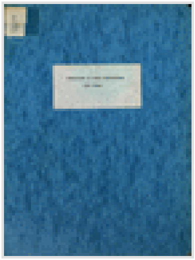

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FATALITIES IN SMALL UNDERGROUND COAL MINES

Committee on Underground Coal Mine Safety
Commission on Engineering and Technical Systems
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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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INTRODUCTION

In July 1982 the Committee on Underground Coal Mine Safety completed its study of safety in U.S. underground coal mines; the results of the study were published in the National Research Council report entitled Toward Safer Underground Coal Mines. One of the findings of this study was:

> THERE IS A STRONG CORRELATION BETWEEN MINE SIZE AND FATAL INJURIES. THE FATALITY RATE IN MINES WITH 50 OR FEWER EMPLOYEES IS NEARLY THREE TIMES THAT OF LARGE MINES (WITH OVER 250 EMPLOYEES), AND ABOUT TWICE THAT OF INTERMEDIATE-SIZED MINES (WITH 51-250 EMPLOYEES).

Although the Committee explored possible reasons for the higher fatality rate in the smaller mines, it was not able to explain this phenomenon fully. Therefore the Bureau of Mines requested that the Committee undertake a supplementary study of fatalities in small underground coal mines. The Committee met in the fall of 1982, discussed the problem, developed an approach to it, approved a program of statistical analyses, and authorized a panel of four committee members to explore the problem in greater depth. The panel, in turn, reviewed the results of the statistical analyses and met with the president of the National Independent Coal Operators Association and with several owners of small underground coal mines for a detailed discussion of the unique problems of small mines. Panel members examined 66 individual fatality reports prepared by Mine Safety and Health Administration (MSHA) inspectors who investigated fatal accidents that occurred in small underground coal mines in 1979 and 1980. This report is the result of those studies, analyses, and deliberations. The first draft was prepared by the panel, but the report has been reviewed and approved by the entire Committee.

In addition to this introduction, the report consists of two parts. The first section, "Conclusions and Recommendations," presents the findings that resulted from the Committee's study and makes recommendations that represent the best judgment of committee members on what should be done to improve safety in small underground coal mines. The second part, "Statistical Analyses," gives the results of the specific statistical analyses undertaken to explore the unique safety problems of small underground coal mines.

This supplementary study reinforces our previous conclusion that smaller underground coal mines have a significantly higher fatality rate than do the larger underground coal mines. We attribute this higher fatality rate to several factors, including the shorter and intermittent mode of operation of these smaller mines and, in the Committee's judgment, a lack of top-quality mining equipment, a lack of adequate financial resources, and inadequacies in the training of workers and managers in these mines.

We conclude that operators of small mines need assistance with respect to safety in their mines and that this assistance should come primarily from the governments of the states in which they operate. Eighty-five percent of the small mines (those having fewer than 50 employees) are concentrated in the states of Kentucky, Virginia, and West Virginia. We recommend that the governments of these states provide assistance, primarily in the form of advice, to the operators of small underground coal mines. The federal government can help by providing technical assistance and training aids, as well as financial assistance to states that undertake this important service.

employees--but this phenomenon does not account for the significantly higher fatality rate of small mines in general.

On the basis of our examination of fatality reports, discussions with operators of small underground coal mines, and the experience of the Committee's three mining engineers and geologist with small mine operations, we believe the following factors exacerbate the safety problem in small mines:

1) The mining equipment in small mines is of lower quality, sometimes secondhand, and less well maintained.

2) The physical condition of employees in small mines is less favorable to safety--small operators sometimes employ workers that large companies will not accept.*

3) The financial resources available to operators of small mines are limited. Hence many of these operators are not able to support the more extensive safety programs employed by some major coal companies (using safety engineers and technicians).

In view of the findings listed above, it is our considered judgment that the maintenance of safety in smaller underground coal mines is more difficult, and has aspects that are different, than the safety problem in larger mines. We believe that the operator of a small mine needs help in maintaining safe working conditions within his mine.** Moreover, we believe that such help, at the present time, should come primarily from the governments of the states that have a large population of small mines. These states are Kentucky, Virginia, and West Virginia. The responsible agencies of these states are:

The Department of Mines and Minerals
Commonwealth of Kentucky
Lexington, Kentucky

The Division of Mines
Department of Labor and Industry
Commonwealth of Virginia
Big Stone Gap, Virginia

Department of Mines
State of West Virginia
Charleston, West Virginia

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*Labor turnover rates might be an additional factor leading to more accidents and more fatalities, but we have no data setting forth comparative labor turnover rates between large and small mines.

