Regulation of Perchloroethylene Dry Cleaning Facilities

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Abstract Perchloroethylene, the primary solvent in the cleaning process in the majority of dry cleaners in the United States, is a man-made organic solvent classified as a "hazardous substance" under the California Hazard Communication Standard due to its health hazards and possible carcinogenic properties. The California Occupational Safety and Health Administration (Cal/OSHA) regulates the workplace 8-hour 25 ppm Permissible Exposure Limit (PEL) of perchloroethylene. This study identified the regulatory process of the PEL in California through phone interviews with Cal/OSHA Consultation Area Offices and compared the regulation of the dry cleaning industry, with respect to all environmental regulations set by the Environmental Protection Agency (EPA), to other industries that use perchloroethylene as a solvent through correlations and comparisons with data from the EPA Sector Notebook Project. I hypothesized that the dry cleaning industry would be regulated less stringently, having fewer and less frequent inspections, than other industries due to the abundance and decentralized nature of the industry. The study determined that the PEL in California is tested only after an employee complaint or an employer request. The comparison data between the dry cleaning industry and various other industries on a nationwide level using EPA Sector Notebook data showed positive correlations between average months between inspections and the number of facilities searched and between the number of inspections and the number of facilities searched. A negative correlation was seen between the average months between inspections and the ratio of facilities inspected to facilities in search. The dry cleaning industry showed a significant difference from other industries in the frequency of inspections and number of facilities in search with data values over two standard deviations away from the mean of all industries. This study concluded that the dry cleaning industry experiences fewer and less frequent inspections as compared to other perchloroethylene industries.

Introduction

The dry cleaning industry is a large industry with a history of regulation due to its use of hazardous solvents. The majority of the dry cleaners in the United States use the chemical perchloroethylene (perc) as the primary solvent in the cleaning process (Adler, 1997). Perchloroethylene (also called tetrachloroethylene) is a man-made colorless, nonflammable organic solvent that evaporates when exposed to air (DHS, 1989). It is considered a "hazardous substance" under the California Hazard Communication Standard due to its health hazards and probable carcinogenic properties. Perchloroethylene enters the human body through skin exposure as well as inhalation through airborne vapors. Health effects range from skin, eyes, nose, and throat irritation to damage to the nervous system, liver, and kidneys. Although percholoroethylene's carcinogenic effects have yet to be determined conclusively in humans, it has been tested in lab animals and found to be carcinogenic (DHS, 1989).

A variety of studies indicate that perchloroethylene has long-term health effects on dry cleaning employees. Jo and Kim (2001) studied the health effects of perchloroethylene in comparison to aromatic compounds such as benzene and toluene on dry cleaning workers. This study concluded that despite adverse health effects of perchloroethylene, the alternative of aromatic compounds resulted in higher average toxic exposure levels and higher toxic concentrations in breath measurements after occupational exposure. Although Jo and Kim (2001) concluded that perchloroethylene is less toxic then other cleaning solvents, many studies have been conducted that show detrimental health effects associated with perchloroethylene. In the United Kingdom, Doyle et al.(1997) found higher rates of spontaneous abortion in dry cleaning workers. Weiss (1995) found an association between perchloroethylene exposure and esophageal and bladder cancer. Ruder (2001) found similar associations and concluded a strong association with exposure and cervical and esophageal cancer.

Despite the abundance of studies regarding the health effects of perchloroethylene, studies that address the regulation of this commonly used and hazardous chemical are absent. The regulation of perchloroethylene in the workplace began on a federal level with the Occupational Safety and Health Act of 1970 under the US Department of Labor. In 1989, the Occupational Safety and Health Administration (OSHA) lowered the 8-hour time weighted average Permissible Exposure Limit for perchloroethylene from 100 ppm to 25 ppm. The lowering of the PEL was overturned in 1993, but many Occupational Safety and Health Administration state

branches, including California's, maintained the lower PEL. Currently in California, the PEL is a time weighted average of 25 ppm of perchloroethylene over an 8-hour period (HSIA, 1999). This study investigates the regulation of the 8-hour Permissible Exposure Limit (PEL) of 25 ppm perchloroethylene by California's Division of Occupational Safety and Health (Cal/OSHA) (OSHA, 2001) for California dry cleaners.

