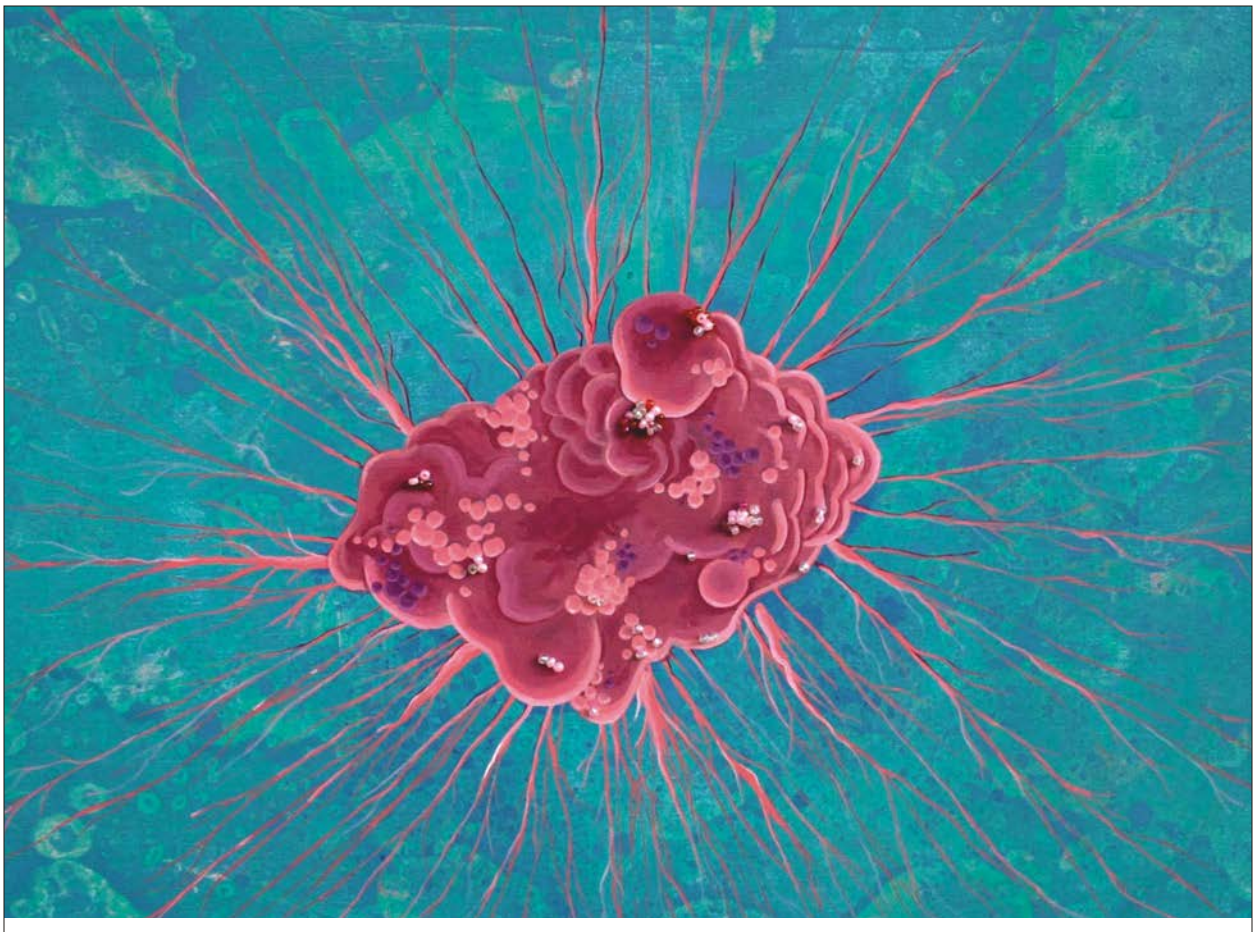

International Journal of Cancer Research

ISSN 1811-9727

Academic Journals Inc.

www.academicjournals.com

International Journal of Cancer Research 3 (2): 74-91, 2007
ISSN 1811-9727

GSTM1 Null Genotype Associated with Age-standardized Cancer Mortality Rate in 45 Countries from Five Continents: An Ecologic Study

Mostafa Saadat
Department of Biology, College of Sciences, Shiraz University, Shiraz 71454, Iran

Abstract: To evaluate the public health impact of association between prevalence of *GSTM1* and *GSTT1* null genotypes and age-standardized cancer mortality rate the present study, using data of 45 countries from five continents was done. Data of prevalence of *GSTM1* and *GSTT1* null genotypes was obtained from published articles in scientific journals. Data about the age-standardized mortality rates due to cancers (per 100,000 population) (for 2002) and total expenditure on health at international dollar rate per capita (for 2003) were obtained from the World Health Organization Web site http://www.who.int. In order to rule out the possible confounding effect of total expenditure on health per capita on the mortality rate, partial correlation analysis was carried out. After controlling the total expenditure on health per capita, significant positive correlation between prevalence of *GSTM1* null genotype and age-standardized cancer mortality rate was observed ($r = 0.301$, $df = 42$, $p = 0.047$).

Key words: *GSTM1*, *GSTT1*, age-standardized mortality rate, total expenditure on health per capita, ecologic study

INTRODUCTION

Glutathione S-transferases (GSTs) are a group of enzymes known to play an important role in the detoxification of several endogenous and exogenous toxic and carcinogenic substances. In human GST enzymes are divided into several classes including mu and theta. *GSTM1* (a member of class mu) and *GSTT1* (a member of class theta) products catalyze the conjugation of glutathione to a number of chemicals present in cigarette smoke including epoxide derivatives of polycyclic aromatic hydrocarbons, the main carcinogens found in tobacco smoke, methylating agents, pesticides, industrial solvents and reactive oxygen species.

Allelic polymorphisms in the *GSTM1* and *GSTT1* genes have been defined. The functional consequences of the *GSTM1* and the *GSTT1* null genotypes are obvious in terms of enzymes activity: no gene, no enzymes and no activity. The disease-association studies were conducted in different populations for various cancers (Engel *et al*., 2002; Garcia-Closas *et al*., 2005; Hashibe *et al*., 2003; La Torre *et al*., 2005; Saadat 2006; Sull *et al*., 2004; Tripathy and Roy 2006; Ye *et al*., 2006; Ye and Parry, 2003; Ye and Song, 2005).

Members of the GST family catalyze detoxification of many alkylating agents, including nitrosoureas, platinum compounds and melphalan. They may also detoxify the free radicals formed by chemotherapy drugs and radiation (Cholon *et al*., 1992; Dulik *et al*., 1986; Lien *et al*., 2002). Several studies support the idea that active *GSTM1* and *GSTT1* enzymes may improve cancerous patients after chemotherapy (Beeghly *et al*., 2006; Sweeney *et al*., 2003; Goto *et al*., 1996). To evaluate the public health impact of prevalence of *GSTM1* and *GSTT1* null genotypes on mortality due to cancers, the association between prevalence of the null-genotypes of GSTs and age-standardized mortality rates due to cancers in 45 countries from five continents was analyzed.

MATERIALS AND METHODS

Data of prevalence of *GSTM1* and *GSTT1* null genotypes was obtained from published articles in scientific journals (Table 1).

Table 1: Prevalence of *GSTT1* and *GSTM1* null genotypes, total expenditure on health per capita and age-standardized cancer mortality rates of the countries

Country	Age-standardized cancer mortality rate (per 100,000 population)	Total expenditure on health at international dollar rate per capita	Null genotype (%)		References
			GSTT1	*GSTM1*	
Argentina	142	1067	11.0	45.0	Moore *et al*., 2004
Australia	127	2874	16.3	45.7	Chenevix-Trench *et al*., 1995; Curran *et al*., 2000
Belgium	148	2828	16.1	51.4	Kellen *et al*., 2006
Brazil	142	597	20.7	35.8	Arruda *et al*., 2001; Canalle *et al*., 2004; Colombo *et al*., 2004; da Fonte de Amorim *et al*., 2002; Gaspar *et al*., 2002; Morari *et al*., 2002; Rossini *et al*., 2002
Bulgaria	125	573	16.1	51.8	Toncheva *et al*., 2004
Canada	138	2989	19.9	53.8	Casson *et al*., 2003; Hamel *et al*., 2000; He *et al*., 2004; Krajinovic *et al*., 1999
Chile	137	707	-	22.6	Alberti *et al*., 1996; Quinones *et al*., 1999, 2001
China	148	278	46.6	55.8	Cai *et al*., 2001; Chan *et al*., 2005; Chen *et al*., 2004; Egan *et al*., 2004; Gao *et al*., 2002; Guo *et al*., 1996; Lan *et al*., 2000; Li *et al*., 2005; London *et al*., 2000; Mu *et al*., 2005; Nan *et al*., 2005; Setiawan *et al*., 2000; Tan *et al*., 2000; Zhong *et al*., 2006; Wang *et al*., 2003
Colombia	117	522	14.6	37.5	Torres *et al*., 2004
Czech Republic	177	1302	18.9	50.6	Holla *et al*., 2006; Sarmanova *et al*., 2000
Denmark	167	2762	11.9	53.9	Christiansen *et al*., 2006; Knudsen *et al*., 1999
Egypt	84	235	27.1	52.3	Abdel-Rahman *et al*., 1996, 1999, 2001; Anwar *et al*., 1996; Hamdy *et al*., 2003
Estonia	150	682	17.9	53.0	Juronen *et al*., 2000; Mikelsaar *et al*., 1994; Tasa *et al*., 1996
Finland	115	2108	12.4	46.4	Hirvonen *et al*., 1993; Mitrunen *et al*., 2001; Piirila *et al*., 2001; Saarikoski *et al*., 1998; Voho *et al*., 2006
France	142	2902	15.6	48.6	Abbas *et al*., 2004; Jourenkova *et al*., 1997, 1998; Jourenkova-Mironova *et al*., 1999a, 1999b; Maugard *et al*., 1998; Stucker *et al*., 2000
Gambia	144	96	43.8	27.3	Kirk *et al*., 2005
Germany	141	3001	17.3	50.9	Brockmoller *et al*., 1993; Gronau *et al*., 2003; Haase *et al*., 2002; Hahn *et al*., 2002; Jahnke *et al*., 1996; Kabesch *et al*., 2004; Ko *et al*., 2001; Matthias *et al*., 1998; Risch *et al*., 2003; Schneider *et al*., 2004; Westphal *et al*., 2000
Greece	132	1997	10.5	47.6	Dialyna *et al*., 2001, 2003; Tsabouri *et al*., 2004
Hungary	201	1269	13.8	47.0	Kiss *et al*., 2000; Schoket *et al*., 2001; Tuimala *et al*., 2002
Iceland	136	3110	20.5	54.2	Gudmundsdottir *et al*., 2001
India	109	82	16.7	23.7	Buch *et al*., 2002; Chacko *et al*., 2005;

