UDC 617.741-004.1-053.9
DOI: 10.21668/health.risk/2018.1.13.eng

RISK FACTORS WHICH CAUSE SENILE CATARACT EVOLVEMENT: OUTLINE

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Examination of natural ageing processes including those caused by multiple external factors has been attracting researchers' attention over the last years. Senile cataract is a multi-factor disease. Expenditure on cataract surgery remain one of the greatest expenses items in public health care. Age is a basic factor which causes senile cataract. Morbidity with cataract doubles each 10 years of life. This outline considers some literature sources which describe research results on influence exerted on cataract evolvement by such risk factors as age, sex, race, smoking, alcohol intake, pancreatic diabetes, intake of certain medications, a number of environmental factors including ultraviolet and ionizing radiation. mane of these factors are shown to increase or reduce senile cataract risk; there are conflicting data on certain factors. The outline also contains quantitative characteristics of cataract risks which are given via odds relation and evolve due to age parameters impacts, alcohol intake, ionizing radiation, etc. The authors also state that still there is no answer to the question whether dose-effect relationship for cataract evolvement is a threshold or non-threshold.

Key words: *multi-factor disease, senile cataract, risk factors, relative risk, odds relation, age parameters, dose-effect relationship.*

Cataract is any persistent opacity occurring in the lens substance or capsule. Cataract as a basic factor causing sight disorders and blindness (33%) in the world [1, 2] is a grave social, medical, and economic issue in many countries [1, 3, 4]; expenses on its surgery treatment contribute into overall public health care expenditure considerably.

Experts spot out senile, congenital, traumatic, complicated, and occupational cataract depending on reasons for its occurrence. Senile cataract (hereinafter called "cataract") is the most frequent. It evolves due to age-related changes in the lens, and morbidity with it grows with age.

There are three main cataract types determined as per clinical and anatomical features: nuclear, cortical, and back subcapsular one; they can occur both separately and in various combinations [5]. Nuclear cataract involves opacities in the lens central part (nucleus); the process is combined with lens fibers becoming sclerosed, with the nucleus color changing to yellowish or even brown, and with overall eyesight deterioration. Cortical cataract involves opacities evolvement in the lens periphery. Separate opacities appear in the cortex with age (they can be spoke-like or sectoral) and they usually don't lead to any clinical symptoms until the lens optical axis area is involved in the process. Back subcapsular cataract (BSC) is a compact opacity which is located in the posterior area of the central cortex under the capsule. It usually oc-

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curs at younger ages and causes a considerable loss in the near vision activity.

Results obtained during multiple research on cataract evolvement reasons revealed that cataract was a multi-factor disease. Cataract evolvement depends on age, sex, race, concomitant somatic or eye pathology, bad habits (smoking or nutrition peculiarities), as well as environmental factors, such as ultraviolet radiation and ionizing radiation, and certain medications intake [4, 6].

Non-radiation factors causing cataract risks.

Age. Age is a basic factor causing cataract risk. Thus, cataract prevalence among people aged 52-62 amounts to 5% [7]; among people aged 60–69, 30%; and among people aged 70 and older, 64% [8]. The fact that morbidity with cataract doubles each 10 years of life after 40 means that practically all people aged 80-90 suffers from cataract [9]. Long-term impacts exerted by oxygen free radicals on the lens tissue are considered to be the main reason for opacities evolvement in the lens which are characteristic for senile cataract. A group of researchers revealed [10] that age had a statistically significant influence on all cataract types evolvement. Odds ratio (OR) per each 10 years of life amounted to 9.90 (95% CI: 8,20 – 11,90) for nuclear cataract; 3.06 (95% CI: 2,76 – 3,40)for cortical cataract; 3.09 (95% CI: 2.71 – 3.51) for back subcapsular cataract; and 6.62 (95% CI: 5.78 – 7.63) for all the cataract types.

Sex. A lot of epidemiologic researchers came to conclusions that cataract risk was a bit higher for women than for men; however, this dependence still remains unclear. Thus, for example, the following work [11] contains some data on OR for morbidity with cataract among women which amounted to 3.03 (95% CI: 1.83 – 5.00) against men. Other research [12] revealed that cataract frequency was a bit higher among women than among men, OR being equal to 1.55 (95% CI: 1.26 – 1.91), while at the same time another research performed as per "case - control" type revealed only a boundary dependence between cortical cataract and sex [13]. Some research contains data on protective effects of substitutive hormonotherapy for women during a period after their menopause [14, 15].

Race. Some researchers state there is a correlation between various cataract types and a patient's race. S.K. West, B. Munoz et al. [16] revealed that African Americans ran 4 times higher cortical cataract risk than White Americans while White Americans ran higher nuclear or back subcapsular cataract risks. Other research results show that cortical cataract prevailed among Latin Americans [17].

Smoking. Table 1 contains results of research related to cataract risk assessment depending on a patient' s smoking status.

Some research revealed a correlation between smoking and the lens nucleus sclerosis and detected a dose-effect dependence; people who gave up smoking ran lower cataract risk than those who continued to do it [18–21], so there was an apparent protective effect of giving up smoking.

