

## The causes of deaths in an industry-dense area: example of Dilovası (Kocaeli)\*

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**Aim:** Chemical pollutants caused by the industry have changed both mortality rates and morbidity patterns causing new illnesses over the last few decades. This study aimed to determine the causes and characteristics of deaths related to cancer in 2004 in Dilovası, Kocaeli, which was mainly used as a production, storage, and transfer area for a variety of industries, such as chemical, metal and metal products, energy, and machinery.

**Materials and methods:** In this cross-sectional study, death records of 8 different registry/record screenings belonging to 4 public institutions in Dilovası in 2004 were investigated. The study population included deaths in 2004 and those whose residencies were in Dilovası.

**Results:** Thirty-three percent of the deaths were caused by cancer, which was diagnosed by a health institution. The risk of death due to cancer was 4.4 (CI: 1.05-21.3) times higher for people who have lived in Dilovası for more than 10 years than the ones who lived there for less than 10 years. This did not change according to age groups and smoking status.

**Conclusion:** As the proportion of deaths caused by cancer is 3 times higher than both the national and world data records, the situation in Dilovası is a public health problem that should be dealt with as soon as possible.

**Key words:** Air pollution, cancer, mortality, industrial area, environment

### Endüstri yoğun bölgede yaşayanlarda ölüm nedenleri: Dilovası örneği (Kocaeli)

**Amaç:** Son bir kaç dekattır sanayi kaynaklı kimyasal kirleticiler, toplumda mortalite hızını ve morbidite paternini değiştirmiş, yeni hastalıkların ortaya çıkmasına neden olmuştur. Bu çalışma, Kocaeli’nde, özellikle kimya, metal ve metal ürünleri, enerji ile makine ve endüstriyel ürünler sektörünün ağırlıklı olarak üretim, depolama ve transfer alanı olarak kullanmakta olduğu Dilovası Beldesindeki 2004 yılı ölümlerinin nedenlerinin saptanması amacıyla gerçekleştirilmiştir.

**Yöntem ve gereç:** Bu kesitsel çalışma Dilovası’ndaki ölümleri saptamak amacıyla dört kamu kurumuna ait sekiz ayrı belge/kayıt taranmıştır. İkameti Dilovası’nda olanlar ve ölümü 2004 yılı içinde gerçekleşenler çalışma kapsamına alınmıştır.

**Bulgular:** Ölenlerin % 33’ü bir sağlık kurumu tarafından tanılanmış kanser hastası olup, ölümleri buna bağlı gerçekleşmiştir. Ölümlerde 10 yıl ve daha uzun süredir Dilovası’nda yaşayanlarda kanser nedeniyle ölme riskinin 10 yıldan az yaşayanlara göre 4.4 (CI: 1,05-21,3) kat daha fazladır. Bu, yaş gruplarına ve sigara içme durumuna göre değişmemiştir.

**Sonuç:** Dilovası’nda kanserden ölme sıklığı Türkiye ve dünya verilerinden üç kat daha fazla olduğu için, bu durum, öncelikli müdahale edilmesi gereken bir halk sağlığı sorunudur.

**Anahtar sözcükler:** Hava kirliliği, kanser, ölümlülük, endüstriyel bölge, çevre

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## Introduction

Environmental pollution has become a global issue affecting the public health. The main 2 reasons for environmental pollution are industrialisation and urbanisation. Chemical pollutants caused by the industry have changed both mortality rates and mortality patterns causing new illnesses over the last few decades. It is known that industrial pollution and cancer are becoming more apparent (1).

It is possible to set up various studies, from descriptive epidemiologic studies to controlled studies, to determine the effects of pollution on public health (2). In addition, a wide spectrum of techniques, from basic statistical techniques to sophisticated modelling in which advanced analysis are used, can be applied as well (3). The mortality studies, for the first step of research, carried out regarding environmental epidemiology are of great value as they further enrich the studies (4). It is suggested that the cancer incidences and mortality rates for those with lung cancer, especially in non-smokers, ought to be exploited further to calculate the effects of environmental pollution on health (5).