Table 1: Continue

Country	Age-standardized cancer mortality rate(per 100,000 population)	Total expenditure on health at international dollar rate per capita	Null genotype (%)		References
			GSTT1	*GSTM1*	
					Girisha *et al*., 2004; Mishra *et al*., 2004; Mittal *et al*., 2004; Nair *et al*., 1999; Sharma *et al*., 2006; Sobti *et al*., 2004, 2005, 2006; Sreelekha *et al*., 2001, Srivastava *et al*., 2004
Iran	113	498	38.2	40.6	Kohan *et al*., 2006; Saadat *et al*., 2004a, 2004b, 2004c; Saadat and Saadat 2000, 2001, 2003a, 2003b; Saadat and Mohabatkar 2004; Sepehr *et al*., 2004; Mohammadzadeh Ghobadloo *et al*., 2004
Italy	134	2266	17.9	49.8	Alberti *et al*., 1996;, Buzio *et al*., 2003; D'Alo *et al*., 2004; Fustinoni *et al*., 2002; Palli *et al*., 2005; Pavanello *et al*., 2002; Sgambato *et al*., 2002
Japan	119	2244	48.5	48.9	Harada *et al*., 2001; Hayashi *et al*., 1992; Inoue *et al*., 2000; Katoh *et al*., 1995, 1996; Kihara *et al*., 1997; Morita *et al*., 1999; Naoe *et al*., 2000; Nimura *et al*., 1997; Sasai *et al*., 1999; Sata *et al*., 2003; Sato *et al*., 1999; Sekine *et al*., 1995; Tanimoto *et al*., 1992
Mexico	88	582	5.1	39.4	David *et al*., 2003; Gallegos-Arreola *et al*., 2004; Romieu *et al*., 2004
Netherlands	155	2987	20.3	47.1	Luchtenborg *et al*., 2005; Oude Ophuis *et al*., 1998; van Delft *et al*., 2001
Norway	137	3809	17.4	46.8	Nedelcheva Kristensen *et al*., 1998; Ryberg *et al*., 1997
Paraguay	141	301	17.9	35.8	Gaspar *et al*., 2002
Poland	180	745	17.3	49.8	Butkiewicz *et al*., 1999; Gajecka *et al*., 2005; Gawronska-Szklarz *et al*., 1999; Lan *et al*., 2001
Portugal	140	1791	25.5	53.5	Krajinovic *et al*., 2002; Lemos *et al*., 1999; Moreira *et al*., 1996
Republic of Korea	169	1074	52.0	52.7	Cho *et al*., 2005; Choi *et al*., 2003; Hong *et al*., 1998; Hong *et al*., 2000; Hur *et al*., 2005; Jong Jeong *et al*., 2003; Lee *et al*., 2002; Park *et al*., 2002; Yim *et al*., 2000
Russia	152	551	20.4	45.2	Ivaschenko *et al*., 2001, 2002; Korytina *et al*., 2005; Vakhitova *et al*., 2001
Saudi Arabia	109	578	8.7	15.4	Abu-Amero *et al*., 2006
Singapore	128	1156	42.6	47.6	Gago-Dominguez *et al*., 2004; Lee *et al*., 1998; Seow *et al*., 2002; Zhao *et al*., 1995, 2001
Slovakia	170	777	18.3	50.7	Dusinska *et al*., 2001; Habalova *et al*., 2004; Salagovic *et al*., 1998, 1999; Somorovska *et al*., 1999
Spain	131	1853	22.2	49.4	Garcia-Closas *et al*., 2005; Gonzalez *et al*., 1998; Hernandez *et al*., 2003; Ladero *et al*., 2006; Ruano-Ravina *et al*., 2003; To-Figueras *et al*., 1997
Sudan	112	54	37.8	38.8	Tiemersma *et al*., 2001
Sweden	116	2704	14.0	54.0	Alexandrie *et al*., 1994, 2004
Tanzania	151	29	25.0	33.0	Dandara *et al*., 2002
Thailand	129	260	47.2	30.2	Kietthubthew *et al*., 2001
Turkey	95	528	22.5	36.7	Balta *et al*., 2003; Ozturk *et al*., 2003; Pinarbasi *et al*., 2003, 2005; Tamer *et al*., 2004, 2005; Toruner *et al*., 2001

Table 1: Continue

Country	Age-standardized cancer mortality rate (per 100,000 population)	Total expenditure on health at international dollar rate per capita	Null genotype (%)		References
			GSTT1	*GSTM1*	
UK	143	2389	15.6	50.6	Allan *et al*., 2001; Zhong *et al*., 1993; Basu *et al*., 1997; Deakin *et al*., 1996; Fryer *et al*., 2000; Lewis *et al*., 2002; Loktionov *et al*., 2001; Rollinson *et al*., 2000; Ye *et al*., 2002; Seedhouse *et al*., 2004; Welfare *et al*., 1999
Ukraine	139	305	14.2	50.6	Ebrahimi *et al*., 2004
USA	134	5711	20.4	44.7	Abdel-Rahman *et al*., 2001; Barnette *et al*., 2004; Chen *et al*., 1997; Cheng *et al*., 1999; Cote *et al*., 2005; Crump *et al*., 2000; Davies *et al*., 2000, 2002; Ford *et al*., 2000; Gertig *et al*., 1998; Gilliland *et al*., 2002; Hakim *et al*., 2004; Hanna *et al*., 2001; Helzlsouer *et al*., 1998; Kelada *et al*., 2000; Li *et al*., 2001; McWilliams *et al*., 2000; Nazar-Stewart *et al*., 2003; Olshan *et al*., 2000; Park *et al*., 1997; Roodi *et al*., 2004; Wrensch *et al*., 2004; Slattery *et al*., 1998; Sweeney *et al*., 2000; Trizna *et al*., 1995; Woo *et al*., 2000
Zimbabwe	122	132	-	30.0	Mukanganyama *et al*., 1997

Since cancers are more common in older age groups, a population that is older will have a higher crude incidence rate. Age-standardized mortality rate is a procedure where weighted averages of age-specific rate are used to modify rates to a standard population in order to minimize the effects of differences in the age composition of given populations (such as provinces or census divisions) when comparing rates for these populations. The purpose of this rate is to compare groups of people from different backgrounds and age structures. The age-standardized rates for both sexes combined also adjust for possible differences in the gender distribution. Here we used the age-standardized cancer mortality rates for both sexes. Data about the age-standardized mortality rates due to cancers (per 100,000 population) (for 2002) and total expenditure on health at international dollar rate per capita (for 2003) were obtained from the World Health Organization Web site http://www.who.int.

Inclusion criteria were availability of data about total expenditure on health at international dollar rate per capita, age-standardized mortality rates due to cancers and prevalence of the GSTs genotypes of the country.

Correlations between the variables were determined using Pearson's correlation coefficient analysis. Also the partial correlation coefficient analysis was done. Statistical analysis was performed using SPSS (version 11.5) statistical software package. p-value less than 0.05 considered statistically significant.

RESULTS AND DISCUSSION

There is significant positive correlation between age-standardized cancer mortality rate and the prevalence of *GSTM1* null genotype ($r = 0.327$, $df = 43$, $p = 0.028$). However, there is no significant correlation between age-standardized cancer mortality rate and the prevalence of *GSTT1* null genotype ($r = -0.01$, $df = 41$, $p = 0.977$).

It is now widely accepted that there is significant differences between populations for *GSTM1* and *GSTT1* null genotypes (Engel *et al*., 2002; Garcia-Closas *et al*., 2005; Hashibe *et al*., 2003; La Torre *et al*., 2005; Saadat 2006; Sull *et al*., 2004; Tripathy and Roy 2006; Ye and Parry, 2003; Ye and Song, 2005; Ye *et al*., 2006). As it is appeared from Table 1, the frequency of *GSTT1* null genotype in European populations is about 10-22% which is increased from north to the south. In Asian

populations both *GSTT1* and *GSTM1* null genotypes increased from west to the east. Therefore, the frequencies of *GSTM1* and *GSTT1* null genotypes showed geographical distributions. On the other hand, total expenditure on health per capita also showed a geographical pattern with highest mean value among European populations. Taken together, in order to show the actual correlation between prevalence of the null genotypes (*GSTM1* and *GSTT1*) and age-standardized cancer mortality rate and rule out the possible confounding effect of total expenditure on health per capita on the mortality rates, partial correlation analysis was carried out. After controlling the total expenditure on health per capita, significant positive correlation between prevalence of *GSTM1* null genotype and age-standardized mortality rate due to cancers was observed ($r = 0.301$, $df = 42$, $p = 0.047$). However, there is no significant correlation between age-standardized cancer mortality rate and the prevalence of *GSTT1* null genotype after controlling for total expenditure on health per capita ($r = 0.028$, $df = 40$, $p = 0.860$). This finding is in the same direction as that reported by several investigators from different populations in the cancers association studies (Engel *et al*., 2002; Garcia-Closas *et al*., 2005; Hashibe *et al*., 2003; La Torre *et al*., 2005; Saadat 2006; Sull *et al*., 2004; Tripathy and Roy 2006; Ye and Parry, 2003; Ye and Song, 2005; Ye *et al*., 2006). There have been a number of studies of GST genetic polymorphisms and outcomes in several types of cancers, such as breast, lung, colorectal and ovarian cancers (Beeghly *et al*., 2006; Goto *et al*., 1996; Okcu *et al*., 2004; Stoehlmacher *et al*., 2002; Sweeney *et al*., 2003; Yang *et al*., 2005). Several studies demonstrated that the survival in cancerous patients with *GSTM1* null genotype was shorter that that in patients with active genotype of *GSTM1* (Beeghly *et al*., 2006; Sweeney *et al*., 2003; Goto *et al*., 1996; Okcu *et al*., 2004). Our present results indirectly, confirmed these studies. Some other studies, however, have reported no relationship or opposite association between *GSTM1* polymorphism and survival (Stoehlmacher *et al*., 2002; Yang *et al*., 2005).