Another research [10] revealed that smokers had higher morbidity with nuclear cataract (OR = 2.06; 95% CI: 1.46 – 2.98), with cortical cataract (OR = 1.33; 95% CI: 1.02 – 1.74), with back subcapsular cataract (OR = 1.39; 95% CI: 1.02 – 1.91), or with any cataract type (OR = 1.48; 95% CI: 1.10 – 1.99) after corrections as per age, sex, body mass index, arterial hypertension, and diabetes. At the same time another research [22] didn't contain any data on such dependence. Elementary

Table 1

Cataract risk depending on a patient's smoking status

Author(s), years	Participants number	Research results OR, 95% CI	Corrections
Delcourt et al. 2000	2584	Smoke at the moment: 2.34 (1.07 – 5.15) Former smokers: 3.75 (2.26 – 6.21)	Sex, age
Theodoropoulou et al. 2011	314, and 314 reference group	Smoke at the moment: 1.99 (1.23 – 3.23) Former smokers: 1.64 (1.02 – 2.70)	Sex, age
Renyi Wu et al. 2010	2927	Smoke at the moment	Sex, age, BMI, Hypertension, diabetes
		Nuclear cataract: 2.06 (1.46 – 2.98)	
		Cortical cataract:1.33 (1.02 – 1.74)	
		Back subcapsular cataract:1.39 (1.02 – 1.91)	
		All types 1.48 (1.10 – 1.99)	

or secondary education (OR = 1.67; 95% CI: 1.06 – 2.64) and low monthly income increased nuclear cataract risk while living in a small apartment increased back subcapsular cataract risks (OR = 1.70; 95% CI: 1.28 – 2.25). Smoking men run 17.9% risk of nuclear cataract evolvement and it was shown that a) smoking led to a statistically significant increased senile cataract risks (all its types) regardless of age, sex, body mass index, hypertension, and diabetes; b) morbidity with nuclear cataract depended on how many cigarettes a patient smoked a day, and it grew together with smoking index increasing.

Alcohol intake. An essence of influence exerted by alcohol on cataract genesis still remains unclear. The lens is sensitive both to oxidative stress induced by alcohol and to direct toxic effects exerted by alcohol and its metabolism products [23–25]. However, data on correlations between alcohol intake and senile cataract are controversial. "Case - control" research results revealed statistically significant increased cataract risks among beer abusers [26] and former alcoholics [27]. Two cohort examinations were conducted, the first among men only and it was based on questioning about cataract and its surgical treatment [28]; the second one was conducted among men and women and involved cataract type determination and surgical case histories [29]. These examinations revealed there was a positive but statistically insignificant correlation between alcohol intake and cataract evolvement. There was prospective research dedicated to assessing influences exerted by alcohol intake on cataract extraction among 77,466 women in the USA (1,468 cataract extractions) who drank more than 25 mg of alcohol a day and it didn't reveal an increased cataract extraction risk; relative risk (RR) amounted to 1.10; 95% CI: 0.90 – 1.35 [30]. Experts examining specific cataract types detected that strong spirits and wine intake was correlated to increased nuclear opacities risks (OR = 1.13; 95% CI: 1.02 – 1.26), while cortical opacities risks became lower when wine was consumed (OR = 0.88; 95% CI: 0.79 – 0.98) [31]. Population prospective cohort research [14] revealed a statistically significant positive correlation between alcohol intake and "operated" cataract risk; the risk grew with an increase in overall consumed alcohol volume; relative risk of "operated" cataract amounted to 1.11 (95% CI: 1.02 – 1.21) after corrections as per age and other potential risk factors. Multifactor analysis showed that an increase in alcohol intake equal to 13 grams a day (330 ml of beer, 150 ml of wine, or 45 ml of strong spirits correspondingly) caused a

7% growth in cataract extraction risk (RR = 1.07; 95% CI: 1.02 – 1.12).

Somatic pathology.

Pancreatic diabetes. Pancreatic diabetes of both 1st and 2nd types is one of the most significant somatic pathologies which cause higher cataract evolvement risks. Research [11] revealed that odds ratio for cataract evolvement in people suffering from pancreatic diabetes amounted to 2.72 (95% CI: 1.72 – 4.28) in comparison with people who didn't have such pathology. Another research [32] revealed that dextrose level in blood taken on an empty stomach being ≥ 6 mmol/l caused higher cataract risk (OR = 1.79; 95% CI: 1.25 – 2.57 against dextrose level being < 6 mmol/l). The same research also outlined that each 1 mmol/l increase in dextrose level in blood taken on an empty stomach was related to 5-year progress in back subcapsular cataract (OR = 1.25; 95% ДИCI: 1.15 – 1.35) and to 10-year progress in cortical one (OR = 1.14; 95% CI: 1.01 – 1.27) and nuclear one (OR = 1.20; 95% CI: 1.01 – 1.43); and here no threshold was detected. Besides it was shown that cataract surgical treatment on patients with the 1st type pancreatic diabetes had to be performed 20 years earlier than in case of people who didn't have pancreatic diabetes [33].

Medications. A lot of research dwells on examining correlations between cataract evolvement and various medications intake.

Results obtained in research on correlations between cataract evolvement risk and glucocorticosteroids (GCS) intake are shown in Table 2.