Kocaeli is one of the most polluted provinces in Turkey as it is a dense industry area and the country's largest highway passes through the city. Industry-based investments have continued without letup since the 1960s after the planning term of Turkey commenced. Fifteen percent of Turkey's accumulative manufacturing industry has been based in Kocaeli over the last 10 years. The share of industry in the Gross National Product for Kocaeli is approximately 73%. There are many leading sectors in the manufacturing industry of the region, such as chemicals and chemical products, basic metal industries, and metal products industry. The share of these sectors in the country is 27%, 21%, and 20%, respectively (6).

Industrial pollution may alter depending on the industrial facilities in the area and can also be seen by the air pollution caused by the pollutant gases emitted (7). Studies have shown that in the residential areas where air pollution is more intense, both morbidity and mortality rates are higher compared to other residential areas. This situation is quite common as the increase of respiratory diseases, cancer incidences, and mortality rates caused by cancer

risks (8-10). Studies on the association between air pollution and cancer reported an increase of lung, liver, and haematopoietic cancer incidences in more polluted areas (10,11). Of the deaths throughout the world, 12.5% is known to be caused by cancer (12), which is 13% in Turkey (13). In research carried out over the past 10 years concerning the burial registry of the Dilovası Municipality, it was determined that 161 deaths (32%), out of 505, were caused by cancer (14). Whereas the proportion throughout Kocaeli is 19%, it is 8% in Kandira region, which is far away from industry. According to the same records, 44% of all cancers originate in the lungs. This is followed by gastrointestinal cancer (25%) and haematopoietic cancer (11%) (15). When the differences between mortality and morbidity patterns are taken into consideration in the residential areas where industry is intense, the need to study the increased cancer mortality in Dilovası is becoming more apparent.

This study aimed to determine the causes and characteristics of deaths related to cancer in 2004 in Dilovası, Turkey, which was mainly used as a production, storage, and transfer area for a variety of industries, such as chemical, metal and metal products, energy, and machinery.

## Materials and methods

This cross sectional study was conducted in the centre of Dilovası district. Dilovası is a district in Kocaeli with 9 seaports, located closely to İstanbul, through which D-100 and TEM highways pass. Since the 1980s, Dilovası has been experiencing significant population growth due to the free trade arrangements and the increase of industrialisation resulting from private sector investments. The population of the town reached 38,418 as of 2000, an increase from 10,600 in 1985 (16,17).

The Dilovası Organized Industrial Zone (DOIZ) is located right in the centre of the district. The legislation for the DOIZ was approved by the Ministry of Industry and Trade in May 2002 and 174 companies are registered. Thirteen percent of the firms in the area operate within the metal and metal products industry sector. A number of these plants process scrap metal. Eleven percent is heavily involved within the paint and chemical industry sector (18).

First, a list of those who had passed away in 2004 was compiled using both registries and these documents collected routinely by 4 different public institutions. These data were obtained from Dilovası Municipality (burial registry of the municipality, death registries of the municipality, and burial reports of the cemeteries of Dilovası), population office (death registration lists, and central vital statistics management system), Kocaeli District Health Directorate (health statistics department and registries of hospitals), and Kocaeli Forensic Medicine Office.

One hundred and nine deaths were determined in these records and documents. Among these 109 deaths, 24 had lived in other places and were buried in Dilovası, 3 were listed as having passed away in 2004 despite the fact they had died before, and 2 of these death records were those of stillborns. Two of them were only listed in one registry each and have yet to be found in other records. Based on these reasons, 31 records were excluded from the study. The remaining 78 deaths, ascertained in the records belonging to 4 public institutions, were residents of Dilovası and their deaths occurred in 2004.

Data were collected using a questionnaire and a verbal autopsy on 24-28 January, 2005. The questionnaire included questions related to age, sex, occupation, duration of residence in the district, characteristics of living quarters, type of heating used in the house, smoking habits, etc. The data were collected by 2 teams consisting of 2 public health specialists and research assistants. Face to face interviews with relatives of the dead person were conducted during home visits. The results showed that 76.8% of the participants who used to live in the same house and gave information were close relatives (mother, father, brother, sister, spouse, or children). The remaining 23.2% were residents of the same home yet not close relatives, such as grandchildren, cousins, or in-laws.

