

Maternal socioeconomic and lifestyle factors during pregnancy and the risk of congenital heart defects

Renata Kučienė, Virginija Dulskienė

Institute of Cardiology, Kaunas University of Medicine, Lithuania

Key words: case-control study; congenital heart defects; socioeconomic factors; smoking.

Summary. The objective of study was to estimate the importance of maternal socioeconomic and lifestyle factors during pregnancy in the risk of congenital heart defects in Kaunas infant population in 1999–2005.

Material and methods. An epidemiological case-control study was conducted. The study comprised 187 newborns with congenital heart defects (cases) and 643 randomly selected newborns without any defects (controls), born in Kaunas city during 1999–2005. Modern epidemiological methods were used for data analysis. A multivariate logistic regression was used to determine adjusted risk factors of congenital heart defects.

Results. The logistic multivariate regression analysis showed that low and moderate maternal education significantly increased the risk of congenital heart defects (primary or basic [OR=3.43; 95% CI, 1.54–7.64] and secondary [OR=1.56; 95% CI, 1.00–2.45] vs advanced vocational or higher education). The housewives and workers had a higher risk of delivering a newborn with congenital heart defects than the office workers (OR=2.34; 95% CI, 1.34–4.10 and OR=1.28; 95% CI, 0.79–2.07, respectively). Maternal smoking during pregnancy tended to increase the risk of congenital heart defects by 48% (OR=1.48; 95% CI, 0.82–2.67).

Conclusions. According to our study results, unfavorable maternal socioeconomic factors and smoking during pregnancy increased the risk of congenital heart defects.

Introduction

Congenital heart defects (CHDs) are among the most frequent major congenital malformations throughout the world, with a prevalence of 8 to 11 per 1000 live births (1–3). They remain a major cause of death in infancy and childhood (4). More than 85% of CHD causes are multifactorial including environmental teratogens with genetic and chromosomal conditions (1).

According to recent reports, the following potential maternal socioeconomic and lifestyle risk factors that are associated with CHD: maternal age (5, 6), marital status (6), education (7), occupation (8), income (7), smoking (9–12), and alcohol use (9, 13).

It is important in research area, whether intensive socioeconomic transformations in Lithuania and the associated lifestyle changes of the society and also women, especially before and during pregnancy, may impact newborn's health. The families, in which defective newborns were born, experience a psychosocial trauma and their quality of life changes. Malformations are the biggest social and economic problem not only in families but in the state as well (3).

The objective of this study was to estimate the importance of maternal socioeconomic and lifestyle factors during pregnancy in the risk of CHDs in Kaunas infant population in 1999–2005.

Materials and methods

A population-based case-control study included all newborns born in Kaunas city during 1999–2005. We used the database containing information on newborn's birth date, gender, health status, and mother's residence. This database served as an initial source for the registration of CHDs. To record all newborn cases of CHD, we used all available information from Kaunas city hospitals, clinics, and consultant centers.

This study involved 187 cases with CHDs and randomly selected 643 controls without any defects. CHDs were registered based on clinical diagnosis after its verification using the data from consulting centers and pediatric outpatient departments. Information on potential newborns' health risk factors was collected by using standardized questionnaires. Case and control mothers were interviewed personally at their home or by phone. The questionnaire consisted

of 55 questions and recorded information on risk factors, referred to such as in the scientific literature: maternal age at delivery, education, marital status, occupation, maternal health, previous pregnancies, psychological stress, health risk behaviors, and hazardous occupational factors.

The importance of maternal socioeconomic (age at delivery, education, marital status, occupation) and lifestyle factors (smoking, alcohol consumption) for CHDs was evaluated. In this study, we did not examine a factor such as household income. Maternal age was categorized as follows: less than 19 years, 20–29 years, 30–34 years, and 35 years and more. Maternal education was grouped into the following categories: primary or basic, secondary, and advanced vocational or higher. According to marital status, mothers were categorized as single and married. Maternal occupations were grouped in the following categories: housewives, workers, office workers, professional workers, farmers, and students. Information about lifestyle factors was estimated by respondents' answers.

Modern epidemiological methods were used for data analysis. We calculated crude and adjusted odds ratios of risk factors along with 95% confidence intervals. A *P* value of <0.05 was considered statistically significant.

