Chapter 5

TESTING THE MODEL I: THE EFFECTS OF ORGANIZATIONAL "CONCERN" ON WORKER HEALTH

This chapter will begin to test the model. The model, it is to be remembered, contends that a variety of specific "historical" factors affected the "concern" displayed by organizations to the hazard of excess mine radiation. The model further states the "concern" evidenced by companies, government agencies and unions shaped the rate and timing of radiation decline.

The analysis of the model will proceed in reverse order, starting with the dependent variable and working back through the chain of hypothesized relationships to what are believed to be ultimate historical factors of a "causal" nature. The chapter is organized as follows: first, there will be a preliminary, descriptive discussion of the dependent variable measuring worker health and safety; then, attention will turn to the "concern" exhibited by companies, government agencies and unions during the twenty year study period. Concern will be studied in terms of the actions taken by organizations to control the hazard. In the next chapter, the analysis will consider the influence of what are hypothesized to be more fundamental factors which actually explain the appearance or absence of organizational "concern."

MEASURING TRENDS IN THE DEPENDENT VARIABLE: WORKER HEALTH

Health conditions in the nation's uranium mines have improved tremendously in the quarter century since the industry began. Radiation in mines today is only a fraction of what it was in earlier times. In fact, most mines are free of any concentrations believed to cause bodily harm.

There has been much variation, however, in the pacing of the curtailment of radiation. Although modest advances occurred fairly regularly, dramatic progress transpired at only a few points in time.

Public Health Service information on radiation in the uranium mines of Colorado, Arizona, New Mexico, Utah and Wyoming, shows that the greatest inroads against excessive radiation were made immediately subsequent to 1960 and 1967. In the year 1960-1961, the average level of radiation declined by 46.4%. Between 1967 and 1968 it dropped another 40%. This

compares to an average annual rate of decline over the 28 year time period of only 8.62%. In general, radiation has declined faster with each successive calendar year. See Table 4.

The irregular pace of radiation decline for the industry as a whole subsumes even more striking irregularities for the group of Colorado mines selected for intensive study. Consisting of more than 500 mines, this group exhibited extreme and fluctuating levels of radiation during most of the decade, 1950-1960. It was only after 1960 that radiation began to decline at a consistently very rapid rate. Great progress was made in all but three mid-decade years. Annual rates of decline between 30% and 40% were typical from 1960 to 1963. Between 1966 and 1967 annual decline rates peaked at 50%. During the decade, 1960-1969, the range of radiation scores found among the sample mines narrowed and the standard deviation associated with the mean grew smaller. Since the mines in the sample come from all sections of the state, lower ranges and standard deviations suggest the problem was being alleviated throughout Colorado. Table 5 summarizes this information. It presents yearly mean radiation levels, rates of decline, standard deviations, sample sizes and ranges of radiation values for the sample of Colorado mines between 1950 and 1969. See Table 5.

THE EFFECTS OF "CONCERN" ON THE DEPENDENT VARIABLE: GOVERNMENT REGULATION

It appears that dramatic decreases in radiation in mines were linked with the demonstration of "concern" by one or another government enforcement agency. Concern took the form of overtly regulating behavior. In Colorado, the government agency responsible for the uranium mining industry was the State Bureau of Mines. This agency was established in March 1895 by an act of the Colorado State Legislature.[83] Its responsibilities included maintaining records of mineral activities in the state and enforcing the laws relating to health and safety. In 1961 the Bureau of Mines began a state-wide program to reduce radiation hazards. This involved a stepped-up campaign of inspections and sanctions of various sorts against mine operators.

That this program had an effect on health conditions is shown in the agency's historical records of state radiation levels. While 39% of the Colorado uranium mines sampled by state inspectors in June, 1961, exhibited radiation in excess of 10.0 Working Levels, only 4½% had such high exposure levels six months later. (See Table 6)

The impressive achievements of this program continued throughout the decade. Ever greater proportions of the state's mining operations met stiffer quality goals. By 1969, workers in nearly 94% of Colorado's mines were exposed to radiation measuring less than 1.0 Working Levels. (See Table 7)

Table 4

Average Concentrations (in W.L.) to which Underground Uranium Miners were Exposed and Rates of Decline: 1940-1968

Year	Average W.L.	Absolute Decline	Rate of Decline (%)	Year	Average W.L.	Absolute Decline	Rate of Decline (%)
[a] 1940	15.0			[b] 1955	7.7		
		0	0			-0.3	-3.9
[a] 1941	15.0			[b] 1956	7.4		
		0	0			-0.4	-5.4
[a] 1942	15.0			[b] 1957	7.0		
		0	0			-0.2	-2.9
[a] 1943	15.0			[b] 1958	6.8		
		-1.0	-6.7			-0.3	-4.4
[a] 1944	14.0			[b] 1959	6.5		
		-1.0	-7.1			-0.9	-13.8
[a] 1945	13.0			[b] 1960	5.6		
		-2.0	-7.1			-2.6	-46.4
[a] 1946	12.0			[b] 1961	3.0		
		-0.5	-16.7			0	0
[a] 1947	10.0			[b] 1962	3.0		
		-0.3	-5.0			0	0
[a] 1948	9.5			[b] 1963	3.0		
		-0.2	-3.2			-0.7	-23.3
[a] 1949	9.2			[b] 1964	2.3		
		-0.3	-2.2			0	0
[a] 1950	9.0			[b] 1965	2.3		
		-0.2	-3.3			-0.2	-8.7
[a] 1951	8.7			[b] 1966	2.1		
		-0.2	-2.3			-0.6	-29.4
[a] 1952	8.5			[b] 1967	1.5		
		-0.3	-2.4			-0.6	-40.0
[a] 1953	8.3			[b] 1968	0.9		
		-0.3	-3.6				
[a] 1954	8.0						
		-0.3	-3.8				

