

Working conditions and pneumoconiosis in Turkish coal miners between 1985 and 2004: a report from Zonguldak coal basin, Turkey

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ÖZET

Zonguldak kömür havzasında çalışan kömür işçilerinde çalışma koşulları ve pnömokonyoz durumu: 1985-2004

Ülkemizde yer altında emek yoğun çalışmayı gerektiren taşkömürü üretimi sadece Zonguldak ili ve çevresinde, Türkiye Taşkömürü Kurumu (TTK) işletmelerinde sürdürülmektedir. Bu işletmede 1960 yılında toz kontrol programı, 1969 yılında da periyodik pnömokonyoz araştırması başlamış olmasına rağmen bölgeye ait basılmış veriler oldukça sınırlıdır. Bu çalışmada, 1985-2004 yıllarına ait işletmelerin tümüne ait toz değerleri ve kömür üretiminde çalışanların tamamına ait sağlık kontrol verileri TTK'dan elde edilerek çalışma alanlarındaki toz konsantrasyonu ile pnömokonyoz prevalansı arasındaki ilişki araştırılmıştır. Çalışma alanlarında 1978 yılından itibaren yer altında ortalama solunabilir toz konsantrasyonu 1.66 mg/m³, yer üstünde ise 0.73 mg/m³ olarak saptanmıştır. İşletmelerdeki toplam işçi sayısı 1985 yılında 38.231 iken, 2004 yılında 8932 işçi yer altında olmak üzere toplam 12.261 işçiye inmiştir. Bu dönemde yer üstünde çalışan işçilerde pnömokonyoz saptanmamıştır. Pnömokonyoz insidansı bu yıllar arasında %0.17-2.8 arasında, prevalans ise %1.23-6.23 aralığında değişmektedir. Pnömokonyoz saptanan olgulardaki radyolojik opasiteler genellikle küçük opasiteler olarak rapor edilmiştir. Sonuç olarak, bu çalışma Zonguldak kömür havzasına ait 20 yıllık pnömokonyoz verilerini sunan ilk çalışmadır. Toz kontrol önlemlerinin uygulamada olmasına ve solunabilir toz konsantrasyonunun yasal sınırın altında bulunmasına rağmen kömür çıkarma noktasında çalışanlarda pnömokonyoz ortaya çıkma riski hala söz konusudur. Çalışma ortamındaki solunabilir toz konsantrasyonunun uluslararası sınır değer olan 1 mg/m³ düzeyine düşürülmesi hedeflenmelidir. Alınacak önlemlerle birlikte bölge verileri daha kapsamlı epidemiyolojik çalışmalarla da irdelenmelidir.

Anahtar Kelimeler: Kömür, pnömokonyoz, kömür tozu.

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SUMMARY***Working conditions and pneumoconiosis in Turkish coal miners between 1985 and 2004: a report from Zonguldak coal basin, Turkey***Meltem TOR¹, Mesut ÖZTÜRK², Remzi ALTIN¹, Arif Hikmet ÇİMRİN³¹ Department of Chest Diseases, Faculty of Medicine, Zonguldak Karaelmas University, Zonguldak, Turkey,² Department of Occupational Safety and Education, Turkish Coal Enterprises, Zonguldak, Turkey,³ Department of Chest Diseases, Faculty of Medicine, Dokuz Eylül University, İzmir, Turkey.