This study also includes a comparison of the dry cleaning industry and various industries, which use perchloroethylene as a solvent and were surveyed in the Environmental Protection Agency (EPA) Sector Notebook Project, concerning the inspection of facilities with regards to laws and regulations imposed by the EPA. Correlations involving the variation of the average months between inspections and the number of inspections against the independent number of facilities in search shed light on the possibility that abundance of facilities in an industry may lead to decreased regulations. Correlations between the average months between inspections and the independent variable of ratio of facilities inspected to facilities in search would reveal a relationship between inspection rate and inspection frequency.

Results of this study will examine the regulatory process of perchloroethylene dry cleaners in practice compared to the regulatory process outlined by the federal government and California state law and allow, on a nationwide level, a comparison of the number of inspections and frequency of inspections of the dry cleaning industry to other industry sectors identified by the EPA.

I hypothesize that due to the abundance and decentralized nature of dry cleaning facilities, the regulation of the 8-hour Permissible Exposure Limit of perchloroethylene and the regulation of the dry cleaning industry as a whole will not be regulated as stringently as other industries, with regards to number and frequency of inspections.

Methods

This study had two components. The first component is the California dry cleaning industry, which includes the dry cleaning facilities in California and their regulatory body, Cal/OSHA. The second component is the dry cleaning industry on a nationwide scale, which involves a study of not only the dry cleaning industry but also other industries surveyed by the EPA that use perchloroethylene as a solvent.

The first component of the study, the dry cleaning facilities in California and their regulatory body Cal/OSHA Consultation Service Area Offices, was studied to determine the regulation of the 8-hour Permissible Exposure Limit. For the purposes of Cal/OSHA's regulatory process, the state of California is divided into consultation service districts with area offices throughout the state. The area offices referenced in the study are the Cal/OSHA Consultation Service Area Offices of Northern California, San Francisco Bay Area, Central Valley, San Fernando Valley, Los Angeles, San Bernardino-Orange, and San Diego. These offices field questions regarding Cal/OSHA regulations as well as advise employers on regulatory processes (Table 1).

Northern California 2424 Arden Way, Ste. 410 Sacramento, CA 95825 (916) 263-0704	**San Francisco Bay Area** 1515 Clay Street, Ste. 1103 Oakland, CA 94612 (510) 622-2891	**Central Valley** 1901 North Gateway Boulevard, Ste. 102 Fresno, CA 93727 (559) 454-1295
San Fernando Valley 6150 Van Nuys Boulevard, Ste. 307 Van Nuys, CA 91401 (818) 901-5754	**Los Angeles** 10350 Heritage Park Drive, Ste. 201 Santa Fe Springs, CA 90670 (562) 944-9366	**San Bernardino, Orange** 464 W. 4th Street, Ste. 339 San Bernardino, CA 92401 (909) 383-4567
-	**San Diego** 7575 Metropolitan Drive, Ste. 204 San Diego, CA 92108 (619) 767-2060	

Table 1. Cal/OSHA Consultation Service Area Offices locations and numbers called.
(Table from http://www.dir.ca.gov/DOSH/consultation_offices.html)

For this study, the technical consultants and industrial hygienists of the Consultation Service Area Offices called to obtain qualitative information on the extent of the regulation of the 8-hour Permissible Exposure Limit for perchloroethylene in the dry cleaning facilities located in their respective districts. Two questions were posed to all service offices:

1. Is Cal/OSHA the regulatory body that regulates the perchloroethylene dry cleaning industry in the state of California?
2. Under what circumstances do they test for the PEL of perchloroethylene?

The answers to these questions were recorded and additional notes were taken if the respondent offered more information on the regulatory process or reasons or speculations for the current regulatory processes.

The second component of the study is the dry cleaning industry on a nationwide scale, which involves a study of not only the dry cleaning industry but also other industries surveyed by the EPA that use perchloroethylene as a solvent. Data from the EPA Sector Notebook Program was utilized in the comparison of the dry cleaning industry with other industries on a nationwide scale with regards to the regulatory amount and frequency.

The Sector Notebook Program is a government-funded program that publishes sector notebooks for selected industries. The notebooks outline the industry's operations, discuss the environmental regulations that apply to the industry, and briefly cover the industry's regulation, compliance, and enforcement records and trends. Of particular interest for this study was the study of enforcement and compliance of selected industries, which compares the industries to each other over the span of five years, 1995-2000. The Sector Notebook for the Dry Cleaning Industry was published in 1995, so for more current data, all data was obtained from the most recent Sector Notebook published in 2000 for the Agricultural Crop Production Industry.