[a] Estimated values; [b] Calculated values.

Sources:

Average W.L. values based on testimony by Lou Gehrig, Acting Surgeon General, United States Public Health Service before Hearings by the Joint Committee on Atomic Energy, Radiation Exposure of Uranium Miners, 1967, p.106; and the Joint Committee on Atomic Energy, Radiation Standards for Uranium Mining, March 17 and 18, 1969, p.157

Table 5

Yearly Mean Radiation Levels, Absolute Declines, Rates of Decline, Standard Deviations, Sample Sizes and Ranges of Radiation Levels in the Sample of Colorado Uranium Mines, 1950-1969

Year	Sample Size	Mean Radiation (W.L.)	Absolute Decline	Rate of Decline (%)	Standard Deviation	Range
1950	30	26.5			15.70	60.5
			-0.1	-0.4		
1951	58	26.4			20.14	116.5
			-2.8	-10.6		
1952	103	23.6			26.54	183.0
			+6.4	+27.1		
1953	127	30.0			87.86	992.0
			-9.5	-31.7		
1954	146	20.5			16.68	148.0
			-5.7	-27.8		
1955	165	14.8			17.18	154.0
			-3.0	-20.3		
1956	212	11.8			16.07	154.0
			+7.8	+83.0		
1957	246	19.6			26.52	247.0
			-7.4	-37.8		
1958	234	12.2			18.20	140.5
			+3.2	+26.2		
1959	260	15.4			25.23	247.0
			-3.7	-24.0		
1960	262	11.7			19.77	156.0
			-4.0	-34.2		
1961	270	7.7			13.72	156.0
			-2.8	-36.4		
1962	249	4.9			7.38	63.6
			-1.8	-36.7		
1963	216	3.1			4.3	35.0
			0	0		
1964	174	3.1			4.1	27.9
			-0.2	-6.5		
1965	182	2.9			5.2	52.0
			-0.1	-3.4		
1966	218	2.8			4.2	39.0
			-1.4	-50.0		
1967	183	1.4			1.6	9.8
			-0.4	-28.5		
1968	161	1.0			1.1	6.9
			-0.4	-40.0		
1969	127	0.6			0.6	4.0

Sources:

The sample of Colorado uranium mines.

Table 6

Immediate Effects of the Colorado Program to Control Mine Radiation, June 1961 - December 1961

Average mine radiation levels (W.L.)	Percentage of Colorado mines at various radiation levels			
	June 30, 1961	August 31, 1961	October 31, 1961	December 31, 1961
0.0 - 1.0 W.L.	18	36	41	45
1.0 - 3.0	14	17	25	28
3.0 - 10.0	29	22	23	23
10.0 +	39	25	11	4

Source:
Annual Report for the Year 1961, Colorado Bureau of Mines, 1962

Table 7

A Summary of Radiation Exposure Levels in Underground Uranium Mines in Colorado, 1961-1969

Average mine radiation levels (W.L.)	Percentage of Colorado mines at various radiation levels during								
	1969	1968	1967	1966	1965	1964	1963	1962	1961
0.0 - 1.0	93.7	83.0	82.0	60.0	52.0	43.0	40.5	52.0	45.0
1.0 - 2.0	5.5	15.6	16.0	34.5	40.5	41.0	47.0	38.0	27.0
2.0 - 5.0	0.9	0.6	1.5	5.5	6.0	16.0	12.5	10.0	23.0
5.0 - 10.0	0.0	0.6	0.5	0.0	0.8	0.0	0.0	0.0	4.5
10.0 +	0.0	0.0	0.5	0.0	0.8	0.0	0.0	0.0	0.0

Sources:
Annual Reports for the Years 1961-1969, Colorado Bureau of Mines

The most striking features of the stepped-up control program initiated by the Bureau of Mines were inspections and sanctions. For example, between 1961 and 1962, the number of inspections conducted in an area of Colorado that contains the majority of the state's uranium mines, District 4, increased by more than 46% from 494 to 917 inspections. This increase reflects greater efforts to monitor the hazard. (See Table 8)

Over time, sanctions of each of several different degrees of severity were more frequently applied to mine operators who violated ventilation codes. While no mine had even been ordered to halt production because of hazardous radiation prior to 1960, Colorado inspection agents issued 65 halt orders in 1969. (See Table 8)