Table 2

Correlation between cataract risk and GCS intake

Author(s), year	Participants number	Research results OR, 95% CI				
Smeeth et al., 2003	15476	Inhalation GCS	System parenteral steroids	System peroral steroids	Inhalation GCS > 1,600 mg/day	Eye drops with GCS
		1,15 (1,03–1,27)	1,56 (1,3–1,82)	1,59 (1,47–1,71)	1,69 (1,17–2,43)	2,12 (1,93–2,33)
Theodoropoulou et al., 2011	314 cases, 314 in reference group	Are taking GCS at the moment 2.59 (0.93 – 7.21)				
Delcourt et al., 2000	2584	GCS were taken orally during 5 and > years 3.25 (1.39 – 7.58)				

A correlation was detected between system corticosteroid intake, especially in high doses and during a long-term period, and cataract evolvement both in children [34] and adults [35]. We should note here that corticosteroids-induced cataracts are usually located in the back part of the lens (back subcapsular cataract). It was also detected that people who took GCS ran higher cataract risk than people who didn't take such medications [28, 36–40].

Statins have been widely used over the last decades to decrease cholesterol in blood plasma in order to prevent cardiovascular diseases. As statins are known to have antioxidant features their intake can lead to lower cataract risks. Research [41] revealed that 5-year morbidity with cataract among people who took statins was lower (12.2%) than among those who didn't take them (17.2%); OR amounted to 0.55 (95% CI: 0.36 – 0.84) allowing for age. When cataract evolvement risk was assessed for non-smokers and people without pancreatic diabetes, OR amounted to 0.40 (95% CI: 0.18 – 0.90) with corrections as per sex, age, and lipids level in blood. It was shown that statins intake lowered senile cataract risk.

So, literature data prove that cataract evolvement risk depends on many factors, such as age, sex, race, smoking, alcohol intake, concomitant somatic or eye pathology, some medications intake etc.

Ionizing radiation as cataract risk factor. The lens is one of the most radiosensitive organs in a human body. It was detected that ionizing radiation impacts caused cataract evolvement [42, 43]. Ionizing radiation influences cubical epithelium cells which are located on the surface of the lens anterior capsule and damages them. After that damaged cells are differentiated and migrate consequently into the peripheral cortex and the lens back pole area and it causes opacities evolvement [43]. Latent period and effects intensity depend on age, sex, and also on a dose, dose intensity, and irradiation fractioning [44, 45]. Some long-term research allowed to make an assumption that radiation-induced cataracts were a determined long-term effect [46]. A lot of research revealed increased risks of morbidity with various cataract types among different people who were exposed to ionizing radiation impacts. Nowadays ionizing radiation impacts are assumed to cause higher risks of, first of all, back subcapsular cataracts, and, to a smaller extent, cortical cataracts. And it is also considered that nuclear cataracts are associated only with age and some other risk factors. However, evidences of this correlation are controversial enough as research was conducted in groups which included people with different irradiation scenarios and observation periods. So, risk assessment of morbidity with various cataract types among people exposed to long-term irradiation in small doses has been of great interest to researchers recently.

Irradiation during atomic bombing. Table 3 shows the results of research on cataract risk among a cohort made up of people who survived the atomic bombing.

In 2004 two works were published; they contained data on research performed on a cohort made up of people who had survived the atomic bombing in Japan. 55 years after the bombing Minamoto et al. examined eyes state in people who had survived in it and who had been younger than 13 at the moment they had been irradiated [47]. Odds ratios for cortical and subcapsular cataract at an irradiation dose being equal to 01 Gy amounted to 1.29 (95% CI: 1.22 – 1.49) and 1.41 (95% CI: 1.21 – 1.64), correspondingly. Authors didn't detect any statistically significant correlation between nuclear cataract and irradiation dose (odds ratio per 1 Gy amounted to 1.1; 95% CI: 0.9 – 1.3). Yamada et al. examined a wide range of non-tumor diseases in people who had survived the atomic bombing and had been observed by doctors for a long time (1958 - 1998), including 975 cataract cases in men and 2,509 ones in women [48]. This research results revealed there was a statistically significant positive correlation between morbidity with cataract and irradiation doses ($p = 0.026$). Morbidity with cataract among people who had been exposed to a dose higher than 1 Gy amounted to 7.98 (95% CI: 0.95 – 15.16) per 10,000 people annually; corresponding relative risk was equal to 1.06 (95% CI: 1.01 – 1.11). Relative risk of morbidity with cataract went down statistically significantly with a growth in age a person had managed to live to by the examination ($p < 0.001$) and with a growth in period of

Table 3

Cataract morbidity risk in a cohort made up of people who survived the atomic bombing

Author(s), year	Observation period	Irradiation dose, target organ	Research results	Corrections
Choshi et al., 1983	1978–1980	Dose on the lens: 0 – 600 rad	RR of BSC: 5.28 for people younger than 50 3.99 for people aged 50 – 59 2.34 for people older than 60 No dependence on a dose was revealed for nuclear or cortical cataract	City, age, sex
Minamoto et al., 2004	2000–2002	Dose on an eye: 0.005 – 2 Sv	OR per 1 Sv for: BSC = 1.41 (95% CI: 1.21 – 1.64) Cortical cataract = 1.29 (95% CI: 1.12 – 1.49) Nuclear cataract = 1.12 (95% CI: 0.94 – 1.30)	City, age, sex, smoking
Nakashima et al., 2006		Dose on an eye: 0 – 4.90 Sv	OR per 1 Sv for: BSC = 1.44 (95% CI: 1.19 – 1.73) Cortical cataract = 1.30 (95% CI: 1.10 – 1.53)	City, age, sex, smoking
Nakashima et al., 2013	1986–2005	Dose on the lens: 0 – 5.14 Gy	OR per 1 Gy for "operated" cataract = 1.33 (95% CI: 1.28 – 1.38)	
Neriishi et al., 2007	2000–2002	Dose on an eye: 0.005 – 4.90 Sv	OR per 1 Sv for "operated" cataract = 1.39 (95% CI: 1.24 – 1.55) Threshold dose = 0.1 Gy	City, age, sex, diabetes
Neriishi et al., 2012	1986–2005	Dose on the lens: 0 – 5.14 Gy Average: 0.54 Gy	Dose-effect linear dependence	Age, sex, social and medical factors
Yamada et al., 2004	1958–1998	Average weighted dose: 0.92 Sv	Cataract RR per 1 Sv = 1.11 (95% CI: 1.03 – 1.19)	City, age, sex, alcohol

time which had passed since the irradiation moment ($p = 0.09$).