From the present data, it might be concluded that prevalence of *GSTM1* null genotype influences cancer mortality rate independent of age and sex structure of the populations, the total expenditure on health per capita and the prevalence of *GSTT1* null genotype. Based on the present finding about 9% ($r^2 = 0.301^2$) of differences between age-standardized cancer mortality rate between countries might be interpreted by the prevalence of *GSTM1* null genotype. It seems that the GSTM1 deficiency accounts relatively high level of cancer mortality, because of the high prevalence of *GSTM1* null genotype. The attributed risk should be estimated in the future studies.

It should be mentioned that the present study has some limitations. First of all, the present study is an ecological study and has limitation of ecological studies. Second, total expenditure on health per capita is not the target confounding variable per se. So, there would be a certain degree of residual confounding still present in the calculated partial correlation coefficients. Third age-standardized mortality rate and total expenditure on health per capita for the study countries was not related to a same year.

Finally, case-control and cohort studies investigating relationship between genetic polymorphisms of *GSTM1* and cancer mortality may confirm the present preliminary data.

ACKNOWLEDGMENT

This study was supported by Shiraz University.

REFERENCES

Abbas, A., K. Delvinquiere and M. Lechevrel *et al*., 2004. *GSTM1*, *GSTT1*, *GSTP1* and *CYP1A1* genetic polymorphisms and susceptibility to esophageal cancer in a French population: Different pattern of squamous cell carcinoma and adenocarcinoma. World J. Gastroenterol., 10: 3389-3393.

Abdel-Rahman, S.Z., A.S. Soliman and M.L. Bondy *et al*., 1999. Polymorphism of glutathione S-transferase loci *GSTM1* and *GSTT1* and susceptibility to colorectal cancer in Egypt. Cancer Lett., 142: 97-104.

Abdel-Rahman, S.Z., M.M. Ammenheuser and J.B. Jr. Ward, 2001. Human sensitivity to 1, 3-butadiene: role of microsomal epoxide hydrolase polymorphisms. Carcinogenesis, 21: 415-423.

Abdel-Rahman, S.Z., R.A. el-Zein, W.A. Anwar and W.W. Au, 1996. A multiplex PCR procedure for polymorphic analysis of *GSTM1* and *GSTT1* genes in population studies. Cancer Lett., 107: 229-233.

Abu-Amero, K.K., O.M. Al-Boudari, G.H. Mohamed and N. Dzimiri, 2006. T null and M null genotypes of the glutathione S-transferase gene are risk factor for CAD independent of smoking. BMC Med. Genet., 7: 38.

Alberti, G., M. Oguni and M. Podgor, *et al*., 1996. Glutathione S-transferase M1 genotype and age-related cataracts. Lack of association in an Italian population. Invest. Ophthalmol. Vis. Sci., 37: 1167-1173.

Alexandrie, A.K., F. Nyberg, M. Warholm and A. Rannug, 2004. Influence of *CYP1A1*, *GSTM1*, *GSTT1* and *NQO1* genotypes and cumulative smoking dose on lung cancer risk in a Swedish population. Cancer Epidemiol. Biomarkers Prev., 13: 908-914.

Alexandrie, A.K., M.I. Sundberg and J. Seidegard *et al*., 1994. Genetic susceptibility to lung cancer with special emphasis on *CYP1A1* and *GSTM1*: A study on host factors in relation to age at onset, gender and histological cancer types. Carcinogenesis, 15: 1785-1790.

Allan, J.M., C.P. Wild and S. Rollinson *et al*., 2001. Polymorphism in glutathione S-transferase P1 is associated with susceptibility to chemotherapy-induced leukemia. Proc. Natl. Acad. Sci. USA, 98: 11592-11597.

Anwar, W.A., S.Z. Abdel-Rahman and R.A. El-Zein *et al*., 1996. Genetic polymorphism of *GSTM1*, *CYP2E1* and *CYP2D6* in Egyptian bladder cancer patients. Carcinogenesis, 17: 1923-1929.

Arruda, V.R., C.S. Lima and C.R. Grignoli *et al*., 2001. Increased risk for acute myeloid leukaemia in individuals with glutathione S-transferase mu 1 (*GSTM1*) and theta 1 (*GSTT1*) gene defects. Eur. J. Haematol., 66: 383-388.

Balta, G., N. Yuksek and E. Ozyurek *et al*., 2003. Characterization of MTHFR, *GSTM1*, *GSTT1*, *GSTP1* and *CYP1A1* genotypes in childhood acute leukemia. Am. J. Hematol., 73: 154-160.

Barnette, P., R. Scholl and M. Blandford *et al*., 2004. High-throughput detection of glutathione S-transferase polymorphic alleles in a pediatric cancer population. Cancer Epidemiol. Biomarkers Prev., 13: 304-313.

Basu, T., R.E. Gale, S. Langabeer and D.C. Linch, 1997. Glutathione S-transferase theta 1 (*GSTT1*) gene defect in myelodysplasia and acute myeloid leukaemia. Lancet, 349: 1450.

Beeghly, A., D. Katsaos and H. Chen *et al*., 2006. Glutathione S-transferase polymorphisms and ovarian cancer treatment and survival. Gynecol. Oncol., 100: 330-337.

Brockmoller, J., R. Kerb and N. Drakoulis *et al*., 1993. Genotype and phenotype of glutathione S-transferase class mu isoenzymes mu and psi in lung cancer patients and controls. Cancer Res., 53: 1004-1011.

Buch, S.C., P.N. Notani and R.A. Bhisey, 2002. Polymorphism at *GSTM1*, GSTM3 and *GSTT1* gene loci and susceptibility to oral cancer in an Indian population. Carcinogenesis, 23: 803-807.

Butkiewicz, D., K.J. Cole and D.H. Phillips *et al*., 1999. *GSTM1*, *GSTP1*, *CYP1A1* and CYP2D6 polymorphisms in lung cancer patients from an environmentally polluted region of Poland: correlation with lung DNA adduct levels. Eur. J. Cancer Prev., 8: 315-323.

Buzio, L., G. De Palma and P. Mozzoni *et al*., 2003. Glutathione S-transferases M1-1 and T1-1 as risk modifiers for renal cell cancer associated with occupational exposure to chemicals. Occup. Environ. Med., 60: 789-793.

Cai, L., S.Z. Yu and Z.F. Zhang, 2001. Glutathione S-transferases M1, T1 genotypes and the risk of gastric cancer: A case-control study. World J. Gastroenterol., 7: 506-509.

Canalle, R., R.V. Burim, L.G. Tone and C.S. Takahashi, 2004. Genetic polymorphisms and susceptibility to childhood acute lymphoblastic leukemia. Environ. Mol. Mutagen, 43: 100-109.

Casson, A.G., Z. Zheng and D. Chiasson *et al*., 2003. Associations between genetic polymorphisms of Phase I and II metabolizing enzymes, p53 and susceptibility to esophageal adenocarcinoma. Cancer Detect. Prev., 27: 139-146.

Chacko, P., T. Joseph and B.S. Mathew *et al*., 2005. Role of xenobiotic metabolizing gene polymorphisms in breast cancer susceptibility and treatment outcome. Mutat. Res., 581: 153-163.

Chan, E.C., S.Y. Lam, K.H. Fu and Y.L. Kwong, 2005. Polymorphisms of the *GSTM1*, *GSTP1*, *MPO*, *XRCC1* and *NQO1* genes in Chinese patients with non-small cell lung cancers: Relationship with aberrant promoter methylation of the *CDKN2A* and *RARB* genes. Cancer Genet. Cytogenet., 162: 10-20.

Chen, C.L., Q. Liu and C.H. Pui *et al*., 1997. Higher frequency of glutathione S-transferase deletions in black children with acute lymphoblastic leukemia. Blood, 89: 1701-1707.

Chen, K., Q.T. Jiang and X.Y. Ma *et al*., 2004. Associations between genetic polymorphisms of glutathione S-transferase M1 and T1, smoking and susceptibility to colorectal cancer: A case-control study. Zhonghua. Zhong. Liu. Za. Zhi., 26: 645-648. Chinese.

Chenevix-Trench, G., J. Young, M. Coggan and P. Board, 1995. Glutathione S-transferase M1 and T1 polymorphisms: Susceptibility to colon cancer and age of onset. Carcinogenesis, 16: 1655-1657.

Cheng, L., E.M. Sturgis and S.A. Eicher *et al*., 1999. Glutathione-S-transferase polymorphisms and risk of squamous-cell carcinoma of the head and neck. Int. J. Cancer, 84: 220-224.

Cho, H.J., S.Y. Lee, C.S. Ki and J.W. Kim, 2005. *GSTM1*, *GSTT1* and *GSTP1* polymorphisms in the Korean population. J. Korean Med. Sci., 20: 1089-1092.

Choi, S.C., K.J. Yun and T.H. Kim *et al*., 2003. Prognostic potential of glutathione S-transferase M1 and T1 null genotypes for gastric cancer progression. Cancer Lett., 195: 169-175.

Cholon, A., A.J. Giaccia and A.D. Lewis *et al*., 1992. What role do glutathione S-transferases play in the cellular response to ionizing radiation? Int. J. Radiat. Oncol. Biol. Phys., 22:759-763.

Christiansen, L., C. Brasch-Andersen and L. Bathum *et al*., 2006. A longitudinal study of the effect of *GSTT1* and *GSTM1* gene copy number on survival. Mech. Ageing Dev., 127: 597-599.

