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PRELIMINARY ANALYSIS OF THE HEALTH STATUS AND RADIATION DOSES OF RESIDENTS OF THE ABAY DISTRICT OF THE ABAY REGION, WHO ARE DESCENDANTS OF PERSONS EXPOSED TO RADIATION DUE TO NUCLEAR WEAPONS TESTS

Galiya A. Alibayeva[1], Lyudmila M. Pivina[2], Nailya Zh. Chaizhunussova[2], Andrey Yu. Orekhov[2], Alexandra V. Lipikhina[2], Meruyert R. Massabayeva[2], Assel Zh. Baibussinova[2], Zhanargul K. Smailova[2], Diana G. Ygiyeva[2], Gulnara B. Batenova[2], Vladlena R. Sabitova[2], Saule K. Kozhanova[2], Dinara A. Mukanova[2], Madina B. Abenova[2], Murat N. Lepesbayev[3], Tokzhan A. Akhmadiyeva[2], Ainash S. Orazalina[2], Saulesh A. Apbassova[2], Dariya M. Shabdarbayeva[2], Altay A. Dyussupov[2]

[1] Semey Hospital of Emergency Medical Care, Semey, Republic of Kazakhstan;
[2] Semey Medical University, Semey, Republic of Kazakhstan;
[3] Forensic Examination Center of the Abai Region, Semey, Republic of Kazakhstan.

Abstract

Introduction. The relevance of this study is determined by the significant number of population groups in the regions of Kazakhstan adjacent to the former Semipalatinsk Nuclear Test Site (SNS), who still live under environmental stress and the associated medical and social consequences.

Aim. This study aimed to conduct a preliminary analysis of the health status and radiation doses of residents of the Abay District of the Abay Region, who are second- and third-generation descendants of people exposed to radiation due to nuclear weapons testing.

Materials and Methods. Study design: cross-sectional screening study. Physical examinations and laboratory tests were conducted, along with a study of sociodemographic factors and radiation doses among the parents and grandparents of the target population of 233 individuals aged 18-65 years in the villages of Karaul and Sarzhal in the Abay District of the Abay Region. Statistical analysis was performed using SPSS 20.0 (IBM Inc., New York, USA) and Jamovi (version 2.5.5; https://www.jamovi.org).

Results. The vast majority of participants included in the study were aged 29 years or younger or 30-39 years. Approximately 70% had lived in the area since birth or for over 30 years. Enlarged peripheral lymph nodes were observed in 6.1% of women. Enlarged thyroid glands were observed in almost all study participants. The median ACTH level in men was slightly elevated compared to normal values. The study results indicate a range of high radiation doses for both first- and second-generation exposed individuals.

Conclusion. To determine the relationship between radiation doses and stochastic and deterministic health effects in the study population, a comparative analysis is required across different dose groups and a control group of people not exposed to radiation.

Keywords: *Semipalatinsk Nuclear Test Site; health effects; screening; radiation; offspring.*

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Резюме

ПРЕДВАРИТЕЛЬНЫЙ АНАЛИЗ СОСТОЯНИЯ ЗДОРОВЬЯ И ДОЗ ОБЛУЧЕНИЯ ЖИТЕЛЕЙ АБАЙСКОГО РАЙОНА ОБЛАСТИ АБАЙ, ЯВЛЯЮЩИХСЯ ПОТОМКАМИ ЛИЦ, ПОДВЕРГШИХСЯ РАДИАЦИОННОМУ ВОЗДЕЙСТВИЮ ВСЛЕДСТВИЕ ИСПЫТАНИЙ ЯДЕРНОГО ОРУЖИЯ

Галия А. Алибаева[1], Людмила М. Пивина[2], Найля Ж. Чайжунусова[2], Андрей Ю. Орехов[2], Александра В. Липихина[2], Меруерт Р. Масабаева[2], Асель Ж. Байбусинова[2], Жанаргуль К. Смаилова[2], Диана Г. Ыгиева[2], Гульнара Б. Батенова[2], Владлена Р. Сабитова[2], Сауле К. Кожанова[2], Динара А. Муканова[2], Мадина Б. Абенова[2], Мурат Н. Лепесбаев[3], Токжан А. Ахмадиева[2], Айнаш С. Оразалина[2], Саулеш А. Апбасова[2], Дария М. Шабдарбаева[2], Алтай А. Дюсупов[2]

[1] Больница скорой медицинской помощи г. Семей, г. Семей, Республика Казахстан;
[2] НАО «Медицинский университет Семей», г. Семей, Республика Казахстан;
[3] Центр судебно-медицинской экспертизы по Абайской области, г. Семей, Республика Казахстан.

