Incidence Rates of Tuberculosis among Children and Adolescents Living in Areas Most Affected by the Chernobyl Disaster

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Introduction

Thirty years ago, on April 26th, 1986, the largest accident in the history of the nuclear industry took place at the Chernobyl nuclear power plant, leading to a massive release of radionuclides into the environment. An area of 155,000 square kilometers was contaminated, with 7.1 million residents. Russia, Ukraine and Belarus suffered most in the catastrophe, and approximately 70 percent of the radioactive fallout descended on Belarus, making it the worst contaminated of all the affected countries. The losses Belarus suffered during the 30-year period of disaster mitigation has been estimated at $235 billion. In 1985, this sum accounted for 32 annual budgets of the Belarusian state.

In Belarus, the overall contaminated area was 46,450 km² or about 23% of the country. The polluted territory was then a densely inhabited area in Belarus with 2.2 million residents. One half of the total number of 118 districts of Belarus was impacted by the Chernobyl disaster. Currently, 21 of the impacted districts are included in the list of the most affected areas.

Background. The Chernobyl accident has attracted the attention of healthcare experts all over the world due to the unprecedented scale of damage the disaster inflicted upon human health. Objectives. To examine incidence rates of tuberculosis and patterns among children and adolescents living in areas most affected by the Chernobyl disaster between 2004 and 2014. Methods. The tuberculosis incidence rate was calculated per 100,000 people. Incidence dynamics were traced for the period 2004 to 2014 and average rates were measured. Average incidence rates were calculated for different age groups, including 0–4 years, 5–9 years, 10–14 years, and 15–19 years, as well as the total value for all those between 0–19 years of age. Average incidence rates were estimated for tuberculosis, pulmonary tuberculosis and extrapulmonary tuberculosis. A comparative analysis of incidence rates of tuberculosis in areas more and less affected by the Chernobyl disaster was conducted. To avoid gender and age disparities among the population in the two different study areas, a method of direct standardization was applied.

Results. Tuberculosis incidence rates showed identical patterns among the population across all areas in this region. At the same time, the incidence rates of tuberculosis, pulmonary tuberculosis, and extrapulmonary tuberculosis were higher among children and adolescents living in the most affected areas in comparison to those living in less affected areas.

Conclusion. The results do not allow us to conclude whether radioactive pollution has a direct impact on incidence of tuberculosis among children and adolescents in the most radioactively contaminated areas. The author believes that the higher incidence rates of tuberculosis in the most affected areas are conditioned by a set of negative factors that have a pernicious influence on the general health of the population, and on the health of children and adolescents in the areas most affected by the Chernobyl disaster.

Competing Interests. The authors declare no competing financial interests.

Patient Consent. Obtained

Ethics Approval. This study was approved by the Ethics Committee of the National Research Practical Centre «Mother and Child» as part of the research project: “Development and Implementation of a Comprehensive System of Measures for Prevention of Tuberculosis among Children’s Population in the Affected Areas.” (State registration number 20143300, date of registration 01/12/2014)

Keywords. Chernobyl accident, affected areas, children, adolescents, tuberculosis
(137Cs) with a 30-year half-life were the two radionuclides that delivered the highest radiation dose to the population as a result of their release into the atmosphere.8

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) reported that “iodine-131 was the main contributor to the thyroid doses, received mainly via internal irradiation within a few weeks after the accident. In contrast, 137Cs was (and remained) the main contributor to the doses to organs and tissues other than the thyroid, due to either internal or external irradiation; these doses would continue to be received at low rates over several decades.”8

UNSCEAR rates the collective thyroid dose to the 98 million residents of the former Soviet Union at 1,600,000 man Gray (man Gy). At the country level, the collective thyroid dose was highest in Ukraine (960,000 man Gy distributed over 51 million people), however the average thyroid dose in Ukraine was about 3 times lower than in Belarus.8 At the regional level, the highest collective thyroid dose was to the population of the Gomel region (located in Belarus), where a collective thyroid dose of about 320,000 man Gy was distributed over a population of 1.6 million people, corresponding to an average thyroid dose of about 200 milligray (mGy).8