The presence of perchloroethylene use in a selected industry was determined by information given in the respective industry's sector notebook. The type and extent of use of perchloroethylene was not taken into account due to the difficulty of creating a qualitative ranking system to determine the importance of perchloroethylene in the selected industry. Among the industries listed in the EPA table of enforcement and compliance, two industries, Forestry and Coal Mining, did not have a sector notebook. Therefore, perchloroethylene use could not be determined, and as such, these industries were not included in this study.

Statistical Techniques Using the data from EPA table of enforcement and compliance over 5-years, the means and standard deviations were calculated for the following categories: Facilities in Search, Facilities Inspected, Number of Inspections, Average Months Between Inspections, Facilities Inspected/Facilities in Search, Facilities with 1 or More Enforcement Actions, Total Enforcement Actions, and Enforcement to Inspection Rate. Individual industry data for each of the above categories were considered significantly different if its value was more than two standard deviations away from the mean of all industries. Correlations were calculated and regression lines plotted for the following: average months between inspections against the

independent number of facilities in search, the number of inspections against the independent number of facilities in search, and the average months between inspections against the independent value of the ratio of facilities inspected to facilities in search. Data analysis and graphing were done on Microsoft Excel 2000.

Results

The qualitative portion of this study, which involved phone interviews with California's Occupational Safety and Health Administration Consultation Area Offices' industrial hygienists and technical consultants, resulted in a response rate of 6 out of 7 Consultation Area Offices contacted. The missing office was the Central Valley office, which does not have an industrial hygienist or technical consultant but rather uses the same hygienist as the San Francisco Bay Area office. I spoke with the industrial hygienist located at the San Francisco Bay Area office, and she spoke on behalf of both San Francisco Bay Area and Central Valley. Therefore, for the purpose of this study the response rate of 6 out of 7 Consultation Area Offices can be considered to be a complete response with all OSHA districts represented.

All Consultation Area Offices were in consensus regarding the two questions posed. In regards to the first question, "Is Cal/OSHA the regulatory body that regulates the perchloroethylene dry cleaning industry in the state of California", all offices confirmed that Cal/OSHA does regulate the perchloroethylene dry cleaning industry. In regards to the second question, "Under what circumstances do they test for the PEL of perchloroethylene, " all offices outline two occasions in which an inspection of the perchloroethylene PEL would be conducted: if an employee files a complaint regarding their exposure to perchloroethylene or if an employer requests an inspection due to implementation of new machinery, adjustments of old machinery, or a change in filtration or perchloroethylene supply. Employee complaints are investigated by the Cal/OSHA Enforcement Unit District Offices and employer requests are investigated by the Consultation Area Offices. Among the additional comments provided by some hygienists and consultants regarding the reasons behind the request dependent regulatory process of the perchloroethylene PEL as opposed to regular or spot inspections were possibilities such as great time commitment required to run an 8-hour test, expense of testing exposures over the 8-hour period, lack of inspectors, high quantity of dry cleaners within each district, and low number of workers to number of facilities ratio.

The five-year dry cleaning enforcement and compliance data in comparison to the rest of the industries that use perchloroethylene as a solvent with respect to inspections was significant in the categories of Facilities in Search and Average Months Between Inspections. The dry cleaning value of 6,063 facilities in the search was 2.38 standard deviations away from the mean of 1,924 facilities. The average months between inspections of a dry cleaning facility was 95 months, 3.90 standard deviations away from the mean of 19 months between inspections of a perchloroethylene facility (Table 2).