Введение. Актуальность данного исследования обусловлена значительной численностью групп населения регионов Казахстана, прилегающих к территории бывшего Семипалатинского ядерного полигона (СЯП), проживающих в условиях экологической нагрузки, и связанными с ней медико-социальными последствиями.

Цель. Целью нашего исследования является предварительный анализ состояния здоровья и дозовых нагрузок жителей Абайского района области Абай, являющихся потомками второго и третьего поколений лиц, подвергшихся радиационному воздействию вследствие испытаний ядерного оружия.

Материалы и методы. Дизайн исследования: поперечное скрининговое исследование. Проведено физикальное обследование и лабораторное исследование, а также исследование социально-демографических факторов и доз облучения родителей, дедушек и бабушек целевого населения сел Караул и Саржал Абайского района области Абай, всего 233 человека в возрасте 18-65 лет. Статистический анализ проводился с применением программ SPSS 20.0 (IBM Inc., New York, USA) и Jamovi (версия 2.5.5; https://www.jamovi.org).

Результаты. Абсолютное большинство лиц, включенных в исследование, было представлено возрастными группами до 29 лет и 30-39 лет. Около 70% из них проживали в данной местности с рождения, либо, более 30 лет. У 6,1% женщин наблюдалось увеличение размеров периферических лимфатических узлов. Практически у всех участников исследования наблюдалось увеличение размеров щитовидной железы. Медианный уровень АКТГ у мужчин был несколько повышен в сравнении с нормальными показателями. Результаты исследования свидетельствуют о диапазоне высоких доз облучения как для экспонированных лиц первого, так и второго поколений.

Заключение. Для определения связи между дозами облучения и стохастическими и детерминированными эффектами в отношении состояния здоровья исследуемых жителей требуется проведение сравнительного анализа в разных дозовых группах и контрольной группе лиц, не подвергавшихся радиационному воздействию.

Ключевые слова: *Семипалатинский ядерный полигон; скрининговые исследования, состояние здоровья, радиация, потомки.*

Для цитирования:

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Түйіндеме

ЯДРОЛЫҚ ҚАРУ СЫНАҚТАРЫНЫҢ САЛДАРЫНАН РАДИАЦИЯЛЫҚ ӘСЕРГЕ ҰШЫРАҒАН АДАМДАРДЫҢ ҰРПАҚТАРЫ БОЛЫП ТАБЫЛАТЫН АБАЙ ОБЛЫСЫ, АБАЙ АУДАНЫ ТҰРҒЫНДАРЫНЫҢ ДЕНСАУЛЫҚ ЖАҒДАЙЫ МЕН СӘУЛЕЛЕНУ ДОЗАЛАРЫН АЛДЫН АЛА ТАЛДАУ

Галия А. Алибаева[1], Людмила М. Пивина[2], Найля Ж. Чайжунусова[2], Андрей Ю. Орехов[2], Александра В. Липихина[2], Меруерт Р. Масабаева[2], Асель Ж. Байбусинова[2], Жанаргуль К. Смаилова[2], Диана Г. Ыгиева[2], Гульнара Б. Батенова[2], Владлена Р. Сабитова[2], Сауле К. Кожанова[2], Динара А. Муканова[2], Мадина Б. Абенова[2], Мурат Н. Лепесбаев[3], Токжан А. Ахмадиева[2], Айнаш С. Оразалина[2], Саулеш А. Апбасова[2], Дария М. Шабдарбаева[2], Алтай А. Дюсупов[2]

[1] Жедел медициналық жәрдем көрсету бойынша Семей қалалық ауруханасы, Семей қ., Қазақстан Республикасы;
[2] «Семей медицина университеті» КеАҚ, Семей қ., Қазақстан Республикасы;
[3] Абай облысы бойынша сот-медициналық сараптама орталығы, Семей қ., Қазақстан Республикасы.

Кіріспе. Бұл зерттеудің өзектілігі бұрынғы Семей ядролық полигоны (СЯП) аумағына іргелес Қазақстан өңірлерінде тұратын халық топтарының айтарлықтай санының қазіргі уақытқа дейін экологиялық жүктемесі жоғары жағдайда өмір сүріп келе жатқанына және медициналық-әлеуметтік салдарларымен байланысты.