Information assembled on the study sample of Colorado mines tends to corroborate the aggregate trends in the data kept by the Colorado Bureau of Mines. The study sample shows that during the second decade of the study (i.e., the 1960's) the average number of visits to mines by inspection agents increased significantly. Concurrently, the percentage of mines subject to reinspection within a single year mushroomed. Prior to 1961, fewer than 1% of the sample groups was visited more than three times in a single year. In 1969, more than half of the 127 mines that operated experienced four visits or more within the year. One mine was reinspected seventeen times in one year. (See Table 9)

Punitive actions were also more common during the second decade of the study period. The percentage of operators receiving mild orders (See Table 10A) to correct ventilation rose over time and peaked in 1966. In that year, 32% of mine operators received at least two or more directives on the subject of radiation. 1966 was also the year during which radiation in the sample declined most drastically.

More stringent sanctions--remove men and cease operations--(See Tables 10B and 10C) were also applied with successively greater frequency. Fewer than 10% of mine operators had been required to remove men and halt productive abilities because of excess radiation prior to 1965. In 1969, however, a full 25% of mine operators experienced such restrictions. (See Table 11)

Thus, a preliminary review of the trends suggests that sharp elevations of government watchdog activities coincided with dramatic declines of mine radiation. Mines were visited more frequently by enforcement agents; operators who ignored health codes risked costly penalties. In the next section, this association will be explored more closely.

Testing the Implications of Government Agency "Concern"

To test whether the supervisory actions of the government actually enhanced worker health (and, if so, which actions were most beneficial) radiation conditions in mines with varying histories of inspections and

Table 8

A Summary of Inspection and Sanction Activities by Colorado Inspection Agents of the State Bureau of Mines, 1950-1970

Year	No. Mines	No. Inspections	Inspections Per Mine	General Order	Remove Men Order	Cease Order[a]	Total Order
1950	115	195	1.7	0	0	0	0
1951	167	195	1.2	0	0	0	0
1952	192	289	1.5	0	0	0	0
1953	215	264	1.2	0	0	0	0
1954	295	287	1.0	0	0	0	0
1955	335	334	1.0	0	0	0	0
1956	354	366	1.0	0	0	0	0
1957	378	393	1.0	0	0	0	0
1958	459	420	1.0	0	0	0	0
1959	424	451	1.1	0	0	0	0
1960	422	567	1.3	0	0	0	0
1961	402	494	1.2	120	11	0	131
1962	331	917	2.8	126	11	4	141
1963	333	806	2.4	120	14	1	135
1964	265	746	2.8	122	13	2	137
1965	279	874	3.1	125	40	1	166
1966	283	1006	3.6	229	48	4	281
1967	262	1483	3.7	167	35	8	210
1968	257	1582	6.2	134	50	3	187
1969	239	1556	6.5	95	62	3	160
1970	235	1531	6.5	97	39	2	138

Sources:

Columns 2, 3, 5, 6, 7, 8: Compiled from the Annual Reports for the Years 1950-1970, Colorado Bureau of Mines

Column 4: For inspections per mine, Col. (3) divided by Col. (2).

[a]Cease Order = Cease Operation Order

Table 9

The Sample of Colorado Uranium Mines:
Inspection Activity

Year	Percentages of mines inspected				
	Not at all	One time	Two times	Three times	Four times or more
1950	n.a.	n.a.	n.a.	n.a.	n.a.
1951	n.a.	n.a.	n.a.	n.a.	n.a.
1952	12.6	63.1	23.3	1.0	0
1953	10.2	61.4	26.0	2.4	0
1954	24.8	40.7	26.9	7.6	0
1955	17.0	38.8	38.8	5.5	0
1956	20.8	56.6	17.9	3.8	0.9
1957	16.3	65.9	14.6	2.8	0.4
1958	14.6	54.5	26.2	4.3	0.4
1959	14.6	55.8	24.6	4.2	0.8
1960	10.7	42.7	28.5	12.6	0.5
1961	13.0	55.2	19.3	8.1	1.5
1962	12.1	45.6	28.2	7.3	6.8
1963	12.5	44.0	24.5	10.6	8.4
1964	9.8	36.8	28.2	14.9	10.3
1965	16.5	30.8	24.2	15.9	12.4
1966	11.0	25.7	18.3	16.1	29.0
1967	14.3	24.7	20.3	13.7	26.8
1968	5.6	24.8	14.3	8.7	46.6
1969	3.1	16.5	11.0	14.2	55.2

Sources:
The sample of Colorado uranium mines.