Compared to Russia and Ukraine, Belarus recorded the highest (rounded) dose to the population of the contaminated areas exposed to radiation as a result of the Chernobyl accident.8 The average thyroid dose was 1.5 times higher in Belarus (182 mGy) than in Ukraine (123 mGy), and 6.7 times higher than in Russia (27 mGy).8 The average effective dose to this population between 1986 and 2005 was 1.2 times higher in Belarus (122 mGy) and 9.9 times higher than the average thyroid dose to school children in all three countries combined (Belarus, Russia and Ukraine) (48 mGy).8 The average thyroid dose to school children in the whole of Belarus was 250.3 mGy, 4 times higher than the average thyroid dose to school children in the whole of Belarus (63 mGy) and 13.2 times higher than the average thyroid dose to school children of the three countries combined (19 mGy).8 The average thyroid dose to adolescents in the Gomel region was 145 mGy, 3.9 times higher than the average thyroid dose to adolescents in the whole of Belarus (37 mGy) and 11.2 times higher than the average thyroid dose to adolescents of the three countries combined (13 mGy).8

Most radionuclides released as a result of the Chernobyl disaster had disintegrated to lower levels by 2008. Currently, 137Cs remains the main contributor to the radiation dose.8 UNSCEAR reports 137Cs to be the main contributor to the dose to organs and tissues other than the thyroid, due to either internal or external irradiation, and contends that the afore-mentioned doses will continue at low rates over the next several decades.8

The total quantity of 137Cs deposited in the former Soviet Union as a result of the accident, including in areas of lesser deposition, was estimated to be approximately 40 PBq (petabecquerels), and apportioned as follows: 40% in Belarus; 35% in the Russian Federation; 24% in Ukraine; and less than 1% in other republics of the former Soviet Union. Regionally the highest estimate of 137Cs density is in the Gomel region at 154 kilobecquerels (kBq)/m2.8

The radioactive nuclides distributed by the Chernobyl accident in the environment had different characteristics as well as biological effects. Radioactive iodine led to

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**Abbreviations**

| Unit | Description | Symbol | Source |
|------|-------------|--------|--------|
| kBq  | Kilobecquerels | UNSCEAR Scientific Committee on the Effects of Atomic Radiation |
| man Gy | Man gray | WHO World Health Organization |
| mGy  | Milligray | 137Cs Caesium-137 |
| mSv  | Millisievert | |
| PBq  | Petabecquerels | |
substantial health effects as a result of the Chernobyl disaster. It has been recognized by the World Health Organization (WHO) that the development of thyroid pathology and subsequent thyroid cancer development among the population affected by the Chernobyl disaster is a result of irradiation with radioactive iodine-131. From 1992 to 2002 in Belarus, Russia and Ukraine, more than 4000 cases of thyroid cancer were diagnosed among those who were children and adolescents (0–18 years) at the time of the accident. The impact of the Chernobyl accident on the health of the Belarus population has attracted the attention of healthcare experts all over the world due to the unprecedented scale of damage the Chernobyl disaster inflicted upon human health. Many people in Belarus have been exposed to long-term small-dose radiation that inflicted grave consequences on the health of the population, especially children. A study by Aleynikova et al. reported an increased incidence of all types of chronic leukemia and non-Hodgkin lymphoma in the Gomel and Mogilev areas. An increase in breast cancer was observed in women from areas in the Gomel region where the deposits of $^{137}$Cs exceeded 555 kBq/m$^2$ from 1990–2003. Breast cancer rates increased by 1.2% among the monitored women of the Vitebsk region and by 5.7% in the Gomel areas with deposits of $^{137}$Cs of more than 185 kBq/m$^2$, while in the areas with deposits of $^{137}$Cs exceeding 555 kBq/m$^2$ there was a breast cancer rate increase of 32.7%. The risk of breast cancer increased by 25% in women who live in contaminated areas. In addition, women aged between 55-59 years constitute the highest risk group in the most contaminated areas of the Gomel region, while in the Vitebsk region, the highest risk group consists of women aged 70-74 years (94.9 ± 6.8 per 100,000 female population). An increase of non-oncological diseases among the population in the contaminated areas such as autoimmune thyroiditis, cataracts and circulatory system diseases was also noted. The increase in disease incidence was linked with radiation exposure combined with a set of factors—environmental, anthropogenic, psychological, social and economic disturbances, the Soviet Union collapse and deterioration of the quality of life. The study also contends that exposure to ionizing radiation might have aggravated and ignited all of these negative factors.