For determination of the cause of death, the documents provided by hospitals and other institutions were examined. If the documents were unavailable or found to be insufficient, a verbal autopsy method including a detailed system questionnaire was used (13) (Figure).

Causes of death were classified as; 1) deaths related to cancer, 2) death related to the respiratory

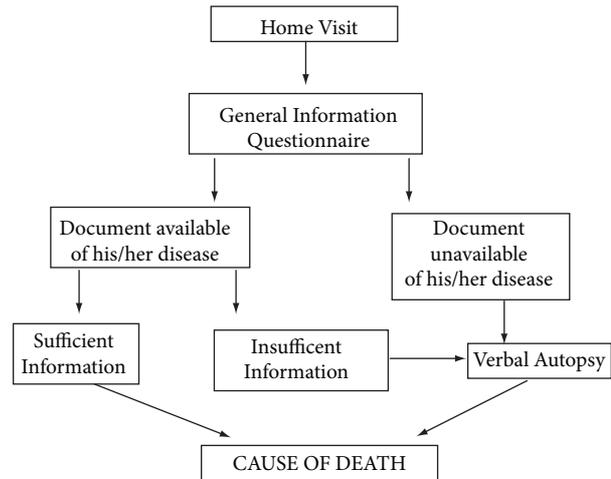


Figure. Flowchart following the determination of causes of deaths.

system diseases excluding cancer, 3) deaths related to the circulatory system, 4) others. People whose relatives were said to have died of cancer were all in possession of the documents taken from hospitals and the other institutions. For this reason, verbal autopsy method was used for the ones who died of an illness other than cancer.

Written permission for the study was obtained from the Dilovası Municipality. Relatives of the dead person were informed both verbally and in writing about the research, and those who agreed to participate were included in the study.

Data were analysed by Epi Info Version 3.3.2, a data analysis software package (19). To compare the rates among the groups, Pearson's chi-square test was used. Mantel-Haenszel chi-square analysis was used to find out if smoking habits and age were confounding factors.

## Results

The crude death rate was 2.0 per 1000 population. Of the 78 deaths, 44 (56.4%) were men and 34 (43.6%) were women (Table 1). The mean age of those who passed away was  $57.1 \pm 23.8$ , the minimum 1-month-old and maximum 102 years of age. Four were infant deaths. Eighteen (19.2%) of the deaths occurred within hospitals. It was found that 67.9% had emigrated from the East Anatolia region and 15.4% from the Black Sea region. Only 4 of the

Table 1. Some characteristics of the study population in Dilovası.

Characteristics	N	%
<b>Gender</b>		
<i>Male</i>	44	56.4
<i>Female</i>	34	43.6
<b>Age Groups</b>		
$\leq 19$	9	11.5
20-44	7	9.0
45-59	11	14.1
$\geq 60$	51	65.4
<b>Duration of living in Dilovası</b>		
$\leq 4$ years	14	17.9
5-9 years	8	10.3
10-19 years	24	30.8
20-29 years	19	24.4
30-39 years	10	12.8
$\geq 40$ years	3	3.8
<b>Total</b>	<b>78</b>	<b>100.0</b>

deceased persons were born in Dilovası. Three of those were in the 0-4 age group and the others were in the 20-24 age group. The average duration they lived in Dilovası was  $17.4 \pm 11.7$  years and the median value was 17 years. Except for the 4 people who were born in Dilovası, the duration of life in Dilovası was calculated by deducting the year of death from the year in which they had migrated to Dilovası.

In Table 2, the distribution of deaths according to their causes is shown. The proportion of cancer among the deaths was determined as 33.3%, approximately

Table 2. Distribution of mortality causes in Dilovası (2004).

Cause of death	%
<b>Cancer (Malignancy)</b>	
<i>Lung cancer</i>	46.2
<i>Stomach cancer</i>	26.9
<i>Prostate cancer</i>	11.5
<i>Colorectal cancer</i>	11.5
<i>Miscellaneous</i>	3.9
Other respiratory diseases except cancer	16.7
Cardiovascular disease	14.1
Miscellaneous	35.9
<b>Total</b>	<b>100.0</b>

half of which were lung cancer (46.2%). Of the deaths that are not related to cancer, respiratory system diseases are in the second place with an average of 16.7%.