Table 10A

Sanction Activity in the Sample of Colorado Uranium Mines: General Orders

Percentage of mines receiving general orders

Year	Not at all	Once	Twice or more
1959	67.6	27.2	5.1
1960	50.6	31.8	17.6
1961	47.5	35.2	17.4
1962	52.1	31.5	16.6
1963	47.1	34.4	18.6
1964	52.2	24.8	22.9
1965	36.4	37.7	25.8
1966	38.1	29.9	32.0
1967	49.4	25.9	24.7
1968	52.3	26.1	21.7
1969	46.8	29.0	24.2

Table 10B

Sanction Activity in the Sample of Colorado Uranium Mines: Remove Men Orders

Percentage of mines receiving remove men orders

Year	Not at all	Once	Twice or more
1959	100	0.0	0.0
1960	93.1	6.5	0.4
1961	96.2	3.0	0.8
1962	96.3	3.2	0.5
1963	94.7	5.3	0.0
1964	93.6	5.7	0.6
1965	86.8	6.6	6.7
1966	79.4	15.5	5.1
1967	83.4	10.8	5.7
1968	84.2	7.2	8.6
1969	74.2	15.3	12.4

Sources:

The sample of Colorado uranium mines.

Table 10C

Sanction Activity in the Sample of Colorado Uranium Mines: Cease Operation Orders

Percentage of mines receiving cease operation orders

Year	Not at all	Once	Twice or more
1959	100	0.0	0.0
1960	97.8	2.2	0.0
1961	98.7	1.3	0.0
1962	99.5	0.5	0.0
1963	98.9	1.1	0.0
1964	99.4	0.6	0.0
1965	96.1	3.3	0.7
1966	95.9	3.6	0.5
1967	91.7	7.1	1.2
1968	96.7	2.0	1.4
1969	96.0	3.2	0.8

Table 11

Mean Inspections and Sanctions Per Mine in the Sample of Colorado Uranium Mines: 1950-1969

Year	Inspections	General order	Remove men	Cease operation
1950	n.a.	n.a.	n.a.	n.a.
1951	n.a.	n.a.	n.a.	n.a.
1952	1.2	0.0	0.0	0.0
1953	1.2	0.0	0.0	0.0
1954	1.2	0.0	0.0	0.0
1955	1.3	0.0	0.0	0.0
1956	1.1	0.0	0.0	0.0
1957	1.1	0.0	0.0	0.0
1958	1.2	0.0	0.0	0.0
1959	1.2	0.4	0.0	0.0
1960	1.6	0.8	0.1	0.02
1961	1.4	0.82	0.1	0.0
1962	1.6	0.82	0.1	0.0
1963	1.6	0.82	0.1	0.0
1964	1.9	0.9	0.1	0.0
1965	1.9	1.2	0.2	0.1
1966	2.6	1.2	0.3	0.05
1967	2.6	1.1	0.3	0.1
1968	3.6	1.1	0.3	0.06
1969	4.9	1.2	0.5	0.06

sanctions were compared. Since overt manifestations of agency "concern" were hypothesized to have driven down radiation levels, it was expected that there would be an inverse association between radiation and enforcement activities.

An initial analysis of inspections and radiation information from the study sample of mines, within the same calendar year, however, illustrated just the opposite. More healthful conditions were associated with mines that had escaped government regulation. For example, in almost every year following 1958, higher radiation was reported for mines that had experienced at least two inspections or more than for mines which had experienced none. (See Table 12A)

In the cases of sanctions, the trend was even more pronounced. Health conditions were considerably more favorable in mines avoiding sanctions of all types. (See Tables 12B and C)

There are several possible explanations for this superficially incongruous result. They all involve biases due to using information on regulation and radiation from the same calendar year. First, a single year was not long enough for regulations to sufficiently lower radiation in mines with stubborn problems. Second, within any single year, information on radiation and regulations, collected by two different agencies, were unstandardized. Third, the nature of the measurement of mine radiation itself was insensitive to changes in radiation within a single calendar year.

It appeared logical to reanalyze the information using radiation levels for the year following a given inspection. For example, a mine's 1968 inspection record would be compared with its 1969 radiation picture.

Results of the "year after" analysis suggested somewhat stronger relationships. At least after 1964, there was an association between regulatory activities in year one and reduced radiation in year two. Mines visited at least once or subject to some type of sanction exhibited lower radiation in the following year than those that escaped all government supervision. Prior to 1964, however, the opposite was true. Lower radiation levels were found among mines that had avoided inspections and sanctions in the previous year. (See Tables 13A and 13B)

There are two possible explanations for the discrepancy in the trends for the years prior and subsequent to 1964. Staff members of the Bureau of Mines attribute the earlier pattern to the failure of inspectors to report visits to mines with low radiation. This would account for the low scores found among mines listed as receiving no inspection or sanctions. After 1964, a more comprehensive system of record keeping was introduced to the agency. It required that inspectors report all their visits to mines regardless of radiation conditions encountered. This reduced the under-reporting bias vis a vis mines with low radiation in the post-1964 period.

