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Research paper

"Better breathing – better life" Medical and technical interdisciplinary project to improve working environment and workers health, 1985-2012.

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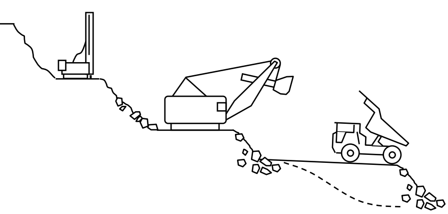
ABSTRACT

Workers in the mining industry and heavy industries are often exposed to a variety of airborne exposures. These exposures may place them at an increased risk for lung disorders and many studies have shown changes in lung function and an increased frequency of respiratory diseases. Effects of preventive Safety Health and Environmental (SHE) work are asked for. Heavy industries often have a long history of systematical medical follow up and a similar history of regular monitoring of the working environment. However, interdisciplinary, medical - technical cooperation varies greatly. Together with the companies and their SHE-service we have developed a method, a database and a data programme (Environmental Index, Miljöindeks), for better follow up of the working environment and the workers health. We have found this to be a useful tool in preventive work. A brief presentation and some results are given.



1. INTRODUCTION

Environmental Index, our interdisciplinary project started in 1985, at Folldal Verk AS. The project was supported by the mining company and their SHE service. In the following years we were also supported by The Confederation of Norwegian Enterprise (NHO) and as a part of the developing programme for the Norwegian mining industry, NORMIN 1991-2001. Mineral companies, both open pit and underground, joined the project.

The data programme was further used for the follow up of foundry workers (Elkem Meraker AS) and electrical fitters (Siemens Trondheim AS). The data base and the data programme were used according to medical professional secrecy by the companies health services.

More than 40 years of testing and documentation of the working environment, primarily in the mining industry, as well as decades of medical follow-up of the individual workers have given us a unique data base, but also methodological challenges.

Together with the companies SHE services we have organized and systematized the results from the medical follow up of the workers and the analysis of the working environment.

A lot of written information and reports have been made, primarily to the companies and their SHE services, but also for general use. This has been done to secure identical, or as good as possible, procedures for the follow up of the workers and the working environment.

Environmental Index has been presented at the International Commission on Occupational Health (ICOH) Congress in Stockholm in 1996, Singapore in 2000 and Cancun, Mexico in 2012 (Furuseth et al. 2012). It has also been presented at the Scandinavian Congresses for the mining industry, in Finland, Sweden and in Norway as well as in Switzerland in 1997 (Myran & Furuseth 1997).

We have argued for interdisciplinary cooperation. We believe this to be the most sensible way of working within SHE and we now have reasons to believe that Environmental Index is a useful tool for achieving good results. This work is now, 2012, continuing in the coal mines at Spitsbergen, in the arctic, in the project "better breathing - better life", together with the company's SHE service.

It is not difficult to understand the doubt, the scepticism we met when we started. Even though it has been hard work, we have been fortunate to work together with encouraging and enthusiastic SHE partners, their companies and their workers.

2. MATERIALS AND METHODS

The database consists of 9 companies, that is 7 mines, underground and open pit, one foundry (Elkem Meraker AS) and one company with electrical fitters (Siemens Trondheim AS) with altogether 1.359 employees.

Systematic medical examinations with interview (working history, tobacco smoking, family history with regard to lung and cardiac diseases etc), medical examinations and lung function tests/spirometries (5.262**)** have been carried through by the companies health services. Chest X-ray and further medical examinations, when needed, have mainly been done at the local or regional hospital.

Information, both oral and written, have been given to secure standard procedures in the medical examinations and lung function tests.

Testing and documentation of mineral dust (both total and respirable fraction), diesel exhaust, radon, blasting fumes, oil mist, ventilation etc. have been done systematically for more than 40 years by professor em. Tom Myran at SINTEF/NTNU Department of Geology and Mineral Resources Engineering, Trondheim, Norway. Even the effects on exposure depending on different personal protective equipment have been measured.

The same or comparable methods have been used in the sampling and analysing of mineral dust and the other air pollutants.

Dr. eng. Georg Brustad has developed a data base and a data programme for the follow-up of the individual worker and the actual exposures. The data base and the data programme are named Environmental Index.

