatic selections for 14 parameters in any combination. 146 automatic service requests have been implemented in order to verify the entered information, eliminate errors and omissions, and compile statistical reports.

With the support of the DoReMi project funded by the European Council [28], work was carried out on the adaptation and assimilation of information for 8,400 people from the register's database with the European database of the MELODI scientific platform for studying the effects of low doses of radiation on the human body.

The following data is integrated into the European platform:
- registration data: identification number, gender, nationality, date of birth, place of birth;
- medical information (where applicable): established diagnoses and dates of their diagnosis, the presence of

congenital anomalies, and for dead people – the date and cause of death;

- dosimetric data: radiation route, radiation dose (based on doses established by Kazakh legislation, which may differ from doses calculated by other methods);

- information about lifestyle factors: smoking, alcohol consumption;

- the presence of biological material: blood, DNA, cancerous and healthy tissues [1,2].

Currently, the SSAMR has personal registration, medical and dosimetric data on 375,253 people, both those exposed to radiation and their descendants, who are represented by: persons currently with the vital status "alive" – 241,729 people, mortality sub-register – 133,524 people.

Three age groups have been formed among the victims and their descendants registered in the SSAMR and living in the country today:

1. Date of birth before 12/31/1962 – 1st generation of victims – persons who lived in the territories adjacent to the Semipalatinsk Nuclear Test Site during the period of atmospheric and ground tests at the landfill and, accordingly, received the most significant radiation exposure. This group accounts for 47.2% of all persons registered in the SSAMR and having the vital status of "alive". Depending on the territory of residence, the individual dose loads of individuals in this group can reach 100 sSv, and in some cases (for an extreme radiation risk zone) exceed 100 sSv.

2. Date of birth from 01.01.1963 to 31.12.1990 – the 2nd generation of victims – persons who lived in the territories adjacent to the Semipalatinsk Nuclear Test Site (SNTS) during the period of underground testing at the site. The number of the group is 41.9% of all persons registered in the SSAMR and having the vital status of "alive". Individual dose loads of this group can reach 20-25 sSv.

3. Date of birth from 01.01.1991 – persons born after the termination of testing for Semipalatinsk Nuclear Test Site (SNTS). They make up 10.9% of all persons registered in the SSAMR and having the vital status of "alive".

Discussion

The SSAMR database is the basis for the formation of various research cohorts and the implementation of scientific research to assess the medical and demographic consequences of radiation exposure among the population of the territories adjacent to the Semipalatinsk Nuclear Test Site (SNTS), the development of methods for the diagnosis of radiation-induced diseases, prevention and rehabilitation of the affected population.

The potential value of the register for scientific research in the field of radiation medicine is confirmed by studies that have been fully [6,11] or partially [17,18] performed using information obtained from the SSAMR database [14].

A cohort epidemiological study of mortality rates conducted over the period 1960-1999 revealed a statistically significant high risk of all-cause mortality (risk ratio RR = 1.83), mortality from esophageal cancer (RR = 3.29), stomach cancer (RR = 2.29), lung cancer (RR = 2.77), and breast cancer in women (RR = 1.85). The highest risk of mortality associated with low-dose radiation exposure was recorded among people aged 0-19 and 20-39 years at the time of exposure [6]. In the same cohort,

cardiovascular diseases were diagnosed in irradiated people significantly more often than for members of the non-irradiated control group (RR = 2.27) and for the population of the Republic of Kazakhstan as a whole (RR = 2.25) [11]. The study of mortality in order to track health effects throughout life, which was started earlier [6, 11], can be expanded and continued in the modern period by increasing the cohort and extending the follow-up period.

Biological studies have been conducted [29,32]. For example, cytogenetic studies of chromosomal aberrations and markers of radiation exposure [13,33]. Possible genetic effects were studied by analyzing the sex ratio among children born to exposed parents [23] and when twins were born in the same population [24].

In 2013-2016, the European Union funded the SEMI-NUC project [15], the main purpose of which was to assess the possibility of creating a long-term prospective cohort to study the health effects of low and moderate doses of radiation resulting from nuclear weapons tests at the Semipalatinsk Nuclear Test Site. Scientists from Europe, Kazakhstan, Japan and the USA participated in the project. One of the goals of the project was to test the possibility of creating a larger cohort than that used in previous studies [6,11]. This goal was initially based on information gathered within the framework of the Kazakh-Japanese project [26,35].

The results of the SEMI-NUC project have shown that the SSAMR is the most comprehensive data source for research on the effects of radiation exposure on public health as a result of the activities of the Semipalatinsk Nuclear Test Site. According to the scientists who participated in the project, the SSAMR database is a new, largely unexplored and valuable resource for assessing the risks to the public associated with exposure to ionizing radiation on the environment. The advantage of the register is that the population is not selected and includes all age groups. The external dose ranges from 0 to 0.3 Gr, which makes SSAMR an important resource for modern research in the field of public health and radiation protection [3].

In continuation of the cross-sectional study conducted in 1998 [17,18], which showed the risk of developing thyroid nodules associated with radiation, a repeat study was conducted in the same cohort of irradiated individuals in the modern period [8,9,4,5,21]. The creation of a study cohort, including individuals who underwent thyroid examinations in 1998, became possible only due to the SSAMR database.