Five-Year Inspection Summary for Industries with Perchloroethylene Use

Industry Sector	Facilities in Search	Facilities Inspected	Number of Inspections	Facilities Inspected / Facilities in Search	Average Months Btwn Inspections
Petroleum Refining	156	148	3,081	0.95	3
Iron and Steel	349	275	4,476	0.79	5
Organic Chemicals	425	355	4,294	0.84	6
Nonferrous Metals	203	161	1,640	0.79	7
Resins and Manmade Fibers	329	263	2,430	0.80	8
Pharmaceuticals	164	129	1,201	0.79	8
Inorganic Chemicals	441	286	3,087	0.65	9
Shipbuilding and Repair	44	37	243	0.84	9
Stone, Clay, Glass & Concrete	615	388	3,474	0.63	11
Aerospace	237	184	1,206	0.78	12
Automobile Assembly	1,260	927	5,912	0.74	13
Fossil Fuel Electric Power	3,270	2,166	14,210	0.66	14
Textiles	355	267	1,465	0.75	15
Lumber and Wood	712	473	2,767	0.66	15
Metal Castings	669	424	2,535	0.63	16
Electronics	1,250	863	4,500	0.69	17
Fabricated Metal Products	2,906	1,858	7,914	0.64	22
Non-Metallic Mineral Mining	5,256	2,803	12,826	0.53	25
Rubber and Plastic	1,818	981	4,383	0.54	25
Air Transportation	444	231	973	0.52	27
Printing	5,862	2,092	7,691	0.36	46
Dry Cleaning	6,063	2,360	3,813	0.39	95
Mean Values	1492	803	4278	0.54	19
Standard Deviation (SD)	1924	858	3604	0.15	20
SDs away from mean value (for Dry Cleaning)	2.38	1.81	-0.13	-1.01	3.90

Table 2. Five-Year Inspection Summary for Industries with Perchloroethylene Use. Table is sorted by Average Months Between Inspections. Note Dry Cleaning has the greatest value for average months between inspections, double the second highest value, Printing, indicating most infrequent inspections. Table adapted from Exhibit 24 "Five-Year Enforcement and Compliance Summary for Selected Industries" in Agricultural Crop Production Industry Sector Notebook, 2000, Environmental Protection Agency.

With respect to enforcements, the dry cleaning industry data was not significant, more than two standard deviations away from the mean of all industries, in any of the following categories: Facilities with 1 or More Enforcement Actions, Total Enforcement Actions, and Enforcement to Inspection Rate. Although not significant, the dry cleaning industry had the lowest Enforcement to Inspection Rate (Table 3).

Five-Year Enforcement Summary for Industries with Perchloroethylene Use

Industry Sector	Facilities w/ 1 or More Enforcement Actions	Total Enforcement Actions	Enforcement to Inspection Rate
Dry Cleaning	55	66	0.02
Non-Metallic Mineral Mining	385	622	0.05
Textiles	53	83	0.06
Printing	238	428	0.06
Rubber and Plastic	178	276	0.06
Electronics	150	251	0.06
Fossil Fuel Electric Power	403	789	0.06
Iron and Steel	121	305	0.07
Automobile Assembly	253	413	0.07
Inorganic Chemicals	89	235	0.08
Stone, Clay, Glass & Concrete	97	277	0.08
Metal Castings	113	191	0.08
Fabricated Metal Products	365	600	0.08
Resins and Manmade Fibers	93	219	0.09
Lumber and Wood	134	265	0.1
Pharmaceuticals	35	122	0.1
Aerospace	67	127	0.1
Air Transportation	48	97	0.1
Organic Chemicals	153	468	0.11
Nonferrous Metals	68	174	0.11
Shipbuilding and Repair	20	32	0.13
Petroleum Refining	124	763	0.25
Mean Values	147	309	0.09
Standard Deviation	113	221	0.04
SDs away from mean value (for Dry Cleaning)	-0.81	-1.10	-1.53

Table 3. Five-Year Enforcement Summary for Industries with Perchloroethylene Use. Table is sorted by Enforcement to Inspection Rate. Note Dry Cleaning has the lowest value for Enforcement to Inspection Rate. Table adapted from Exhibit 24 "Five-Year Enforcement and Compliance Summary for Selected Industries" in Agricultural Crop Production Industry Sector Notebook, 2000, Environmental Protection Agency.

Comparison of the dry cleaning industry to various other industries sampled by the EPA Sector Notebook Program resulted in a positive correlation between average months between

inspections and the number of facilities in search, with average months being the dependent variable and number of facilities being the independent variable (Figure 1). The positive correlation reflects the trend that the greater number of facilities in a given industry the less frequent the inspections of those facilities. The dry cleaning data point for this correlation, representing 6,063 facilities in the search and 95 months between inspections and as indicated by the red data point, is the farthest outlier from the regression line.