Results

The distribution of case infants with CHD and healthy control infants and the risk of CHD according to maternal socioeconomic and lifestyle factors are presented in Table.

The majority of mothers having newborns with CHDs were aged 20–29 years. The mean age at delivery was 27.8 years (range, 15 to 43 years) for cases and 28.6 years (range, 17 to 47 years) for controls. The group of mothers aged 20–29 years was selected as the reference group, and the odds ratios to deliver a newborn with CHD for other age groups were calculated (Table). The risk was increased by 43% among young mothers (≤ 19 years), but did not reach statistical significance.

The majority of mothers both in case and control groups were married, although 8.7% of all study mothers were single (Table). Single mothers were more likely to have a 32% increased risk of having a newborn with CHD as compared with married mothers (reference group) (NS).

Half of case mothers had advanced vocational or higher education. Low and moderate maternal education was associated with a significantly higher risk of CHD. Mothers with primary or basic education

had a 5.06-fold higher risk of delivering a newborn with CHD (95% CI, 2.44–10.48) ($P < 0.001$), while secondary education was associated with a 2.28-fold increased CHD risk as well (95% CI, 1.58–3.27) ($P < 0.001$), if compared with women who had advanced vocational or higher education (Table).

The prevalence of CHD was highest among the newborns of workers, office workers, and housewives. The information about maternal occupation was missing for 9 women (1.1%). Office workers were used as the reference group when the risk to deliver a newborn with CHD was compared. Housewives had a 3.67-fold higher risk of having a newborn with CHD (95% CI, 2.27–5.93) ($P < 0.001$), while the odds ratios of CHD among the newborns of professional workers and workers were 2.69 (95% CI, 1.05–6.89) ($P < 0.05$) and 1.81 (95% CI, 1.20–2.71) ($P < 0.01$), respectively (Table). The occupation as professional worker was not included in the multivariate logistic regression model due to the small number of mothers with this occupation.

Housewives and workers accounted for 50% and 31.3% in the group of case mothers with primary or basic education, and in the group of case mothers with secondary education, there were 55.9% of workers and 30.9% of housewives. Accordingly, in the group of control mothers with low and moderate education, housewives and workers made up the greatest proportions. More than half (52.1%) of case and 65.5% of control mothers working as office workers had advanced vocational or higher education.

The analysis of lifestyle factors revealed that 12.8% of case mothers smoked cigarettes during pregnancy: 9.6% of them smoked less than 10 cigarettes per day and 3.2%, 10 and more cigarettes per day. More than one-quarter (25.1%) of case mothers smoked three or more years before pregnancy and 3.7% about two years. Among smoking mothers in both the groups, 32.7% continued this habit during pregnancy. The risk to deliver a newborn with CHD was more than twice higher among smoking women (OR=2.45; 95% CI, 1.43–4.20) ($P < 0.001$) (Table). The odds ratio of having a newborn with CHD for mothers who smoked before pregnancy three or more years was 2.16 (95% CI, 1.44–3.22) ($P < 0.001$) if compared with nonsmoking women. The odds ratio for mothers who smoked less than 10 cigarettes per day during pregnancy was 2.04 (95% CI, 1.13–3.70), while the highest odds ratio was for women who smoked 10 and more cigarettes per day (OR=6.14; 95% CI, 1.71–21.04), but there was a small number of exposed cases.

Table. The proportions of cases and controls and odds ratios to deliver a newborn with CHD according to maternal socioeconomic and lifestyle factors (1999–2005)