3. CHALLENGES AND STRATEGIES IN PREVENTIVE SHE WORK

Apart from hard physical labour, miners have been and still are exposed to such agents as mineral dust with varying degrees of respirable crystalline alpha-quartz, asbestos, diesel exhaust and blasting fumes (gases and particulate matter), nitrous oxides, sulphur dioxide (in rich sulphide ores), chemical products (synthetic resins), radon and oil mist. That is; Royal Straight Flush with regard to exposures.

The risk of developing lung diseases depends on the exposures and workers in other heavy industries with similar exposures (lung irritating agents) face the same challenges.

Work related illnesses, f.ex lung diseases, do not occur by chance. They do occur as a result of years of exposure to these agents and similar results are seen in different industries with similar exposures.

According to The Directorate for Labour Inspection's yearly reports, the general tendency in mining and heavy industries in Norway during the last decades is that the workplaces have been safer.

Our investigations have documented that the exposures have become more complex with both additive and synergistic effects. There are grounds to claim that they have become healthier (Myran 2004).

The mining industry and many heavy industries often have a long history of systematical medical follow up and a similar history of regular monitoring of the working environment. However, interdisciplinary, medical - technical cooperation varies greatly.

Fig. 1 shows an example of an industry with a long history of follow-up, both medical and technical but great variation in interdisciplinary cooperation in preventive, SHE, work.

Figure 1. "Royal Straight Flush" with regard to exposures and reports.

Both industry, their SHE-services and the workers have been asking for effective strategies and examples and effects of preventive SHE work. Some strategies are obviously better than others with respect to prevention of lung diseases as illustrated in Fig. 2. The question is whether they are possible to carry through? The Exposure assessments, for example as a basis for reaction is too difficult and too insecure to be used alone in heavy industries, for obvious reasons, see Fig. 3. Working for example 10 years in the same mine, the exposures will be quite different for a miner working from 1968 to 1978 compared to a miner working from 1978 to 1988.

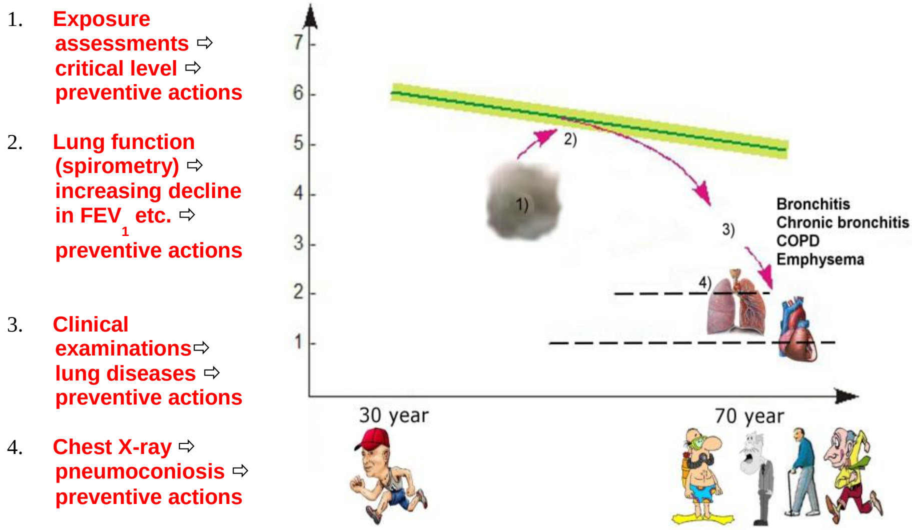


Figure 2. Strategies in preventive work.

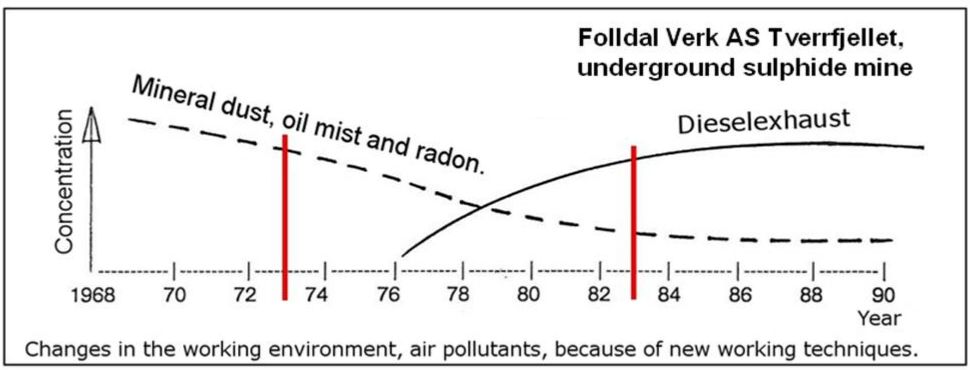


Figure 3. Changing working environment. Challenges in using exposures in risk evaluation.