Colombo, J., A.R. Rossit and A. Caetano *et al*., 2004. *GSTT1*, *GSTM1* and CYP2E1 genetic polymorphisms in gastric cancer and chronic gastritis in a Brazilian population. World J. Gastroenterol., 10: 1240-1245.

Cote, M.L., S.L. Kardia and A.S. Wenzlaff *et al*., 2005. Combinations of glutathione S-transferase genotypes and risk of early-onset lung cancer in Caucasians and African Americans: a population-based study. Carcinogenesis, 26: 811-819.

Crump, C., C. Chen and F.R. Appelbaum *et al*., 2000. Glutathione S-transferase theta 1 gene deletion and risk of acute myeloid leukemia. Cancer Epidemiol. Biomarkers Prev., 9: 457-460.

Curran, J.E., S.R. Weinstein and L.R. Griffiths, 2000. Polymorphisms of glutathione S-transferase genes (*GSTM1*, *GSTP1* and *GSTT1*) and breast cancer susceptibility. Cancer Lett., 153: 113-120.

da Fonte de Amorim, L., A. Rossini and G. Mendonca *et al*., 2002. *CYP1A1*, *GSTM1* and *GSTT1* polymorphisms and breast cancer risk in Brazilian women. Cancer Lett., 181: 179-186.

D'Alo, F., M.T. Voso, F. Guidi *et al*., 2004. Polymorphisms of *CYP1A1* and glutathione S-transferase and susceptibility to adult acute myeloid leukemia. Haematologica, 89: 664-670.

Dandara, C., J. Sayi and C.M. Masimirembwa *et al*., 2002. Genetic polymorphism of cytochrome P450 1A1 (*CYP1A1*) and glutathione transferases (M1, T1 and P1) among Africans. Clin. Chem. Lab. Med., 40: 952-957.

David, G.L., I. Romieu and J.J. Sienra-Monge *et al*., 2003. Nicotinamide adenine dinucleotide (phosphate) reduced:quinone oxidoreductase and glutathione S-transferase M1 polymorphisms and childhood asthma. Am. J. Respir. Crit. Care Med., 168: 1199-1204.

Davies, S.M., L.I. Robison and J.D. Buckley *et al*., 2000. Glutathione S-transferase polymorphisms in children with myeloid leukemia: A Children's Cancer Group study. Cancer Epidemiol, Biomarkers Prev., 9: 563-566.

Davies, S.M., S. Bhatia and J.A. Ross *et al*., 2002. Glutathione S-transferase genotypes, genetic susceptibility and outcome of therapy in childhood acute lymphoblastic leukemia. Blood, 100: 67-71.

Deakin, M., J. Elder and C. Hendrickse *et al*., 1996. Glutathione S-transferase *GSTT1* genotypes and susceptibility to cancer: studies of interactions with *GSTM1* in lung, oral, gastric and colorectal cancers. Carcinogenesis, 17: 881-884.

Dialyna, I.A., D.A. Arvanitis and D.A. Spandidos, 2001. Genetic polymorphisms and transcriptional pattern analysis of *CYP1A1*, AhR, *GSTM1*, *GSTP1* and *GSTT1* genes in breast cancer. Int J Mol. Med., 8: 79-87.

Dialyna, I.A., S. Miyakis, N. Georgatou and D.A. Spandidos, 2003. Genetic polymorphisms of *CYP1A1*, *GSTM1* and *GSTT1* genes and lung cancer risk. Oncol. Rep., 10: 1829-1835.

Dulik, D.M., C. Fenselau and J. Hilton *et al*., 1986. Characterization of melphalan-glutathione adducts whose formation is catalyzed by glutathione transferases. Biochem. Pharmacol., 35: 3405-3409.

Dusinska, M., A. Ficek and A. Horska *et al*., 2001. Glutathione S-transferase polymorphisms influence the level of oxidative DNA damage and antioxidant protection in humans. Mutat. Res., 482: 47-55.

Ebrahimi, M., S.V. Podolskaya and N.G. Gorovenko, 2004. Genetic polymorphisms of glutathione S-transferase mu1 (*GSTM1*) and theta1 (*GSTT1*) and bronchial asthma susceptibility in Ukrain population. Iranian J. Biotechnol., 2: 230-235.

Egan, K.M., Q. Cai and X.O. Shu *et al*., 2004. Genetic polymorphisms in *GSTM1*, *GSTP1* and *GSTT1* and the risk for breast cancer: results from the Shanghai Breast Cancer Study and meta-analysis. Cancer Epidemiol. Biomarkers Prev., 13: 197-204.

Engel, L.S., E. Taioli and R. Pfeiffer *et al*., 2002. Pooled analysis and meta-analysis of glutathione S-transferase M1 and bladder cancer: A HuGE review. Am. J. Epidemiol., 156: 95-109.

Ford, J.G., Y. Li and M.M. O'Sullivan *et al*., 2000. Glutathione S-transferase M1 polymorphism and lung cancer risk in African-Americans. Carcinogenesis, 21: 1971-1975.

Fryer, A.A., A. Bianco and M. Hepple *et al*., 2000. Polymorphism at the glutathione S-transferase *GSTP1* locus. A new marker for bronchial hyperresponsiveness and asthma. Am. J. Respir. Crit. Care Med., 161: 1437-1442.

Fustinoni, S., L. Soleo and M. Warholm *et al*., 2002. Influence of metabolic genotypes on biomarkers of exposure to 1,3-butadiene in humans. Cancer Epidemiol. Biomarkers Prev., 11: 1082-1090.

Gago-Dominguez, M., J.E. Castelao and C.L. Sun *et al*., 2004. Marine n-3 fatty acid intake, glutathione S-transferase polymorphisms and breast cancer risk in post-menopausal Chinese women in Singapore. Carcinogenesis, 25: 2143-2147.

Gajecka, M., M. Rydzanicz and R. Jaskula-Sztul *et al*., 2005. *CYP1A1*, *CYP2D6*, *CYP2E1*, *NAT2*, *GSTM1* and *GSTT1* polymorphisms or their combinations are associated with the increased risk of the laryngeal squamous cell carcinoma. Mutat. Res., 574: 112-123.

Gallegos-Arreola, M.P., B.C. Gomez-Meda and G. Morgan-Villela *et al*., 2003-2004. *GSTT1* gene deletion is associated with lung cancer in Mexican patients. Dis. Markers, 19: 259-261.

Gao, C.M., T. Takezaki and J.Z. Wu *et al*., 2002. Glutathione-S-transferases M1 (*GSTM1*) and *GSTT1* genotype, smoking, consumption of alcohol and tea and risk of esophageal and stomach cancers: A case-control study of a high-incidence area in Jiangsu Province, China. Cancer Lett., 188: 95-102.

Garcia-Closas, M., N. Malats and D. Silverman *et al*., 2005. NAT2 slow acetylation, *GSTM1* null genotype and risk of bladder cancer: Results from the Spanish Bladder Cancer Study and meta-analyses. Lancet, 366: 649-659.

Gaspar, P.A., M.H. Hutz and F.M. Salzano *et al*., 2002. Polymorphisms of *CYP1A1*, CYP2e1, *GSTM1*, *GSTT1* and TP53 genes in Amerindians. Am. J. Phys. Anthropol., 119: 249-256.

Gawronska-Szklarz, B., J. Lubinski and J. Kladny *et al*., 1999. Polymorphism of *GSTM1* gene in patients with colorectal cancer and colonic polyps. Exp. Toxicol. Pathol., 51: 321-325.

Gertig, D.M., M. Stampfer and C. Haiman *et al*., 1998. Glutathione S-transferase *GSTM1* and *GSTT1* polymorphisms and colorectal cancer risk: A prospective study. Cancer Epidemiol. Biomarkers Prev., 7: 1001-1005.

Gilliland, F.D., Y.F. Li and L. Dubeau *et al*., 2002. Effects of glutathione S-transferase M1, maternal smoking during pregnancy and environmental tobacco smoke on asthma and wheezing in children. Am. J. Respir. Crit. Care Med., 166: 457-463.

Girisha, K.M., A. Gilmour and S. Mastana *et al*., 2004. T1 and M1 polymorphism in glutathione S-transferase gene and coronary artery disease in North Indian population. Indian J. Med. Sci., 58: 520-526.

Gonzalez, M.V., V. Alvarez and M.F. Pello *et al*., 1998. Genetic polymorphism of N-acetyltransferase-2, glutathione S-transferase-M1 and cytochromes P450IIE1 and P450IID6 in the susceptibility to head and neck cancer. J. Clin. Pathol., 51: 294-298.

Goto, I., S. Yoneda, M. Yamamoto and K. Kawajiri, 1996. Prognostic significance of germ line polymorphisms of the *CYP1A1* and glutathione S-transferase genes in patients with non-small cell lung cancer. Cancer Res., 56: 3725-3730.

Gronau, S., D. Koenig-Greger, M. Jerg and H. Riechelmann, 2003. Gene polymorphisms in detoxification enzymes as susceptibility factor for head and neck cancer? Otolaryngol. Head Neck Surg., 128: 674-680.

Gudmundsdottir, K., L. Tryggvadottir and J.E. Eyfjord, 2001. *GSTM1*, *GSTT1* and *GSTP1* genotypes in relation to breast cancer risk and frequency of mutations in the p53 gene. Cancer Epidemiol. Biomarkers Prev., 10: 1169-1173.

Guo, J.Y., D.S. Wan, R.P. Zeng and Q. Zhang, 1996. The polymorphism of *GSTM1*, mutagen sensitivity in colon cancer and healthy control. Mutat. Res., 372: 17-22.

Haase, D., C. Binder, J. Bunger *et al*., 2002. Increased risk for therapy-associated hematologic malignancies in patients with carcinoma of the breast and combined homozygous gene deletions of glutathione transferases M1 and T1. Leuk. Res., 26: 249-254.

Habalova, V., J. Salagovic, I. Kalina and J. Stubna, 2004. Combined analysis of polymorphisms in glutathione S-transferase M1 and microsomal epoxide hydrolase in lung cancer patients. Neoplasma, 51: 352-357.

Hahn, M., G. Hagedorn, E. Kuhlisch *et al*., 2002. Genetic polymorphisms of drug-metabolizing enzymes and susceptibility to oral cavity cancer. Oral. Oncol., 38: 486-490.