In 2006 and 2013 Nakasima et al. published a reanalysis of data obtained on a cohort of people who had survived the atomic bombing in Japan and detected a statistically significant "dose - effect" relationship; cataract morbidity risk here went down with a growth in age a person had managed to live to [49, 50]. Odds ratio per 1 Sv amounted to 1.44 (95% CI: 1.19 – 1.73) for back subcapsular cataract and to 1.30 (95% CI: 1.10 – 1.53) for cortical cataract in people who had been 10 years old at the irradiation moment. Authors didn't reveal any statistically significant "dose - effect" relationships for nuclear cataract. Odds ratio grew with an increase in an irradiation dose for cortical and subcapsular cataract, a threshold dose was estimated to be equal to 0.6 Sv.

In 2007 and 2012 Neriishi et al. published results of their research on "dose - effect" relationship for clinically significant cataracts [51, 52]. The research included 3,791 people who had survived the bombing and 479 "operated" cataract cases; it detected some proves of a linear, and not a linear-quadratic, "dose - effect" dependence, and an estimated threshold irradiation dose amounted to 0.1 Gy.

Irradiation related to the Chernobyl' nuclear power plant disaster. In 2007 Worgul et al. published their analysis of cataracts frequency among Ukrainian liquidators of the Chernobyl' disaster consequences which was estimated 12-14 years after their irradiation. The model allowed for an age at the irradiation moment, sex, a dose with a 50 mGy interval, smoking status, diabetes, and some other potential mixing factors [53]. The authors revealed a statistically significant increase in non-nuclear (cortical and back subcapsular) cataracts: odds ratio per 1 Gy amounted to 1.65 (95% CI: 1.18 – 2.30), and a dose threshold for these cataracts was estimated to be equal to 0.50 (95% CI: 0.17 – 0.69) Gy. Odds ratio for all the cataract types amounted to 1.70 (95% CI: 1.22 – 2.38), and a threshold dose was equal to 1.50 (95% CI: 1.17 – 1.65) Gy.

Medical irradiation. In 1999 Hall et al. examined the lens opacities frequency among Sweden population who had been exposed to ionizing irradiation in their childhood as a results of skin hemangioma treatment [54]. The lens opacities frequency was shown to be higher in people who had undergone radiotherapy in their childhood against the reference group (37% and 20% correspondingly). After a correction per age at the examination moment odds ratio per 1 Gy was equal to 1.50 (95% CI: 1.15 – 1.95) for cortical cataract and to 1.49 (95% CI: 1.07 – 2.08) for bask subcapsular cataract.

Research on cataract risks among medical staff in the USA in 2008 [55] revealed that cataract evolvement risk grew by 15% annually. Female sex, smoking index being more than 15 packets/year, increased body mass index, diabetes, arterial hypertension, hypercholesterolemia, or arthritis increased cataract evolvement risk; at the same time, intake of 1 to 10 alcohol portions a week decreased cataract risk in comparison with those who drank less than 1 alcohol portion a week. The authors detected a statistically significant increase in cataract frequency in people who underwent a lot of diagnostic X-ray procedures (>25) against those who were exposed to a smaller number of such procedures (<5) with hazard ratio (HR) being equal to 1.4 (95% CI: 1.2 – 1.7). Hazard ratio (HR) for cataract extraction amounted to 1.50 (95% CI: 1.09 – 2.06) in this research. Hazard ratio per 1 Gy for people who underwent 3 and more X-ray diagnostic procedures on their faces and necks in comparison with those who didn't have to undergo any such procedures amounted to 1.25 (95% CI: 1.06 – 1.47); hazard ratio for cataract extraction amounted to 1.71 (95% CI: 1.09 – 2.68).

Cosmic radiation. Some research concentrated on the lens opacities frequency among aviation pilots and astronauts exposed to chronic occupational irradiation.

In 2001 Cucinotta et al. detected increased cataract evolvement risk in NASA astronauts [56]. A number of space flights being more than 2 against those who didn't have any or who participated in only one flight, astronauts' age, and a flight slope were statistically significant modifying factors. Hazard ratio (HR) for cataract evolvement at the age of 60 was estimated to be equal to 2.35 (95% CI: 1.01 – 5.51); and at the age of 65, 2.44 (95% CI: 1.20 – 4.98).

In 2005 Raffnson et al. applied "case - control" technique to examine whether the lens opacity frequency was related to an aviation pilot occupation [57]. The analysis allowed for a working period, flying hours per year, flight schedule and routes, and an accumulated irradiation dose calculated on the basis of the above mentioned data. Only nuclear cataract frequency (out of four cataract types - nuclear, cortical, central optical zoned and back subcapsular cataract) was statistically higher in pilots who had regular flights in comparison with people who never worked as pilots with odds ratio being 3.02 (95% CI: 1.44 – 6.35). Age turned out to be a statistically significant factor. Thus, odds ratio for people aged 50 against people aged 40 amounted to 1.17 (95% CI: 1.12 – 1.22). Besides, research results revealed that pilots tended to have cataracts at younger ages. Research results on examining cataract evolvement risk under exposure to solar ionizing radiation are given in Table 4.