The working environment and the exposures are most often complex, for example "mixed dust". Risk evaluation is difficult, especially when workers are exposed to many different exposures which all act on the same target organ, the respiratory system. Workers also often do different types of work during their working day and change working environment and type of work during their working career. Companies reorganizes, introduces new working techniques and close down. A correct working history with regard to type of work and exposures may be difficult to obtain, even within the same company. Misunderstanding and misclassification may happen. One also has to regard the individual's susceptibility to disease.

To use the results from clinical examinations, that is diagnosed lung diseases and positive chest X-ray as a basis for reaction is of little value for those affected (moderate to severe Chronic Obstructive Pulmonary Disease (COPD), and lung fibrosis), but may be beneficial for their "descendants" and other groups of workers in the same or similar industries. See Fig. 2.

Changes in lung function, for example increasing decline in FEV1, forced expiratory volume in one second, as a basis for reaction might be possible if available necessary "tools".

Yearly decline in lung function because of tobacco smoking and exposures may be tiny, but may have long term significance with regard to future ill-health or disease.

Even though lung function tests were done regularly, we registered that the results seldom were used in preventive work. Results were most often compared to predicted values instead of the individual worker's norm or curve. In spirometry the "normal range" is wide and results were often classified as just normal, within the normal range. There were little focus on changes and variation in the spirometric results even though this might be the first sign of lung diseases. We wanted to see if it could be possible to react against changes in lung function, spirometry, before lung diseases developed (Fig. 2.) We therefore developed a data base and a data programme for better follow-up of the individual worker's lung function, norm. We also wanted to combine lung function to exposures to establish more knowledge about connections between exposures and lung diseases and use this as a basis for preventive actions.

The data base was to be used according to medical professional secrecy by the companies health services.

4. ENVIRONMENTAL INDEX

The data base and the data program is approved by the Norwegian Data Inspectorate and the Norwegian Regional Ethical Committee (1994 and May 2010). The data programme gives a view of the workers medical status and exposures. See Fig. 4.