Hakim, I.A., R.B. Harris, H.H. Chow *et al*., 2004. Effect of a 4-month tea intervention on oxidative DNA damage among heavy smokers: Role of glutathione S-transferase genotypes. Cancer Epidemiol. Biomarkers Prev., 13: 242-249.

Hamdy, S.I., M. Hiratsuka, K. Narahara *et al*., 2003. Genotype and allele frequencies of TPMT, NAT2, GST, SULT1A1 and MDR-1 in the Egyptian population. Br. J. Clin. Pharmacol., 55: 560-569.

Hamel, N., S. Karimi and M.N. Hebert-Blouin *et al*., 2000. Increased risk of head and neck cancer in association with *GSTT1* nullizygosity for individuals with low exposure to tobacco. Int. J. Cancer, 87: 452-454.

Hanna, E., S. MacLeod, E. Vural and N. Lang, 2001. Genetic deletions of glutathione-S-transferase as a risk factor in squamous cell carcinoma of the larynx: A preliminary report. Am. J. Otolaryngol., 22: 121-123.

Harada, S., H. Tachikawa and Y. Kawanishi, 2001. Glutathione S-transferase M1 gene deletion may be associated with susceptibility to certain forms of schizophrenia. Biochem. Biophys. Res. Commun., 281: 267-271.

Hashibe, M., P. Brennan and R.C. Strange *et al*., 2003. Meta- and pooled analyses of *GSTM1*, *GSTT1*, *GSTP1* and *CYP1A1* genotypes and risk of head and neck cancer. Cancer Epidemiol. Biomarkers Prev., 12: 1509-1517.

Hayashi, S., J. Watanabe and K. Kawajiri, 1992. High susceptibility to lung cancer analyzed in terms of combined genotypes of P450IA1 and Mu-class glutathione S-transferase genes. Jpn. J. Cancer Res., 83: 866-870.

He, J.Q., J.E. Connett and N.R. Anthonisen *et al*., 2004. Glutathione S-transferase variants and their interaction with smoking on lung function. Am. J. Respir. Crit. Care Med., 170: 388-394.

Helzlsouer, K.J., O. Selmin and H.Y. Huang *et al*., 1998. Association between glutathione S-transferase M1, P1 and T1 genetic polymorphisms and development of breast cancer. J. Natl. Cancer Inst., 90: 512-518.

Hernandez, A., W. Cespedes and N. Xamena *et al*., 2003. Glutathione S-transferase polymorphisms in thyroid cancer patients. Cancer Lett., 190: 37-44.

Hirvonen, A., K. Husgafvel-Pursiainen, S. Anttila and H. Vainio, 1993. The *GSTM1* null genotype as a potential risk modifier for squamous cell carcinoma of the lung. Carcinogenesis, 14: 1479-1481.

Holla, L.I., A. Stejskalova and A. Vasku, 2006. Polymorphisms of the *GSTM1* and *GSTT1* genes in patients with allergic diseases in the Czech population. Allergy, 61: 265-267.

Hong, Y.J., J.K. Lee, G.H. Lee and S.I. Hong, 2000. Influence of glutathione S-transferase M1 and T1 genotypes on larynx cancer risk among Korean smokers. Clin. Chem. Lab. Med., 38: 917-919.

Hong, Y.S., J.H. Chang and O.J. Kwon *et al*., 1998. Polymorphism of the *CYP1A1* and glutathione-S-transferase gene in Korean lung cancer patients. Exp. Mol. Med. 30: 192-198.

Hur, S.E., J.Y. Lee, H.S. Moon and H.W. Chung, 2005. Polymorphisms of the genes encoding the *GSTM1*, *GSTT1* and *GSTP1* in Korean women: No association with endometriosis. Mol. Hum. Reprod., 11: 15-19.

Inoue, H., C. Kiyohara and T. Marugame *et al*., 2000. Cigarette smoking, *CYP1A1* MspI and *GSTM1* genotypes and colorectal adenomas. Cancer Res., 60: 3749-3752.

Ivaschenko, T.E., O.G. Sideleva and V.S. Baranov, 2002. Glutathione- S-transferase micro and theta gene polymorphisms as new risk factors of atopic bronchial asthma. J. Mo.l Med., 80: 39-43.

Ivashchenko, T.E., O.G. Sideleva, M.A. Petrova *et al*., 2001. Genetic factors in predisposition to bronchial asthma Genetika, 37: 107-111. Russian.

Jahnke, V., C. Matthias, A. Fryer and R. Strange, 1996. Glutathione S-transferase and cytochrome-P-450 polymorphism as risk factors for squamous cell carcinoma of the larynx. Am. J. Surg., 172: 671-673.

Jong Jeong, H., H. Jin Kim and I. Young Seo *et al*., 2003. Association between glutathione S-transferase M1 and T1 polymorphisms and increased risk for bladder cancer in Korean smokers. Cancer Lett., 202: 193-199.

Jourenkova, N., M. Reinikainen and C. Bouchardy *et al*., 1998. Larynx cancer risk in relation to glutathione S-transferase M1 and T1 genotypes and tobacco smoking. Cancer Epidemiol. Biomarkers Prev., 7: 19-23.

Jourenkova, N., M. Reinikanen and C. Bouchardy *et al*., 1997. Effects of glutathione S-transferases *GSTM1* and *GSTT1* genotypes on lung cancer risk in smokers. Pharmacogenetics, 7: 515-518.

Jourenkova-Mironova, N., A. Voho and C. Bouchardy *et al*., 1999a. Glutathione S-transferase *GSTM1*, GSTM3, *GSTP1* and *GSTT1* genotypes and the risk of smoking-related oral and pharyngeal cancers. Int. J. Cancer, 81: 44-48.

Jourenkova-Mironova, N., A. Voho and C. Bouchardy *et al*., 1999b. Glutathione S-transferase GSTM3 and *GSTP1* genotypes and larynx cancer risk. Cancer Epidemiol. Biomarkers Prev., 8: 185-188.

Juronen, E., G. Tasa and S. Veromann *et al*., 2000. Polymorphic glutathione S-transferases as genetic risk factors for senile cortical cataract in Estonians. Invest. Ophthalmol. Vis. Sci., 41: 2262-2267.

Kabesch, M., C. Hoefler and D. Carr *et al*., 2004. Glutathione S transferase deficiency and passive smoking increase childhood asthma. Thorax, 59: 569-573.

Katoh, T., N. Nagata and Y. Kuroda *et al*., 1996. Glutathione S-transferase M1 (*GSTM1*) and T1 (*GSTT1*) genetic polymorphism and susceptibility to gastric and colorectal adenocarcinoma. Carcinogenesis, 17: 1855-1859.

Katoh, T., S. Kaneko and K. Kohshi *et al*., 1999. Genetic polymorphisms of tobacco- and alcohol-related metabolizing enzymes and oral cavity cancer. Int. J. Cancer, 83: 606-609.

Kelada, S.N., S.L. Kardia and A.H. Walker *et al*., 2000. The glutathione S-transferase-mu and -theta genotypes in the etiology of prostate cancer: genotype-environment interactions with smoking. Cancer Epidemiol. Biomarkers Prev., 9: 1329-1334.

Kellen, E., M. Zeegers and A. Paulussen *et al*., 2006. Fruit consumption reduces the effect of smoking on bladder cancer risk. The Belgian case control study on bladder cancer. Int. J. Cancer, 118: 2572-2578.

Kietthubthew, S., H. Sriplung and W.W. Au, 2001. Genetic and environmental interactions on oral cancer in Southern Thailand. Environ. Mol. Mutagen., 37: 111-116.

Kihara, M., M. Kihara and A. Kubota *et al*., 1997. *GSTM1* gene polymorphism as a possible marker for susceptibility to head and neck cancers among Japanese smokers. Cancer Lett., 112: 257-262.

Kirk, G.D., P.C. Turner and Y. Gong *et al*., 2005. Hepatocellular carcinoma and polymorphisms in carcinogen-metabolizing and DNA repair enzymes in a population with aflatoxin exposure and hepatitis B virus endemicity. Cancer Epidemiol. Biomarkers Prev., 14: 373-379.

Kiss, I., J. Sandor and G. Pajkos *et al*., 2000. Colorectal cancer risk in relation to genetic polymorphism of cytochrome P450 1A1, 2E1 and glutathione-S-transferase M1 enzymes. Anticancer Res., 20: 519-522.

Knudsen, L.E., H. Norppa and M.O. Gamborg *et al*., 1999. Chromosomal aberrations in humans induced by urban air pollution: influence of DNA repair and polymorphisms of glutathione S-transferase M1 and N-acetyltransferase 2. Cancer Epidemiol. Biomarkers Prev., 8: 303-310.

Ko, Y., J. Abel and V. Harth *et al*., 2001. Association of *CYP1B1* codon 432 mutant allele in head and neck squamous cell cancer is reflected by somatic mutations of p53 in tumor tissue. Cancer Res., 61: 4398-4404.

Kohan, L., S. Omidvari and M. Saadat, 2006. Combination of *XRCC1*, *GSTM1* and *GSTT1* genetic polymorphisms and susceptibility to male breast cancer. Int. J. Cancer Res., 2: 415-419.

Korytina, G.F., D.G. Yanbaeva and L.I. Babenkova *et al*., 2005. Genetic polymorphisms in the cytochromes P-450 (1A1, 2E1), microsomal epoxide hydrolase and glutathione S-transferase M1, T1 and P1 genes and their relationship with chronic bronchitis and relapsing pneumonia in children. J. Mol. Med., 83: 700-710.

Krajinovic, M., D. Labuda and D. Sinnett, 2002. Glutathione S-transferase P1 genetic polymorphisms and susceptibility to childhood acute lymphoblastic leukaemia. Pharmacogenetics, 12: 655-658.

Krajinovic, M., D. Labuda and C. Richer *et al*., 1999. Susceptibility to childhood acute lymphoblastic leukemia: influence of *CYP1A1*, *CYP2D6*, *GSTM1* and *GSTT1* genetic polymorphisms. Blood, 93: 1496-1501.