**All of our data come from mines that report to MSHA, have been certified for operation by MSHA, and hence are presumed to meet MSHA's minimum requirements for safety. They nevertheless need help in maintaining safe operating conditions.

The principal form of assistance that states should offer to operators of small mines consists of advisory services of the following nature:

1) The operator of a small mine needs technical assistance pertaining to the physical conditions in his mine: the geology of the mine, appropriate mining methods, safe use of mining equipment, dust control, ventilation, etc.

2) The operator of a small mine needs advice concerning miner training, specifically on-the-job training and the use of job safety analysis (see p. 123 of Toward Safer Underground Coal Mines). For example, where required, a state advisor should spend several hours with each miner in a typical small mine, one employing up to 10 or 20 miners. He should observe how the miner goes about his job and give him advice on safe procedures. As a result of his observations, the advisor could develop a written safe job procedure to be given to the miner and to the operator. On subsequent visits the state advisor could observe whether the miner's safe work performance has improved.

The federal government, acting through the Mine Safety and Health Administration, can help to improve the safety of small underground coal mines principally in two ways:

1) By providing technical information and training aids to state mining agencies.

2) By providing grants-in-aid to states to support their advisory efforts for small coal mines.

3

STATISTICAL ANALYSES OF SMALL UNDERGROUND COAL MINES

Introduction

In its report Toward Safer Underground Coal Mines, the Committee emphasized that smaller mines, in particular mines with 50 or fewer employees, were found to have a fatality rate nearly three times higher than that in mines with over 250 employees, and nearly twice that of mines with 51-250 employees. This strong correlation between mine size and fatality rates was evident in all the data from the Mine Safety and Health Administration we examined dating back to 1969. Furthermore, the association was not explainable by company ownership, union status, seam thickness, or any of the other factors we examined.

It was also seen that the distribution of types of accidents causing fatalities did not vary much across mine size. This indicates that the larger fatality rate in small mines is not the result of an increase in a specific type of accident (e.g., roof falls). Rather, the data indicated that smaller mines are more likely than larger mines to have fatalities from each of the major types of accidents. This would suggest that the problem in small mines is not isolated to a specific work activity (such as roof bolting), but is present in all aspects of the mining effort.

One explanation (considered in our earlier report) of the association between mine size and fatality rates is that in large mines there are proportionally more workers away from the working face and therefore at reduced risk for a fatality. If this were true, then smaller mines would have larger fatality rates even though the risks for miners at the working face were the same as in larger mines. We allowed for this possibility in our analyses (see pp. 91-93) but found that, at best, it could explain only a part of the strong association between mine size and fatality rates.

The present report summarizes the Committee's additional analyses of the relationship between mine size and fatality rates. As in our earlier report, we focus primarily on information collected from MSHA accident/injury and employment/production reports. We begin by examining features of small mines that distinguish them from larger mines and looking at how this might bear on their chances for fatal injuries. We then carry out analyses to determine whether and how much these factors help to explain the association.

Characteristics of Small Mines

Fatality Rates by Size

Table 1 gives a breakdown of fatality rates (R_1)* by mine size for the period 1975-80. The category 1-50 employees, used in the Committee's earlier report, has been divided into three subcategories: 1-10, 11-20, and 21-50 employees. A finer gradation of the 1-10 category is not warranted, because of both the small numbers of employee-hours of risk and an apparent bias in the reporting practices of very small mines (to be discussed later).

TABLE 1 Fatality Rates by Mine Size, 1975-80
(standard errors are in parentheses)

Mine Size (number of employees)	No. of Mines	Fatalities	Million Employee-Hours	Fatality Rate (R_1)
1-10	1,683	26	24.4	.21 (.04)
11-20	1,150	53	55.2	.19 (.03)
21-50	700	58	111.0	.10 (.01)
51-150	324	139	232.9	.12 (.01)
151-250	133	85	223.0	.08 (.01)
250+	149	151	610.8	.05 (.01)

Note that mines with 20 or fewer employees have a fatality rate (.20) about twice that of mines with 21-50 employees. Thus the trend of increasing fatality rate with decreasing size continues within the 1-50 category.