Table 12A

Mean Radiation Levels in Mines with Varying Histories of Inspections in the Sample of Colorado Mines, 1950-1969

(Radiation and regulation information from the same calendar year)

Year	Working Levels in mines receiving inspections that total to		
	None	One	Two or more
1950	n.a.	n.a.	n.a.
1951	n.a.	n.a.	n.a.
1952	23.4	24.2	21.8
1953	32.1	33.9	21.1
1954	19.3	21.5	20.0
1955	11.8	14.3	16 4
1956	8.4	12.4	12.1
1957	19.5	20.1	13.7
1958	14.5	11.3	16.1
1959	14.7	13.6	23.5
1960	6.9	10.1	13.8
1961	7.9	6.2	10.5
1962	2.3	3.9	5.2
1963	1.2	2.7	3.9
1964	2.6	2.8	3.8
1965	1.9	3.1	3.2
1966	2.6	2.2	3.0
1967	n.a.	n.a.	n.a.
1968	2.3	0.4	2.2
1969	0.3	0.4	0.6

Table 12B

Mean Radiation Levels in Mines Receiving Varying Numbers of General Orders in the Sample of Colorado Mines, 1959-1969

(Radiation and regulation information from the same calendar year.)

Year	Working Levels in mines receiving general orders that total to	
	None	One or more
1959	13.4	21.1
1960	12.0	11.9
1961	5.6	12.6
1962	3.6	8.4
1963	2.3	4.1

Table 12B (continued)

Year	Working Levels in mines receiving general orders that total to: None	One or more
1964	2.1	5.4
1965	2.4	4.4
1966	2.0	4.2
1967	1.0	2.2
1968	1.4	1.3
1969	0.5	0.8

Sources:
The sample of Colorado uranium mines.

Table 12C

Mean Radiation Levels in Mines Receiving Varying Numbers of Remove Men Orders in the Sample of Colorado Mines, 1960-1969
(Radiation and regulation information from the same calendar year.)

	Working Levels in mines receiving remove men orders that total to: None	One or more
1960	11.5	17.8
1961	6.5	32.9
1962	4.5	17.2
1963	2.8	12.5
1964	2.8	10.4
1965	3.2	5.8
1966	2.0	6.9
1967	1.1	2.9
1968	1.1	1.4
1969	0.5	n.a.

Sources:
The sample of Colorado uranium mines.

Table 13A

Mean Radiation Levels in Mines with Varying Histories of Inspections in the Sample of Colorado Mines, 1960-1969

(Radiation information for the year following regulations.)

Inspection Year	Working Levels in mines receiving inspections that total to: None	One or more
1959	11.37	12.23
1960	6.1	7.2
1961	7.23	4.5
1962	1.73	3.7
1963	2.08	3.2
1964	3.06	2.42
1965	2.55	2.34
1966	2.59	2.26
1967	2.35	0.8
1968	0.6	0.6

Table 13B

Mean Radiation Levels in Mines Receiving Varying Numbers of General Orders in the Sample of Colorado Mines, 1960-1969

(Radiation information for the year following regulations.)

Inspection Year	Working Levels in mines receiving general orders that total to: None	One or more
1959	12.8	15.6
1960	9.25	6.7
1961	4.1	5.22
1962	2.9	3.15
1963	2.7	2.97
1964	2.3	4.84
1965	2.1	2.1
1966	3.3	1.54
1967	2.3	0.86
1968	2.9	0.66

Sources:
The sample of Colorado uranium mines.

Another explanation stresses the greater effectiveness of regulation subsequent to 1964. After this date, most mines had the technology to reduce radiation. With this technology it often took little more than moving a fan closer to an entrance or turning it on a few hours before the working day began to reduce radiation even further. Prior to 1964, however, many operators still relied on natural ventilation. Without the requisite equipment, no amount of regulation could bring down levels in mines that presented severe problems.

A third approach was explored which appeared to be logically equipped to handle the impact (if there was an impact at all) of organizational concern on the elimination of the health hazard. In this approach, a mine's inspection and sanction record for a given year was matched against the difference between its radiation level in that and the following year. A positive difference between the two year's radiation levels indicated radiation was reduced, a negative difference, the opposite.

Using this approach, statistical analysis illustrated a clearer association between regulation and radiation reduction. Significant reductions in the hazard occurred among mines subject to each type of government "concern." In every year, the average radiation reduction was greater among mines that had experienced some inspections or sanctions than it was among mines that had experienced none. Subsequent to 1962, in fact, the absence of some type of regulation was generally accompanied by a deterioration in conditions in the following year. These findings were statistically significant at the .05 level. (See Tables 14A,B,C)

The analysis also showed that radiation decline from one year to the next varied directly with the type of government regulation imposed. Thus, while mines with one or more inspections experienced an average yearly decline in radiation of 1.6 working levels between 1959 and 1967, mines with one or more general and remove men orders in the same period experienced average yearly declines of 3.3 and 8.3 working levels, respectively. (See Tables 14A,B and C)

Thus, three methods were used to exposure the relationship between regulations and radiation levels in mines. The first approach suffered from various pitfalls as a result of using regulation and radiation information from the same calendar year. The second analysis, which used radiation levels for the year following a given inspection, was an improvement. It showed that after 1964 the lowest radiation levels were found among mines that had experienced inspections and sanctions. The third approach, however, was superior to both. It alone demonstrated the impact of regulation on the elimination of a health hazard. Even though regulation did not lead to the lowest levels before 1964, the third analysis showed that it was consistently associated with yearly, radiation declines. The absence of regulation was frequently accompanied by an increase in radiation and the largest yearly declines were found among mines that had experienced the most severe sanctions.