Table 4

Cataract evolvement risk among astronauts and pilots

Author(s), Year	Observation period	Irradiation dose	Research results	Corrections
Chylack et al., 2009	2004–2006	Median dose on the lens 12.9 mSv	OR for BSC= 2.33 (95% CI: 1.16 – 4.26)	Age, solar ultraviolet radiation, place of residence, nutrition peculiarities
Chylack et al., 2012	2004–2006	Median dose on the lens 12.9 mSv	Cosmic ionizing irradiation is related to greater BSC size and is not related to nuclear cataract	Age, solar radiation, place of residence, nutrition peculiarities
Cucinotta et al., 2001	1977–1988	Dose on the lens 0.2 – 91.0 mSv	Hazard ratio = 2.6 (95% CI: 1.5 – 4.8)	Diabetes, renal failure, steroids intake, eyes diseases
Rafnsson et al., 2005	1996–2001	1–48 мЗв	Increased nuclear cataract risk in pilots	Age, smoking, a habit to go sunbathing

Table 5

Cataract evolvement risk for intervention surgery staff

Author(s), year	Research model	Results, back subcapsular opacities HR per 1 Gy	
		Cardiosurgeons	Nurses
Ciraj-Bjelac O., 2012	Case - control	2.6 (95% CI: 1.2 – 5.4)	2.2 (95% CI: 0.98 – 4.9)
Vano E., 2010	Case - control	3.2 (95% CI: 1.7 – 6.1)	1.7 (95% CI: 0.8 – 3.7)

Occupational irradiation. Over the last years some data on cataract risks for workers exposed to occupational long-term irradiation have been collected [58]. A statistically significant linear correlation between morbidity with cataract and a total external gamma-irradiation dose was detected; excessive relative risk (ERR/Gy) was equal to 0.28 (95% CI: 0.20 – 0.37). Risk assessment varied insignificantly when additional correlations per various non-radiation factors (smoking status and alcohol intake, smoking index, arterial hypertension, body mass index, and diagnosed "grave myopia") were included. Introduction of correction per a neutron irradiation dose caused a significant increase in external gamma-irradiation ERR/Gy for morbidity with cataract (Err/Gy = 0.31; 95 % CI: 0.22 – 0.40).

Cataract risk assessment for intervention surgeons has been of great interest recently as they are usually exposed to long-term occupational irradiation. Research [59, 60] contains some data on statistically significant increased risk of back subcapsular opacities evolvement in intervention cardiosurgeons. Cataract evolvement risk for auxiliary medical staff was statistically insignificant. The research results are given in Table 5.

So, literature data show that senile cataract is a multi-factor disease. The following cataract risk factors are proved to be significant: sex, age, smoking, alcohol intake, concomitant ophthalmologic pathology, certain somatic diseases (pancreatic diabetes, for example), certain medications intake, exposure to ultraviolet radiation etc.

Over the last years researchers have detected increased risk of specific cataract types under exposure to ionizing radiation as well as made some attempts to estimate a threshold external gamma-radiation dose for various cataract types evolvement. As a result of the research [53] a threshold external gamma-radiation dose amounted to 0.35 (95% CI: 0.19 – 0.66) Gy for back subcapsular cataract; and to 0.34 (95% CI: 0.18 – 0.51) for cortical cataract. Research performed on cohorts made up of people who had survived the atomic bombing [40] revealed that a threshold dose for BSC amounted to 0.7 (95% CI: 0.0 – 2.9) Gy; and to 0.6 (95% CI: 0.0 – 1.4) Gy for cortical cataract. According to different research results a threshold dose for "operated" cataract amounted to 0.50 (95% CI: 0.17 – 0,65) Gy [59]; 0.41 (95% CI: 0.04 – 1.03) Gy [14]; and 0.50 (95% CI: 0.10 – 0.95) Gy [41].

However, a question whether a "dose - effect" relationship is a threshold or a non-threshold one for cataract evolvement still remains open.

References

1. Abraham A.G., Condon N.G., West Gower E. The new epidemiology of cataract. *Ophthalmol. Clin. North. Am.*, 2006, vol. 19, no. 4, pp. 415–425. DOI: 10.1016/j.ohc.2006.07.008

2. Pascolini D., Mariotti S.P. Global estimates of visual impairment: 2010. *Br. J. Ophthalmol.*, 2012, vol. 96, no. 5, pp. 614–618. DOI: 10.1136/bjophthalmol-2011-300539

3. Resnikoff S., Pascolini D., Etya'ale D., Kocur I., Pararajasegaram R., Pokharel G.P., Mariotti S.P. Global data on visual impairment in the year 2002. *Bull. World Health Organ*, 2004, vol. 82, no. 11. – P. 844–851. DOI: /S0042-96862004001100009

4. Ainsbury E.A., Barnard S., Bright S., Dalke C., Jarrin M., Kunze S. [et al.]. Ionizing radiation induced cataracts: recent biological and mechanistic developments and perspectives for future research. *Mutat. Res.*, 2016, no. 770 (Pt. B), pp. 238–261. DOI: 10.1016/j.mrrev.2016.07.010

5. Chylack L.T.Jr., Wolfe J.K., Singer D.M., Leske M.C., Bullimore M.A., Bailey I.L. [et al.]. The lens opacities classification system III. The Longitudinal Study of Cataract Study Group. *Arch. Ophthalmol.*, 1993, vol. 111, no. 6, pp. 831–836.