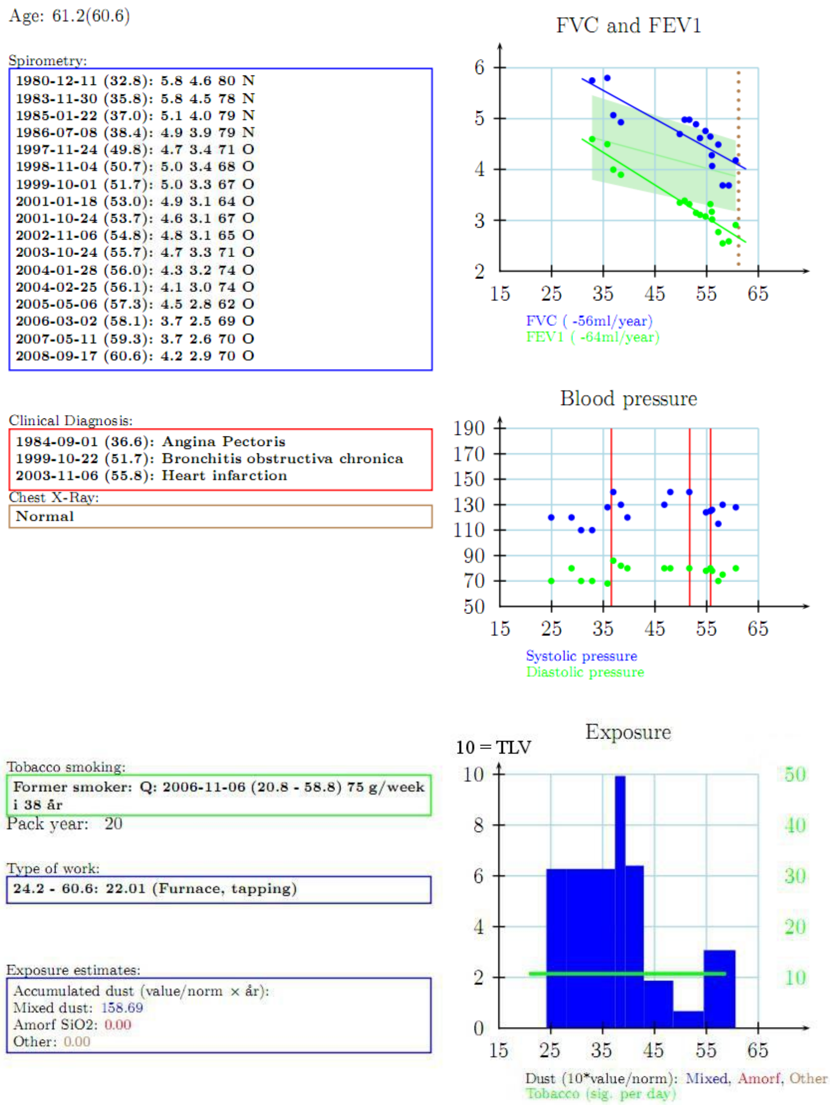


Figure 4. Environmental Index. Medical and Exposure Journal. Spirometry means lung function test. N means normal lung function and O means obstructive impairment (asthma, COPD, emphysema). FVC means Forced vital capacity and FEV1 means Forced expiratory volume in one second. Changes in lung function, here decline, in FVC and FEV1 are given in ml/year. Normal decline is 30 ml/year (men). The age of the worker at the time of the test (spirometry) or diagnosis, is shown (in brackets). Tobacco smoking. Q means quit, or stopped smoking, 06.11.2006 in this example. Exposure estimation. The actual exposure is divided by the Threshold Limit Value and multiplied by 10.

The data programme easily presents the development of the individual workers lung function based on regression analysis, see Fig.5 and Fig 6.

Fig. 5 also illustrates effects of intervention. the actual foundry worker had a high total exposure of gases/fumes from the furnace. The positive effects on lung function are due to bettering of the working environment, treatment of coronary heart disease and abandoning of tobacco smoking.

The next example, Fig.6 shows the effects of treatment of hypertension and improved working environment. The actual miner had a high exposure to coal dust through 27 years of mine working.

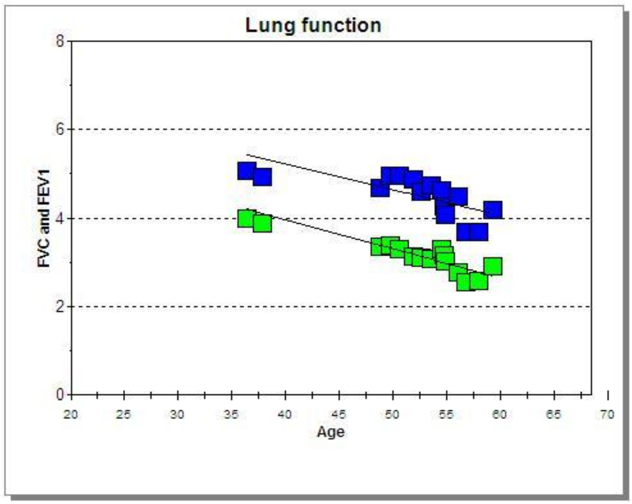


Figure 5. Example from Elkem Meraker. Id 45. FVC in blue, FEV1 in green.

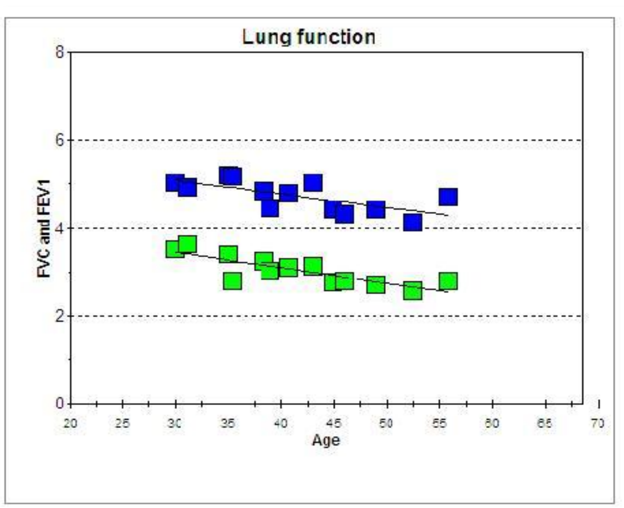


Figure 6. Example from Elkem Meraker. Id 45. FVC in blue, FEV1 in green.