Risk factors	Cases		Controls		Crude OR (CI)
	N (187)	%	N (643)	%	
Age, years					
20–29 (reference group)	107	57.2	345	53.7	
≤19	8	4.3	18	2.8	1.43 (0.60–3.38)
30–34	38	20.3	179	27.8	0.68 (0.45–1.03)
≥35	28	15.0	101	15.7	0.89 (0.55–1.43)
No data	6	3.2	0	0	
Marital status					
Married (reference group)	160	85.5	590	91.8	
Single	19	10.2	53	8.2	1.32 (0.76–2.29)
No data	8	4.3	0	0	
Education					
Advanced vocational/higher (reference group)	94	50.2	476	74.0	
Primary/basic	16	8.6	16	2.5	5.06 (2.44–10.48)
Secondary	68	36.4	151	23.5	2.28 (1.58–3.27)
No data	9	4.8	0	0	
Maternal smoking during pregnancy					
No (reference group)	147	78.6	602	93.6	
Yes	24	12.8	40	6.2	2.45 (1.43–4.20)
No data	16	8.6	1	0.2	
Duration (in years) of smoking before pregnancy					
None (reference group)	118	63.2	526	81.7	
1–2 years	7	3.7	19	3.0	1.64 (0.67–3.99)
≥3 years	47	25.1	97	15.1	2.16 (1.44–3.22)
No data	15	8.0	1	0.2	
Alcohol use during pregnancy					
None (reference group)	146	78.1	569	88.4	
Several times within a week	4	2.1	9	1.4	1.73 (0.52–5.70)
Several times within a month	22	11.8	64	10.0	1.34 (0.79–2.24)
No data	15	8.0	1	0.2	
Occupation					
Office worker (reference group)	56	29.9	323	50.2	
Housewife	42	22.5	66	10.3	3.67 (2.27–5.93)
Worker	60	32.1	191	29.7	1.81 (1.20–2.71)
Farmer	1	0.5	3	0.5	1.92 (0.19–18.81)
Professional worker	7	3.8	15	2.3	2.69 (1.05–6.89)
Student	12	6.4	45	7.0	1.53 (0.76–3.08)
No data	9	4.8	0	0	

Almost 14% of case and 11.4% of control mothers consumed alcohol during pregnancy (Table). The risk of delivering a newborn with CHD for mothers who used alcohol several times within a month was increased by 34% and for those who consumed several times within a week by 73%, but it did not reach statistical significance. This factor was not included in the multivariate logistic regression model, because

the amount of consumed alcohol was not precisely estimated.

The factors increasing the risk of CHD statistically significantly were selected and included in the multivariate logistic regression model, and adjusted odds ratios were calculated (Fig).

The results of our multivariate analysis showed that the risk of CHD was 2.34 times higher among

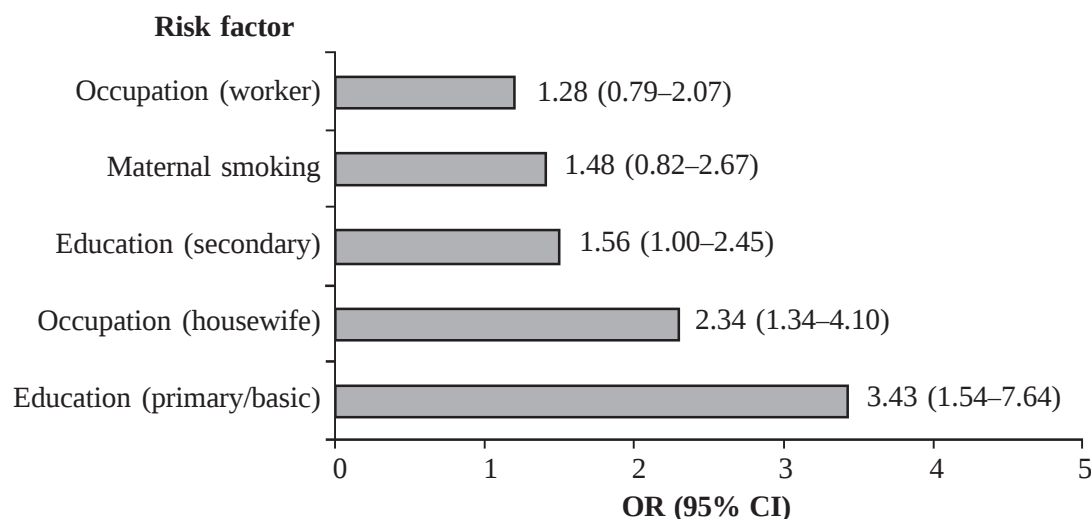


Fig. The adjusted odds ratios (OR) and 95% confidence intervals (CI) to deliver an infant with CHD by maternal socioeconomic and lifestyle factors (multivariate logistic regression analysis)

the newborns of housewives (adjusted OR=2.34; 95% CI, 1.34–4.10), if compared with the newborns of office workers. The risk of delivering an infant with CHD was by 28% higher among workers (adjusted OR=1.28; 95% CI, 0.79–2.07). Women with primary or basic education had a 3.43-fold higher risk of delivering a newborn with CHD (95% CI, 1.54–7.64), while the adjusted odds ratio for women who had secondary education was 1.56 (95% CI, 1.00–2.45), if compared to mothers with advanced vocational or higher education.