6. Prokofyeva E., Wegener A., Zrenner E. Cataract prevalence and prevention in Europe: a literature review. *Acta Ophthalmol*, 2013, vol. 91, no. 5, pp. 395–405. DOI: 10.1111/j.1755-3768.2012.02444.x

7. Klinicheskie rekomendatsiyu. Oftal'mologiya [Clinical recommendations. Ophthalmology]. In: L.K. Moshetova, A.P. Nesterov, E.A. Egorov, eds. Moscow, GEOTAR-Media Publ., 2008, 255 p. (in Russian).

8. Das B.N., Thompson J.R., Patel R., Rosenthal A.R. The prevalence of eye disease in Leicester: a comparison of adults of Asian and European descent. *J. R. Soc. Med.*, 1994, vol. 87, no. 4, pp. 219–222.

9. Wong T.Y., Chong E.W., Wong W.L., Rosman M., Aung T., Loo J.L. [et al.]. Singapore Malay Eye Study Team. Prevalence and causes of low vision and blindness in an urban Malay population: the Singapore Malay Eye Study. *Arch. Ophthalmol.*, 2008, vol. 126, no. 8, pp. 1091–1099. DOI: 10.1001/archopht.126.8.1091

10. Wu R., Wang J.J., Mitchell P., Lamoureux E.L., Zheng Y., Rochtchina E. [et al.]. Smoking, Socioeconomic Factors, and Age-Related Cataract: The Singapore Malay Eye study. *Arch. Ophthalmol.*, 2010, vol. 128, no. 8, pp. 1029–1035. DOI: 10.1001/archophthalmol.2010.147

11. Delcourt C., Cristol J.P., Tessier F., Leger C.L., Michel F., Papoz L. Risk factors for cortical, nuclear, and posterior subcapsular cataracts: the POLA study. Pathologies Oculaires Liées à l'Age. *Am. J. Epidemiol.*, 2000, vol. 151, no. 5, pp. 497–504.

12. Laitinen A., Laatikainen L., Harkanen T., Koskinen S., Reunanen A., Aromaa A. Prevalence of major eye diseases and causes of visual impairment in the adult Finnish population: a nationwide population-based survey. *Acta Ophthalmol.*, 2009, vol. 88, no 4, pp. 463–471. DOI: 10.1111/j.1755-3768.2009.01566.x

13. Theodoropoulou S., Theodossiadis P., Samoli E., Vergados I., Lagiou P., Tzonou A. The epidemiology of cataract: a study in Greece. *Acta Ophthalmol.*, 2011, vol. 89, no 2, pp. e167–173. DOI: 10.1111/j.1755-3768.2009.01831.x

14. Lindblad B.E., Hakansson N., Philipson B. Alcohol Consumption and Risk of Cataract Extraction. *Ophthalmology*, 2007, vol. 114, no. 4, pp. 680–685. DOI: 10.1016/j.ophtha.2006.07.046

15. Kanthan G.L., Wang J.J., Burlutsky G., Rochtchina E., Cumming R.G., Mitchell P. Exogenous oestrogen exposure, female reproductive factors and the long-term incidence of cataract: the Blue Mountains Eye Study. *Acta Ophthalmol.*, 2010, vol. 88, no 7, pp. 773–778. DOI: 10.1111/j.1755-3768.2009.01565.x

16. West S.K., Munoz B., Schein O.D., Duncan D.D., Rubin G.S. Racial differences in lens opacities: the Salisbury Eye Evaluation (SEE) Project. *Am. J. Epidemiol.*, 1998, vol. 148, no 11, pp. 1033–1039.

17. Varma R., Torres M. Prevalence of lens opacities in Latinos: the Los Angeles Latino Eye Study. *Ophthalmology*, 2004, vol. 111, no. 8, pp. 1449–1456. DOI: 10.1016/j.ophtha.2004.01.024

18. Kelly S.P., Thornton J., Edwards R., Sahu A., Harrison R. Smoking and cataract: review of casual association. *J. Cataract. Refract. Surg.*, 2005, vol. 31, no. 12, pp. 2395–2404. DOI: 10.1016/j.jcrs.2005.06.039

19. Mukesh B.N., Le A., Dimitrov P.N., Ahmed S., Taylor H.R., McCarty C.A. Development of cataract and associated risk factors: the Visual Impairment Project. *Arch. Ophthalmol.*, 2006, vol. 124, no. 1, pp. 79–85. DOI: 10.1001/archopht.124.1.79

20. Lindblad B.E., Hakansson N., Philipson B., Wolk A. Hormone replacement therapy in relation to risk of cataract extraction: A prospective study of women. *Ophthalmology*, 2010, vol. 117, no. 3, pp. 424–430. DOI: 10.1016/j.ophtha.2009.07.046

21. Lindblad B.E., Hakansson N., Svensson H. [et al.]. Intensity of smoking and smoking cessation in relation to risk of cataract extraction: a prospective study of women. *Am. J. Epidemiol.*, 2005, vol. 162, no. 1, pp. 73–79. DOI: 10.1093/aje/kwi168

22. Tan J.S., Wang J.J., Younan C., Cumming R.G., Rochtchina E., Mitchell P. Smoking and the long-term incidence of cataract: the Blue Mountains Eye Study. *Ophthalmic Epidemiol.*, 2008, vol. 15, no 3, pp. 155–161. DOI: 10.1080/09286580701840362

23. Harding J.J., van Heyningen R. Beer, cigarettes and military work as risk factors for cataract. *Dev. Ophthalmol*, 1989, no. 17, pp. 13–16.