5. CHANGES IN LUNG FUNCTION AND TOBACCO SMOKING

Large Lung diseases are related to exposures. It is generally accepted that changes in lung function precedes lung diseases and perhaps also cardio vascular diseases (Friedman et al. 1976). Tobacco smoking reduces lung function and is the main cause to COPD.

In the time period from 1985 to1990 2/3 of the workers were daily smokers and former smokers while 1/3 had never smoked. The percentage of daily smokers and former smokers were, and still are a little higher than what is seen in the general Norwegian population, see Table 1.

On the other hand, statistics must be interpreted with caution. Now and then smokers in population studies are usually around 10%. These smokers are classified as smokers in our study and the amount of tobacco smoked is given, for example 15 cigarettes per week. Smokers who have smoked for decades are still classified as smokers until 5 years break, thereafter as former smokers.

Compared to population studies our classification will give more daily smokers, less former smokers, as well as non-smokers. In some studies smokers who have stopped smoking for more then 2 years are classified as non-smokers.

The negative effects of tobacco smoking on health are well documented. Tobacco use in the Norwegian population is also well described by professor Per Bakke (Bakke et al. 1990) and by SIRUS, Norwegian Institute for Alcohol and Drug Research (Lund and Lindbak 2004). Compared to the figures in these papers we therefore conclude that smoking among the workers examined do not differ strikingly from what is seen in the general population.

Table 1. Smoking habits.

	Norwegian population. (Bakke et al. 1990)	Miners, 1989-1995	Electrical fitters. Siemens Trondheim. 1994/1995
Number		770	100
Mean age		43 years	44 years
Daily smokers Former smokers Non-smokers	42% 24% 34%	47,2% 23,3% 29,5%	42,7% 19,1% 38,2%
	100%	100%	100%

Tobacco smoking workers in these industries have an obstructive tendency in their lung function, judged by the spirometric results, almost 20 years earlier than their non smoking colleagues, see Fig. 7.

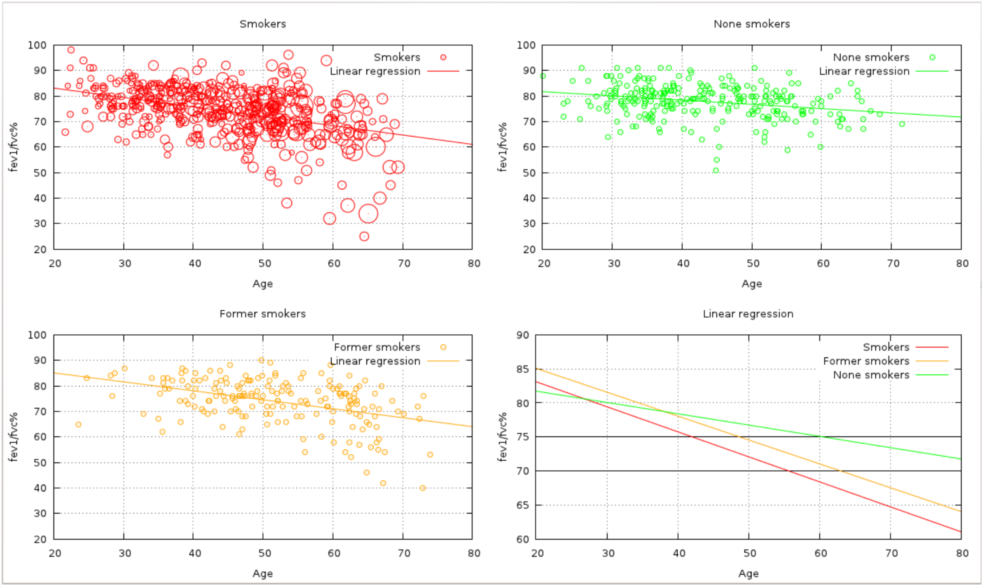


Figure 7. Tobacco smoking and changes in lung function measured by the FEV1/FVC ratio. Smokers 379, former smokers 185, none smokers 269, total 833. 3 spirometries and more.