In addition, after the Chernobyl disaster, epidemiological surveys revealed a rise in the rate of tuberculosis in the radioactively polluted areas. The tuberculosis incidence rate in 1985 was 75.8 cases per 100,000 people and the most destructive forms of tuberculosis accounted for 17.2% of all cases, while in 1996 the tuberculosis incidence rate was 84.0 cases per 100,000 people and the most destructive forms of tuberculosis accounted for 41.7% of all cases.

From 1991 to 1995, the tuberculosis incidence rates in Belarus increased by 42.5%, while the rates of mortality caused by tuberculosis increased by 28.6%. The incidence rates for pulmonary tuberculosis with bacterioexcretion increased from 12.8 cases per 100,000 people in 1991 to 17.9 cases in 1995. In the Gomel region the tuberculosis incidence rates increased from 50.4 cases per 100,000 people in 1993 to 60.5 cases per 100,000 people in 1996. The spread of tuberculosis across the radioactively polluted areas has been linked with a comprehensive set of negative factors, such as cuts in the number of preventive X-ray examinations of the population, rising levels of migration outflow from the regions with high tuberculosis rates, worsening socioeconomic situation, poverty, micro-epidemics of tuberculosis among alcohol and drug addicts, and fear of X-rays.

Studies conducted between 1983 and 1996 found higher rates of drug-resistant tuberculosis, tuberculosis mortality rates and tuberculosis relapse rates in areas more affected by the Chernobyl disaster compared to areas less affected by the disaster. Tuberculosis incidence rates among children and adolescents from different areas of Belarus did not vary much before the Chernobyl disaster. After the disaster, tuberculosis incidence rates among children and adolescents increased in the Gomel region, reaching 2.7 times the national average in 1994, and tripling between 1985 to 1996, increasing from 4.1 cases per 100,000 people in 1985 to 12.8 cases per 100,000 people in 1996.

Prior to this, tuberculosis incidence rates had decreased by 7.6% among children in the monitored areas of the Gomel region from 1981–1985. From 1991–1995, tuberculosis incidence rates among children in these areas increased by 45.8%.

Currently, the incidence rates of tuberculosis in Belarus are significantly lower than those in other post-Soviet countries. However, according to the Global Tuberculosis Report 2015 of the WHO, Belarus was listed among 27 other countries with a high multidrug-resistant tuberculosis burden. Incidence rates of tuberculosis among children and adolescents are closely linked to the spread of tuberculosis among adults. Considering the
prevalence of aggressive infections among the adult population, a study of tuberculosis incidence rates among children and adolescents is useful. Research on tuberculosis incidence rates among children and adolescents is also important for forecasting the future of the tuberculosis epidemic and developing appropriate prevention measures.

The objective of this study was to examine tuberculosis incidence rates and patterns among children and adolescents living in areas most affected by the Chernobyl disaster, analyzing data from 2004 to 2014.

**Methods**

Radioactively contaminated areas were legally defined by the Republic of Belarus on May 26, 2012 in a statue (No. 385-3) titled "The legal regime for territories affected by radioactive contamination as a result of the disaster at the Chernobyl Nuclear Power Station." The statute defined radioactive contamination zones as the areas across Belarus with a density of soil contamination of $^{137}$Cs, strontium-90, or plutonium-238, -239, and -240 exceeding 1480 kBq/m² (40 Ci/km²) or soil contamination density of strontium-90 or plutonium-238, -239, and -240 exceeding 111 and 3.7 kBq/m² (3 and 0.1 Ci/km²), respectively.

