

THYROID CANCER IN UKRAINIAN POPULATION GROUPS AFFECTED BY THE CHERNOBYL ACCIDENT

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ABSTRACT

The study goal was to investigate thyroid cancer morbidity in population groups affected by the Chernobyl catastrophe. The study period comprised 1994-2006 for clean-up workers and 1990-2006 for Chernobyl evacuees and residents of contaminated territories. A significant increase of thyroid cancer incidence was registered in all observed population groups. The most significant excess over the national level was identified in clean-up workers. This amounted to a factor of 5.9, while it was 5.5 for the evacuees and 1.7 for the residents. The highest thyroid cancer risk was observed in persons exposed to radioiodine in childhood and adolescence.

Key words: Chernobyl accident, Recovery operations worker, Evacuee, Resident of contaminated territory, Thyroid cancer

1 INTRODUCTION

Thyroid cancer is among the most frequent malignancies of endocrine glands. At the same time, its portion of total cancer incidence is comparatively small (less than 0.5 % in males and about 1 % in females). It is necessary to note the substantial variability of thyroid cancer incidence worldwide (Parkin, Whelan, Ferlay, Teppo, & Thomas, 2002). An excess of thyroid cancer was among the most expected consequences of the Chernobyl accident based on the high sensitivity of thyroid gland to the carcinogenesis associated with exposure to ionizing radiation as reported previously (Shore, 1992; Akiba, Lubin, & Ezaki, 1991). According to Illyin, Balonov, Buldakov, Bur'yak, Gordeev, Dement'ev, et al. (1990) the predicted possible amount of excess cases of malignant thyroid tumors for the whole population of those contaminated with ¹³¹I raions (administrative units) was assessed to be 200 over a 30 year period. The percentage of malignant thyroid tumors in excess of the spontaneous level in the central regions of the Soviet Union, including Ukraine, might be 5 % among children and 0.9 % among adults. Mabuchi, Cardis, Preston, Ivanov, Okeanov, & Prisyazhniuk (1998) presented projections of substantial lifetime excess of thyroid cancer in inhabitants of the most contaminated regions that amounted to from 6 to 300 % depending on the average dose received. While realization of the dramatic scenario has been thoroughly studied and reported in those exposed as children (Cardis, Kesminiene, Ivanov, Malakhova, Shibata, Khrouch, et al., 2005; Kazakov, Demidchik, & Astakhova, 1992; Likhtarev, Kairo, Shpak, Tronko, & Bogdanova (1999); Tronko, Boblyyova, Bogdanova, Epstein, Likhtaryov, Markov, et al., 2003) only partial information on thyroid cancer in adults affected by the accident is available (Prisyazhnyuk, Gulak, Gristchenko, & Fedorenko, 2002; Ivanov, Tsyb, Ivanov, & Pokrovsky, 2004).

The stated goals of our study are to investigate thyroid cancer morbidity in Ukraine as a whole and in different population groups affected by the Chernobyl catastrophe and to evaluate quantitatively the realized incidence excess depending on the dose of ¹³¹I exposure.

2 MATERIAL AND METHODS

The study period for Chernobyl accident recovery operations workers (CRW) was 1994-2006 and that for evacuees from the 30-km restriction zone around the Chernobyl NPP and residents of contaminated territories was 1990–2006. The local cancer registry was used as the main data source for cancer cases among residents of the contaminated territories. It had been established to perform a retrospective (since 1980) and current collection of information on all cancer cases in the Luginy, Narodichy, and Ovruch districts of the Zhytomir region and the Borodyanka, Ivankiv, Poleskoye, and Chernobyl (1981-1985) districts of the Kyiv region. These six districts are referred to in the text below as the territories most heavily contaminated with radionuclides. Since 1989 when the National Cancer Registry of Ukraine was established, these two institutions have shared information on new cancer cases registered in contaminated territories.

From 1999 through 2004, this study was supported within the frame work of the French-German Initiative for Chernobyl, Project No 3 “Health effects of the Chernobyl accident”, Subprojects 3.1.1 “Solid cancer incidence in the most highly contaminated region of the Ukraine”, and 3.1.1S “Thyroid cancer in adolescents and adults in the most affected territories of the Ukraine after the Chernobyl accident”.