In Turkey, bituminous coal mining is performed only in Zonguldak coal basin since 1940. Pneumoconiosis surveillance programs and dust control measures are in effect, but published pneumoconiosis data from this area is lacking. In this study, we aimed to evaluate the change in prevalence and case detection between 1985 and 2004 and assess the correlation between the dust concentration in workplaces and the prevalence of pneumoconiosis. Data on respirable dust concentrations and number of workers diagnosed as pneumoconiosis between 1985 and 2004 were obtained from Turkish Coal Enterprises authorities. Mean respirable dust concentrations in workplaces underground and on the ground were 1.66 mg/m³ and 0.73 mg/m³ respectively. Total number of workers decreased from 38,231 in 1985 to 12,261 in 2004 including 8932 underground workers. In this period, pneumoconiosis has not been reported in the ground workers. Incidence of pneumoconiosis ranged between 0.17-2.8 percent and prevalence ranged between 1.23-6.23 percent between 1985 and 2004. Radiologic opacities compatible with pneumoconiosis were predominantly small opacities. This is the first report about the incidence and prevalence rate of coal worker's pneumoconiosis in the main coal mining area of Turkey. Dust measurement and screening standards should be improved and adapted to international standards and we conclude that surveillance data should be closely monitored in this region and further epidemiologic studies in this area are warranted.

Key Words: Coal, pneumoconiosis, coal dust.

Bituminous coal mining is performed only in Zonguldak province and surrounding area in Northern Anatolian region since 1940 under a governmental authority, Turkish Coal Enterprises (TCE). TCE controls the coal production in 14 different production facilities. This institution also owns a mining machine factory and coal washing plants. Since the initiation of production, 60 million tons of commercial coal had been mined in this area. The estimated total coal reserve is 1.3 billion tons (1). As coal reserves are found as coal strata under the ground, underground coal mining is still labor intensive in this region despite the developments in mining technology. Coal mining is carried out with a team of workers whose jobs have been categorized in two areas: underground, and ground. Underground jobs include those in preparation, mining and transport of coal, while ground jobs are mainly in transport, coal preparation and storing sections.

The risk of coal workers' pneumoconiosis (CWP) depends on the total dust burden in the lungs. The occurrence of CWP is related to the coal rank, which is based on its carbon content (anthracite has the highest rank followed by bituminous, sub-bituminous and lignite) (2). In the higher ranking coals, there may be a greater relative surface area of the coal dust particles and higher surface-free radicals and higher silica content (3). Silica exposure and hence silicosis is more common in mines with a high ranking coal (4). The coal in Zonguldak coal basin is bituminous type and silica proportion in the coal dust itself is estimated as 1-5%.

Dust control programs started in 1960 with the routine measurement of respirable dust concentrations (RDC) in all TCE facilities. Since 2000, the exposure limit for respirable coal mine dust has been limited to 5.0 mg/m³ if SiO₂ content is less than 5%. If SiO₂ content is more

than 5%, then the cut-off level is calculated with a formula: $25/\text{SiO}_2\% \text{ mg/m}^3$ (5).

For TCE employees, CWP screening had been performed by chest microfilms between 1969 and 1990. After 1991, standard 35 x 35 mm chest X-rays have been used and were read by certified readers.

In this study, we aimed to evaluate the change of incidence and prevalence of CWP between 1985 and 2004 in reference to periodic health examination data of TCE, and also to assess the relationship between the dust concentration of workplaces and pneumoconiosis.

MATERIALS and METHODS

The data presented here were obtained with the official permission of the TCE authorities. The data included dust measurements from all mining facilities in the region between 1985 and 2004 and health records of coal mine workers excluding the office workers and mine engineers in that period.

Dust Measurements

In all working places, dust measurements are performed according to the regulations of Turkish coal industry (6).

a. Periodic measurements: Monthly in coal longwalls and tailgates, once in every four months in maingates, and once in six months in underground transport units and once a year on the ground,

b. Preventive measurements: Additional measurements are performed until levels normalize in areas with high dust concentrations,

c. Investigative measurements: Performed whenever a new production technique is employed or a new machine is used, or whenever there is a complaint at a certain area.