Мақсат. Ядролық қару сынақтарының салдарынан радиациялық әсерге ұшыраған адамдардың екінші және үшінші буын ұрпақтары болып табылатын Абай облысы, Абай ауданы тұрғындарының денсаулық жағдайы мен сәулелік жүктемелерін алдын ала талдау.

Материалдар мен әдістер. Зерттеу дизайны: көлденең скринингтік зерттеу. Физикалық тексеру мен зертханалық талдау, сондай-ақ әлеуметтік-демографиялық факторлар мен ата-аналарының, әжелері мен аталарының сәулелену дозаларын зерттеу жүргізілді. Зерттеу Абай облысы Абай ауданының Қарауыл және Саржал ауылдарының 18-ден 65 жасқа дейінгі 233 тұрғынын қамтыды. Статистикалық талдау SPSS 20.0 (IBM Inc., New York, USA) және Jamovi (нұсқа 2.5.5; https://www.jamovi.org) бағдарламалары арқылы жүргізілді.

Нәтижелер. Зерттеуге қатысқан адамдардың басым көпшілігі 29 жасқа дейінгі және 30–39 жас аралығындағы топтарға жатты. Олардың шамамен 70%-ы осы өңірде туған немесе 30 жылдан астам уақыт бойы тұрып келеді. Әйелдердің 6,1%-ында шеткі лимфа түйіндерінің ұлғаюы байқалды. Зерттеуге қатысушылардың барлығына дерлік қалқанша безінің үлкеюі тән болды. Ерлердегі адренокортикотропты гормон (АКТГ) деңгейінің медианалық көрсеткіші қалыпты мәндерден сәл жоғары болды. Зерттеу нәтижелері сәулеленуге ұшыраған бірінші және екінші буын өкілдері үшін жоғары дозалық ауқымның бар екенін көрсетті.

Қорытынды. Сәулелену дозалары мен денсаулық жағдайына әсер ететін стохастикалық және детерминистік факторлар арасындағы байланысты анықтау үшін әртүрлі дозалық топтар мен радиациялық әсерге ұшырамаған бақылау тобы арасында салыстырмалы талдау жүргізу қажет.

***Түйінді сөздер**: Семей ядролық полигоны; скринингтік зерттеулер, денсаулық жағдайы, радиация, ұрпақтар.*

Дәйексөз үшін:

Алибаева Г.А., Пивина Л.М., Чайжунусова Н.Ж., Орехов А.Ю., Липихина А.В., Масабаева М.Р., Байбусинова А.Ж., Смаилова Ж.К., Ыгиева Д.Г., Батенова Г.Б., Сабитова В.Р., Кожанова С.К., Муканова Д.А., Абенова М.Б., Лепесбаев М.Н., Ахмадиева Т.А., Оразалина А.С., Апбасова С.А., Шабдарбаева Д.М., Дюсупов А.А. Ядролық қару сынақтарының салдарынан радиациялық әсерге ұшыраған адамдардың ұрпақтары болып табылатын Абай облысы, Абай ауданы тұрғындарының денсаулық жағдайы мен сәулелену дозаларын алдын ала талдау // Ғылым және Денсаулық сақтау. 2025. Vol.27 (5), Б. 32-39. *doi 10.34689/SH.2025.27.5.004*

Introduction

The relevance of this study is determined by the significant number of population groups in the regions of Kazakhstan adjacent to the former Semipalatinsk Nuclear Test Site (SNTS), who still live under environmental stress and the associated medical and social consequences [1]. Since the closure of the nuclear test site in 1989, a considerable amount of information has appeared in the media that does not always accurately reflect the real situation regarding radiation contamination and its consequences for public health. The population has lived under the threat of radiation for many decades, fearing for their lives, health, and the future of their descendants [10].

Considering that nuclear weapons tests conducted over 40 years at the Semipalatinsk nuclear test site caused significant damage to human health and the environment

and led to an increase in overall morbidity and mortality among the population, the areas adjacent to the test site in the East Kazakhstan, Pavlodar, and Karaganda regions were recognized as an environmental disaster zone [5, 8]. The long-term effects of nuclear testing, passed down from generation to generation, continue to impact the population today. Currently, the studied territories of the Abay region are home not only to people who were directly exposed to external gamma irradiation and internal chronic irradiation, but also to their descendants of the second and third generations, for whom the genetically determined effects of ionizing radiation contribute to increasing health damage [2, 6]. While a significant number of domestic and international studies have been directed toward examining the health status of the descendants of the first and second generations of the designated population in previous years, the children and grandchildren of exposed individuals currently require a comprehensive assessment of both their somatic health and genetic disorders that could lead to the manifestation of stochastic or deterministic effects in the form of hereditary diseases or oncological problems.