Maternal smoking during pregnancy tended to increase the risk of CHDs (adjusted OR=1.48; 95% CI, 0.82–2.67).

Discussion

An epidemiological case-control study was conducted in order to assess the relations between maternal socioeconomic and lifestyle factors during pregnancy and CHD risk. The effect of above-mentioned risk factors for CHD was evaluated, and their crude and adjusted odds ratios were calculated.

Housewives differ from women working during pregnancy; they may represent mothers whose newborns have the lowest risk of adverse pregnancy outcomes (14). According to the results of our study, a higher risk of CHD among the newborns of housewives and workers compared with infants of office workers could be partly explained by the facts that the majority of women had primary or basic and secondary education, they smoked more both before and during pregnancy. Workers are employed in occupations with exposures to strenuous physical exertion, chemicals, ionizing radiation, heat, noise,

vibration, infectious agents, and stress. These factors can, in some cases, pose risks to pregnant workers and their developing fetuses (15).

Educational level, occupational status, and income are dimensions of socioeconomic status (16). Education most strongly and consistently predicts health (17); it may directly influence knowledge about health protective behaviors, accessing health services and psychosocial mechanisms such as engagement in social network and ability to cope with life stressors (18). Kramer et al. reported that a low level of education limits a person's access to jobs and other social resources. Poor socioeconomic conditions lead to unhealthy behaviors (17), which can affect the mother's and newborn's health. High socioeconomic status, whatever the measure, is associated with better health status (19).

There are very few articles presenting the results about the association between unfavorable maternal socioeconomic factors (education, occupation, and income) and the risk of CHD. In 2007, Yang et al. published the results of study that lower maternal education was associated with an increased risk of dextrotransposition of great arteries (7). Researchers reported that low socioeconomic status increased the risk of conotruncal heart defects (20, 21) and dextrotransposition of great arteries (22). However, some studies showed no association between maternal education, income, occupation and risk of CHD (23, 24).

The findings of our population-based study indicated that maternal smoking during pregnancy tended to increase the risk of CHD. Few studies have investigated the association between maternal cigarette

smoking and CHD. The results from recent study by Malik et al. showed the association between the risk of septal defects in infants and exposure to moderate and heavy smoking as compared with exposure to light smoking, and maternal smoking of ≥ 25 cigarettes per day was associated with right-sided obstructive defects (12). According to the case-control study performed in Lithuania, maternal smoking increased the risk of having an infant with CHD two times (6). Kallen found a statistically significant association between some groups of CHD (either truncus abnormalities or atrial septal defects) and maternal smoking (10). In a retrospective cohort study, Woods and Raju found that abnormalities of the cardiovascular system are significantly associated with maternal smoking (11). The Baltimore-Washington Infant Study reported an adjusted 12-fold increased risk to have an infant with pulmonic stenosis for women who were >34 years and who smoked more than one pack cigarettes per day (9). Maternal cigarette smoking during pregnancy leads to perinatal mortality, preterm delivery, growth retardation, and congenital anomalies (11, 24–28).

This study investigated an infant population in only one town of Lithuania. No studies have been

performed about the associations between maternal socioeconomic and lifestyle factors during pregnancy and CHD in all Lithuania. It is important to carry out research in other towns of the country because it could reflect real infants' state of health and risk factors of CHD as well.

Conclusions

1. Univariate analysis revealed that maternal education (primary or basic and secondary); occupation including housewives, workers, and professional workers; and maternal smoking during pregnancy were associated with a significantly increased risk of congenital heart defects.

2. Logistic multivariate regression analysis showed that low and moderate maternal education (primary or basic and secondary) significantly increased the risk of congenital heart defects, if compared with women with advanced vocational or higher education.

3. The housewives had a 2.34-fold increased risk of delivering a newborn with congenital heart defects, and this risk was 28% higher among workers, if compared with the office workers.

4. Maternal smoking during pregnancy tended to increase the risk of congenital heart defects by 48%.

Motinos socialiniai, ekonominiai ir gyvenamosios veiksniai nėštumo metu bei gimtų širdies ydų rizika

Renata Kučienė, Virginija Dulskienė

Kauno medicinos universiteto Kardiologijos institutas

Raktažodžiai: atvejo ir kontrolės tyrimas, gimtos širdies ydos, socialiniai ir ekonominiai veiksniai, rūkymas.