Respirable dust concentration (RDC) of working environment of mines were determined gravimetrically by Casella 113A device. The sampling locations are determined as: production regions (i.e. heading faces, longwall faces), gate roads, stone drifts and haulage roads and num-

bered by the authority. The dust samplers are placed to the air flow direction and at breathing level of workers at around 170 cm. Air sampling up to 50 L/min is possible with Casella 113A. Preventive measurements and erroneous measurements should be repeated with three devices, the first one is placed 10 m above the roof bolt, the second one 20-30 m distal to the main-gate workplace and the third one 50 m distal to the tailgate workplace respectively. The device is so placed that large dust particle collecting channels are exposed to the airflow and water level is horizontal. If the workplace airflow is greater than 2 m/sec, then the device is placed perpendicular to the airflow.

Hund device gives on the other hand instant results gravimetrically, and it does not need further laboratory analysis. For the dust measurements, glass fiber filters (Whatman GFA) are used, and for additional silica measurements membraneous filters are preferred. Whatman filters can capture dust with 0-5 microns in diameter.

Mineral Analysis

Membraneous filters are burnt and SiO_2 level in the remaining ash is compared to light refractance through KBr tablets which is used as a reference. Thus, SiO_2 content (%) can be calculated (7).

Pneumoconiosis Evaluation

Preplacement and periodic health examinations of all coal workers are done by TCE health authorities. According to the regulations, coal mine authorities are required to provide periodic chest X-rays for underground coal miners and ground workers. If the periodic chest X-ray taken every 12 months reveals changes compatible with CWP with a profusion of 1/0 or more according the ILO 1980 classification by local workplace physicians, the worker, named as new CWP case, is referred to the regional occupational hospital for further evaluation to confirm the diagnosis of CWP by a panel of at least three pulmonary physicians including ILO and Turkish Ministry of Health certified readers. If the panel of readers do not reach a consensus on the case as a CWP, High Resolution

Computerized Tomography (HRCT) and histopathological confirmation may also be required to confirm the diagnosis. Confirmation of the diagnosis may sometimes take few years due to bureaucratic obstacles. The reason is merely medical but rather due to delays in exchange of information between TCE health authorities and the database of the government supported social insurance system. In the mean time, workplaces of new cases are changed to a less dusty work environment until the diagnosis is confirmed. When the diagnosis is confirmed as “definite CWP”, worker is replaced to a less dusty area (mostly to a ground job), and the cases are referred to as “old CWP” cases.

Statistical Analysis

From 1985 to 2004, 98.7% of the cases who were referred as “new CWP cases” were underground workers. For this reason the number of underground workers is accepted as population at risk. Incidence rate is calculated as the total number of new CWP cases divided by the total number of underground worker population. Prevalence rate is calculated as the sum of the total number of CWP cases divided by the total number of underground worker population.

RESULTS

From 1978 to 2004 approximately 31.000 workplace coal dust measurements were performed.

RDC in this period are shown in Table 1. According to the data, mean RDC in workplaces underground and on the ground were 1.66 mg/m³ and 0.73 mg/m³ respectively. The highest values were measured in the longwalls and mine shafts. Mineral content of the dust in various workplaces are shown in Table 2. From 1985 to 2004, distribution of job categories both in underground and ground workers were shown in Table 3. In this period, 98.6% of the new CWP cases were underground coal workers. Majority of new CWP cases were working in production sites. Job categories of the new CWP cases were as follows: 1536 (40%) in production (long-wall mining), 1278 (33.2%) in transport, 974 (25.4%) in preparation sections and 53 (1.4%) on the ground. Job distribution of new CWP cases according to mine facility is shown in Table 4.

Between 1985 to 2004, 3841 new cases were reported and referred to the regional occupational hospital for further evaluation. Of these cases, 730 workers (19.0%) were confirmed as definite CWP after a complete formal reevaluation as described. During this period, number of underground workers decreased from 23.756 to 8.932. CWP prevalence rate ranged between 1.2% and 6.2% and incidence rate ranged between 0.17-2.78%. Although incidence numbers undulated in the past, it has a tendency to decrease in the last five years (Table 5).

Table 1. Mean dust concentration in working area by facilities (mg/m³).