The government, however, is only one of three organizations of interest here. The next section examines "concern" shown by companies.

Table 14A

Mean Differences in Radiation Levels From One Year to the Next in Mines with Varying Histories of Inspections in the Sample of Colorado Mines, 1960-1969

Inspection Year	Working level differences in mines receiving inspections that total to: None	One or more	One or more - None
1959	5.8	7.9	2.1
1960	0.5	6.13	5.63
1961	2.9	4.5	1.6
1962	-0.05	1.7	1.75
1963	-1.5	-0.1	1.37
1964	-0.7	0.8	0.07
1965	-0.3	0.9	1.21
1966	-0.5	1.0	1.5
1967	-0.15	0.8	0.9
1968		0.2	
Average Annual Decline:	0.60	2.38	Average Annual Difference: 1.6

Regulation information matched against differences between radiation information in one year and the following.

Table 14B

Mean Differences in Radiation Levels From One Year to the Next in Mines With Varying Numbers of General Orders in the Sample of Colorado Mines, 1960-1969

Inspection Year	Working level differences in mines receiving general orders that total to: None	One or more	One or more - None
1959	1.25	6.1	4.85
1960	3.5	6.1	2.6
1961	0.97	5.5	4.53

Table 14B (continued)

Inspection Year	Working level differences in mines receiving general orders that total to: None	One or more	One or more - None
1962	0.03	7.8	7.5
1963	-0.4	0.25	0.15
1964	0.8	0.84	0.04
1965	0.6	0.95	0.35
1966	-1.1	2.5	3.6
1967	-1.15	1.18	2.33
1968	-2.3	1.79	4.09
Average Annual Decline:	2.5	3.3	Average Annual Difference: 3.0

Regulation information matched against differences between radiation information in one year and the following.

Table 14C

Mean Differences in Radiation Levels From One Year to the Next in Mines With Varying Numbers of Remove Men Orders in the Sample of Colorado Mines, 1960-1969

Inspection Year	Working level differences in mines receiving remove men orders that total to: None	One or more	One or more - None
1960	3.9	16.2	12.3
1961	1.8	22.24	20.44
1962	1.28	13.67	12.39
1963	-0.35	3.17	3.52
1964	-0.27	5.3	5.57
1965	0.1	6.6	6.5
1966	-0.37	5.0	5.37
1967	-0.46	1.84	2.30
1968	-1.08	0.87	1.95
Average Annual Decline:	0.51	8.3	Average Annual Decline: 7.8

Regulation information matched against differences between radiation information in one year and the following.

Sources:

The sample of Colorado uranium mines.

THE EFFECTS OF CONCERN ON THE DEPENDENT VARIABLE: COMPANY ACTIONS

Company "concern" consisted of attempts to reduce mine radiation in advance of mandatory requirements to do so. Such attempts took the form of direct expenditures for equipment and personnel to improve radiation. A superficial look at the trends in company "concern" suggests that it too tended to coincide with declines in mine radiation. On closer inspection, it appears that the companies demonstrated their most intense concern subsequent to the initiation of government regulation.

From the limited information available, there is some indication that at least the largest companies in Colorado took actions to control radiation in advance of government regulations. For example, the two largest companies both began to test for mine radiation in 1956. This was prior to the 1959 announcement by the Public Health Service that excessive numbers of lung cancers were occurring among American miners. On the other hand, it was well after initial efforts by Colorado health officials (in 1949 and 1950) to persuade industry representatives to prevent a repetition of the European tragedies in mining.

1956 also saw the introduction of at least one staff person in the two largest companies to deal with the problem of radiation. At this time, company expenditures for ventilation amounted to about 25¢ per ton.

A comparison between radiation in mines owned by large companies and small ones suggests that, for whatever reasons, large was better than small during the study period (1950-1969). While both groups exhibited a certain amount of fluctuation during the decade, 1950-1959, the group of mines owned by large companies generally had lower annual levels of radiation and faster annual rates of radiation decline. This group displayed considerable radiation decline at an average annual rate of -4.6% between 1950 and 1959. Mines owned by small companies, on the other hand, showed no regular decline between 1950 and 1959. It was not until 1959 that the smaller mines as a group began to show such decline. This coincided with the announcement of statistically significant excesses of mine radiation among United States miners. 1959 was also the year the Colorado Bureau of Mines began regulating ventilation conditions more closely. (See Table 15)

Intense company "concern" by the large operators, however, also followed the promulgation of restrictive standards and the initiation of stricter government control programs in the 1960s. In 1961, following the onset of the control program undertaken by the Colorado Bureau of Mines, the two largest companies reported a doubling of their expenditures for ventilation from 25¢ to 50¢ a ton. At approximately the same time, the number of employees devoted to the problem also rose. (See Table 16)

Company "concern" became even more striking after the Department of Labor regulation of June 1967 concerning acceptable radiation levels in mines. Spokesmen for the two largest firms reported that their expenditures for ventilation nearly tripled at about this time from pre-1966