Thirty-five percent of the subjects who died from cancer were housewives, 23% were farmers, and 15% were construction workers. None of them worked in industrial sectors. Cancer causes were not significantly correlated with gender (chi-square = 1.277, df = 1, P = 0.258).

The risk of death related to cancer for people who have lived in Dilovası for more than 10 years is 4 times higher than the ones who have lived there less than 10 years (odds ratio: 4.4; CI: 1.05-21.3) (Table 3). Cancer due to living in Dilovası for a period of more than 10 years depends on age groups and smoking habits (Tables 4 and 5).

Table 3. Distribution of the deaths according to duration of life in Dilovası (2004).

Duration of living in Dilovası	Cancer	Other causes
$\geq 10$ years	23	33
$\leq 9$ years	3	19
OR = 4.41 (CI = 1.05-21.3)		

## Discussion

As a result of this study, which aims to determine the causes of mortality in Dilovası, it was ascertained that the proportion of deaths related to cancer in Dilovası, where industrial and residential areas are very closely located, are higher than that of Turkey as well as the rest of the world.

It is known that being exposed to air pollution for a long time increases the risk of respiratory illnesses and respiratory system cancers (20). It has also been observed that the mortality rate related to lung cancer has increased due to air pollution caused by industry (21,22). According to the World Health Report 2004, 12.5% of the deaths in the world are caused by cancer (12). It was found in the present study that the rate of cancer-related death in Dilovası (33%) is 2.6- and 2.7-fold more than that of Turkey and the world, respectively.

Table 4. Distribution according to duration of life and age groups at death from cancer and other causes in Dilovası.

Duration of living in Dilovası	Age groups			
	≤44 Years		≥45 Years	
	Cancer	Other causes	Cancer	Other causes
≥10 years	4	4	19	29
≤9 years	-	8	3	11
	OR = 0.00		OR = 2.40	

Mantel-Haenszel Chi-Square Analysis OR = 3.83 P > 0.05

Table 5. Distribution according to living duration and smoking status at death from cancer and other causes in Dilovası.

	Smoker or Ceased		Non-smoker	
	Cancer	Other causes	Cancer	Other causes
	≥10 years	15	15	8
≤9 years	3	3	-	16
	OR = 1.0		OR = 0.0	

Mantel-Haenszel Chi-Square Analysis OR = 3.44 P > 0.05

When cancer-related deaths are taken into consideration, the respiratory system cancers are far more than expected. According to the findings of WHO, of the deaths throughout the world, 17.5% are lung, 11.9% are stomach, 8.7% are colorectal, and 3.8% are prostate cancers (12). This study showed that among the deaths caused by cancer in Dilovası in 2004, lung cancer is 2.6, prostate cancer is 2.6, and stomach cancer is 2.3, times higher than the overall average around the world.

One of the biggest difficulties of studying the long-term effects of air pollution is the measurement of the pollution levels (23). Approximately 30,000 chemicals are commonly used today in industry and less than 1% of these have been subjected to a detailed assessment in terms of their toxicity and health risks (24). Some pollutants, such as suspended particular matter, sulphur dioxide, nitrogen dioxide, ozone, and carbon monoxide, are used for routine air quality monitoring. In spite of the fact that the carcinogenic

substances are found in air pollutants and that these pollutants are determined to increase the risk of cancer, these substances cannot be monitored in routine measurements. It is also difficult to determine the level of exposure of the people living in the area as it is effected by both atmospheric dispersion and meteorological conditions (24). For this reason, the known outcomes of contaminants on humans are usually based on occupational medicinal studies.

The urban settlement in Dilovası has grown rapidly since the 1970s when the industrial enterprises have started being established and during this time the distance between the enterprises and the residences has started vanishing. Despite the fact that metal dust and smoke emitted by the factories are causing air pollution, this pollution cannot be shown by routine measurements. In routine air pollution measurements, only sulphur dioxide and suspended particular matters are measured and frequently determined under threshold limit values (6). It is thought that not

having the appropriate parameters for measurement prevents the air pollution from being shown.