At the time of the accident, the total population of the most contaminated raions was 360.7 thousand including 74.4 thousand children aged 0-14 years (Prysyazhnyuk, Gristchenko, Zakordonets, Fuzik, Slipeniuk, & Ryzhak, 1995). In 2006, the population of six districts excluding the now evacuated Chernobyl district was 193.3 thousand including 29.9 thousand children (Derzhcomstat, State Committee of Statistics of Ukraine, 2005). For the data collection, all relevant medical documents (including emergency notifications of new cancer cases as well as death certificates) were obtained from all medical institutions where these patients were diagnosed and treated. These documents were cross-checked to eliminate duplicates and were then entered into the final data base. 12,458 new cases of cancer were registered in 1990-2006.

The data of the State Registry of Ukraine on Chernobyl victims were used to investigate cancer incidence among CRW (1986-1987 were the years of participation in clean-up activities) and among evacuees. The 1986-1987 data for CRW relate to a group of 105.4 thousand persons in 2006, namely those who resided in the Dnepropetrovsk, Donetsk, Kharkov, Kyiv, and Lugansk regions and in Kyiv City. In addition were the evacuees from Prypyat and the 30 km zone, who resettled in the territory of Ukraine, a group that included 53.4 thousand persons in 2006. The data were compared with the data base of the national cancer-registry. After this procedure, all duplicates and cases without validated diagnosis were eliminated. During 1994-2006, there were 6451 new cancer cases registered among CRW and, in 1990-2006, 2500 among evacuees (Prysyazhnyuk, Gristchenko, Fedorenko, Fuzik, Gulak, Slipeniuk, et al., 2002). The analysis was carried out with the standard methods of descriptive epidemiology: calculation of crude, age-specific, and age-adjusted incidence rates with standard errors and confidence intervals. The world population structure was used as the standard. For indirect standardization (calculation of standardized incidence ratio – SIR) the age-specific cancer incidence rates of the Ukrainian population in 1998 were used. To reveal possible tendencies, linear regression coefficients were calculated.

3 RESULTS AND DISCUSSION

In the 20 years following the Chernobyl accident in Ukraine, as a whole, thyroid cancer incidence exceeded spontaneous rates a factor of two in males and three in females. (Figure 1)

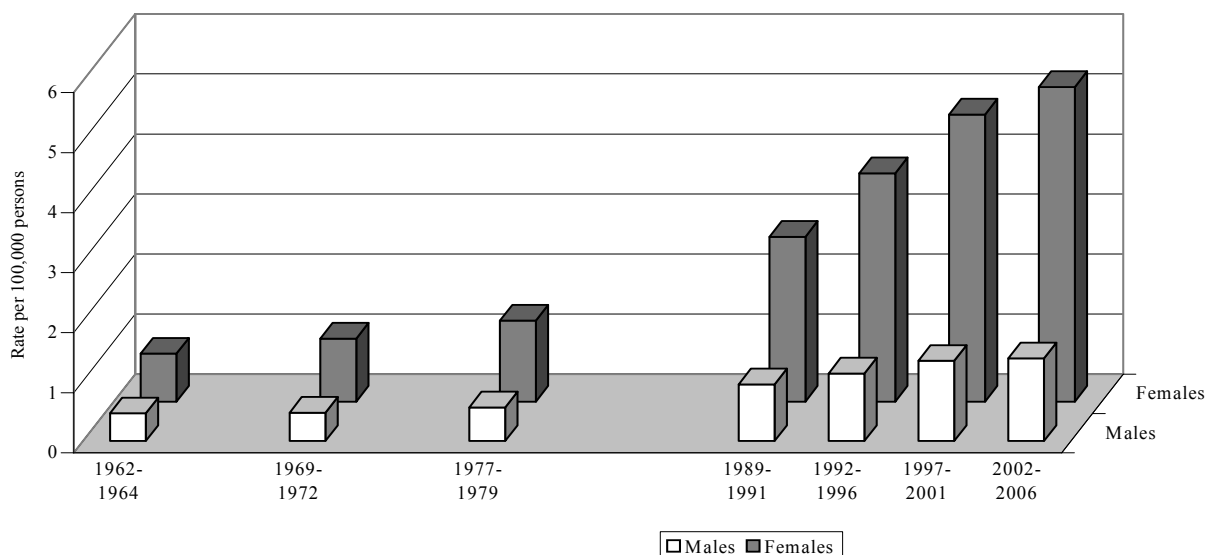


Figure 1. Age-standardized average annual thyroid cancer incidence rates in Ukraine in separate time periods (males and females)

The first cases of thyroid cancer in children who resided in the most contaminated territories were observed in 1990 (Prysyazhnyuk, Pjatak, Buzunov, & Beral, 1991). Before that time, no case of the disease had been registered for the children of these territories.