Table 15

A Comparison of Mean Radiation Levels and Rates of Decline of Radiation in Mines Owned by Large and Small Companies, 1950-1969

Year	Yearly average Working Levels in mines owned by: Small Companies	Annual Decline %	Large Companies	Annual Decline %
1950	24.3		29.4	
		+34.3		- 8.2
1951	33.0		26.8	
		-38.5		- 4.3
1952	19.1		25.6	
		+172.2		-10.9
1953	55.9		22.7	
		-58.0		- 5.1
1954	22.9		21.5	
		-23.8		-23.6
1955	17.2		16.2	
		-17.0		-25.0
1956	14.1		11.9	
		+43.7		+69.8
1957	20.7		20.9	
		-39.6		-34.2
1958	12.1		13.4	
		+71.0		- 2.8
1959	21.4		13.0	
		-18.3		- 2.1
1960	17.3		10.1	
		-30.1		-36.9
1961	11.8		6.0	
		-32.0		-34.3
1962	7.7		3.5	
		-49.3		-23.0
1963	3.9		2.7	
		+ 5.1		- 7.4
1964	4.1		2.5	
		0		0
1965	4.1		2.5	
		+ 5.0		-12.0
1966	4.3		2.2	
		-61.0		-41.0
1967	1.7		1.3	
		+12.0		0
1968	1.9		1.3	
		-63.0		-53.8
1969	0.7		0.6	

Table 16

Estimated Expenditures for Ventilation and Personnel Devoted to Reducing Radiation by the Largest Uranium Mining Companies in Colorado, 1950-1971

Year	Expenditures Per Ton	Personnel Devoted to Radon Control
1950	$0.20	0
1951	$0.20	0
1952	$0.20	0
1953	$0.20	0
1954	$0.20	0
1955	$0.20	0
1956	$0.25	1
1957	$0.25	1
1958	$0.25	1
1959	$0.25	1.5
1960	$0.25	1.5
1961	$0.50	2
1962	$0.50	2
1963	$0.50	1.5
1964	$0.50	1.5
1965	$0.50	1.5
1966	$0.75	2
1967	$1.00	4.5
1968	$1.40	5.5
1969	$1.50	5
1970	$1.50	n.a.
1971	$2.50	n.a.

Sources

Information supplied by R.C. Beverly, Director of Environmental Control, Metal and Mining Division, Union Carbide Corporation; and Anthony M. Mastrovich, Vice President, AMAX Uranium Corporation.

levels of 50¢ a ton. When the new law became effective in 1967, expenditures immediately rose to $1.40 per ton. An industry-wide survey conducted by the Atomic Energy Commission between 1966 and 1968 suggests that this trend was typical. Although the survey did not use the same sample as that used in the current study, it represents basically the same types of companies. Within the 1966-1968 period, the Atomic Energy Commission report states that ventilation costs expended by a sample of Colorado companies rose 200% from 48¢ a ton to $1.47. In the six months immediately following the promulgation of the new law, ventilation costs mushroomed 75¢ from 84¢ to $1.47 a ton. At the same time, capital expenditures increased more than 500% and total installed fan capacity at the group of sampled mines increased by more than 50%. (See Table 17)

The policy statements of the state lobbying agency, the Colorado Mining Association, indicate the bulk of company "concern" was manifested subsequent to the onset of restrictive regulations. A content analysis of the policy statements of that body between 1950 and 1970 showed that prior to the Colorado control program of 1961, only 11 lines out of the total 1905 lines of statement were devoted to the general subject of health and safety in all types of mines. No explicit mention was made of the radiation hazard during this time although more than 11% of the space was devoted to the subject of uranium mining (i.e., 217 lines).

Subsequent to 1961, the subject of health and safety gained more attention. Between 1961 and 1967, 63 lines out of a total 1540 treated this topic. Uranium mining was discussed in 90 lines, although once again, no explicit reference was made to the problem of excess radiation.

It was after the promulgation of strict radiation standards in 1967, however, that the Colorado Association first mentioned the hazard in its official statements. Out of a total 883 lines of statement between 1968 and 1970, 31 lines dealt with the subject of radiation (3%). The space devoted to general health and safety also increased. Nearly 6% of the policy statements were devoted to the latter topic. This amounted to 51 lines. Attention to uranium mining remained relatively consistent at approximately 10% or 91 lines. (See Table 18)

Without fail, industry comments on the subject of radiation in mines expressed opposition to the duplication of policing and inspection activities by federal and state level agencies. Other statements conveyed industry opposition to the standards imposed by the Department of Labor on radiation. In the words of the industry, such standards were "untested, unlawful, unrealistic and unnecessary."[84] The remaining space devoted to these topics called for new efforts to update the technology and information necessary to achieve a "fair and reasonable radiation exposure standard."[84]

The behavior of national industry associations resembled that of the Colorado body. The American Mining Association created its first committee on mine safety in 1967, immediately after the June regulation of the Department of Labor. The first action of the newly formed committee was to request that the Secretary of Labor withdraw his order, or, alternatively suspend enforcement on it for 18 months.[85]