According to the measurements made by The Scientific and Technological Research Council of Turkey in Dilovası, of the 167 factories, 34 (20.3%) are known to be a serious threat to the environment due to their being a source of pollutants (25). It may be possible for the chemical pollutants to enter the human body via the food chain and by the pollutants in both air and water. Unfortunately, neither routine records to determine the amount of this pollution nor any special reports regarding this issue exists.

According to the results of the study, increases in prostate and stomach cancers (excluding the lung cancer) are observed. An association between prostate cancer and exposure to cadmium is documented (26), and various epidemiological and experimental studies contributed to this idea (27,28). A study carried out in Dilovası in April 2006 reported that, in air and dust measurements, cadmium is 30 times more than the national limits and 240 times more than the EU limits (average  $1.195 \mu\text{g}/\text{nm}^3$ ) (25).

It is known that exposure to environmental factors is supposed to take longer in cancer pathogenesis (29). The duration of being exposed to air pollution is gaining importance as Dilovası is an area with a high contingent of migrants. In the present study it was observed that the risk of death due to cancer is 4.4 times higher for people who lived in Dilovası for 10 or more than 10 years. The variable age should be accepted as a potential confounder since the cancer incidences increase due to exposure to the factor which plays a role in cancer pathogenesis caused by ageing. It was observed in the present study that age is not a confounding factor. Another confounding factor is smoking status. The relation between lung cancer and smoking has definitely been established (30). For this reason, when the relationship between lung cancer and air pollution is studied, smoking habits should be taken into consideration as a confounding variable. It was also determined that the risk of dying in Dilovası due to residing there for more than 10 years is unrelated to smoking status; thus smoking is not a confounding factor.

This study had some limitations. Since this study aims to obtain the rate of cancer related deaths among total death, it is highly important to reach the data

regarding the total death. The crude death rate in the region is reported to be 2.4 per 1000 (Kocaeli District Health Directorate, 2005). Ninety-two death cases are expected to happen in Dilovası when this rate is taken into consideration. Despite having reached and searched all the registries concerning mortality records in Turkey, 78 deaths were determined in this study. It is thought that not all the mortality records have been reached as the number of the ones reached is below the number expected. In addition, crude death rate in Dilovası is lower than it is in Turkey. One main reason for this is the different population structure. There is a high migration rate to Dilovası by the labour force (young and healthy people) as it is a highly industrial zone. For this reason, crude death rate is expected to be low in Dilovası. If all the death cases that could not be obtained in this study were caused by anything but cancer, the deaths related to cancer would have been calculated as 28% instead of 33%. This result itself is well over the average of Turkey and the world and does not change the main result of the study.

In conclusion, since the mortality rate in Dilovası is found to be so high, immediate action for the public health should be taken. This situation should be considered as the outcome of both the economy and industry ignoring 'humanity and nature'. The area must be investigated in detail by a multi-sector team consisting of independent academicians and precautions should be taken immediately to prevent these people from suffering further, including the employees of the enterprises. Moreover, the results of the study should be supported by further studies. Both health and mortality records should be kept in accord with international standards. Industrial and environmental measures should be taken. Measures for the industry: 1) raw material, process and emission must be known in detail and inspected, 2) hazard and risk maps must be prepared and monitored, 3) the capacity increase enabling the increase of emission size should not be permitted within the facilities, 4) the storage areas with flammable and explosive substances, fossil fuel storage, and decomposition areas must be moved out of residential areas, 5) the inspection mechanisms and conditions regarding the seaports should be reconsidered and altered accordingly. Measures for the environment: 1) environmental laws must be

applied and the public should feel that the issues in question are dealt with, 2) environment directorate should be functional and supported in terms of both equipment and manpower, 3) pollution monitoring

parameters should be determined and followed regularly and also be shared with the public, 4) pollution must be stopped, 5) polluted areas should be rehabilitated.

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