Table 2 gives a breakdown of mines by state and size. The table includes only those seven states with at least 20 million hours of underground coal mine employment during 1978-80. For each state the table gives the number of mines in each size category and the proportion of the state's employee-hours accounted for by that category. For example, in Kentucky there are 434 mines having from 1 to 10 employees, and these mines account for 4 percent of Kentucky's employee-hours. The last column of the table gives the percentage of each state's total hours accounted for by mines with 1-50 employees.

*Defined as the number of fatalities per 200,000 employee-hours or during one year for 100 full-time workers. The estimated standard errors, given in parentheses, are computed as $R_1/\sqrt{n}$, where n is the number of fatalities.

TABLE 2 Number of Mines by State and Size, 1978-80 (percentages of employee-hours accounted for by corresponding size category are in parentheses)

State	Size Category (number of employees underground) 1-10	11-20	21-50	51-150	151-250	251+	Percentage of Hours in Mines with 1-50 Employees
Alabama	7 (<1)	1 (<1)	1 (<1)	5 (11)	1 (3)	1 (85)	1
Illinois	1 (<1)	1 (<1)	2 (<1)	6 (5)	4 (7)	19 (88)	1
Kentucky	434 (4)	355 (10)	183 (15)	67 (24)	27 (22)	16 (25)	29
Ohio	4 (<1)	3 (<1)	1 (<1)	4 (2)	9 (21)	11 (76)	1
Pennsylvania	112 (1)	20 (1)	24 (3)	33 (14)	21 (18)	32 (63)	5
Virginia	285 (6)	261 (16)	81 (14)	41 (31)	8 (13)	6 (20)	36
West Virginia	211 (1)	244 (4)	231 (12)	124 (24)	43 (21)	36 (38)	17

Note that three states, Kentucky, Virginia, and West Virginia, have sizable numbers of their underground coal miners in small mines. In all other states, less than 5 percent of the underground coal mining workforce is employed in small mines. Thus the problem of small mines is concentrated in Kentucky, Virginia, and West Virginia, which in terms of both number of mines and employee-hours account for over 85 percent of the small (1-50 employee) coal mines in the United States.

Size and Seam Thickness

Table 3 gives a breakdown of mines by seam thickness and size. It is clear that, in general, smaller mines have thinner coal seams than do larger mines. However, within each size category there is no clear association between seam thickness and fatality rates. In particular, there appears to be no obvious relationship between seam thickness and the fatality rate in small mines. In contrast, within each thickness category the fatality rate tends to decline with increasing mine size. Thus the association between mine size and fatality rate is not due to differences between small and large mines with respect to seam thickness.

Note also from Table 3 that a sizable proportion (accounting for 41 percent of the employee-hours) of the small mines have unspecified seam thickness, which means that their seam thicknesses were not reported on the MSHA quarterly reports. In contrast, mines with unspecified seam thickness account for only 9 percent of the employee-hours in mines with over 50 employees. Because of this large amount of missing information, it is not possible to give a more detailed analysis of seam thickness in small mines.

Mining Method

The MSHA computer files used in the Committee's earlier report did not provide information on mining method. However, MSHA inspection reports contain information on both the mining method and number of active sections (which can be regarded as a surrogate for the number of employees). Table 4 gives the joint distribution of mines by size and mining method. The data are for the period 1973-79.

For example, between 1973 and 1979 there were 5,075 quarters worked in mines having two active sections. Of these mines, the relative proportion of conventional mining was 31 percent. The table shows that conventional mining is more common in mines with fewer active sections.