A comprehensive assessment of the health indicators of residents of ecologically unfavorable areas underlies the development of primary and secondary prevention programs for their health problems. This assessment requires a thorough study of the demographic indicators and ecological trajectory of the affected population [11].

The aim of our study was to conduct a preliminary analysis of the health status and radiation doses of residents of the Abay District of the Abay Region, who are second- and third-generation descendants of people exposed to radiation due to nuclear weapons testing.

Materials and methods

The study population comprised residents of the Abay district of the Abay region, who are descendants of the population exposed to radiation as a result of nuclear weapons testing in the second and third generations, living in areas of environmental risk. Exclusion criteria were organic central nervous system damage, decompensated somatic diseases; history of viral hepatitis B and C; individuals not associated with nuclear weapons testing at the SNTS for various reasons.

The study focused on the health status of individuals living in environmental risk areas. Study design: cross-sectional screening study.

A physical examination and laboratory testing were conducted, along with a study of socio-demographic factors and radiation doses received by parents and grandparents that could affect the health of the target population of 233 individuals aged 18-65 years in the villages of Karaul and Sarzhal in the Abay District. These included on-site visits in accordance with the study protocol and the addition of information on the individuals to the State Scientific Automated Medical Registry (SSAMR) database. The SSAMR is located at the Research Institute of Radiation Medicine and Ecology and is the official database of all individuals involved in past radiation incidents related to nuclear weapons testing at the SNTS.

Information on personal dose load was copied from the SSAMR for parents, grandparents and relatives of individuals included in the study (if information on them was available in the SSAMR).

Research methods. For each patient included in the study of somatic and psychological health, an "Examination Form" was created, including: the patient's informed consent to participate in the health study; "Questionnaire for the participant in the scientific research project" to assess the clinical condition of the patient (anamnesis, chronic diseases, anthropometry, lymph node status, thyroid gland size, physical examination, complete blood count (CBC), biochemical parameters (calcium, potassium, sodium, magnesium, glycated hemoglobin, total protein, ALT, AST, creatinine, thyroid hormones - T4, TSH, TPO antibodies, stress hormones - ACTH, cortisol, insulin). The examination form also included parameters characterizing the socio-demographic characteristics and harmful habits of the study participants.

The sample size was calculated based on the number of residents of the area recorded in the SSAMR (the general population for the study group) during the period of weapon testing at the SNTS. The prevalence of somatic disorders among individuals exposed to radiation is 30-40% [7]. The Sample XS statistical program was used to determine the sample size, with a margin of error of 5%; the design effect is considered to be 1.0 by default.

The sample was representative, that is, it corresponded to the main characteristics of the population being studied, such as age, gender, and socio-professional status.

Statistical data processing:

Quantitative parameters were assessed for normal distribution using the Shapiro-Wilk test (for fewer than 50 subjects) or the Kolmogorov-Smirnov test (for more than 50 subjects). Normally distributed quantitative parameters were described using mean values (M) and standard deviations (SD), along with 95% confidence intervals (95% CI). In the absence of normal distribution, quantitative data were described using the median (Me) and interquartile range (IQR). Categorical data were described using absolute values and percentages. Comparisons between two groups for a non-normally distributed quantitative parameter were performed using the Mann-Whitney U test. Comparison of percentages in the analysis of four-field contingency tables was performed using the Pearson chi-square test (for expected value greater than 10) and Fisher's exact test (for expected value less than 10). Statistical analysis was performed using SPSS 20.0 (IBM Inc., New York, USA) and Jamovi (version 2.5.5; https://www.jamovi.org).

Results

Table 1 presents the socio-demographic characteristics of the study population. The vast majority of people included in the study were third-generation descendants of exposed individuals, aged up to 29 years and 30-39 years (78.1% in total). About 70% of them had lived in the given area since birth or for more than 30 years. Differences in the parameter of residence in the given area between men and women were statistically significant (p=0.031). This selection of study subjects was due to the fact that information for inclusion in the study was taken from the SSAMR, which provides a high degree of reliability of their belonging to radiation risk groups. 57.9% of study participants had secondary vocational education, and 10.3% had higher education. About 70% of men had previously served in the armed forces. Only 19.8% of men and 1.4% of women were nicotine dependent ($p < 0.001$), and alcohol consumption was noted in the survey by 14% of men and 7.5% of women.