24. Jacques P.F., Chylack L.T. Jr., McGandy R.B., Hartz S.C. Antioxidant status in persons with and without senile cataract. *Arch. Ophthalmol.*, 1988, vol. 106, no. 3, pp. 337–340.

25. Cumming R.G., Mitchell P. Alcohol, smoking, and cataracts: the Blue Mountains Eye Study. *Arch. Ophthalmol.*, 1997, vol. 115, no. 10, pp. 1296–1303.

26. Harding J.J., van Heyningen R. Drugs, including alcohol, that act as risk factors for cataract, and possible protection against cataract by aspirin-like analgesics and cyclopenthiazide. *Br. J. Ophthalmol.*, 1988, vol. 72, no. 11, pp. 809–814.

27. Ritter L.L., Klein B.E., Klein R., Mares-Perlman J.A. Alcohol use and lens opacities in the Beaver Dam Eye Study. *Arch. Ophthalmol.*, 1993, vol. 111, no. 1, pp. 113–117.

28. Manson J.E., Christen W.G., Seddon J.M., Glynn R.J., Hennekens C.H. A prospective study of alcohol consumption and risk of cataract. *Am. J. Prev. Med.*, 1994, vol. 10, no. 3, pp. 156–161.

29. Cumming R.G., Mitchell P., Leeder S.R. Use of inhaled corticosteroids and the risk of cataracts. *N. Engl. J. Med.*, 1997, vol. 337, no. 1, pp. 8–14. DOI: 10.1056/NEJM199707033370102

30. Chasan-Taber L., Willett W.C., Seddon J.M., Stampfer M.J., Rosner B., Colditz G.A. [et al.]. A prospective study of alcohol consumption and cataract extraction among U.S. women. *Ann. Epidemiol.*, 2000, vol. 10, no. 6, pp. 347–53.

31. Morris M.S., Jacques P.F., Hankinson S.E., Chylack L.T. Jr., Willett W.C., Taylor A. Moderate alcoholic beverage intake and early nuclear and cortical lens opacities. *Ophthalmic. Epidemiol.*, 2004, vol. 11, no. 1, pp. 53–65. DOI: 10.1076/opep.11.1.53.26439

32. Kanthan G.L., Mitchell P., Burlutsky G., Wang J.J. Fasting blood glucose levels and the longterm incidence and progression of cataract – the Blue Mountains Eye Study. *Acta Ophthalmol.*, 2011, vol. 89, no. 5, pp. e434–e438. DOI: 10.1111/j.1755-3768.2011.02149.x

33. Grauslund J., Green A., Sjolie A.K. Cataract surgery in a population-based cohort of patients with type 1 diabetes: long-term incidence and risk factors. *Acta Ophthalmol.*, 2011, vol. 89, no. 1, pp. 25–29. DOI: 10.1111/j.1755-3768.2009.01619.x

34. Limaye S.R., Pillai S., Tina L.U. Relationship of steroid dose to degree of posterior subcapsular cataracts in nephrotic syndrome. *Ann. Ophthalmol.*, 1988, vol. 20, no. 6, pp. 225–227.

35. Skalka H.W., Prchal J.T. Effect of corticosteroids on cataract formation. *Arch. Ophthalmol.*, 1980, vol. 98, no. 10, pp. 1773–1737.

36. The Childhood Asthma Management Program Research Group. Long-term effects of budesonide or nedocromil in children with asthma. *N. Engl. J. Med.*, 2000, vol. 343, no. 15, pp. 1054–1063. DOI: 10.1056/NEJM200010123431501

37. Agertoft L., Pedersen S. Bone mineral density in children with asthma receiving long-term treatment with inhaled budesonide. *Am. J. Respir. Crit. Care Med.*, 1998, vol. 157, no. 1, pp. 178–183. DOI: 10.1164/ajrccm.157.1.9707072

38. Jick S.S., Vasilakis-Scaramozza C., Maier W.C. The risk of cataract among users of inhaled steroids. *Epidemiology*, 2001, vol. 12, no. 2, pp. 229–234.

39. Garbe E., Suissa S., LeLorier J. Association of inhaled corticosteroid use with cataract extraction in elderly patients. *JAMA*, 1998, vol. 280, no. 6, pp. 539–543.

40. Smeeth L., Boulis M., Hubbard R., Fletcher A.E. A population based case-control study of cataract and inhaled corticosteroids. *Br. J. Ophthalmol.*, 2003, vol. 87, no. 10, pp. 1247–1251.

41. Klein B.E., Klein R., Lee K., Grady L.M. Statin use and incident nuclear cataract. *JAMA*, 2006, vol. 295, no. 23, pp. 2752–2758. DOI: 10.1001/jama.295.23.2752

42. Otake M., Schull W.J. A review of forty-five years study of Hiroshima and Nagasaki atomic bomb survivors. Radiation cataract. *J. Radiat. Res. (Tokyo),* 1991, no. 32, pp. 283–293.