2. **Zone of primarily resettlement**—area with soil contamination density of $^{137}$Cs exceeding 1480 kBq/m² (40 Ci/km²) or soil contamination density of strontium-90 or plutonium-238, -239, and -240 exceeding 111 and 3.7 kBq/m² (3 and 0.1 Ci/km²), respectively.

3. **Zone of subsequent resettlement**—area with soil contamination density of $^{137}$Cs between 555-1480 kBq/m² (15-40 Ci/km²), soil contamination density of strontium-90 between 74-111 kBq/m² (2.3 Ci/km²), or soil contamination density of plutonium-238, -239, and -240 between 1.85-3.7 kBq/m² (0.05-0.1 Ci/km²). The average annual effective radiation dose to the population in these territories may exceed 5 mSv (over the level of natural and technogenic background). The zone also includes areas with lower soil contamination density for these radionuclides, but where the average annual effective radiation dose to the population exceeded 5 mSv.

4. **Zone with the right of resettlement**—area with soil contamination density of $^{137}$Cs between 185-555 kBq/m² (5-15 Ci/km²), strontium-90 between 18.5-74 kBq/m² (0.5-2 Ci/km²), or plutonium-238, -239, and -240 between 0.74-1.85 kBq/m² (0.02-0.05 Ci/km²). The annual effective radiation dose to the population in those territories may exceed 1 mSv (over the level of natural and technogenic background). The zone also includes areas with lower soil contamination density of these radionuclides, but where the average annual effective radiation dose to the population exceeded 1 mSv.

5. **Zone of residence with periodic radiation monitoring**—area with a soil contamination density of $^{137}$Cs between 37-185 kBq/m² (1-5 Ci/km²), strontium-90 between 5.55-18.5 kBq/m² (0.15-0.5 Ci/km²), or plutonium-238, -239, and -240 between 0.37-0.74 kBq/m² (0.01-0.02 Ci/km²). The average annual effective radiation dose to the population in these territories may exceed 1 mSv (over the level of natural and technogenic background).

In Belarus, the Gomel region occupies the largest territory, accounting for a fifth of the country’s land. This region was the most affected by the Chernobyl disaster. Table 1 gives the number of settlements located in the radioactively polluted territories in the Gomel region between 2004 and 2014, according to the data of the Central Statistics Committee of the Gomel region. Table 2 shows the total population living in the settlements in the Gomel region situated in the radioactively polluted areas between 2004 and 2014 according to the data of the Central Statistics Committee of the Gomel region.

For the present study, a database was developed where all primary cases of tuberculosis among children and adolescents in the Gomel region during 2004–2014 were recorded. The Gomel region accounts for 25.2% of all registered tuberculosis cases among children and adolescents in the Republic of Belarus. The following criteria were considered in the analysis: tuberculosis verified by the bacteriological method and/or radiological method, patient age between 0–19 years, and permanent residence of patient in the Gomel region. Patient consent was obtained. This study was approved by the Ethics Committee of the National Research Practical Centre «Mother and Child» as part of the research project: "Development and Implementation of a Comprehensive System of Measures for Prevention of Tuberculosis among Children's Population in the..."
Affected Areas." (State registration number 20143300, date of registration 01/12/2014).

All children and adolescents diagnosed with tuberculosis and recorded in this database were then divided into two groups. The first group included children and adolescents living in the areas most affected by the Chernobyl disaster. The second group included children and adolescents living in less affected areas of the Gomel region.

The overall characteristics of the areas most affected by the Chernobyl disaster in the Gomel region are presented in Table 3.