Table 1.

Socio-demographic characteristics of the studied population.

Parameter	Male (N=86)	Female (N=147)	Total (N=233)	p value
Age (years)				
<29	56.0 (65.1%)	101.0 (68.7%)	157.0 (67.4%)	0.8521
30-39	11.0 (12.8%)	14.0 (9.5%)	25.0 (10.7%)	
40-49	18.0 (20.9%)	31.0 (21.1%)	49.0 (21.0%)	
> 50	1.0 (1.2%)	1.0 (0.7%)	2.0 (0.9%)	
Duration of residence in the area				
Since birth	66.0 (76.7%)	84.0 (57.1%)	150.0 (64.4%)	0.0311
<1 year	14.0 (16.3%)	46.0 (31.3%)	60.0 (25.8%)	
Up to 10 years	0.0 (0.0%)	4.0 (2.7%)	4.0 (1.7%)	
10-30 years	2.0 (2.3%)	5.0 (3.4%)	7.0 (3.0%)	
>30 years	4.0 (4.7%)	8.0 (5.4%)	12.0 (5.2%)	
Military service	59.0 (68.6%)	1.0 (0.7%)	60.0 (25.8%)	<0.0011
Education				
Incomplete secondary	15.0 (17.4%)	31.0 (21.1%)	46.0 (19.7%)	0.7351
Secondary vocational	49.0 (57.0%)	86.0 (58.5%)	135.0 (57.9%)	
Secondary	11.0 (12.8%)	17.0 (11.6%)	28.0 (12.0%)	
Higher	11.0 (12.8%)	13.0 (8.8%)	24.0 (10.3%)	
Dispensary registration	13.0 (15.1%)	29.0 (19.7%)	42.0 (18.0%)	0.2471
Currently smokes	17.0 (19.8%)	2.0 (1.4%)	19.0 (8.2%)	<0.0011
Alcohol consumption	12.0 (14.0%)	11.0 (7.5%)	23.0 (9.9%)	0.1101
Pearson's Chi-squared test				

The clinical parameters of the subjects and the median laboratory values are presented in Table 2. Blood pressure measurements showed that the median values were within the target range for both men and women. Heart rate parameters were also within the normal range for both sexes.

Table 2.

Clinical characteristics of study participants.

Parameter	Male (N=86)	Female (N=147)	p value
Systolic blood pressure (Me, IQR)	110 (10)	110 (20)	0.039[1]
Diastolic blood pressure (Me, IQR)	80 (10)	70 (10)	<0.001[1]
Heart rate/min (Me, IQR)	80 (2)	80 (5)	0.018[1]
Lymphadenopathy:			
Enlargement	0.0 (0.0%)	9 (6.1%)	0.029[2]
Significant enlargement	1 (1.2%)	0 (0.0%)	
Thyroid gland			
Increase to 1-2 degrees	63 (73.25%)	106 (72.1%)	0.802[1]
Increase to 3rd degree	23 (26.75%)	41 (27.9%)	
Laboratory data			
Ca, mmol/L (Me, IQR)	2.32 (0.1)	2.29 (0.13)	0.029
K, mmol/L (Me, IQR)	4.1 (0.37)	4.2 (0.4)	0.144
Na, mmol/L (Me, IQR)	141 (2.0)	141 (2.0)	0.415
Mg, mmol/L (Me, IQR)	0.79 (0.09)	0.78 (0.07)	0.293
Glycated hemoglobin, % (Me, IQR)	5.24 (0.54)	5.15 (0.38)	0.231
Total protein (Me, IQR)	72.18 (5.24)	71.2 (4.09)	0.613
ALT U/L (Me, IQR)	15.6 (15.46)	11.38 (8.73)	0.208
AST U/L (Me, IQR)	18.12 (7.25)	12.45 (6.5)	0.813
Creatinine μmol/L (Me, IQR)	64.56 (14.9)	54.87 (14.0)	<.001
Thyroxine mIU/L (Me, IQR)	12.2 (1.9)	11.8 (1.6)	0.115
TSH mIU/L (Me, IQR)	1.52 (1.67)	1.79 (1.47)	0.993
ACTH pmol/L (Me, IQR)	19.9 (15.3)	13.4 (11.79)	0.114
Cortisol nmol/L (Me, IQR)	286.0 (138.7)	256.9 (110.9)	0.097
Insulin mIU/ml (Me, IQR)	6.5 (5.8)	7.1 (5.8)	0.230