Starting from that period, an increasing incidence was marked not only in children (Tronko & Bogdanova, 1997) but also in adolescents and adults (Prysyazhnyuk, Romanenko, Grystchenko, Zakordonets, Fedorenko, Fuzik et al., 2004). Investigation conducted in the frame of the French-German Initiative for the period 1990-1999 in 3 oblasts with substantial ^{131}I fall-outs showed for the first time a relationship between the level of radioiodine fall-outs and the thyroid cancer incidence rate (Table 1).

Table 1. Truncated age-adjusted incidence rate (TASR) in 1991-1999 in adolescents and adults inhabiting the Zhytomir, Kyiv, and Cherkiv regions in territories with different levels of ^{131}I deposition

Gender	TASR per 100 000 population on territories of ^{131}I deposition (kBq/m^2)		
	≤ 100	100-200	≥ 200
Male	1.53 ± 0.26	2.20 ± 0.20	2.56 ± 0.25
Female	3.94 ± 0.26	10.36 ± 0.41	10.21 ± 0.46

The truncated age-standardized incidence rate in territories with a level of contamination $<100 \text{ kBq m}^{-2}$ did not exceed 2 cases per year per 100,000 males and 5 cases per year per 100,000 females. However, in territories with medium and high levels of contamination ($100\text{-}200 \text{ kBq m}^{-2}$ and $>200 \text{ kBq m}^{-2}$, respectively), a significant increase in the thyroid cancer incidence rate was registered. The excess amounted to 4 cases per year per 100,000 males and 16 cases per year per 100,000 females in 1998-1999. The effect of the exposure to radioiodine, i.e. the excess of thyroid cancer, kept increasing during the study period.

A comparative analysis of the thyroid cancer incidence rate in different groups of the affected population (Table 2) suggests that the most significant excess over the national level during the study period occurred in CRW. This amounted to a factor of 5.9, while it was 5.5 for the evacuees. Among the residents of the territories that were most heavily contaminated with radionuclides, a statistically significant excess of thyroid cancer incidence (by a factor of 1.7) was registered for the time period 1990-2006.

Table 2. Standardized incidence rates (SIR) values for thyroid cancer (Code ICD-10 C73) in different groups of the Ukrainian population affected by the Chernobyl accident

Groups of observation (period of observation)	Observed numbers of cases	Expected numbers of cases	SIR (%)	95% CI
Residents of contaminated territories (1990-2006)	283	169.4	167.0	147.6 - 186.5
Recovery operation workers 1986-1987 (1994-2006)	274	46.1	594.2	523.8 -664.6
Evacuees from 30km zone (1990-2006)	213	39.1	544.9	471.7 - 618.1

These figures illustrate the lack of effectiveness of the prophylactic measures taken by medical authorities in 1986 (stable iodine administration) in order to prevent radioiodine accumulation in thyroid.

The highest thyroid cancer risks were observed in persons exposed to radioiodine in childhood and adolescence. Comparative medico-geographical analysis in regions of Ukraine tested the average accumulated thyroid doses (mGy) in young persons (1-18 years old) at the moment of accident and thyroid cancer incidence rate in this cohort 20 years later.

There is a correspondence between factorial (doses) and observed results (thyroid cancer incidence rate in 2006 in irradiated cohort 1-18 years old at the moment of accident) ($r=0.5023$, P , 0.01). This is the reason we searched for the linear regression equation between dose and incident rate (Figure 2).

The abscissa axis represents the average accumulated dose (Gy), and the ordinate axis represents the incidence rate per 10,000 population. Therefore, the regression coefficient **b** actually reflects a rate change per 10,000 of 1 Gy. That is, the excess absolute risk is $4,92 \cdot 10^{-4}$ prsGy. The ratio of **b** to **a** (the incidence rate for an average accumulated dose equal to 0) indicates an excess relative risk of 22,2/Gy.

Note that in this cohort attributable risk = $\frac{ERR}{(1 + ERR)} \cdot 100 = 95,7\%$. (1)

Therefore, most thyroid cancer cases in this cohort have a radiogenic origin.