The list of areas most affected by the Chernobyl disaster was made in

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| Total Number of Settlements Located in Radioactive Contamination Zones | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---------------------------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|
| Total number of settlements with resident population | 1,481 | 1,427 | 1,426 | 1,426 | 1,404 | 1,404 | 1,402 | 1,313 | 1,309 | 1,308 | 1,308 |

| Zones: | | | | | | | | | | | |
| Zones of residence with periodic radiation monitoring | 748 | 801 | 802 | 802 | 795 | 794 | 790 | 939 | 932 | 929 | 928 |
| Zones with right of resettlement | 681 | 589 | 588 | 586 | 580 | 576 | 574 | 347 | 344 | 337 | 337 |
| Zones of subsequent resettlement | 33 | 24 | 24 | 22 | 21 | 21 | 21 | 13 | 13 | 12 | 12 |

Table 1 — Number of Settlements Located in the Radioactively Polluted Territories in the Gomel Region Between 2004-2014

| Population | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|-----------------|------|------|------|------|------|------|------|------|------|------|------|
| Total population in zones of residence with periodic radiation monitoring | 1,142,201 | 1,023,944 | 1,017,956 | 1,013,215 | 1,012,087 | 1,011,955 | 1,000,627 | 879,335 | 882,655 | 886,375 | 889,374 |
| Total population in zones with the right of resettlement | 949,154 | 874,122 | 870,081 | 867,429 | 868,235 | 869,803 | 858,511 | 782,232 | 786,417 | 791,106 | 795,428 |
| Total population in zones of subsequent resettlement | 177,456 | 145,923 | 144,066 | 142,204 | 140,856 | 139,182 | 139,220 | 95,261 | 94,413 | 93,477 | 92,158 |
| Total population | 15,591 | 3,899 | 3,809 | 3,582 | 2,996 | 2,970 | 2,896 | 1,842 | 1,825 | 1,792 | 1,788 |

Table 2 — Total Population Living in Settlements in the Gomel Region Situated in Radioactively Polluted Areas Between 2004–2014

Data adapted from statistics compiled by the Central Statistics Committee of the Gomel region.29
compliance with the decree of the Council of Ministers of the Republic of Belarus of June 9, 2000, No 845, and includes the following 13 areas in the Gomel region: Bragin, Buda-Koshelevo, Vetka, Dobrush, Elsk, Kalinkovichi, Korma, Lelchitsy, Narovlia, Rahachou, Rechitsa, Khoiniki and Chechersk. The location of these areas is shown in Figure 1.

The list of less affected areas is comprised of 8 territories in the Gomel region that were not mentioned in the list of the areas most affected by the Chernobyl disaster, including the region’s major city Gomel. These areas include Gomel city, Zhitkovichy, Zhlobin, Loyev, Mozyr, Octyabr, Petrikov, and Svetlogorsk.

Calculations were made for the intensive indicators of tuberculosis incidence rate per 100,000 people in the present study. The incidence dynamics were traced during the period from 2004 to 2014 and the average rates were measured. Average tuberculosis incidence rates were calculated for different age groups, including 0–4 years, 5–9 years, 10–14 years, and 15–19 years, as well as the total value for all those between 0–19 years. Average incidence rates were estimated for tuberculosis, pulmonary tuberculosis and extrapulmonary tuberculosis (for the period from 2004 to 2014). A comparative analysis of tuberculosis incidence rates in the areas most affected by the Chernobyl disaster and less affected areas of the Gomel region was conducted. To avoid gender and age disparities among the population in the two different study areas, a method of direct standardization was applied. Data on age composition of the population of Belarus for the period 2004–2014 was used as a standard for calculating incidence rates. The official census data of the National Statistical Committee of the Republic of Belarus...

### Table 3 — Characteristics of the Gomel Areas Most Affected by the Chernobyl Disaster

Data adapted from statistics of the Department for Elimination of the Consequences of the Catastrophe at the Chernobyl NPP from the Ministry for Emergency Situations of the Republic of Belarus.
Results

From 2004–2014, tuberculosis incidence rates decreased among the population aged between 0–19 years living in the Gomel region. As depicted in Figure 2, a decrease in tuberculosis incidence rates was recorded among the population inhabiting both study areas. Nevertheless, tuberculosis incidence rates in the population in the areas most affected by the Chernobyl disaster decreased at a swifter pace. The annual screening by the Mantoux tuberculin skin test that had been compulsory for all children was cancelled in 2011. Moreover, the decrease in tuberculosis incidence rates in the Gomel region is in line with the general tendency of declining tuberculosis incidence rates currently observed throughout the world.