La Torre, G., S. Boccia and G. Ricciardi, 2005. Glutathione S-transferase M1 status and gastric cancer risk: a meta-analysis. Cancer Lett., 217: 53-60.

Ladero, J.M., C. Martinez and E. Garcia-Martin *et al*., 2006. Glutathione S-transferase M1 and T1 genetic polymorphisms are not related to the risk of hepatocellular carcinoma: A study in the Spanish population. Eur. J. Cancer, 42: 73-77.

Lan, Q., W.H. Chow and J. Lissowska *et al*., 2001. Glutathione S-transferase genotypes and stomach cancer in a population-based case-control study in Warsaw, Poland. Pharmacogenetics, 11: 655-661.

Lan, Q., X. He and D.J. Costa *et al*., 2000. Indoor coal combustion emissions, *GSTM1* and *GSTT1* genotypes and lung cancer risk: A case-control study in Xuan Wei, China. Cancer Epidemiol. Biomarkers Prev., 9: 605-608.

Lee, E., Y. Huang and B. Zhao *et al*., 1998. Genetic polymorphism of conjugating enzymes and cancer risk: *GSTM1*, *GSTT1*, NAT1 and NAT2. J. Toxicol. Sci., 23 (Suppl 2): 140-142.

Lee, S.J., S.H. Cho and S.K. Park *et al*., 2002. Combined effect of glutathione S-transferase M1 and T1 genotypes on bladder cancer risk. Cancer Lett., 177: 173-179.

Lemos, M.C., F.J. Cabrita and H.A. Silva *et al*., 1999. Genetic polymorphism of CYP2D6, *GSTM1* and NAT2 and susceptibility to haematological neoplasias. Carcinogenesis, 20: 1225-1229.

Lewis, S.J., N.M. Cherry and R.M. Niven *et al*., 2002. *GSTM1*, *GSTT1* and *GSTP1* polymorphisms and lung cancer risk. Cancer Lett., 180: 165-171.

Li, H., X.L. Chen and H.Q. Li, 2005. Polymorphism of CYPIA1 and *GSTM1* genes associated with susceptibility of gastric cancer in Shandong Province of China. World J. Gastroenterol., 11: 5757-5762.

Li, R., A.R. Folsom and A.R. Sharrett *et al*., 2001. Interaction of the glutathione S-transferase genes and cigarette smoking on risk of lower extremity arterial disease: the Atherosclerosis Risk in Communities (ARIC) study. Atherosclerosis, 154: 729-738.

Lien, S., A.K. Larsson and B. Mannervik, 2002. The polymorphic human glutathione transferase T1-1, the most efficient glutathione trasferase in the denitrosation and inactivation of the anticancer drug 1,3-bis(2-chloroethyl)-1-nitrosourea. Biochem. Pharmacol., 63: 191-197.

Loktionov, A., M.A. Watson and M. Gunter *et al*., 2001. Glutathione-S-transferase gene polymorphisms in colorectal cancer patients: interaction between *GSTM1* and GSTM3 allele variants as a risk-modulating factor. Carcinogenesis, 22: 1053-1060.

London, S.J., J.M. Yuan and F.L. Chung *et al*., 2000. Isothiocyanates, glutathione S-transferase M1 and T1 polymorphisms and lung-cancer risk: A prospective study of men in Shanghai, China. Lancet, 356: 724-729.

Luchtenborg, M., M.P. Weijenberg and E. Kampman *et al*., 2005. Cigarette smoking and colorectal cancer: APC mutations, hMLH1 expression and *GSTM1* and *GSTT1* polymorphisms. Am. J. Epidemiol., 161: 806-815.

Matthias, C., U. Bockmuhl and V. Jahnke *et al*., 1998. Polymorphism in cytochrome P450 CYP2D6, *CYP1A1*, CYP2E1 and glutathione S-transferase, *GSTM1*, GSTM3, *GSTT1* and susceptibility to tobacco-related cancers: Studies in upper aerodigestive tract cancers. Pharmacogenetics, 8: 91-100.

Maugard, C.M., J. Charrier and Y.J. Bignon, 1998. Allelic deletion at glutathione S-transferase M1 locus and its association with breast cancer susceptibility. Chem. Biol. Interact., 111-112: 365-375.

McWilliams, J.E., A.J. Evans and T.M. Beer *et al*., 2000. Genetic polymorphisms in head and neck cancer risk. Head Neck, 22: 609-617.

Mikelsaar, A.V., G. Tasa, P. Parlist and M. Uuskula, 1994. Human glutathione S-transferase *GSTM1* genetic polymorphism in Estonia. Hum. Hered., 44: 248-251.

Millikan, R., G. Pittman and C.K. Tse *et al*., 2000. Glutathione S-transferases M1, T1 and P1 and breast cancer. Cancer Epidemiol. Biomarkers Prev., 9: 567-573.

Mishra, D.K., A. Kumar, D.S. Srivastava and R.D. Mittal, 2004. Allelic variation of *GSTT1*, *GSTM1* and *GSTP1* genes in North Indian population. Asian Pac. J. Cancer Prev., 5: 362-365.

Mitrunen, K., N. Jourenkova and V. Kataja *et al*., 2001. Glutathione S-transferase M1, M3, P1 and T1 genetic polymorphisms and susceptibility to breast cancer. Cancer Epidemiol. Biomarkers Prev., 10: 229-236.

Mittal, R.D., D.S. Srivastava and A. Mandhani *et al*., 2004. Polymorphism of *GSTM1* and *GSTT1* genes in prostate cancer: A study from North India. Indian J. Cancer, 41: 115-119.

Mohammadzadeh Ghobadloo, S., B. Yaghmaei and A. Allameh *et al*., 2004. Polymorphisms of glutathione S-transferase M1, T1 and P1 in patients with HBV-related liver cirrhosis, chronic hepatitis and normal carriers. Clin. Biochem., 39: 46-49.

Moore, L.E., J.K. Wiencke and M.N. Bates *et al*., 2004. Investigation of genetic polymorphisms and smoking in a bladder cancer case-control study in Argentina. Cancer Lett., 211: 199-207.

Morari, E.C., J.L. Leite and F. Granja *et al*., 2002. The null genotype of glutathione S-transferase M1 and T1 locus increases the risk for thyroid cancer. Cancer Epidemiol. Biomarkers Prev., 11: 1485-1488.

Moreira, A., G. Martins and M.J. Monteiro *et al*., 1996. Glutathione S-transferase mu polymorphism and susceptibility to lung cancer in the Portuguese population. Teratog. Carcinog. Mutagen, 16: 269-274.

Morita, S., M. Yano and T. Tsujinaka *et al*., 1999. Genetic polymorphisms of drug-metabolizing enzymes and susceptibility to head-and-neck squamous-cell carcinoma. Int. J. Cancer, 80: 685-688.

Mu, L.N., Q.Y. Lu and S.Z. Yu *et al*., 2005. Green tea drinking and multigenetic index on the risk of stomach cancer in a Chinese population. Int. J. Cancer, 116: 972-983.

Mukanganyama, S., C.M. Masimirembwa, Y.S. Naik and J.A. Hasler, 1997. Phenotyping of the glutathione S-transferase M1 polymorphism in Zimbabweans and the effects of chloroquine on blood glutathione S-transferases M1 and A. Clin. Chim. Acta., 265: 145-155.

Nair, U.J., J. Nair, B. Mathew and H. Bartsch, 1999. Glutathione S-transferase M1 and T1 null genotypes as risk factors for oral leukoplakia in ethnic Indian betel quid/tobacco chewers. Carcinogenesis, 20: 743-748.

Nan, H.M., J.W. Park and Y.J. Song *et al*., 2005. Kimchi and soybean pastes are risk factors of gastric cancer. World J. Gastroenterol., 11: 3175-3181.

Naoe, T., K. Takeyama and T. Yokozawa *et al*., 2000. Analysis of genetic polymorphism in *NQO1*, GST-M1, GST-T1 and CYP3A4 in 469 Japanese patients with therapy-related leukemia/ myelodysplastic syndrome and de novo acute myeloid leukemia. Clin. Cancer Res., 6: 4091-4095.

Nazar-Stewart, V., T.L. Vaughan and P. Stapleton *et al*., 2003. A population-based study of glutathione S-transferase M1, T1 and P1 genotypes and risk for lung cancer. Lung Cancer, 40: 247-258.

Nedelcheva Kristensen, V., T.I. Andersen and B. Erikstein *et al*., 1998. Single tube multiplex polymerase chain reaction genotype analysis of *GSTM1*, *GSTT1* and *GSTP1*: Relation of genotypes to TP53 tumor status and clinicopathological variables in breast cancer patients. Pharmacogenetics, 8: 441-447.

Nimura, Y., S. Yokoyama and M. Fujimori *et al*., 1997. Genotyping of the *CYP1A1* and *GSTM1* genes in esophageal carcinoma patients with special reference to smoking. Cancer, 80: 852-857.

Okcu, M.F., M. Selvan and L.E. Wang *et al*., 2004. Glutathione S-transferase polymorphisms and survival in primary malignant glioma. Clin. Cancer Res., 10: 2618-2625.

Olshan, A.F., M.C. Weissler, M.A. Watson and D.A. Bell, 2000. *GSTM1*, *GSTT1*, *GSTP1*, *CYP1A1* and *NAT1* polymorphisms, tobacco use and the risk of head and neck cancer. Cancer Epidemiol. Biomarkers Prev., 9: 185-191.

Oude Ophuis, M.B., E.M. van Lieshout and H.M. Roelofs *et al*., 1998. Glutathione S-transferase M1 and T1 and cytochrome P4501A1 polymorphisms in relation to the risk for benign and malignant head and neck lesions. Cancer, 82: 936-943.

Ozturk, O., T. Isbir and I. Yaylim *et al*., 2003. *GSTM1* and *CYP1A1* gene polymorphism and daily fruit consumption in Turkish patients with non-small cell lung carcinomas. *In vivo*, 17: 625-632.

Palli, D., C. Saieva and S. Gemma *et al*., 2005. *GSTT1* and *GSTM1* gene polymorphisms and gastric cancer in a high-risk Italian population. Int. J. Cancer, 115: 284-289.