Mine locations	Underground						On ground			
	Funnel	Coal longwall	Bottom	Gallery	Transport	Mean	Washery	Atelier	Other	Mean
Armutcuk	2.62	2.58	1.86	0.81	1.25	1.82	0.90	0.69	0.77	0.79
Kozlu	3.56	1.61	2.20	1.10	1.31	2.31				
Uzulmez	0.95	1.45	1.31	1.06	0.62	1.08	0.77		0.54	0.65
Gelik	3.20	2.96	0.61	0.84	1.30	1.78				
Kilimli	1.47	2.01	1.98	1.20	1.63	1.66				
Karadon	2.51	2.42	1.24	1.13	1.54	1.77	0.98		0.73	0.85
Amasra	1.58	1.87	1.35	0.97	1.00	1.35	0.43	0.88	0.62	0.64
Merkez								0.73		0.73
Mean	2.41	1.92	1.44	1.05	1.07	1.58	0.74	0.77	0.66	0.72

Table 2. Coal ash content (from Karadon facility).

Ingredient	Contents (%)
SiO ₂	45.70
Al ₂ O ₃	26.26
Fe ₂ O ₃	8.16
CaO	6.84
MgO	2.01
K ₂ O	2.74
Na ₂ O	0.71
TiO	1.16
P ₂ O ₅	0.39
SO ₃	4.60
Others	1.43
Total	100.0

Table 3. Number of workers in the workplace by years.

Year	Number of workers		
	Total	On ground	Underground
1985	38.231	14.475	23.756
1986	36.557	14.354	22.203
1987	36.623	14.309	22.314
1988	36.476	13.927	22.549
1989	35.492	13.624	21.868
1990	34.349	13.389	20.960
1991	31.215	12.938	18.277
1992	29.495	12.492	17.003
1993	28.429	11.837	16.592
1994	23.964	9537	14.427
1995	21.520	8172	13.348
1996	20.403	7375	13.028
1997	18.674	6397	12.277
1998	17.406	5722	11.684
1999	16.180	5281	10.899
2000	18.232	4994	13.238
2001	18.025	4600	13.425
2002	15.761	4000	11.761
2003	14.062	3723	10.339
2004	12.261	3329	8932

To exemplify the distribution of opacity shape and profusion in definite CWP cases, we analysed radiologic data of 350 definite CWP cases (Table 6). According to the available data, p 1/0-1/2 and p 2/1-2/3 opacities comprised the majority, 46.8% and 29.4% respectively. Irregular opacities (s, t, u) were seen less compared to round opacities in this sample population of definite CWP. No progressive massive fibrosis case was reported among this series.

Mean working years in new cases were 14.9, 13.1 and 13.5 years in preparation workers, long-wall miners and other underground workers respectively. When we assess the relationship between new CWP diagnosis and their working history, we found 8 cases (< 1%) with less than 5 years of coal mining history, 151 (4%) with a 6-10 years, 555 (14%) with a 11-15 years history, 1247 (92%) with 16-20 years, and 1914 (50%) with more than 20 years working history.

Mean age at the time of diagnosis as a new case were 37.7, 38.1 and 39.7 in preparation workers, long-wall miners and other underground workers respectively. Among new CWP cases; 9 cases were aged between 20-25, 155 (4%) between 26-30, 857 (20%) between 31-35, 1465 (35%) between 36-40, and 1770 cases (41%) over 40. According to these results, new CWP tends to develop in workers older than 30.

DISCUSSION

Due to the effective dust control measures, CWP development decreased in many important coal mining countries in the last 20 years according to published data. The most important result of this study is that; despite effective dust control measures, there is no significant reduction in CWP prevalence and incidence rates in the last 20 years in Turkey's major coal basin. Present working conditions may still cause CWP and mostly underground coal workers constitute the population at risk. CWP develops on average at the end of 13 years of underground coal dust mine exposure, so there is a considerable latency.