The average rate of tuberculosis incidence among children and adolescents aged 0–19 years for the period 2004–2014 was calculated. The average rate of tuberculosis incidence in the areas most affected by the disaster was determined to be 7.32 cases per 100,000 people, which is 1.5 times higher than the average rate of tuberculosis incidence in less affected areas (4.86 cases per 100,000 people).

To exclude differences in the age of the population in the two different study areas, standard rates of tuberculosis incidence in the population in the two different areas in the Gomel region between 2004 and 2014 were determined. A method of direct standardization was applied to determine standard rates. The composition of the Belarusian population aged between 0–19 years between 2004 and 2014 was taken as a standard. The results are shown in Figure 3.

As seen in Figure 3, after tuberculosis incidence rates were standardized, the disparity between the rates in the areas most affected by the disaster and less affected areas became more conspicuous. Before the standardization, the tuberculosis incidence in the most affected areas was 1.5 times higher than the tuberculosis incidence in less affected areas (7.32 vs 4.86 cases per 100,000 people), and after standardization the rate was 1.7 times higher (8.24 vs 4.79 cases per 100,000 people).

Therefore, supposing the population aged between 0–19 years in the two study areas of the Gomel region was age-homogeneous, tuberculosis incidence rates in the most affected areas would be 1.7 times higher than in less affected areas. Thus, the differences in the age structure of the population had an impact on tuberculosis incidence rates among these two different populations. These estimates may indicate higher prevalence rates of tuberculosis infection among children and adolescents in the areas most affected by the Chernobyl disaster.

A study on tuberculosis incidence rates was carried out focusing on the population inhabiting the areas of the Gomel region and the Republic of Belarus in general were used for calculating indicators of tuberculosis incidence rates.
localization of the pathological process in the human body, i.e. pulmonary tuberculosis vs extrapulmonary tuberculosis. The average pulmonary tuberculosis incidence rates among the population aged between 0–19 years during 2004–2014 were determined. The pulmonary tuberculosis incidence rate in the most affected areas was 5.20 cases per 100,000 people, which is 1.4 times higher than the pulmonary tuberculosis incidence rates in less affected areas (3.75 cases per 100,000 people).

Similar to the results on tuberculosis incidence, standardized rates of pulmonary tuberculosis incidence in the population aged between 0–19 years in the two study areas were determined. The outcomes of those calculations are shown in Figure 4.

As seen in Figure 4, after the pulmonary tuberculosis incidence rates were standardized by age, the disparity between the rates became more conspicuous. Before standardization, the pulmonary tuberculosis incidence in the most affected areas was 1.4 times higher than in less affected areas (5.20 vs. 3.75 cases per 100,000 people), and after standardization the rate was 2.9 times higher (6.13 vs. 2.11 cases per 100,000 people). Therefore, if we assume that the population in the two study areas in the Gomel region had a homogeneous age structure, the pulmonary tuberculosis incidence rates in the most affected areas would be 2.9 times higher than in less affected areas. Thus, the differences in age structure of the population had an effect on pulmonary tuberculosis incidence rates among the population in the two different study areas in the Gomel region. Again, these estimates may point to the higher incidence rates of pulmonary tuberculosis among children and adolescents in the most affected areas.
The average extrapulmonary tuberculosis incidence rate among the population aged between 0–19 years during 2004–2014 was determined. The average extrapulmonary tuberculosis incidence rate in the most affected areas was 2.12 cases per 100,000 people, which is 1.9 times higher than the rate in less affected areas (1.11 cases per 100,000 people). Extrapulmonary tuberculosis is characterized by a more severe clinical course. The disease is less effectively treated than pulmonary tuberculosis and there are more cases of failed treatment. The higher incidence of extrapulmonary tuberculosis among children and adolescents in the most affected areas indirectly indicates a more severe tuberculosis clinical course among the population in these areas. Similarly, standardized rates for extrapulmonary tuberculosis in the population aged between 0–19 years in the two different study areas were determined. The results are shown in Figure 5.