In order for mining method to explain any sizable portion of the association between mine size and fatality rate, two conditions must hold. First, mining method must be correlated with fatality rate. Since over 90 percent of all mining in the United States is conventional or continuous mining, this means that the fatality rates corresponding to these methods must be substantially different. Second, the distribution of mining method must vary considerably across mine size. The data in Table 4 indicate that conventional mining is more common in small mines than in larger mines. However, based on other analyses (see

TABLE 3 Fatality Rates by Seam Thickness and Mine Size, 1975-80 (standard errors are in parentheses)

Seam Thickness	Mine Size 1-50	51-150	151-250	251+
Less than 48 in.				
No. of Mines	916	119	34	17
Hours (millions)	69.7	80.6	53.1	57.4
R_1	.18 (.02)	.09 (.02)	.05 (.01)	.05 (.01)
49 in.-60 in.				
No. of Mines	197	57	37	37
Hours (millions)	21.6	48.4	66.0	140.6
R_1	.10 (.03)	.07 (.02)	.09 (.02)	.05 (.01)
61 in.-72 in.				
No. of Mines	104	28	14	30
Hours (millions)	10.2	26.0	25.8	140.7
R_1	.18 (.06)	.09 (.03)	.04 (.02)	.05 (.01)
73 in.-84in.				
No. of Mines	31	13	20	27
Hours (millions)	2.4	10.8	37.6	122.3
R_1	.08 (.08)	.13 (.05)	.11 (.02)	.05 (.01)
More than 84 in.				
No. of Mines	55	26	11	26
Hours (millions)	7.9	24.6	20.6	111.8
R_1	.10 (.05)	.20 (.04)	.08 (.03)	.05 (.01)
Unspecified seam thickness				
No. of Mines	2,228	81	17	12
Hours (millions)	77.8	42.5	19.9	38.0
R_1	.14 (.02)	.20 (.03)	.07 (.03)	.03 (.01)

p. 104 of our earlier report), there do not appear to be marked differences in the fatality rates of these two mining methods. Thus it does not appear as if mining method per se could explain any material amount of the elevated fatality rate in smaller mines.

Mine Size and Age

In Toward Safer Underground Coal Mines (pp. 100-104), we indicated that the age of a miner was strongly and negatively correlated with disabling injury rates, but that age did not appear to be correlated with fatality rates.

TABLE 4 Conventional Versus Continuous Mining Methods by Mine Size, 1973-79

Mine Size (number of sections)	Number of Mine Quarters	Relative Proportion of Conventional Mining*
1	23,560	.60
2	5,075	.31
3-4	4,188	.27
5-7	2,817	.20
8-10	1,472	.17
11 or more	846	.10

*The proportion is the number of sections using conventional mining divided by the number of sections using conventional or continuous mining.

In our previous study we were able to obtain the then-current age distribution of miners in the major companies that operate underground coal mines by requesting those data directly from the coal companies. The 15 coal companies that responded represent approximately one half of the underground coal mining population of the United States. On the basis of this age data we were able to demonstrate that younger miners (age 18-24) have a disabling injury rate that is three times that of miners over 45. However, we found no correlation between age and fatality rates. This implies that even if the age distribution in small mines is different from that in large mines, it would not explain the association between mine size and fatality rates.

Nevertheless, in trying to learn more about small mines we felt it important to have some indication of how age distribution varies with mine size. Data on age distribution were obtained from MSHA coal dust files for the years 1972-76 and are presented in Appendix A. We see from Tables A.1 through A.5 that age distribution varies with time as shown in Figure A.1. In particular, the age of the mining population decreased during the period 1972-76, as indicated by the significant decrease in the percentage of miners 46 and older and the increase in the percentage of miners in the 18-35 age group. However, for each time period the age distribution in smaller mines is quite similar to that in larger mines.

In conclusion, we find that the age distribution of miners in the small mines is not substantially different from the age distribution of all underground coal miners. Hence our previous finding with respect to the correlation of age and injury rate still applies, as does our recommendation for increased emphasis on the training of younger miners.

Underreporting

Whereas it is generally accepted that nearly all fatalities are reported to MSHA, hours of employment are not so completely reported. Hence, if underreporting of employee-hours is more common in smaller mines, the computed fatality rate for smaller mines would tend to be inflated.