In a large surveillance study from USA, overall prevalence rate of simple and complicated CWP

Table 4. New pneumoconiosis cases by mining job description (1985-2004).

Facility	Underground			On ground			Total
	Mining section + Longwall + Production	Preparation	Transport + Other	Washery	Atelier	Other	
Armutçuk	112	71	92	-	-	9	284
Kozlu	266	169	223	-	-	3	661
Uzulmez	377	239	312	-	-	2	930
Karadon	664	421	551	-	-	32	1668
Amasra	117	74	100	-	-	4	295
Merkez	0	0	0	-	-	3	3
Total	1536	974	1278	-	-	53	3841

Table 5. Number of workers in the workplace and pneumoconiosis by years.

Year	Underground workers	Workers with CWP			Prevalence rate (%)	Incidence rate (%)
		New	Old	Total		
1985	23.756	105	481	586	2.47	0.44
1986	22.203	95	347	442	1.99	0.43
1987	22.314	76	263	339	1.52	0.34
1988	22.549	66	211	277	1.23	0.29
1989	21.868	224	295	519	2.37	1.02
1990	20.960	270	259	529	2.52	1.29
1991	18.277	509	534	1043	5.71	2.78
1992	17.003	206	306	512	3.01	1.21
1993	16.592	224	386	610	3.68	1.35
1994	14.427	173	169	342	2.37	1.89
1995	13.348	56	276	332	2.49	0.41
1996	13.028	118	344	462	3.55	0.87
1997	12.277	172	349	561	4.57	1.40
1998	11.684	218	287	505	4.32	1.87
1999	10.899	287	392	679	6.23	2.63
2000	13.238	60	387	447	3.38	0.45
2001	13.425	39	276	315	2.35	0.29
2002	11.761	48	225	273	2.32	0.40
2003	10.339	150	167	317	3.07	1.45
2004	8932	15	131	146	1.63	0.17

were found as 30% in the early 70's, whereas in mines of Utah and Colorado it was found as 5% due to production of low quality coal. On the other hand, in anthracite mines of Pennsylvania,

the prevalence rates of simple and complicated CWP were found as 46% and 14% respectively (8). These findings also show the expected positive correlation between the coal rank and the

Table 6. The distribution of lesions by shape and profusion in a sample population with old CWP (n= 350).

Lesion		Workers	
Shape	Profusion	n	%
p	1/0-1/2	164	46.8
q	1/0-1/2	15	4.3
s	1/0-1/3	21	6.0
t	1/0-1/3	8	2.4
p	2/1-2/3	103	29.4
q	2/1-2/3	18	5.1
s	2/1-2/3	13	3.7
t	2/1-2/3	2	0.6
p	3/3	4	1.1
q	3/3	1	0.3
u	1/1	1	0.3
Total		350	100.0

occurrence of CWP. As working duration increased in the 1980's, the prevalence rates also increased up to 20%, but later in the 1990's, due to the effective dust control measures the prevalence rate decreased to less than 3% (3, 9). Studies from India, South Africa, and European Union also reported prevalence rates around 3% (10-12). However, new cases are still being diagnosed. Thus, dust control measures should definitely be improved. For this reason, NIOSH has recommended to lower the permissible exposure limit for respirable coal mine dust from 2 mg/m³ to 1 mg/m³ (9).

Two points about TCE should be emphasized. The first one is the underground location of the coal in this basin renders a change in labor intensive working conditions impossible. Long wall caving in these mines are still mostly manual and very labor intensive. In a recent study from Turkey, Onder et al. reported that production workers are exposed to higher dust concentration levels than the other category of workers and also, new CWP cases are mostly reported among those miners working in production regions such as longwall and heading faces (13). In our study, 1536 (40%) new CWP cases

were working in production (long-wall mining), 1278 (33.2%) in transport and 974 (25.4%) in preparation sections. Secondly, nearly all newly diagnosed cases are underground coal miners with a median working history of 13 years which support the low intensity and chronic exposure in most situations.