Currently, two international scientific projects are being carried out based on the SSAMR database:

• Contract CRA-ENV-2024-6 dated 09.12.2024 of the Federal Agency for Radiation Protection (Germany) for a scientific project on the topic «Analysis of the risk of exposure to radioactive fallout from Soviet nuclear weapons tests based on the register of the Research Institute of Radiation Medicine and Ecology». The project will create an unprecedented cohort of more than 50,000 people who lived during the period of atmospheric nuclear tests (1949-1962) in the territories of the Abai, Beskaragai, Borodulikha and Zhanasemey districts of the Abai region;

• Japan Society for the Promotion of Science (KAKENHI) (grants' numbers JP26257501 and 19H01149) to Professor Masaharu Hoshi, Member of JRRS, by the Environmental Radioactivity Research Network Center

(ERAN) (grants' numbers F-22-14, F-23-14, I-24- 09 and F-24-04). The project is aimed at assessing the dose loads of 8000 people from 18 of the most exposed settlements in the region [30, 31].

As well as the scientific study «Integral assessment of the effect of ionizing radiation on the health of descendants of people exposed to radiation», conducted by the NCJSC «Semey Medical University» within the framework of program-specific financing of the Ministry of Education and Science of the Republic of Kazakhstan, in the course of which this article was prepared.

In addition to studying the effects of radiation on public health, SSAMR can also serve as a good basis for studying psychological effects [27, 10]. The SSAMR database also provides a unique opportunity to evaluate epigenetics and intergenerational research on the risks of diseases caused by radiation exposure, as it contains information about subsequent generations of victims.

At the same time, it should be noted that the work on the formation of the register database is far from being completed. It has been established that currently about 700 thousand people live in the territories of the Abai region, East Kazakhstan, Pavlodar and Karaganda regions, related to radiation situations of previous years and in need of medical and social measures aimed at reducing the damage to their health from radiation exposure.

Further improvement of the register as a system of long-term personal accounting of victims living in the territories adjacent to the Semipalatinsk Nuclear Test Site (SNTS) will allow for the implementation of:

- long-term monitoring of the health status of residents of the registry;
- assessment of the medical, psychological, radiation, epidemiological and social situation;
- identification of causal relationships between health indicators and risk factors;
- information support for special scientific research of a fundamental and applied nature (biomedical, hygienic, clinical, epidemiological, sociological);
- development of measures based on the Register data aimed at reducing the negative effects of testing on the health of the affected population.

Conclusion

The SSAMR, which is at the disposal of the Research Institute of Radiation Medicine and Ecology of NCJSC «Semey Medical University», is a unique database that includes information on all generations of the exposed population and allows conducting scientific and clinical research using modern technologies for long–term monitoring of people exposed to radiation. The register's database allows for fundamental and applied radiation epidemiological studies based on long-term automated personal records of people exposed to radiation, for dynamic monitoring of their health, their children and subsequent generations, as well as for predicting the health level of the affected population.

The applied value of the register makes it possible to form risk groups for the development of specific diseases, monitor the demographic situation, trends in morbidity and mortality in order to determine the main patterns of development of the situation characterizing the level of public health, to develop a modern therapeutic and preventive strategy aimed at reducing morbidity and mortality from radiation-induced diseases.

The introduction of information on morbidity and mortality, the creation of «thematic» sub-registers in the register structure makes it possible to objectively assess the range of somatic-stochastic effects and risks of radiation exposure both for people exposed to direct radiation and for their descendants. SSAMR is the basis for conducting research of any orientation, regardless of the research methods and models used.

Due to the accounting and monitoring carried out on the basis of the functioning of the SSAMR, the population affected by the activities of the Semipalatinsk Nuclear Test Site is under constant medical supervision, has the opportunity to undergo in-depth medical examination and rehabilitation treatment at the Research Institute of Radiation Medicine and Ecology.

The population covered by the register is the most suitable for a long-term prospective study of the health effects of exposure to radioactive fallout in the area of the Semipalatinsk Nuclear Test Site. There are not many populations in the world that have been exposed to low doses of radiation for a long time and that are suitable for research on the incidence of ionizing radiation exposure. Cohorts of individuals from a well-maintained and regularly updated registry can be used for prospective epidemiological studies of the relationship between radiation and morbidity, in particular cardiovascular and oncological.

Thus, the SSAMR, created and operating at the Research Institute of Radiation Medicine and Ecology of NCJSC «Semey Medical University», is a unique and valuable resource for further study of the effects of low doses and low levels of radiation on health. It is important to coordinate any current or future research in order to avoid duplication of work and to use the synergy of different methodological approaches [3].

Conflict Of Interest

The authors declare no conflicts of interest. This manuscript has not been previously published and is not under consideration for publication in other publications.

Author's Contribution

All authors have made an equal contribution to the development of the concept, methodology, data analysis and preparation of the manuscript. All the authors reviewed the final version of the manuscript and approved it.

Use of Artificial Intelligence Tools: *During the preparation of this manuscript, ChatGPT (OpenAI; accessed April 2025) was used to improve the English language and clarity. The authors reviewed and edited the output as necessary and take full responsibility for the final content.*

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