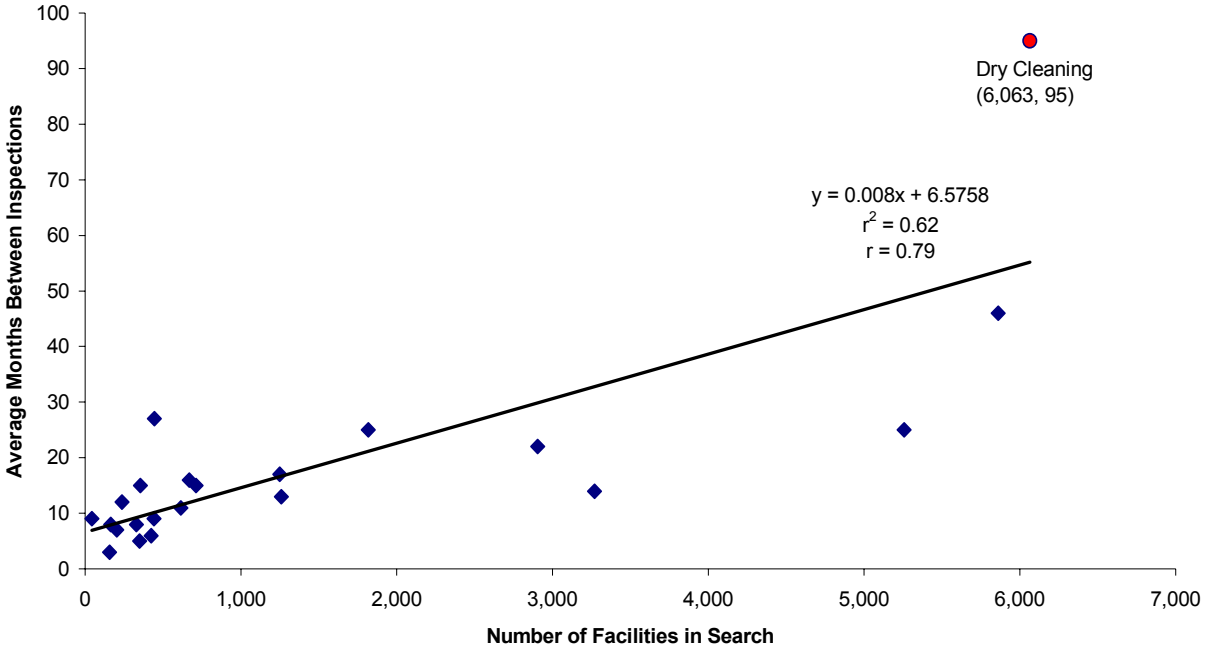

Figure 1. Positive Correlation between Average Months Between Inspections and Number of Facilities in Search. Dry Cleaning data point, featured in red, is the farthest outlier from the regression line. Its position above the regression line indicates a greater average number of months than would be expected by the number of facilities.

The number of inspections, dependent variable, and the number of facilities in search, independent variable, were also positively correlated (Figure 2). The positive correlation reflects the trend that the greater the number of facilities in the search, the greater the number of inspections. The dry cleaning data point for this correlation, representing 3,813 inspections and 6,063 facilities in the search and as indicated by the red data point, is one of the farthest outliers from the regression line.