If a mine reports an injury to MSHA in a quarter when it has not submitted an employment/production report, MSHA creates a dummy employment/production report for the mine in that quarter so that the injury will be accepted by the computer. Between 1978 and 1980 there were 10 fatal accidents for which dummy employment/production forms had to be created. If the fatality rate for mines that do not report hours is the same as that for other mines (i.e., $R_1 = .07$), then we would expect there to be 28.6 million employee-hours of unreported employment during this three-year period (because 28.6 million employee-hours and a fatality rate of .07 correspond to 10 fatalities). Since there were some 634 million employee-hours reported during this period, any underreporting would be too small to have any effect on the overall association between mine size and fatality rate. Of the 10 fatalities for which dummy employment/production reports were created, in the 6 that occurred in 1979-80 the mines had 11 or fewer employees. This suggests that nonreporting of employee-hours worked occurs mainly in very small mines. If so, the fatality rates in Table 1 for mines with 1-10 employees may be unreliable. For this reason it is preferable to consider the broader category of 1-20 employees as an entity, because there are sufficient employee-hours in this category that the fatality rate would not be severely biased by underreporting.

Duration of Active Operation

The Committee noted in its report (p. 84) that small mines appeared to remain in active operation for less time than do large mines. Table 5 examines this point by indicating the number of quarters of active operation by mine size for 1975-80. Note that over half (57 percent) of the small (1-50 employee) mines were operational for 6 or fewer of the 24 quarters during this six-year period. In contrast, only 4 percent of the larger mines were operational for so little time.

This striking difference between small and large mines gives rise to several possible explanations for the association between mine size and fatality rates.

Number of Quarters Opened Table 6 compares fatal accident rates in small (1-50 employee) mines according to the number of quarters open (i.e., with some production) during 1975-80.* Note that small mines open for one to six quarters have about twice the fatality rate of small mines open for more than six quarters. A closer inspection of the 1-6 category reveals that the fatality rates for mines open 1-2, 3-4, and 5-6 quarters are .51, .23, and .23, respectively. Thus the small mines

*In this and subsequent tables we use fatal accident rates, in which accidents with multiple fatalities count as a single fatality in the calculation.

TABLE 5 Distribution of Mines by Size and Number of Quarters Operational, 1975-80 (column percentages are in parentheses)

No. of Quarters Operational in 1975-80	Mine Size 1-50	51-150	151-250	251+	Total No. of Mines
1-2	1,048 (30)	8 (2)	1 (1)	0	1,057 (26)
3-4	564 (16)	5 (2)	2 (2)	0	571 (14)
5-6	413 (12)	8 (2)	3 (2)	0	424 (10)
7-8	294 (8)	18 (6)	7 (5)	1 (1)	320 (8)
9-10	251 (7)	16 (5)	1 (1)	1 (1)	269 (7)
11-12	222 (6)	18 (6)	4 (3)	1 (1)	245 (6)
13-14	168 (5)	16 (5)	5 (4)	0	189 (5)
15-16	130 (4)	20 (6)	5 (4)	5 (3)	160 (4)
17-18	118 (3)	29 (9)	5 (4)	1 (1)	153 (4)
19-20	87 (2)	32 (10)	9 (7)	5 (3)	133 (3)
21-22	89 (3)	26 (8)	10 (8)	8 (5)	133 (3)
23-24	148 (4)	126 (39)	81 (61)	126 (85)	481 (12)
TOTAL	3,532	322	133	148	4,135

TABLE 6 Fatal Accident Rate in Small Mines (1-50 Employees), 1978-80, by Number of Quarters Open (standard errors are in parentheses)

No. of Quarters Open	Fatal Accidents	Hours (millions)	Fatal Accident Rate (R_1)
1-6	37	26.58	.28 (.05)
7-12	23	43.77	.11 (.02)
13-18	33	49.97	.13 (.02)
19-24	44	70.25	.13 (.02)

that are open for very short periods have a greater fatality rate than do those open for longer periods. The same comparison was made separately for mines with 1-20 employees and 21-50 employees. For each size category the fatality rate was highest in mines open only one to six quarters.

Note that the fatality rates in small mines that are open for more than six quarters are still higher than those in large mines. Thus the elevated fatality rate in small mines open one to six quarters does not explain the higher overall rate of fatalities in small mines. However, it does indicate a subcategory of these mines where the fatality problem appears to be more acute.

For small mines that operate intermittently, the length of a period of shutdown might have some influence on the safe operation of the mine, but shutdown time is not reported to MSHA. MSHA knows only whether the mine operated during a given quarter. Hence only intermittency of operation could be investigated, and, as we have seen, mines that open and close repeatedly tend to have a higher fatality rate.