Santrauka. *Tyrimo tikslas.* Įvertinti motinos socialinių, ekonominių ir gyvenamosios veiksmų nėštumo metu įtaką gimtų širdies ydų rizikai Kauno vaikų populiacijoje 1999–2005 m.

Metodika. Atliktas epidemiologinis atvejo ir kontrolės tyrimas. Tirtųjų kontingentas – 187 naujagimiai, turintys gimtas širdies ydas (atvejai) ir 643 atsitiktinės atrankos būdu atrinkti naujagimiai, neturintys jokių apsigimimų (kontrolinė grupė), gimę 1999–2005 m. Kauno mieste. Duomenims apdoroti taikyti šiuolaikinės epidemiologijos analizės metodai. Gimtų širdies ydų riziką didinantiems veiksniams nustatyti naudojome daugiaveiksnią logistinę regresiją.

Rezultatai. Daugiaveiksnių logistinės regresijos analizės duomenimis, motinos žemas ir vidutinis išsilavinimas buvo reikšmingai susijęs su gimtų širdies ydų rizika: pradinis ar pagrindinis (šansų santykis (ŠS)=3,43; 95 proc. pasikliautinis intervalas (PI) 1,54–7,64) ir vidurinis (ŠS=1,56; 95 proc. PI 1,00–2,45), lyginant su aukštesniu ar aukštesniu išsilavinimu. Namų šeimininkės ir darbininkės nustatyta didesnė rizika pagimdyti naujagimį su gimtais širdies defektais palyginus su tarnautojomis (atitinkamai – ŠS=2,34; 95 proc. PI 1,34–4,10 ir ŠS=1,28; 95 proc. PI 0,79–2,07). Motinos rūkymas nėštumo metu turėjo tendenciją 48 proc. didinti gimtų širdies ydų riziką (ŠS=1,48; 95 proc. PI 0,82–2,67).

Išvados. Mūsų tyrimo duomenimis, nepalankūs motinos socialiniai, ekonominiai veiksniai bei rūkymas nėštumo metu didino gimtų širdies ydų riziką.