It is tempting here to mention the English doctor Charles Turner Thackrah (1795-1833) in Sheffield, England. It was for example in the early 1800's recorded that the use of "sandstone" constituted a health risk. Sandstone contains much quartz. C.T. Thackrah in 1831 published observations that workers in Sheffield's steel industry who ground knives in dry and crushed sandstone seldom lived to an age greater than 30. On the other hand it was observed that a tested group who ground knives in crushed sandstone with water added had a life-expectation that was almost 20 years longer.

A well known and accepted fact is also seen in our work; Cessation of tobacco smoking reduces the decline in lung function, both FEV1 and FVC. See also Fig. 5.

Even though tobacco smoking is the main cause of chronic pulmonary diseases, one must also be aware of other possible agents and among these are mineral dust (Becklake 1989).

6. EXPOSURE AND LUNG DISEASES, FOLLDAL VERK AS.

The history of Folldal Verk AS starts in 1748, with the mining of copper. The present mine at Tverrfjellet started with production in 1968 (Fig.8). The main ores were sulphur, copper, zinc and magnetite. Small amounts of gold and silver were also found. The mine closed down in 1993.

Figure 8. Folldal Verk AS.

The working environment changed during the production period, see Fig. 3. The content of crystalline quartz was lower (1-10%, mean 5%) in this ore, compared to the old mines in Folldal (2-28%).

Workers examined were 129. They had all been systematically examined for years, with interviews, medical examinations, regularly lung function tests and chest X-ray every third year.

The different workplaces were classified and the individual workers exposure to mineral dust were estimated by using results from decades of measurements, both total and respirable mineral dust.

We found that workers with lung diseases do have a higher exposure to mineral dust than healthy workers. The same tendency, correlation, is seen in all age groups after the age of 30. It is however only significant in the 40-60 year age group ($P < 0,05$). The results were not adjusted for tobacco smoking.

7. EFFECTS OF PREVENTIVE HSE WORK, ELKEM MERAKER AS.

When Elkem Meraker AS closed down in 2006, the foundry had been in production since year 1900 (Fig. 9). The initial production was calcium carbide, CaC2. Since 1990 they were a Si-metal foundry, producing Si-metal and micro silica.

Figure 9. Elkem Meraker AS.

The foundry started an interdisciplinary project in 1994, called ”Better working environment – better health”. The main purpose was to improve the working environment and to reduce exposures, including tobacco smoking, to have more focus on protective equipment, systematization and improvement of the medical follow up etc. The project created great enthusiasm.

Better ventilation, extraction of smoke from the furnace, oven, encapsulation of the process of packing of micro silica etc. gave significant reduction of smoke/fumes and silica dust. Together with tobacco cessation and earlier medical intervention and treatment this also reduced the workers lung function decline.

The foundry closed down in 2006. The oldest workers, workers with lung diseases and reduced lung function were offered medical follow up yearly after 2006.

We register a positive tendency with regard to lung function decline, also among the oldest workers. In the recent years the decline in lung function among the workers examined is similar to what is seen in the general population.

Table 2. Reduction in lung function, FEV1,in different time periods. Mean reduction in FEV1, in ml/year. N varies between 119 to 26 in the different time periods.

From	1987	1987	1987	2002	2002
To	2001	2005	2009	2005	2009
All workers	60 ml/year	57	53	43	34 ml/year
> 40 years	64 ml/year	62	59	40	34 ml/year

We also register that the number of COPD seems low, and mainly stage 1-2, that is moderate COPD.

We believe that these positive results are due to improved working environment, reduction in exposures, better protective equipment, less tobacco smoking and systematically and thorough medical examinations and follow-up with lung function tests together with interdisciplinary cooperation and great enthusiasm.

8. STORE NORSKE SPITSBERGEN GRUBEKOMPANI, SNSG AS, 2011

Store Norske is the northernmost mining company in the world. Store Norske was established in 1916 and currently operates two coal mines on Svalbard: Svea Nord, 60 kilometers south of Longyearbyen, and the Gruve 7 mine, in the valley of Adventdalen outside Longyearbyen. With 350 employees, Store Norske is the largest cornerstone enterprise on Svalbard. The company is an important contributor to a stable and robust community in Longyearbyen.

Figure 10. Svea Nord.

There is a positive trend with regard to exposures, ventilation, protective equipment and tobacco smoking. The reduction in lung function, FEV1 is now similar or less than what is seen in the general population, see Table 3.

Table 3. Development of lung function among coal miners. N = 408 workers with 1.478 spirometries. Time period 1982/1983 – 2011, nearly 30 yrs.