Table 17

Average Radiation Levels and Uranium Mining Costs in Colorado, 1966-1968

	January-June 1966	July-December 1966	January-June 1967	July-December 1967	January-June 1968
Operating Costs					
Per Ton	$ .48	$ .51	$ .61	$ .84	$1.47
Per Pound (U_3O_8)	$ .09	$ .11	$ .13	$ .19	$ .34
Capital Expended	$34,094	$2,500	$18,587	$31,394	$218,793
Average Production Ton/Month	14,967	14,044	15,245	14,880	11,502
Average Radiation Level (W.L.s)	3.16	4.13	2.40	0.93	0.89

Sources:
Atomic Energy Commission, Grand Junction Office, "Radiation Control Study," October 23, 1968, Table 3

Table 18

A Content Analysis of the Annual Policy Statements of the Colorado Mining Association, 1950-1970

Year	Total Number Statement Lines	Lines devoted to: Uranium Mining	Mine Radiation	General Health and Safety
1950	116	0	0	0
1951	169	3	0	0
1952	142	0	0	0
1953	165	10	0	0
1954	165	16	0	0
1955	178	37	0	0
1956	241	34	0	5
1957	n.a.	n.a.	n.a.	n.a.
1958	545	90	0	6
1959	184	30	0	0
1960	n.a.	n.a.	n.a.	n.a.
1961	120	0	0	0
1962	n.a.	n.a.	n.a.	n.a.
1963	326	7	0	14
1964	382	50	0	19
1965	300	3	0	15
1966	412	30	0	15
1967	n.a.	n.a.	n.a.	n.a.
1968	318	17	4	14
1969	345	17	14	19
1970	220	37	13	17

Sources:

Compiled from the National Western Mining Conference, "Resolutions and Declaration of Policy," The Colorado Mining Association, 1950-1970

Another industry association, the Atomic Industrial Forum, also established a committee on mining and milling. In 1971, it initiated discussions on coordinating an industry-wide effort to research the subject of radiation control. It was the first suggestion of this nature to ever appear.[86]

Thus, although mild efforts were made by some of the largest companies to monitor radiation in advance of government decrees to do so, the bulk of company "concern" followed in the wake of such orders.

THE EFFECTS OF CONCERN ON THE DEPENDENT VARIABLE: UNION ACTION

Union influence in the control of radiation was virtually nonexistent during most of the study period. Prior to 1960, the attendance registers at most official[87] meetings on the subject of radiation fail to show any union presence. At the Governors' Conference on Health Hazards in Uranium Mines in 1960, only one labor representative appeared.

By its own admission, labor involvement in mine hazards dates only from 1967.[88] At that time the Department of Labor promulgated standards for the control of radiation. Labor representatives testified at government hearings on the topic and defended the Secretary of Labor's actions to a broad spectrum of critics.

In 1971, labor involvement increased. At that time, the Bureau of Mines proposed a variance from prevailing radiation codes. This program permitted workers to remain in mines where radiation exceeded permissible levels with the use of respirators. Union representatives felt that these provisions were not adequate and requested public hearings on the matter on July 16, 1971. In addition, unions adopted a list of provisions on the subject of variances. Labor organizations featured prominently in both the conduct of public hearings in New Mexico on January 7, 1972 and in the controversy surrounding their outcome.

The paucity of union efforts to reduce the radiation hazard reflects a more general absence of labor involvement with the industry. While several mines were organized by labor organizations in 1969, only one Colorado mine was represented by a union between 1950 and 1969.

Several reasons have been advanced for the lack of union involvement in the industry at an earlier time. One interviewee, for example, cited the National Labor Relations Board ruling making the individual mine the unit of organization. No sooner was a mine organized than operations would shift to a new site and organizers would have to petition anew for representation.[89]

Other respondents blamed the extremely small size of the uranium mining industry and the typical mining unit in Colorado. It is estimated that only 6,000 men have mined uranium in this country at some point of

time. In Colorado, most miners worked in mines that employed fewer than five men. Such mines were termed "dogholes." Small mines were often inaccessible and uneconomical. In addition, their employees tended to reject the union. This was because the worker labored side-by-side with the owner. Such workers were unsympathetic to a formalized system of representation.

Another explanation puts the blame on the pay system in the industry. Miners were paid generous incentives for extra production; they resented any restrictions on the length of their working day or week. As one organizer puts it, "All they wanted was to work 25 hours a day, 8 days a week."[90]

The upshot was the unions never succeeded in organizing Colorado uranium miners. Until the late 1960s, labor organizations contributed little, if anything, to the process of reducing radiation in mines. Although some labor organizers interviewed in the project suggested that union influence in the mines was indirectly exercised through the uranium processing mills and plants which were represented by unions, a test of this hypothesis showed it to be untrue.[91] Rather, labor organizations were not associated with lower radiation in mines in any regular manner. For this reason the union will no longer be considered in the analysis of organizational "concern" on worker health.