43. Gus'kova A.K., Baisogolov G.D. Luchevaya bolezn' cheloveka [Human radiation sickness]. Moscow, Meditsina Publ., 1971, 380 p. (in Russian).

44. Merriam G.R., Focht E.F. A clinical study of radiation cataracts and the relationship to dose. *Am. J. Roentgenol. Radiat.Ther. Nucl. Med.*, 1957, vol. 77, no. 5, pp. 759–785.

45. Wilde G., Sjostrand J. A clinical study of radiation cataract formation in adult life following c irradiation of the lens in early childhood. *Br. J. Opthalmol.*,1997, vol. 81, no. 4, pp. 261–266.

46. Hall E.J. Radiobiology for the Radiologist, 4th ed. Philadelphia: J.B. Lippincott, 1994, 478 p.

47. Minamoto A., Taniguchi H., Yoshitani N., Mukai S., Yokoyama T., Kumagami T. [et al.]. Cataract in atomic bomb survivors. *Int. J. Radiat. Biol.*, 2004, vol. 80, no. 5, pp. 339–345. DOI: 10.1080/09553000410001680332

48. Yamada M., Wong F.L., Fujiwara S., Akahoshi M., Suzuki G. Noncancer disease incidence in atomic bomb survivors 1958–1998. *Radiat. Res.*, 2004, vol. 161, no. 6, pp. 622–632.

49. Nakashima E., Neriishi K., Minamoto A. A reanalysis of atomic-bomb cataract data, 2000–2002, a threshold analysis. *Health Phys.*, 2006, vol. 90, no. 2, pp. 154–160.

50. Nakashima E., Neriishi K., Minamoto A., Ohishi W., Akahoshi M. Radiation dose responses, thresholds, and false negative rates in a series of cataract surgery prevalence studies among atomic bomb survivors. *Health Phys.*, 2013, vol. 105, no. 3, pp. 253–260. DOI: 10.1097/HP.0b013e3182932e4c

51. Neriishi K., Nakashima E., Akahoshi M., Hida A., Grant E.J., Masunari N. [et al.]. Radiation dose and cataract surgery incidence in atomic bomb survivors, 1986–2005. *Radiology*, 2012, vol. 265, no. 1, pp. 167–174. DOI: 10.1148/radiol.12111947

52. Neriishi K., Nakashima E., Minamoto A., Fujiwara S., Akahoshi M., Mishima H.K., [et al.]. Postoperative cataract cases among atomic bomb survivors, radiation dose response and threshold. *Radiat. Res.*, 2007, vol. 168, no. 4, pp. 404–408. DOI: 10.1667/RR0928.1

53. Worgul B.V., Kundiyev Y.I., Sergiyenko N.M., Chumak V.V., Vitte P.M., Medvedovsky C., [et al.]. Cataracts among Chernobyl clean-up workers, implications regarding permissible eye exposures. *Radiat. Res.*, 2007, vol. 167, no. 2, pp. 233–243.

54. Hall P., Granath F., Lundell M., Olsson K., Holm L.E. Lenticular opacities in individuals exposed to ionizing radiation in infancy. *Radiat. Res.*, 1999, vol. 152, no. 2, pp. 190–195.

55. Chodick G., Bekiroglu N., Hauptmann M., Alexander B.H., Freedman M., Drudy M.M., [et al.]. Risk of cataract after exposure to low doses of ionizing radiation, a 20-year prospective cohort study among US radiologic technologists. *Am. J. Epidemiol.*, 2008, vol. 168, no. 6, pp. 620–631. DOI: 10.1093/aje/kwn171

56. Cucinotta F.A., Manuel F.K., Jones J., Iszard G., Murrey J., Djojonegro B., Wear M. Space radiation and cataracts in astronauts. *Radiat. Res.*, 2001, vol. 156, no. 5 (Pt. 1), pp. 460–466.

57. Rafnsson V., Olafsdottir E., Hrafnkelsson J., Sasaki H., Arnarsson A., Johansson F. Cosmic radiation increases the risk of nuclear cataract in airline pilots. *Arch. Opthalmol.*, 2005, vol. 123, no. 8, pp. 1102–1105. DOI: 10.1001/archopht.123.8.1102

58. Azizova T.V., Bragin E.V., Hamada N., Bannikova M.V. Risk of Cataract Incidence in a Cohort of Mayak PA Workers following Chronic Occupational Radiation Exposure. *PLoS ONE*, 2016, vol. 11, no. 10, pp. e0164357. DOI: 10.1371/journal. pone.0164357

59. Ciraj-Bjelac O., Rehani M., Minamoto A., Sim K.H., Liew H.B., Vano E. Radiation-induced eye lens changes and risk for cataract in interventional cardiology. *Cardiology*, 2012, vol. 123, no. 3, pp. 168–171. DOI: 10.1159/000342458

60. Vano E., Kleiman N.J., Duran A., Rehani M.M., Echeverri D., Cabrera M. Radiation cataract risk in interventional cardiology personnel. *Radiat. Res*., 2010, vol. 174, no. 4, pp. 490–495. DOI: 10.1667/RR2207.1

Bragin E.V. Risk factors which cause senile cataract evolvement: outline. Health Risk Analysis, 2018, no. 1, pp. 113–125. DOI: 10.21668/health.risk/2018.1.13.eng

Received: 07.03.2018
Accepted: 23.03.2018
Published: 30.03.2018