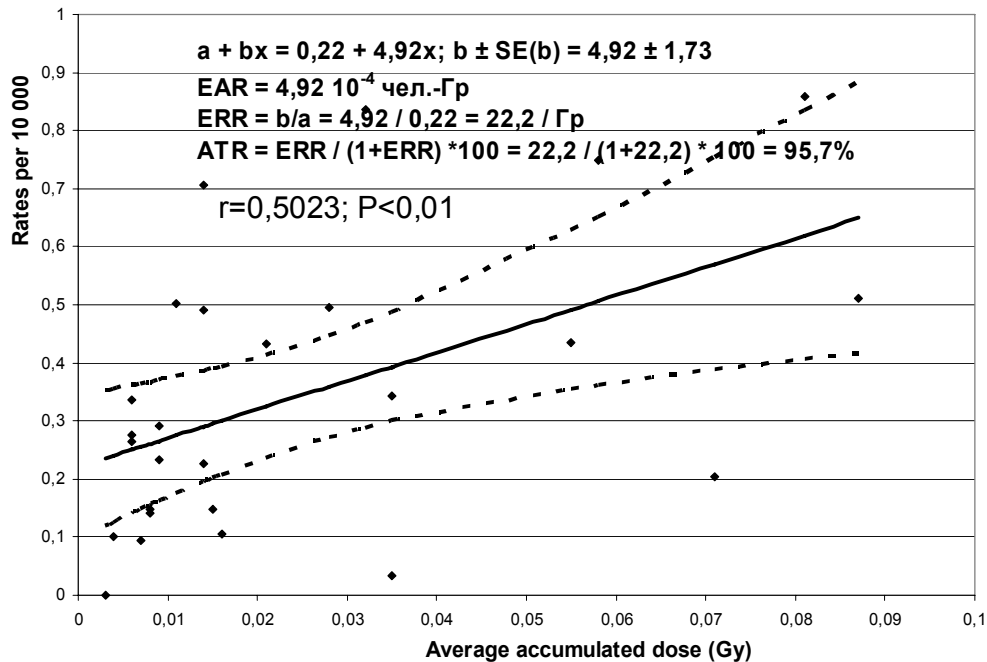


Figure 2. Parameters of a linear regression equation between average regional thyroid doses of children and adolescents (1-18 years old) in 1986 and thyroid cancer incidence rates in this cohort in 2006 in regions of Ukraine

During the long term observation of cancer incidence rates, new diagnostic methods and procedures, which could influence morbidity figures, were implemented. This is called the screening-technological effect. A method of eliminating this phenomenon was proposed and used in this study. The comparative analysis of two cohorts [1982-1986 years of birth (exposed to radioiodine) and 1987-1991 years (non-exposed)] in regions with the highest integral deposition of radioiodine (Kyiv, Chernigiv, and Zhytomir regions) was carried out (Figure 3).

Because both cohorts were screened in the same manner, conclusions about the effect of irradiation in successive attained age periods could be made. In the age period 10-14 years, the risk for cohort 1982-1986 of thyroid cancer is 9.7 times higher than for the 1987-1991 cohort; for 15-19 years the risk is 3.4 times higher.