Park, H.S., E.H. Ha, K.H. Lee and Y.C. Hong, 2002. Benzo (a) pyrene-induced DNA-protein crosslinks in cultured human lymphocytes and the role of the *GSTM1* and *GSTT1* genotypes. J. Korean Med. Sci., 17: 316-321.

Park, J.Y., J.E. Muscat and Q. Ren *et al*., 1997. *CYP1A1* and *GSTM1* polymorphisms and oral cancer risk. Cancer Epidemiol. Biomarkers Prev., 6: 791-797.

Pavanello, S., P. Simioli and S. Lupi *et al*., 2002. Exposure levels and cytochrome P450 1A2 activity, but not N-acetyltransferase, glutathione S-transferase (GST) M1 and T1, influence urinary mutagen excretion in smokers. Cancer Epidemiol. Biomarkers Prev., 11: 998-1003.

Piirila, P., H. Wikman and R. Luukkonen *et al*., 2001. Glutathione S-transferase genotypes and allergic responses to diisocyanate exposure. Pharmacogenetics, 11: 437-445.

Pinarbasi, H., Y. Silig and M. Gurelik, 2005. Genetic polymorphisms of GSTs and their association with primary brain tumor incidence. Cancer Genet. Cytogenet., 156: 144-149.

Pinarbasi, H., Y. Silig and O. Cetinkaya *et al*., 2003. Strong association between the *GSTM1*-null genotype and lung cancer in a Turkish population. Cancer Genet. Cytogenet., 146: 125-129.

Quinones, L., D. Lucas and J. Godoy *et al*., 2001. *CYP1A1*, *CYP2E1* and *GSTM1* genetic polymorphisms. The effect of single and combined genotypes on lung cancer susceptibility in Chilean people. Cancer Lett., 174: 35-44.

Quinones, L., F. Berthou and N. Varela *et al*., 1999. Ethnic susceptibility to lung cancer: differences in CYP2E1, *CYP1A1* and *GSTM1* genetic polymorphisms between French Caucasian and Chilean populations. Cancer Lett., 141: 167-171.

Risch, A., H. Ramroth and V. Raedts *et al*., 2003. Laryngeal cancer risk in Caucasians is associated with alcohol and tobacco consumption but not modified by genetic polymorphisms in class I alcohol dehydrogenases ADH1B and ADH1C and glutathione-S-transferases *GSTM1* and *GSTT1*. Pharmacogenetics, 13: 225-230.

Rollinson, S., P. Roddam and E. Kane *et al*., 2000. Polymorphic variation within the glutathione S-transferase genes and risk of adult acute leukaemia. Carcinogenesis, 21: 43-47.

Romieu, I., J.J. Sienra-Monge and M. Ramirez-Aguilar *et al*., 2004. Genetic polymorphism of *GSTM1* and antioxidant supplementation influence lung function in relation to ozone exposure in asthmatic children in Mexico City. Thorax, 59: 8-10.

Roodi, N., W.D. Dupont, J.H. Moore and F.F. Parl, 2004. Association of homozygous wild-type glutathione S-transferase M1 genotype with increased breast cancer risk. Cancer Res., 64: 1233-1236.

Rossini, A., D.C. Rapozo and L.M. Amorim *et al*., 2002. Frequencies of *GSTM1*, *GSTT1* and *GSTP1* polymorphisms in a Brazilian population. Genet. Mol. Res., 1: 233-240.

Ruano-Ravina, A., A. Figueiras, L. Loidi and J.M. Barros-Dios, 2003. *GSTM1* and *GSTT1* polymorphisms, tobacco and risk of lung cancer: A case-control study from Galicia, Spain. Anticancer Res., 23: 4333-4337.

Ryberg, D., V. Skaug and A. Hewer *et al*., 1997. Genotypes of glutathione transferase M1 and P1 and their significance for lung DNA adduct levels and cancer risk. Carcinogenesis, 18: 1285-1289.

Saadat, I. and M. Saadat, 2000. The glutathione S-transferase mu polymorphism and susceptibility to acute lymphocytic leukemia. Cancer Lett., 158: 43-45.

Saadat, I. and M. Saadat, 2001. Glutathione S-transferase M1 and T1 null genotypes and the risk of gastric and colorectal cancers. Cancer Lett., 169: 21-26.

Saadat, I. and M. Saadat, 2003a. Glutathione S-transferase M1 and T1 null genotypes and risk of breast cancer. Arch. Iranian Med., 6: 273-277.

Saadat, M., 2006. Genetic polymorphisms of glutathione S-transferase T1 (*GSTT1*) and susceptibility to gastric cancer: A meta-analysis. Cancer Sci., 97: 505-509.

Saadat, M. and H. Mohabatkar, 2004. Polymorphisms of glutathione S-transferases M1 and T1 do not account for interindividual differences for smoking behavior. Pharmacol. Biochem. Behavior, 77: 793-795.

Saadat, M., A. Bahaoddini and H. Mohabatkar, 2004a. Polymorphisms of glutathione S-transferase M1 and T1 modulate blood pressure of individuals chronically exposed to natural sour gas containing sulfur compounds. Biochem. Biophys. Res. Commun., 316: 749-752.

Saadat, M. and I. Saadat, 2003b. Offspring sex ratio is not associated with parental *GSTT1* and *GSTM1* null genotypes. Reprod. Toxicol., 17: 345-347.

Saadat, M., I. Saadat, Z. Saboori and A. Emad, 2004b. Combination of *CC16*, *GSTM1* and *GSTT1* genetic polymorphisms is associated with asthma. J. Allergy Clin. Immunol., 113: 996-998.

Saadat, M., M. Farvardin-Jahromi and H. Saadat, 2004c. Null genotype of glutathione S-transferase M1 is associated with senile cataract susceptibility in non-smoker females. Biochem. Biophys. Res. Commun., 319: 1287-1291.

Saarikoski, S.T., A. Voho and M. Reinikainen *et al*., 1998. Combined effect of polymorphic *GST* genes on individual susceptibility to lung cancer. Int. J. Cancer, 77: 516-521.

Salagovic, J., I. Kalina and J. Stubna *et al*., 1998. Genetic polymorphism of glutathione S-transferases M1 and T1 as a risk factor in lung and bladder cancers. Neoplasma, 45: 312-317.

Salagovic, J., I. Kalina and V. Habalova *et al*., 1999. The role of human glutathione S-transferases M1 and T1 in individual susceptibility to bladder cancer. Physiol. Res., 48: 465-471.

Sarmanova, J., L. Tynkova and S. Susova *et al*., 2000. Genetic polymorphisms of biotransformation enzymes: Allele frequencies in the population of the Czech Republic. Pharmacogenetics, 10: 781-788.

Sasai, Y., S. Horiike and S. Misawa *et al*., 1999. Genotype of glutathione S-transferase and other genetic configurations in myelodysplasia. Leuk. Res., 23: 975-981.

Sata, F., H. Yamada and T. Kondo *et al*., 2003. Glutathione S-transferase M1 and T1 polymorphisms and the risk of recurrent pregnancy loss. Mol. Hum. Reprod., 9: 165-169.

Sato, M., T. Sato, T. Izumo and T. Amagasa, 1999. Genetic polymorphism of drug-metabolizing enzymes and susceptibility to oral cancer. Carcinogenesis, 20: 1927-1931.

Schneider, J., U. Bernges, M. Philipp and H.J. Woitowitz, 2004. *GSTM1*, *GSTT1* and *GSTP1* polymorphism and lung cancer risk in relation to tobacco smoking. Cancer Lett., 208: 65-74.

Schoket, B., G. Papp and K. Levay *et al*., 2001. Impact of metabolic genotypes on levels of biomarkers of genotoxic exposure. Mutat. Res., 482: 57-69.

Seedhouse, C., R. Faulkner and N. Ashraf *et al*., 2004. Polymorphisms in genes involved in homologous recombination repair interact to increase the risk of developing acute myeloid leukemia. Clin. Cancer Res., 10: 2675-2680.

Sekine, Y., S. Hommura and S. Harada, 1995. Frequency of glutathione-S-transferase 1 gene deletion and its possible correlation with cataract formation. Exp. Eye Res., 60: 159-163.

Seow, A., J.M. Yuan and C.L. Sun *et al*., 2002. Dietary isothiocyanates, glutathione S-transferase polymorphisms and colorectal cancer risk in the Singapore Chinese Health Study. Carcinogenesis, 23: 2055-2061.

Sepehr, A., F. Kamangar and C.C. Abnet *et al*., 2004. Genetic polymorphisms in three Iranian populations with different risks of esophageal cancer, an ecologic comparison. Cancer Lett., 213: 195-202.

Setiawan, V.W., Z.F. Zhang and G.P. Yu *et al*., 2000. *GSTT1* and *GSTM1* null genotypes and the risk of gastric cancer: a case-control study in a Chinese population. Cancer Epidemiol. Biomarkers Prev., 9: 73-80.

Sgambato, A., B. Campisi and A. Zupa *et al*., 2002. Glutathione S-transferase (*GST*) polymorphisms as risk factors for cancer in a highly homogeneous population from southern Italy. Anticancer Res., 22: 3647-3652.

Sharma, A., A. Mishra and B.C. Das *et al*., 2006. Genetic polymorphism at *GSTM1* and *GSTT1* gene loci and susceptibility to oral cancer. Neoplasma, 53: 309-315.

Slattery, M.L., J.D. Potter and W. Samowitz *et al*., 1998. NAT2, GSTM-1, cigarette smoking and risk of colon cancer. Cancer Epidemiol. Biomarkers Prev., 7: 1079-1084.

Sobti, R.C., A.I. Al-Badran and S. Sharma *et al*., 2005. Genetic polymorphisms of CYP2D6, *GSTM1* and *GSTT1* genes and bladder cancer risk in North India. Cancer Genet. Cytogenet., 156: 68-73.

Sobti, R.C., S. Kaur and P. Kaur *et al*., 2006. Interaction of passive smoking with GST (*GSTM1*, *GSTT1* and *GSTP1*) genotypes in the risk of cervical cancer in India. Cancer Genet. Cytogenet., 166: 117-123.