As demonstrated by the results, standardization of rates did not impact the incidence ratio for extrapulmonary tuberculosis in the two different study areas. Before the rates were standardized, the incidence rate of extrapulmonary tuberculosis in the most affected areas was 1.9 times higher than the rate of extrapulmonary tuberculosis in less affected areas (2.12 vs 1.11 cases per 100,000 people), and after standardization the same rate was found, i.e. a 1.9-fold difference (2.11 vs 1.11 cases per 100,000 people). Thus, differences in the age structure of the population did not affect the extrapulmonary tuberculosis incidence rates in the population of the two different areas in the Gomel region. As previously noted, these estimates suggest the presence of higher prevalence rates of extrapulmonary tuberculosis in children and adolescents in the most affected areas. The average incidence rates in different age groups (0–4; 5–9; 10–14; 15–19 years) in the two study areas for the period 2004–2014 were determined. The results of the calculations are shown in Figure 6.

It has been found that tuberculosis incidence rates increase with age, which is a general characteristic of tuberculosis epidemiology. The present study found this trend to be a long-standing pattern for both of the study areas. The lowest tuberculosis rates were detected in the youngest age group (0–4 years). The tuberculosis incidence rates for the group aged between 0–4 years in the most affected areas were 15.1% lower than in the less affected areas (1.8 cases per 100,000 people in the most affected areas vs 2.12 cases in less affected areas). For the group aged between 5–9 years, tuberculosis incidence rates were higher than for the group aged between 0–4 years. The tuberculosis incidence rates for the group aged between 5–9 years were 1.8 times higher in the most affected areas compared to the less affected areas (4.44 cases vs 2.51 cases per 100,000 people, respectively). For the group aged between 10–14 years, tuberculosis incidence rates were relatively identical for the two study areas (3.62 cases vs 3.67 cases per 100,000 people, respectively). The low tuberculosis incidence rates for the groups aged between 0–4, 5–9 and 10–14 years may be partially explained by insufficient tuberculosis diagnostics among children in these age groups.

The highest incidence of tuberculosis
was detected in the oldest age group (between 15–19 years). The tuberculosis incidence was 2.1 times higher in the most affected areas than in less affected areas (19.53 cases vs 9.36 cases per 100,000 people, respectively). The tuberculosis incidence rates observed for the group aged between 15–19 years may be a more realistic reflection of the general epidemic situation of tuberculosis among the population, because in Belarus, adolescents at this age are examined for tuberculosis more thoroughly. The population aged between 15–19 years is screened for tuberculosis by the following two methods: skin testing (Mantoux tuberculin skin test or the Diaskin test) and by the radiological method.

The present study revealed a higher tuberculosis incidence among adolescents living in the areas most affected by the Chernobyl disaster than from less affected areas, as well as different tendencies in incidence rates of pulmonary and extrapulmonary tuberculosis among various age groups of the population.

The incidence rates of pulmonary tuberculosis in the population of the two study areas had identical patterns and were marked by a wide range of fluctuations—from 0.36 cases to 17.4 cases per 100,000 people. While rates were low among children, rates were high among adolescents. This pattern is shown in Figure 7.

The lowest pulmonary tuberculosis incidence rates were detected in children in the youngest age group (0–4 years) living in the most affected areas, 2.9 times lower than in less affected areas (0.36 cases vs 1.06 cases per 100,000 people, respectively). The incidence of pulmonary tuberculosis in children aged between 5–9 years was 2.9 times higher in the most affected areas than in less affected areas (1.8 cases vs 2.12 cases per 100,000 people, respectively). The incidence rates of pulmonary tuberculosis in children aged between 10–14 years were 1.8 times higher in the most affected areas than in less affected areas (2.51 cases vs 1.48 cases per 100,000 people in less affected areas). The highest incidence rates of pulmonary tuberculosis were found in adolescents aged between 15–19 years. Thus, the incidence rates in the most affected areas were 2.1 times higher than in less affected areas (17.4 cases vs 8.32 cases per 100,000 people, respectively). The discrepancy between the incidence rates of pulmonary tuberculosis may be closely related to the dissimilar requirements for tuberculosis screening among different age groups of the population. For instance, younger children are selectively examined for tuberculosis and only by the Mantoux tuberculin skin test.