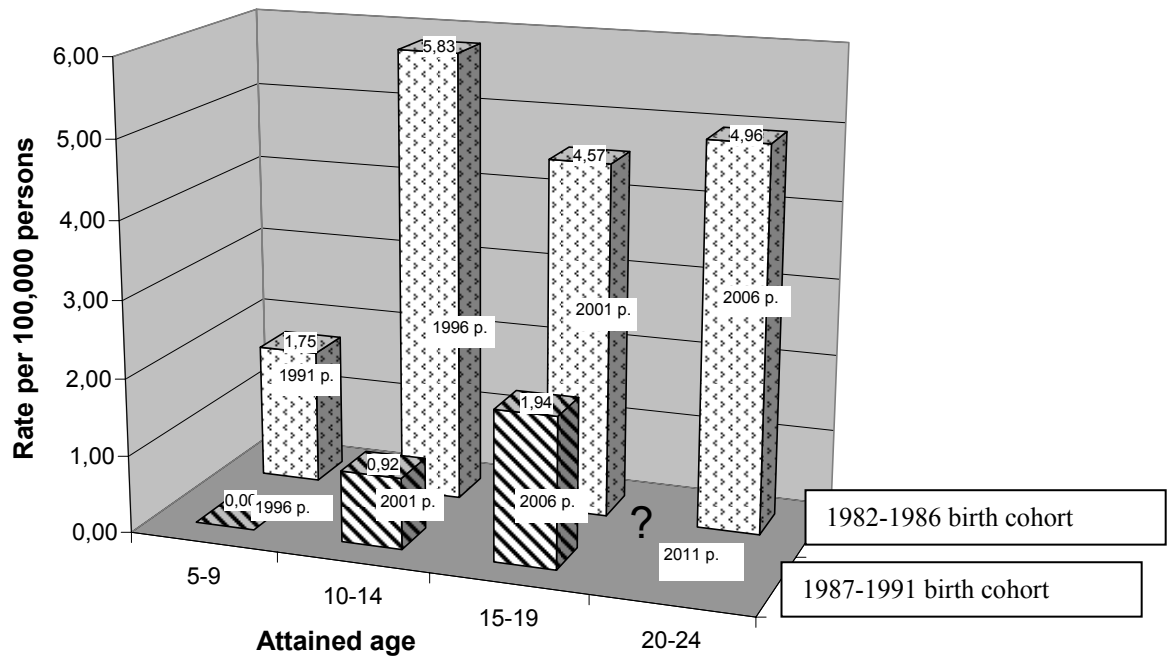


Figure 3. Dynamics of the thyroid cancer incidence in birth cohorts 1982-1986 and 1987-1997 (Zhitomirska, Kyivska, and Chernihivska oblasts)

It is necessary to note that in territories with low doses of thyroid irradiation, the incidence does not differ substantially in the identified birth cohorts.

4 CONCLUSION

In all population groups affected by the Chernobyl accident, a significant increase of thyroid cancer incidence was registered. The increase was found not only in children but also in adolescents and adults. It appears to be associated, at least partly, with the fall-out of radioiodine. At the same time, we cannot disclaim the significant role that external irradiation played in the total dose received by clean-up workers.

It was difficult to evaluate completely in the present descriptive study the contribution of increased screening of the thyroid glands to the observed increase of thyroid cancer. Based on the experience of previous studies on health effects of irradiation, the excess of solid cancer including that of the thyroid was observed decades after exposure. Therefore, we should continue to monitor thyroid cancer in groups of affected populations. The data suggest the necessity for epidemiological monitoring of thyroid cancer and a concentration of efforts to perform analytical epidemiological studies that will evaluate radiation risks at low doses of irradiation.

The documentation of dosimetric information will be essential for future attempts to examine – and possibly improve – current estimates of the risk of radiation associated thyroid cancer.

5 REFERENCES

Akiba, S., Lubin, J., & Ezaki, E. (1991) Thyroid cancer incidence among atomic bomb survivors in Hiroshima and Nagasaki 1958-1959. *Technical Report, TR 5-91*. Radiation Effects Research Foundation, Hiroshima, Japan.

Cardis, E., Kesminiene, A., Ivanov V., Malakhova, I., Shibata, Y., Khrouch, V., Drozdovich V., Maceica E., Zvonova I., Vlassov, O., Bouville, A., Goulko, G., Hoshi, M., Abrosimov, A., Anoshko, J., Astakhova, L., Chekin, S., Demidchik, E., Galanti, R., Ito, M., Korobova, E., Lushnikov, E., Maksioutov, M., Masyakin, V., Nerovnia, A., Parshin, V., Parshkov, E., Piliptsevich, N., Pinchera, A., Polyakov, S., Shabeka, N., Suonio, E., Tenet, V., Tsyb, A., Yamashita, S., & Williams, D. (2005) Risk of Thyroid Cancer After Exposure to ¹³¹I in Childhood. *Journal of the National Cancer Institute, vol. 97 (10)*, pp. 724 – 732.

Derzhcomstat (State committee of statistics) of Ukraine (2005) *Distribution of stable population of Ukraine according to gender and age on the 1st January 2005*. Statistical collection. Kiev., Ukraine. 412 p. (in Ukrainian)

Ilyin, L.A., Balonov, M.I., Buldakov, L.A., Bur'yak, V.N., Gordeev, K.I., Dement'ev, S.I., Zhakov, I.G., Gubovsky, G.A., Kondrusev, A.I., Konstantinov, Y.O., Linge, I.I., Likhtarev, I.A., Lyaginskaya, A.M., Matyunin, V.A., Pavlovsky, O.A., Potapov, A.I., Prisyazhnyuk, A.E., Ramsaev, P.V., Romanenko, A.E., Savkin, M.N., Starkova, N.T., Tron'ko, N.D., & Tsyb, A.F. Radiocontamination patterns and possible health consequences of the accident at the Chernobyl nuclear power station (1990) *J. Radiol. Prot.* 10 (1), pp 3-29.