Number of Runs A related hypothesis is that small mines that open and close regularly are at higher risk for a fatal accident than are those that are open continuously. Unfortunately, our analyses are limited because we can measure continuity of operation only on a quarterly basis.

Let a "run" be defined as a period of time during which a mine is open. Thus if a mine is open all of 1975, closed in 1976-79, open for the first quarter of 1980, and closed for the rest of 1980, it will have two runs. Table 7 gives the fatality rate by the number of quarters open and the number of runs.

TABLE 7 Fatal Accident Rate by Quarters Open and Number of Runs in Small (1-50 Employee) Mines, 1975-80 (standard errors are in parentheses)

No. of Quarters Open	No. of Runs 1	2	3 or More
1-6	.28 (.05)	.27 (.10)	.27 (.19)
7-12	.09 (.03)	.12 (.05)	.14 (.07)
13-18	.12 (.03)	.10 (.04)	.23 (.07)
19-24	.13 (.02)	.09 (.03)	.21 (.09)
TOTAL	.14 (.02)	.12 (.02)	.20 (.07)

After controlling for the number of quarters open, there is an indication that small mines that open intermittently may be at greater risk of a fatality than small mines that do not open and close repeatedly. However, the overwhelming number of employee-hours (119.7 million) occur in mines with only one run. The intermittently operated small mines are the source of a relatively small percentage of the total employee-hours worked in small mines. This means that even if the fatal accident rate is higher in these intermittently open mines, they account for relatively few additional fatalities.

Declining Fatality Rates Another hypothesis that might explain the higher fatality rate in small mines is that the risk of a fatality is greatest shortly after a mine first opens and thereafter declines--i.e., that there is a learning curve that reduces the risk of fatalities with time. Such a curve, if it does exist, might take the form shown in Figure 1.

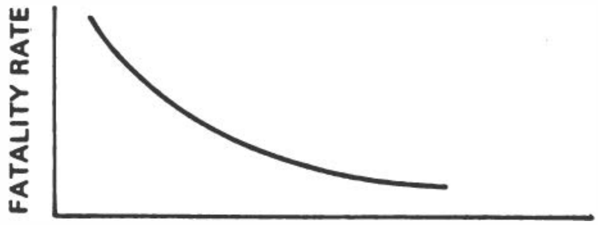

FIGURE 1 A hypothetical learning curve relating fatality rate to time of operation.

If this hypothesis were true, it would go a long way toward explaining the higher fatality rate in small mines, since these tend to stay open for less time than do larger mines. That is, it could be that a small mine and large mine that have been active over the same period have equal fatality rates, but that, overall, smaller mines have higher fatality rates simply because they remain open for less time than do larger mines.

To explore this possibility, we computed changes in mine fatality rates over time, focusing only on small mines open continuously for seven or more quarters. Table 8 gives the fatality rates for different times since opening. There is no clear indication of a time trend in the fatality rate. Thus it does not appear that the higher fatality rate in small mines is due to a learning-curve phenomenon.

TABLE 8 Time Trends in Small (1-50 Employee) Mines Open Continuously for More Than Seven Quarters in 1975-80 (standard errors are in parentheses)

	Time Since First Opened					
	0-6 Months	7-12 Months	13-18 Months	19-24 Months	25-48 Months	49-96 Months
Fatal Accident Rate	.14 (.05)	.08 (.03)	.09 (.04)	.09 (.04)	.10 (.01)	.19 (.01)

Summary

The fatality rate in small mines (those with 1-50 employees) is higher among smaller mines within the 1-50 category. Specifically, the fatality rate in mines with 1-20 employees is considerably higher than that in mines with 21-50 employees. The possibility of underreporting of employee-hours in very small mines (1-10 employees) prevents any separate conclusions for this category.

Small coal mines are concentrated in the states of Kentucky, Virginia, and West Virginia. In every other state, mines with 1-50 employees account for no more than 5 percent of the total employee-hours.