A dramatically different tendency was revealed in the analysis of incidence rates of extrapulmonary tuberculosis among different age groups of the population. These rates showed only minor fluctuations compared to pulmonary tuberculosis. The highest incidence was estimated at 2.96 cases per 100,000 people, while the lowest rate was 1.04 cases per 100,000 people. The incidence for all age groups was higher among the population in the most affected areas compared to less affected areas. This pattern is shown in Figure 8.

The incidence rates of extrapulmonary tuberculosis for the youngest age
The incidence rates of extrapulmonary tuberculosis among children aged 0–4 years in the most affected areas were 1.4 times higher than for the same age group in less affected areas (1.44 cases vs 1.06 cases per 100,000 people, respectively). The incidence rates of extrapulmonary tuberculosis among children aged 5–9 years in the most affected areas were 2.2 times higher than for the same age group in less affected areas (2.96 cases vs 1.35 cases per 100,000 people, respectively). The incidence rates of extrapulmonary tuberculosis for children aged between 10–14 years was 1.9 times higher in the most affected areas compared to less affected areas. The tuberculosis incidence rates among the population in the most affected areas were 1.5 times higher than among the population in less affected areas.

Discussion

The present research revealed similar epidemiological tendencies in tuberculosis distribution in all study areas among those aged between 0–19 years. From 2004 to 2014, there was a decrease in tuberculosis incidence across all areas of the Gomel region. The observed decrease in tuberculosis incidence rates in the Gomel region appears to be in line with the general tendency of declining tuberculosis incidence rates currently observed globally.

At the same time, the present study found that the tuberculosis incidence was higher in the most affected areas compared to less affected areas. The tuberculosis incidence rates among the population in the most affected areas were 1.5 times higher than among the population in less affected areas. The current research found a higher incidence of pulmonary and extrapulmonary tuberculosis in the population in the most affected areas. The incidence of pulmonary tuberculosis among the population aged 0–19 years from the most affected areas was 1.4 times higher than in the same age group in less affected areas. The incidence of extrapulmonary tuberculosis was 1.9 times higher in the population of the most affected areas than in the population of less affected areas.

After standardization, the disparity between the tuberculosis incidence rates in the two study areas increased. The same pattern was noted for pulmonary tuberculosis incidence. The results demonstrated that the higher prevalence of tuberculosis and pulmonary tuberculosis in the areas most affected by the Chernobyl disaster is not conditioned by the age structure of the population in those areas. This clearly points to a higher prevalence of tuberculosis infection among the population in the areas most affected by the disaster.

In the course of the comparative analysis of the tuberculosis incidence across age groups, a clear pattern emerged showing that the incidence of pulmonary tuberculosis increased with age. The highest rates of pulmonary tuberculosis were detected in the oldest age group of adolescents,
Tuberculosis among Children and Adolescents near the Chernobyl Disaster

Conclusion

The results of the present study do not allow us to conclude whether radioactive pollution has a direct impact on tuberculosis incidence among children and adolescents in the most radioactively contaminated areas of the Gomel region. However, the author believes that the higher tuberculosis incidence rates in the most affected areas of the Gomel region are conditioned by a set of negative factors that have a pernicious influence on the health of the population in these areas.

The results of the present study demonstrate the need for enhanced tuberculosis prevention among children and adolescents living in the areas most affected by the Chernobyl disaster. The data acquired in the course of the present research can be further applied to the planning and implementation of tuberculosis prevention campaigns among the population in the areas most affected by the Chernobyl disaster.

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Figure 8 — Average incidence rates of extrapulmonary tuberculosis across age groups in the Gomel region for the period 2004–2014

Those between 15–19 years. The same pattern was found both of the study areas. Moreover, the incidence of extrapulmonary tuberculosis in all studied age groups was higher in the most affected areas.
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