Ivanov, V., Tsyb, A., Ivanov, S., & Pokrovsky, V. (2004) *Medical radiological consequences of the Chernobyl catastrophe in Russia: Estimation of radiation risks*. St. Petersburg: Nauka, 387 p.

Kazakov, V. S., Demidchik, E. P., & Astakhova, L. N. (1992) Thyroid cancer after Chernobyl. *Nature* 359, 21.

Likhtarev, I.A., Kairo, I.A., Shpak, V.M., Tronko, M.D., & Bogdanova, T.I. (1999) Radiation-induced and background thyroid cancer of Ukrainian children (dosimetric approach). *International Journal of Radiation Medicine* 3-4, pp 51-66.

Mabuchi, K., Cardis, E., Preston, D.L., Ivanov, V.K., Okeanov, A.E., & Prisyazhniuk, A.E. (1998) Predictions of Cancer after the Chernobyl Accident. *WHO/HICARE symposium on Radiological accidents and Environmental Epidemiology: A Decade after the Chernobyl Accident. Proceedings: 24-25 August 1996, Hiroshima, Japan*, pp. 19 – 23.

Parkin, D.M., Whelan, S.L., Ferlay, T., Teppo, L., & Thomas, D.B. (Eds.) (2002) *Cancer incidence in Five Continents, vol. VIII*. IARC, Lyon.

Prisyazhnyuk, A., Pjatak, O., Buzunov, V., & Beral, V. (1991) Cancer in the Ukraine, post-Chernobyl. *Lancet*, 338: 1334-5.

Prisyazhnyuk, A., Gristchenko, V., Zakordonets, V., Fuzik, M., Slipeniuk, K., & Ryzhak, I. (1995) The time trends of cancer incidence in the most contaminated regions of the Ukraine before and after the Chernobyl accident. *Radiat. Environ. Biophys.* vol.34, pp.3-6.

Prisyazhnyuk, A., Gulak, L., Gristchenko, V., Fedorenko, Z. (2002) Cancer incidence in Ukraine after the Chernobyl accident. In *Chernobyl: Message for the 21st Century. Esceptra Medica, International Congress Series 1234*. Yamashita, S., et al. (Eds.), pp. 281-291.

Prisyazhnyuk, A., Gristchenko, V., Fedorenko, Z., Fuzik, M., Gulak, L., Slipeniuk, K., & Bormosheva, I. (2002) Review of epidemiological finding in study of medical consequences of the Chernobyl accident in Ukrainian population. In *Recent Research Activities about the Chernobyl NPP Accident in Belarus, Ukraine and Russia*. Imanaka, T. (Ed.) Kyoto, Japan, pp.188-201.

Prisyazhnyuk, A., Romanenko, A., Grystchenko, V., Zakordonets, V., Fedorenko, Z., Fuzik, M., Gulak, L., Slipenyuk, K., Gorokh, Y., Ryzhov, A., Sumkina, Y., Kairo, I., Shpak, V., Tirmarche, M., Becker, S., Valenty, M., & Bazyka, D. (2004) Solid cancers and thyroid cancer in the most affected territories of Ukraine after the Chernobyl accident. International workshop on: *The French-German Initiative: Results and Their Implication for Man and Environment*. October 5th-6th 2004, Kiev, Ukraine, pp. 35-36.

Shore, R.E. (1992) Issues and epidemiological evidence regarding radiation-induced thyroid cancer. *Radiat. Res.* 131, pp. 98-111.

Tronko, M., Bobylyova, O., Bogdanova, T., Epstein, O., Likhtaryov, I., Markov, V., Oliynyk, V., Tereshchenko, V., Shpak, V., Beebe, G., Bouville, A., Brill, A., Burch, D., Fink, D., Greenebaum, E., Howe, G., Luckyanov, N., Masnyk, I., McConnell, R., Robbins, J., Thomas, T., & Voilleque, P. (2003) Thyroid gland and radiation (Ukrainian-American Thyroid Project). In: *Radiation and humankind*. Shibata, Y., Yamashita, S., Watanabe, M., & Tomonaga, M. (Eds.) *Esceptra Medica, International Congress Series*, Elsevier: Amsterdam, pp. 91-104.

Tronko, M.D. & Bogdanova, T.I. (1997) *Thyroid cancer in children in Ukraine (consequences of Chernobyl catastrophe)*. Kyiv: Chernobylinform, 200 p., In Russian.

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