[1]Mann–Whitney U test; [2]Pearson's Chi-squared test
ALT – alanine transferase, AST – aspartate transferase, TSH – thyroid-stimulating hormone, ACTH – adrenocorticotropic hormone, HR – heart rate

Enlarged peripheral lymph nodes were observed in 6.1% of women. Almost all study participants had an enlarged thyroid gland, which is not typical for the general population, as literature suggests that women are significantly more likely to have thyroid disease than men [12]. Median levels of calcium, potassium, sodium, and magnesium, glycated hemoglobin, liver enzymes, and creatinine were within normal limits in both men and women. Creatinine levels in women were, on average, statistically significantly lower than in men, consistent with accepted norms for this laboratory parameter [9]. Free thyroxine levels in both sexes were also within reference limits, although closer to the lower limit of normal. The median ACTH level in men was slightly elevated compared to normal values (below 18 pmol/L in the morning, below 11 pmol/L in the evening), which may indicate stress in the adaptation system. Cortisol levels were within normal limits in both men and women. Insulin levels were also within normal limits in both men and women.

When assessing the health status of second- and third-generation descendants of individuals directly exposed to ionizing radiation, we were particularly interested in assessing the radiation doses to their immediate relatives (parents and grandparents) since this could shed light on the presence of a link between radiation-induced genetic effects. The median radiation doses of the individuals studied were 6.4 cSv for both sexes, 6.6 cSv for women and 5.7 cSv for men. The parental doses were significantly higher: 67.4 cSv and 50 cSv for women and men, respectively, from the father, and 42.4 cSv and 35 cSv from the mother. It should be noted that the median radiation doses to grandparents, both on the paternal and maternal sides, were in the high-dose range of 95.8–100.0 cSv (Table 3).

Table 3.

Characteristics of radiation doses of the subjects studied, as well as their previous generations (cSv, Median (IQR)).

Parameter	Male	Female	Total	p
Dose	5.7 (2.2-12.6)	6.6 (2.7- 11.8)	6.4 (2.6-12.3)	0.588
Father's dose	50.0 (25.7-100.0)	67.4 (25.4- 100.0)	62.9 (25.7-100.0)	0.879
Mother's dose	35.0 (18.5- 99.8)	42.4 (23.8- 100.0)	37.1 (20.0- 100.0)	0.693
Paternal grandfather's dose	100.0 (93.8-100.0)	95.8 (87.9- 100.0)	96.8 (90.0- 100.0)	0.073
Paternal grandmother's dose	100.0 (95.2- 100.0)	100.0 (92.3- 100.0)	100.0 (93.0- 100.0)	0.776
Maternal grandfather's dose	96.1 (91.4- 100.0)	96.8 (96.1- 100.0)	96.5 (92.6- 100.0)	0.677
Maternal grandmother's dose	100.0 (100.0-100.0)	98.1 (95.5- 100.0)	100.0 (96.2- 100.0)	0.561

When assessing the radiation doses to the descendants of individuals exposed to radiation, depending on age, it was found that the highest doses were received by older individuals: for second-generation descendants over 50 years old, the average doses ranged from 15 to 22 cSv, for those 40-49 years old - from 10 to 20 cSv, while for third-generation descendants, the peak radiation dose, on average, was 4-5 cSv (Figure 1).