Sobti, R.C., S. Sharma and A. Joshi *et al*., 2004. Genetic polymorphism of the *CYP1A1*, CYP2E1, *GSTM1* and *GSTT1* genes and lung cancer susceptibility in a north Indian population. Mol. Cell Biochem., 266: 1-9.

Somorovska, M., E. Jahnova and J. Tulinska *et al*., 1999. Biomonitoring of occupational exposure to styrene in a plastics lamination plant. Mutat. Res., 428: 255-269.

Sreelekha, T.T., K. Ramadas and M. Pandey *et al*., 2001. Genetic polymorphism of *CYP1A1*, *GSTM1* and *GSTT1* genes in Indian oral cancer. Oral. Oncol., 37: 593-598.

Srivastava, D.S., A. Kumar, B. Mittal and R.D. Mittal, 2004. Polymorphism of *GSTM1* and *GSTT1* genes in bladder cancer: a study from North India. Arch. Toxicol., 78: 430-434.

Stoehlmacher, J., D.J. Park and W. Zhang *et al*., 2002. Association between glutathione S-transferase P1, T1 and M1 genetic polymorphism and survival of patients with metastatic colorectal cancer. J. Nat. Cancer Inst., 94: 936-942.

Stucker, I., M. Jacquet and I. de Waziers *et al*., 2000. Relation between inducibility of *CYP1A1*, *GSTM1* and lung cancer in a French population. Pharmacogenetics, 10: 617-627.

Sull, J.W., H. Ohrr, D.R. Kang and C.M. Nam, 2004. Glutathione S-transferase M1 status and breast cancer risk: a meta-analysis. Yonsei Med. J., 45: 683-689.

Sweeney, C., D.C. Farrow and S.M. Schwartz *et al*., 2000. Glutathione S-transferase M1, T1 and P1 polymorphisms as risk factors for renal cell carcinoma: A case-control study. Cancer Epidemiol. Biomarkers Prev., 9: 449-454.

Sweeney, C., V. Nazar-Stewart and P.L. Stapleton *et al*., 2003. Glutathione S-transferase M1, T1 and P1 polymorphisms and survival among lung cancer patients. Cancer Epidemiol. Biomarkers Prev., 12: 527-533.

Tamer, L., M. Calikoglu and N.A. Ates *et al*., 2004. Glutathione-S-transferase gene polymorphisms (*GSTT1*, *GSTM1*, *GSTP1*) as increased risk factors for asthma. Respirology, 9: 493-498.

Tamer, L., N.A. Ates and C. Ates *et al*., 2005. Glutathione S-transferase M1, T1 and P1 genetic polymorphisms, cigarette smoking and gastric cancer risk. Cell Biochem. Funct., 23: 267-272.

Tan, W., N. Song and G.Q. Wang *et al*., 2000. Impact of genetic polymorphisms in cytochrome P450 2E1 and glutathione S-transferases M1, T1 and P1 on susceptibility to esophageal cancer among high-risk individuals in China. Cancer Epidemiol. Biomarkers Prev., 9: 551-556.

Tanimoto, K., S. Hayashi, K. Yoshiga and T. Ichikawa, 1999. Polymorphisms of the *CYP1A1* and *GSTM1* gene involved in oral squamous cell carcinoma in association with a cigarette dose. Oral. Oncol., 35: 191-196.

Tasa, G., E. Juronen and M. Viikmaa *et al*., 1996. Distribution of glutathione S-transferase T1 phenotypes in the Estonian population. Gene Geogr., 10: 181-189.

Tiemersma, E.W., R.E. Omer and A. Bunschoten *et al*., 2001. Role of genetic polymorphism of glutathione-S-transferase T1 and microsomal epoxide hydrolase in aflatoxin-associated hepatocellular carcinoma. Cancer Epidemiol. Biomarkers Prev., 10: 785-791.

To-Figueras, J., M. Gene and J. Gomez-Catalan *et al*., 1997. Glutathione S-transferase M1 (*GSTM1*) and T1 (*GSTT1*) polymorphisms and lung cancer risk among Northwestern Mediterraneans. Carcinogenesis, 18: 1529-1533.

Toncheva, D.I., N. Von Ahsen and S.Y. Atanasova *et al*., 2004. Identification of *NQO1* and GSTs genotype frequencies in Bulgarian patients with Balkan endemic nephropathy. J. Nephrol., 17: 384-389.

Torres, M.M., C.P. Acosta and D.M. Sicard *et al*., 2004. Genetic susceptibility and risk of gastric cancer in a human population of Cauca, Colombia] Biomedica, 24: 153-162. Spanish.

Toruner, G.A., C. Akyerli and A. Ucar *et al*., 2001. Polymorphisms of glutathione S-transferase genes (*GSTM1*, *GSTP1* and *GSTT1*) and bladder cancer susceptibility in the Turkish population. Arch. Toxicol., 75: 459-464.

Tripathy, C.B. and N. Roy, 2006. Meta-analysis of glutathione S-transferase M1 genotype and risk toward head and neck cancer. Head Neck 28: 217-224.

Trizna, Z., G.L. Clayman and M.R. Spitz *et al*., 1995. Glutathione S-transferase genotypes as risk factors for head and neck cancer. Am. J. Surg., 170: 499-501.

Tsabouri, S., I. Georgiou, A. Katsaraki and K.L. Bourantas, 2004. Glutathione sulfur transferase M1 and T1 genotypes in chronic lymphoblastic leukemia. Hematol. J., 5: 500-504.

Tuimala, J., G. Szekely and S. Gundy *et al*., 2002. Genetic polymorphisms of DNA repair and xenobiotic-metabolizing enzymes: role in mutagen sensitivity. Carcinogenesis, 23: 1003-1008.

Vakhitova. IuV., Z.M. Sultanaeva, T.V. Viktorova *et al*., 2001. Analysis of polymorphism of the glutathione S-transferase gene in populations of the Volga-Ural region Genetika, 37: 268-270. Russian.

van Delft, J.H., M.S. Steenwinkel and J.G. van Asten *et al*., 2001. Biological monitoring the exposure to polycyclic aromatic hydrocarbons of coke oven workers in relation to smoking and genetic polymorphisms for *GSTM1* and *GSTT1*. Ann. Occup. Hyg., 45: 395-408.

Voho, A., O. Impivaara and J. Jarvisalo *et al*., 2006. Distribution of glutathione S-transferase M1, P1 and T1 genotypes in different age-groups of Finns without diagnosed cancer. Cancer Detect. Prev., 30: 144-151.

Wang, J., Y. Deng, J. Cheng, J. Ding and S. Tokudome, 2003. GST genetic polymorphisms and lung adenocarcinoma susceptibility in a Chinese population. Cancer Lett., 201: 185-193.

Welfare, M., A. Monesola Adeokun, M.F. Bassendine and A.K. Daly, 1999. Polymorphisms in *GSTP1*, *GSTM1* and *GSTT1* and susceptibility to colorectal cancer. Cancer Epidemiol. Biomarkers Prev., 8: 289-292.

Westphal, G.A., A. Schnuch and T.G. Schulz *et al*., 2000. Homozygous gene deletions of the glutathione S-transferases M1 and T1 are associated with thimerosal sensitization. Int. Arch. Occup. Environ. Health, 73: 384-388.

Woo, M.H., J.J. Shuster and C. Chen *et al*., 2000. Glutathione S-transferase genotypes in children who develop treatment-related acute myeloid malignancies. Leukemia, 14: 232-237.

Wrensch, M., K.T. Kelsey and M. Liu *et al*., 2004. Glutathione-S-transferase variants and adult glioma. Cancer Epidemiol. Biomarkers Prev., 13: 461-467.

Yang, G., X.O. Shu and Z.X. Ruan *et al*., 2005. Genetic polymorphisms in glutathione S-transferase genes (*GSTM1*, *GSTT1* and *GSTP1*) and survival after chemotherapy for invasive breast carcinoma. Cancer, 103: 52-58.

Ye, Z. and H. Song, 2005. Glutathione S-transferase polymorphisms (*GSTM1*, *GSTP1* and *GSTT1*) and the risk of acute leukaemia: A systematic review and meta-analysis. Eur. J. Cancer, 41: 980-989.

Ye, Z. and J.M. Parry, 2002. Genetic polymorphisms in the cytochrome P450 1A1, glutathione S-transferase M1 and T1 and susceptibility to colon cancer. Teratog. Carcinog. Mutagen, 22: 385-392.

Ye, Z. and J.M. Parry, 2003. A meta-analysis of 20 case-control studies of the glutathione S-transferase M1 (*GSTM1*) status and colorectal cancer risk. Med. Sci. Monit., 9: SR83-91.

Ye, Z., H. Song and J.P. Higgins *et al*., 2006. Five glutathione S-transferase gene variants in 23,452 cases of lung cancer and 30, 397 controls: Meta-analysis of 130 studies. PLoS. Med., 3: e91.

Yim, J.J., G.Y. Park and C.T. Lee *et al*., 2000. Genetic susceptibility to chronic obstructive pulmonary disease in Koreans: combined analysis of polymorphic genotypes for microsomal epoxide hydrolase and glutathione S-transferase M1 and T1. Thorax, 55: 121-125.

Zhao, B., A. Seow and E.J. Lee *et al*., 2001. Dietary isothiocyanates, glutathione S-transferase -M1, -T1 polymorphisms and lung cancer risk among Chinese women in Singapore. Cancer Epidemiol. Biomarkers Prev., 10: 1063-1067.

Zhao, B., E.J. Lee and J.Y. Wong *et al*., 1995. Frequency of mutant *CYP1A1*, NAT2 and *GSTM1* alleles in normal Indians and Malays. Pharmacogenetics, 5: 275-280.

Zhong, S., A.H. Wyllie and D. Barnes *et al*., 1993. Relationship between the *GSTM1* genetic polymorphism and susceptibility to bladder, breast and colon cancer. Carcinogenesis, 14: 1821-1824.

Zhong, S.L., S. Zhou, X. Chen and M. Huang, 2006. Rapid determination of common mutations in glutathione S-transferase gene by PCR-based methods in healthy Chinese. Clin. Chim. Acta., 364: 205-208.