	All until June 2000	All from July 2000 and to April 2011
All	38 ml/year N= 143 Age 43.4 year 5.4 spirometries	27.6 ml/year N= 110 Age 40.1 year 3.6 spirometries
Age > 40 year	38 ml/year N= 88 Age 48.6 year 5.5 spirometries	28.9 ml/year N= 52 Age 48.7 year 3.6 spirometries

9. SOME OTHER RESULTS OBTAINED THROUGH THE PROJECT PERIOD, 1985-2012

There is an obstructive tendency in the lung function tests of the workers examined, in varying degree and severity in the different companies.

Exposures varies considerably within and between the different companies.

Workers developing lung diseases do have a twice as great decline in FEV1 as normal, while workers with cardiovascular diseases have a nearly four times normal decline.

Cessation of tobacco smoking, treatment of cardiovascular diseases and improved working environment all reduce the decline in lung function, FEV1.

10. DISCUSSION AND CONCLUSION

Follow up and studies of groups of workers create challenges and are often difficult too interpret and understand. Workers who continues to work in industries with high exposures and a supposed higher risk of developing lung diseases sometimes do have better lung function than workers in industries with less or lesser risk (Burge 1994).

If workers with established lung diseases quit work more frequent than workers in industries with lesser risk, this could explain such findings. However, among the workers examined, few workers did quit because of lung diseases. At both Follldal Verk AS and Elkem Meraker AS workers who had stopped working also were invited to follow up examinations and many joined the medical examinations the following years. These are all included in the data base, the analysis and in the shown results.

The results from the examinations of the working environment, sampling and analyzing of mineral dust, ventilation etc. were generally more actively used by the companies compared to the results from the medical examinations.

It is well known that many airborne exposures may give lung diseases and a lot of studies also show connections between exposures at work and an increased lung function (FEV1) decline.

There seems to be connections between changes in lung function and coronary heart diseases, for example reduction in vital capacity, VC or FVC and an increased risk of coronary heart disease. Friedman et al. (1976) concluded that “Diminished vital capacity deserves continued attention as a possible coronary risk factor. Its relation to subsequent coronary events is not well explained.”

We register that cessation of tobacco smoking, improved working environment, early treatment of cardiovascular and lung diseases all reduce the decline in the worker's lung function, FEV1.

Our data also indicate that reduction in lung function may be associated with the development of cardio vascular disease.

Preventive measures, both technical and medical, to reduce exposures and better medical surveillance do reduce lung function loss, prevent lung diseases and improve the workers’ health. Interdisciplinary cooperation together with the companies HSE services make this possible and the work is now continuing in the coal mines in Spitsbergen in the project "better breathing - better life".

REFERENCES

Bakke, P., Gulsvik, A., Eide, GE., Hanoa, R., 1990: Smoking habits and lifetime occupational exposure to gases or dust, including asbestos and quartz, in a Norwegian community. Scand. J. Work. Environ. Health; 16:195-202.

Becklake, M R., 1989: Occupational exposures: Evidence for a causal association with chronic obstructive pulmonary disease. Am. Rev. Respir. Dis., 140:85-91.

Burge, P.S., 1994: Occupation and chronic obstructive pulmonary disease (COPD). Eur. Respir. J., 7:1032-1034.

Friedman, GD., Klatsky, AL., Siegelaub, AB., 1976: Lung Function and Risk of Myocardial Infarction and Sudden Cardiac Death. N. Engl. J. Med. 294:1071-1075.

Furuseth, K., Myran, T., Brustad, G.,2012: Medical/technical interdiciplinary project to improve working environment and Workers health. Environmental Index, "better breathing - better life". 30th International Congress on Occupational health (ICOH). March 2012. Cancun, Mexico. Paper, page 72.

Lund, M. and Lindbak R., 2004: "Tall om tobakk 1973-2003". Norwegian Institute for Alcohol and Drug Research. SIRUS-skrifter, 2/2004.

Myran, T., 2004: Health and Safety in Norwegian Tunnelling. Norwegian Tunnelling Society, Publication No 13, page 13-16.

Myran, T., Furuseth, K., 1997: Challenges and progress in health and safety work in the mining industry and tunnel construction in Norway. IOHA, Int. Occ. Hyg. Ass. The 3 rd Int. Scientific Conference. Sveits. September 1997. Occupational Hygiene. Vol 4 (3-6), page 427-441. Reprint directly form the publisher.