References

1. Botto LD, Correa A. Decreasing the burden of congenital heart anomalies: an epidemiologic evaluation of risk factors and survival. *Prog Ped Cardiol* 2003;18:111-21.
2. Cleves MA, Ghaffar S, Zhao W, Mosley BS, Hobbs CA. First year survival of infants born with congenital heart defects in Arkansas (1993–1998): a survival analysis using registry data. *Birth Defects Res A Clin Mol Teratol* 2003; 67:662-8.
3. Dulskienė V, Malinauskienė V, Azaravičienė A, Kučienė R. Įgimtų širdies ydų paplitimas ir diagnostika Kauno vaikų populiacijoje 1999–2005 m. (The incidence and diagnostics of congenital heart defects in Kaunas infant population during 1999–2005.) *Medicina (Kaunas)* 2008;44:139-46.
4. Boneva RS, Botto LD, Moore CA, Yang Q, Correa A, Erickson JD. Mortality associated with congenital heart defects in the United States: trends and racial disparities, 1979–1997. *Circulation* 2001;103:2376-81.
5. Reefhuis J, Honein MA. Maternal age and non-chromosomal birth defects, Atlanta – 1968–2000: teenager or thirty-something, who is at risk? *Birth Defects Res A Clin Mol Teratol* 2004;70:572-9.
6. Dulskienė V, Gražulevičienė R. Kenksmingi aplinkos veiksniai bei oro užterštumas formaldehidu ir įgimtos širdies anomalijos. (Environmental risk factors and outdoor formaldehyde and risk of congenital heart malformations.) *Medicina (Kaunas)* 2005;41:787-95.
7. Yang J, Carmichael SL, Canfield M, Song J, Shaw GM; National Birth Defects Prevention Study. Socioeconomic status in relation to selected birth defects in a large multi-centered. US case-control study. *Am J Epidemiol* 2008;167: 145-54.
8. Chia SE, Shi LM, Chan OY, Chew SK, Foong BH. A population-based study on the association between parental occupations and some common birth defects in Singapore (1994–1998). *J Occup Environ Med* 2004;46:916-23.
9. Ferencz C, Loffredo CA, Correa-Villasenor A, Wilson PD. Genetic and environmental risk factors of major congenital heart disease: the Baltimore-Washington Infant Study 1981–1989. Armonk (NY): Futura Publishing Company; 1997.
10. Kallen K. Maternal smoking and congenital heart defects. *Eur J Epidemiol* 1999;15:731-7.
11. Woods SE, Raju U. Maternal smoking and the risk of congenital birth defects: a cohort study. *J Am Board Fam Pract* 2001;14:330-4.
12. Malik S, Cleves MA, Honein MA, Romitti PA, Botto LD, Yang S, et al. Maternal smoking and congenital heart defects. *Pediatrics* 2008;121:810-6.
13. Martinez-Frias ML, Bermejo E, Rodriguez-Pinilla E, Frias JL. Risk for congenital anomalies associated with different sporadic and daily doses of alcohol consumption during pregnancy: a case-control study. *Birth Defects Res A Clin Mol Teratol* 2004;70:194-200.
14. Ahmed P, Jaakkola JJ. Maternal occupation and adverse pregnancy outcomes: a Finnish population-based study. *Occup Med (Lond)* 2007;57:417-23.
15. Feinberg JS, Kelley CR. Pregnant workers. A physician's guide to assessing safe employment. *West J Med* 1998;168:86-92.
16. Braveman PA, Cubbin C, Egerter S, Chideya S, Marchi KS, Metzler M, et al. Socioeconomic status in health research: one size does not fit all. *JAMA* 2005;294:2879-88.
17. Kramer MS, Séguin L, Lydon J, Goulet L. Socio-economic disparities in pregnancy outcome: why do the poor fare so poorly? *Paediatr Perinat Epidemiol* 2000;14:194-210.
18. Smith GD, Ben-Shlomo Y. Inequalities in health: what is happening and what can be done. In Smith GG, editor. *Health inequalities: lifecourse approaches*. Bristol: The Policy Press; 2003. p. 475-8.
19. Singh-Manoux A, Marmot MG, Adler NE. Does subjective social status predict health and change in health status better than objective status? *Psychosom Med* 2005;67:855-61.
20. Vrijheid M, Dolk H, Stone D, Abramsky L, Alberman E, Scott JE. Socioeconomic inequalities in risk of congenital anomaly. *Arch Dis Child* 2000;82:349-52.
21. Loffredo CA, Silbergeld EK, Ferencz C, Zhang J. Association of transposition of the great arteries in infants with maternal exposures to herbicides and rodenticides. *Am J Epidemiol* 2001;153:529-36.
22. Carmichael SL, Nelson V, Shaw GM, Wasserman CR, Croen LA. Socio-economic status and risk of conotruncal heart defects and orofacial clefts. *Paediatr Perinat Epidemiol* 2003; 17:264-71.
23. Botto LD, Lynberg MC, Erickson JD. Congenital heart defects, maternal febrile illness, and multivitamin use: a population-based study. *Epidemiology* 2001;12:485-90.
24. Hobbs CA, James SJ, Parsian A, Krakowiak PA, Jernigan S, Greenhaw JJ, et al. Congenital heart defects and genetic variants in the methylenetetrahydrofolate reductase gene. *J Med Genet* 2006;43:162-6.
25. Secker-Walker RH, Vacek PM. Relationships between cigarette smoking during pregnancy, gestational age, maternal weight gain, and infant birthweight. *Addict Behav* 2003;28: 55-66.
26. Ananth CV, Platt RW. Reexamining the effects of gestational age, fetal growth, and maternal smoking on neonatal mortality. *BMC Pregnancy Childbirth* 2004;4:22.
27. Morales-Suarez-Varela MM, Bille C, Christensen K, Olsen J. Smoking habits, nicotine use, and congenital malformations. *Obstet Gynecol* 2006;107:51-7.
28. Nielsen A, Hannibal CG, Lindekilde BE, Tolstrup J, Frederiksen K, Munk C, et al. Maternal smoking predicts the risk of spontaneous abortion. *Acta Obstet Gynecol Scand* 2006;85:1057-65.

Received 20 May 2008, accepted 6 November 2009
 Straipsnis gautas 2008 05 20, priimtas 2009 11 06