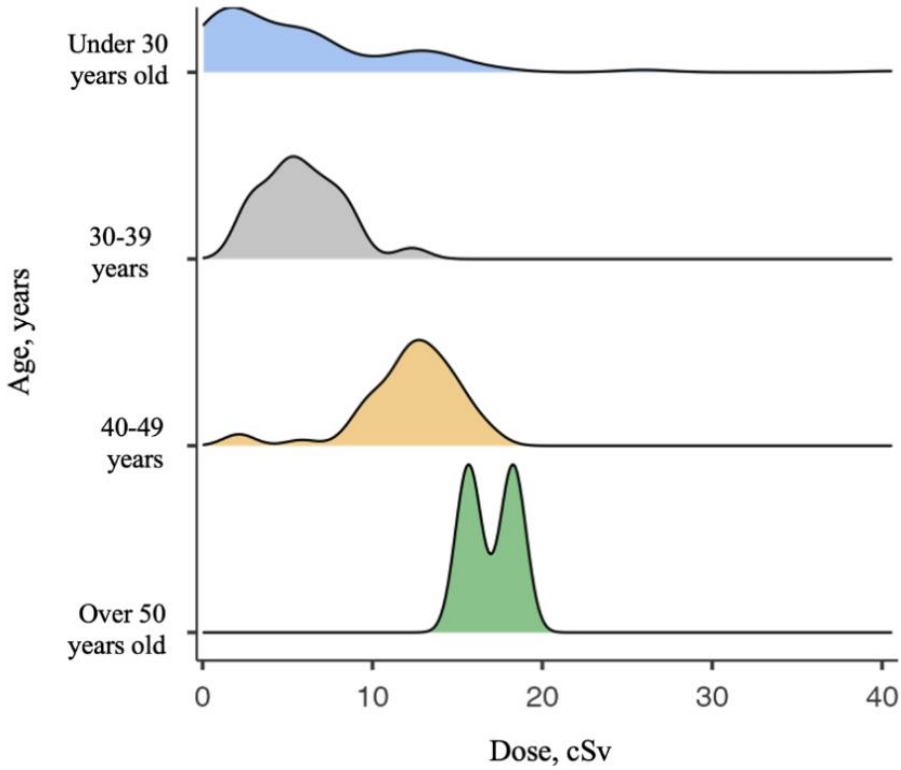

Figure 1. Doses of descendants of persons exposed to radiation, depending on age.

Discussion

Thus, our preliminary analysis of the health status of second- and third-generation descendants of the radiation-exposed population living around the nuclear testing site revealed a high range of doses for both individuals directly exposed to nuclear weapons testing and their second-generation descendants. This is due to the fact that these individuals were born to irradiated parents and were directly exposed both in utero and during childhood, when target organs are most sensitive to radiation exposure [4]. Furthermore, they received relatively high doses of internal radiation through the food chain in the form of milk from domestic cows consuming grass in radiation-contaminated areas, which negatively impacted thyroid function [3]. This is confirmed by our findings of thyroid enlargement in virtually all study participants, even third-generation offspring, despite the low-dose radiation range. Although median levels of free thyroxine and thyroid-stimulating hormone were within normal limits, the fact that thyroxine levels were closer to the lower limits of normal, as well as elevated ACTH levels, indicates stress on the adaptive system of the study participants.

Our study has several limitations, due to the recent completion of screening studies and the insufficient availability of the database for the control area, which is not associated with radiation events related to nuclear weapons testing. Therefore, a comparative analysis of health indicators for the different dose groups and the control group will be conducted later.

Conclusion

This study presents the results of a descriptive analysis of health indicators and radiation doses in second- and third-generation descendants of residents of the Abay District of the Abay Region exposed to radiation from nuclear weapons testing. The study results demonstrate a range of high radiation doses for both first- and second-generation exposed individuals. To determine the relationship between radiation doses and stochastic and deterministic effects on the health of the study residents, a comparative analysis is required across different dose groups and a control group of individuals not exposed to radiation.