The data on seam thickness, age of miner, and mining method indicate that none of these factors has any substantial impact on the relationship between mine size and fatality rates. Mines with fewer miners tend to have smaller coal seam thicknesses. However, there is no apparent association between seam thickness and fatalities. The age distribution of workers in small mines, estimated by indirect methods, does not appear to be substantially different from the age distribution in larger mines.

There is a striking difference between small and large mines with respect to the length of time they remain open. The majority (57 percent) of small mines were active for six or fewer quarters in 1975-80, compared with only 4 percent of larger mines. Mines open for one to six quarters had a substantially higher fatality rate than did mines open for seven or more quarters. However, this phenomenon can explain little of the overall difference in fatality rates between large and small mines.

APPENDIX A

This appendix evaluates the age distribution of workers in small underground coal mines and compares it with the age distribution of workers in larger mines. Tables A.1, A.2, A.3, A.4, and A.5 present the number of miners by mine size and age for the years 1972, 1973, 1974, 1975, and 1976, respectively. Figure A.1 plots the percentage of the workforce in each age category as a function of time over the period 1972-76.

These data were obtained by merging the MSHA coal dust files from 1972-76 with the information from the mines we considered in our 1978-80 analysis. Because of the way we selected mines, no interpretation can be given to the numbers but only to the relative proportions in the various age categories. Two things emerge from these data. First, for each year the age distributions of the four size categories are similar. For example, in 1972 the proportion of miners age 18-25 was about 18 percent in each mine size category. This is consistent with our earlier conclusion that the age distribution in small mines is similar to that in larger mines.

The second noteworthy point is the change in age distribution with time (see Figure A.1). Note that the 36-45 age group remains steady at about 15 percent, whereas the two youngest categories are steadily rising and the older group is steadily dropping. This reflects the influx of younger miners after the oil embargo in late 1973. Apparently, things reversed a bit between 1976 and 1980; in our earlier study we found the proportions in the four age categories to be 12 percent (age 18-24), 40 percent (age 25-34), 22 percent (age 35-44), and 26 percent (age 45+).*

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*Note that these age categories are a bit different from those in Tables A.1-A.5 and Figure A.1.

TABLE A.1 Number of Miners by Mine Size and Age, 1972

Mine Size	Age 18-25	26-35	36-45	46+	Total
1-50	1,394 (18)	1,514 (19)	1,329 (17)	3,595 (46)	7,832
51-150	2,106 (18)	2,547 (22)	2,155 (19)	4,726 (41)	11,534
151-250	2,095 (17)	2,345 (20)	1,976 (16)	5,585 (47)	12,001
251+	4,938 (20)	5,365 (21)	3,825 (15)	10,927 (44)	25,055
TOTAL	10,533 (19)	11,771 (21)	9,285 (16)	24,833 (44)	56,422

NOTE: Numbers in parentheses are the percentage of miners in each age interval for the indicated mine size category.

TABLE A.2 Number of Miners by Mine Size and Age, 1973

Mine Size	Age 18-25	26-35	36-45	46+	Total
1-50	1,168 (21)	1,348 (24)	941 (17)	2,158 (38)	5,615
51-150	1,740 (20)	2,149 (25)	1,634 (19)	3,112 (36)	8,635
151-250	2,045 (23)	2,106 (24)	1,515 (17)	3,228 (36)	8,894
251+	4,133 (22)	4,650 (25)	3,009 (16)	7,014 (37)	18,806
TOTAL	9,086 (22)	10,253 (24)	7,099 (17)	15,512 (37)	41,950

NOTE: Numbers in parentheses are the percentage of miners in each age interval for the indicated mine size category.

TABLE A.3 Number of Miners by Mine Size and Age, 1974

Mine Size	Age 18-25	26-35	36-45	46+	Total
1-50	1,357 (27)	1,459 (29)	728 (15)	1,423 (29)	4,967
51-150	1,659 (25)	1,832 (28)	1,144 (17)	1,911 (29)	6,546
151-250	1,909 (28)	1,721 (26)	1,052 (16)	2,044 (30)	6,726
251+	3,820 (27)	3,866 (27)	2,073 (15)	4,338 (31)	14,097
TOTAL	8,745 (27)	8,878 (27)	4,997 (15)	9,716 (30)	32,336

NOTE: Numbers in parentheses are the percentage of miners in each age interval for the indicated mine size category.