Although there has been a tendency of a decrease in the incidence and prevalence in the last 5 years, considering the last 20 years there has been similar undulations in the incidence and prevalence rates. So this decline should be interpreted with caution. The decrease in the number of the workers on the other hand reflects the administrative strategy with considerable lay-offs and retirement incentives in the past 20 years. Failing periodic medical examinations may have also caused underestimation of the real problem. If a new CWP case is determined during periodic medical examination in the health office of TCE, he is then referred to the regional occupational hospital for further evaluation by a board of pulmonary physicians to confirm the diagnosis of CWP. The official diagnosis takes a few years due to bureaucratic delays related to the procedures of the governmental insurance system. In the mean time, workplace of new case is changed to a less exposure area on the ground until the diagnosis is confirmed. Whenever diagnosis is confirmed as "definite CWP", worker is then replaced to a less dusty area on the ground mostly, and these cases are referred to as "old CWP" cases. Workers who are reluctant to pass through these series of procedures may sometimes avoid periodic medical examination on purpose, as they are worried about losing their benefits. This is one of the reasons why they are sometimes diagnosed at a later stage with a more severe form of CWP. Overestimation of the numbers of actual CWP cases is another problem in some situations. There are two factors crucial in overestimation. First, periodic medical examinations of individual workers may fail especially during periods of increased lay-offs and retirement incentives. Especially the retired workers with a diagnosis of "new CWP" are reported as mild CWP cases for the sake of economic benefits.

During the initial diagnosis, the majority of “definite CWP” workers have p and q lesions with low grade profusion as shown on a sample group’s data in Table 6. On the other hand, final confirmation of larger lesions and high profusion on chest X-ray is often delayed due to the problems in the periodic examinations as described above. Another problem to be mentioned is that there are workers missing periodic medical examinations intentionally which may have caused delays in the diagnosis. We have also reported earlier that in our country chest X-rays are generally low in quality and do not meet the criteria of ILO standards in most cases (14). Education and necessary qualifications of the readers are other important issues. This should be also taken into consideration for the better interreader agreement and consistency of the radiological interpretation.

There are limitations of this study;

- a. If the periodic chest X-ray reveals changes compatible with CWP, upon being read by local occupational physicians, the worker, as being new CWP case, is sent to the regional occupational hospital for further evaluation by a board of pulmonary physicians to confirm the diagnosis of definite CWP. The members of this board are not necessarily to be qualified readers, and there is always a chance of error in the definite diagnosis of CWP,
- b. After reporting a new case, the time interval till definite diagnosis is sometimes quite long due to bureaucratic procedures in Turkey. This delay also causes discordance in the actual number of definite cases especially in calculating statistical parameters. The other limitation of this study is that as the individual personal respirable dust concentrations can not be obtained, we can not report the actual correlation between coal mine dust exposure and CWP development,
- c. We could not include the number of the retired coal miners in our evaluation,
- d. We do not have data about the natural history of CWP in definite cases after cessation of the coal mine dust exposure.

In conclusion, this study is important because it is the first study reporting pneumoconiosis data from major coal mining area of Turkey. Despite current limitations in diagnosis and follow-up of CWP cases, we have shown that CWP prevalence is similar to the published data from countries where effective dust control measures are in practice. Dust measurement and screening standards should be revised because new cases are still diagnosed every year. Effective dust control measures should be employed especially in underground long wall mining, preparation and transport sections. Dust control measures must be more effective and acceptable respirable dust concentration should be lowered to 1.0 mg/m³ in Turkey. All chest X-rays must be read by certified readers, and standard reader education and certification programs should be organised. Surveillance results should be reported without any delay, and affirmative action should be taken for workplace dust control.

In conclusion, dust measurement and screening standards should be improved and adapted to international standards in this coal facility and surveillance data should be closely monitored and further epidemiologic studies in this area are warranted.

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