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Information about the authors:
Galiya Alibayeva - Semey Hospital of Emergency Medical Care, Semey, Kazakhstan; 140A Michurina Street, Semey 071400, Kazakhstan, Tel: +7 (7222) 77 73 38, E-mail: galiya.5@mail.ru, https://orcid.org/0000-0002-1503-4663
Lyudmila Pivina - Department of Emergency Medicine, Semey Medical University, Semey, Kazakhstan 103 Abay Street, Semey 071400, Kazakhstan, Tel: +77222522251, E-mail: lyudmila.pivina@smu.edu.kz, https://orcid.org/0000-0002-8035-4866
Nailya Chaizhunussova - Department of Public Health, Semey Medical University 103 Abay Street, Semey 071400,Kazakhstan, Tel: +77771450100, E-mail: n.nailya@mail.ru, https://orcid.org/0000-0002-6660-7118
Andrey Orekhov - Department of Therapy, Semey Medical University, Semey, Kazakhstan, 103 Abay Street, Semey 071400, Kazakhstan, Tel: +77222522251, E-mail: andrey.orekhov@smu.edu.kz, https://orcid.org/0000-0001-7201-1399
Alexandra Lipikhina – Research Institute of Radiation Medicine and Ecology, Semey, Kazakhstan, 071400, Kazakhstan, Tel: +77779812127, E-mail: a.v.lipikhina@mail.ru, https://orcid.org/0000-0001-6980-999X
Meruyert Massabayeva - Semey Medical University, Semey, Kazakhstan, 103 Abay Street, Semey 071400, Kazakhstan, Tel: +77222522251, E-mail: meruyert.massabayeva@smu.edu.kz, https://orcid.org/0000-0001-8240-361X
Assel Baibussinova - Epidemiology and biostatistics department, Semey Medical University, Semey, Kazakhstan, 103 Abay Street, Semey 071400, Kazakhstan, Tel: +77222522251, E-mail: assel.baibussinova@smu.edu.kz, https://orcid.org/0000-0003-3447-6245
Zhanargul Smailova - Semey Medical University, Semey, Kazakhstan, 103 Abay Street, Semey 071400, Kazakhstan, Tel: +77222522251, E-mail: zhanargul.smailova@smu.edu.kz, https://orcid.org/0000-0002-4513-4614
Diana Ygiyeva - Semey Medical University, Semey, Kazakhstan; 103 Abay Street, Semey 071400, Kazakhstan, Tel: +77072808992, E-mail: diana.ygiyeva@smu.edu.kz, https://orcid.org/0000-0001-8391-8842
Gulnara Batenova - Department of Emergency Medicine, Semey Medical University, Semey, Kazakhstan 103 Abay Street, Semey 071400, Kazakhstan, Tel: +77751030602, E-mail: gulnara.batenova@smu.edu.kz, https://orcid.org/0000-0003-3198-1860
Vladlena Sabitova - Semey Medical University, Semey, Kazakhstan; 103 Abay Street, Semey 071400, Kazakhstan, Tel: +77779900030, E-mail: sabitovavladlena@gmail.com, https://orcid.org/0000-0002-5893-3618
Saule Kozhanova - Department of Anatomy, Histology and Topographic Anatomy named after Professor, Doctor of Medical Sciences, N.A.Khlopov, Semey Medical University, Semey, Kazakhstan; 103 Abay Street, Semey 071400, Kazakhstan, Tel: +77077215568, E-mail: saule.kozhanova@smu.edu.kz, https://orcid.org/0000-0003-3807-9765
Dinara Mukanova – Department of Simulation and Educational Technologies**,** Semey Medical University, Semey, Kazakhstan; 103 Abay Street, Semey 071400, Kazakhstan, Tel: +77222522251, E-mail: dinara.mukanova@smu.edu.kz, https://orcid.org/0000-0001-5186-2346
Madina Abenova - Epidemiology and biostatistics department, Semey Medical University, Semey, Kazakhstan, 103 Abay Street, Semey 071400, Kazakhstan, Tel: +77222522251, E-mail: madina.abenova@smu.edu.kz, https://orcid.org/0000-0002-4219-5737
Murat Lepesbayev - Forensic Examination Center of the Abai Region, Semey, Kazakhstan, 3 Sechenov Street, Tel: +77222522251, E-mail: king87ml@gmail.com, https://orcid.org/0009-0006-9810-9232
Tokzhan Akhmadiyeva - Semey Medical University, Semey, Kazakhstan; 103 Abay Street, Semey 071400, Kazakhstan, Tel: +77222522251, E-mail: dinara.mukanova@smu.edu.kz, https://orcid.org/0009-0001-4806-2329
Ainash Orazalina - Department of Molecular Biology and Medical Genetics named after Academician of the National Academy of Sciences of the Republic of Kazakhstan T.K. Raisov, Semey Medical University, Tel: +77772354772, e-mail: ainash.orazalina@smu.edu.kz, https://orcid.org/0000-0003-4594-0138
Saulesh Apbassova - Department of Pathological Anatomy and Forensic Medicine, Semey Medical University 103 Abay Street, Semey 071400, Kazakhstan, Tel: +77079196975, E-mail: apbasova65@mail.ru, https://orcid.org/0000-0001-6650-4971
Dariya Shabdarbayeva - Doctor of Medical Sciences, Professor, Vice Rector for Science, Semey Medical University", Semey, Kazakhstan, phone 8 707 365 82 71, e-mail: dariya_kz@bk.ru, https://orcid.org/0000-0001-9463-1935
Altay Dyussupov - Chairman of the Board-Rector, Semey Medical University, Semey, Kazakhstan 103 Abay Street, Semey, 071400, Kazakhstan, Tel: +77222522251, E-mail: altay.dyusupov@smu.edu.kz, https://orcid.org/0000-0003-0875-1020

Corresponding Author:
Lyudmila Pivina - Candidate of Medical Sciences, Professor**,** Department of Emergency Medicine, Semey Medical University, Semey, Republic of Kazakhstan.
Address: 071400, st. Abaya 103, Semey, Republic of Kazakhstan
E-mail: lyudmila.pivina@smu.edu.kz
Phone: +77222522251