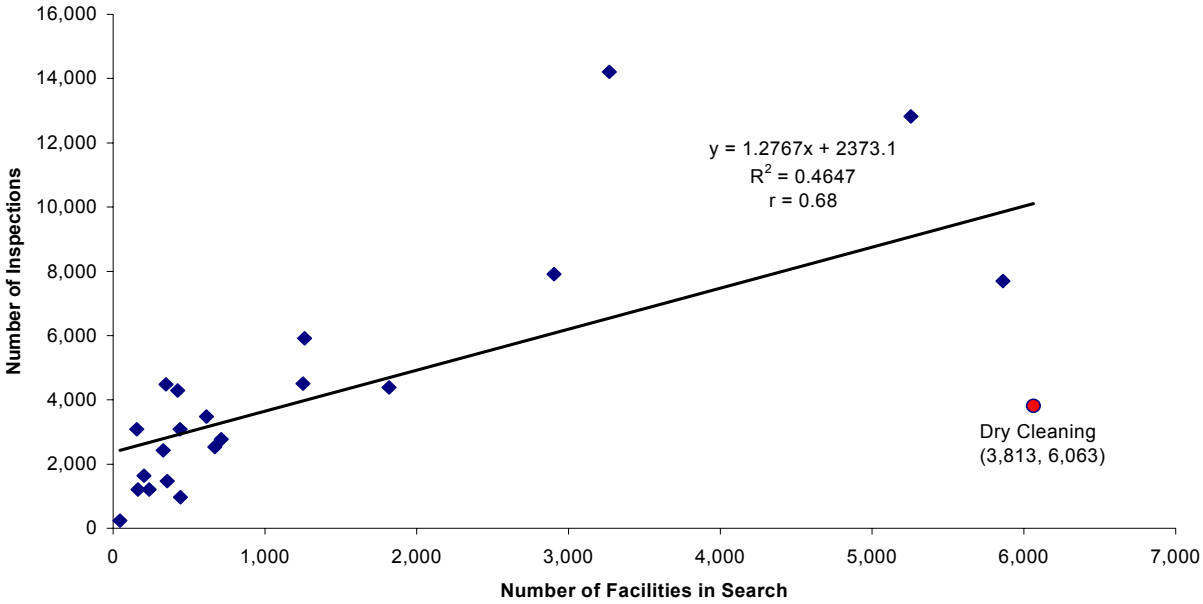

Figure 2. Positive Correlation between Number of Inspections and Number of Facilities in Search. Dry Cleaning data point, featured in red, is one of the farthest outliers from the regression line. Its position below the regression line indicates a lower number of inspections than would be expected by the number of facilities.

The final correlation between the average months between inspections, dependent variable, and the ratio of facilities inspected to facilities in search, independent variable, was negatively correlated (Figure 3). The negative correlation reflects the trend that the lower the inspection rate, the greater the length of time between inspections. The dry cleaning data point for this correlation, representing an inspection ratio of 0.39 and 95 months between inspections and as indicated by the red data point, is the farthest outlier from the regression line.

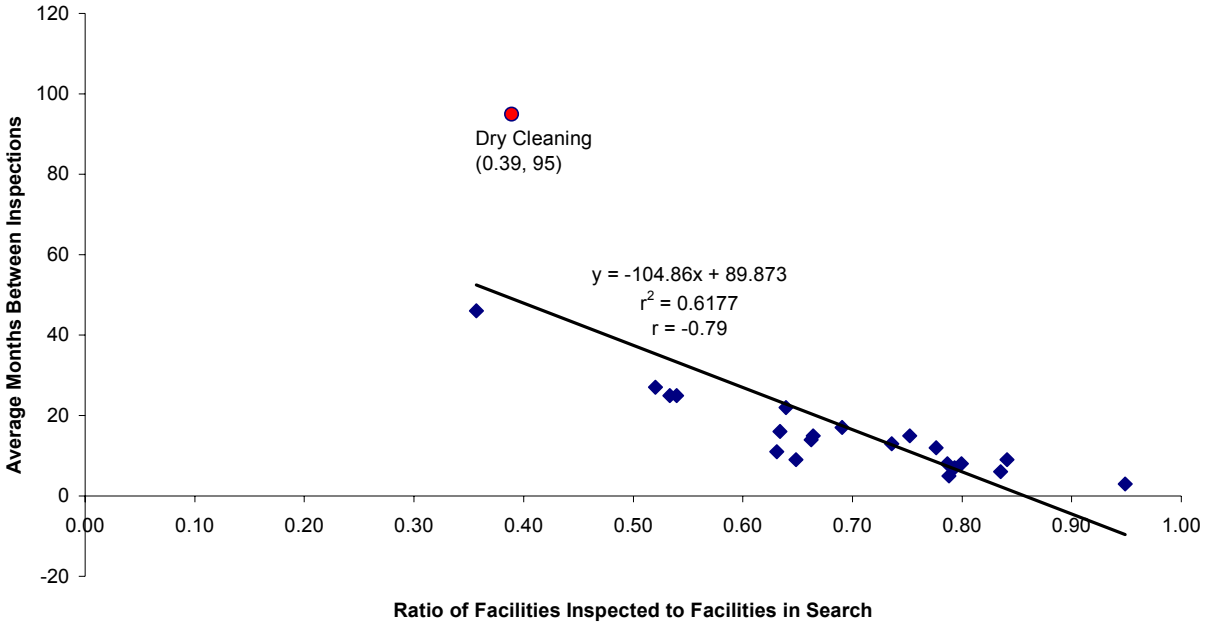

Figure 3. Negative Correlation between Average Months Between Inspections and Ratio of Facilities Inspected to Facilities in Search. Dry Cleaning data point, featured in red, is one of the farthest outliers from the regression line. Its position above the regression line indicates a longer period of time between inspections than would be expected by the inspection ratio.

Discussion

The results of this study indicate that the 8-hour PEL of perchloroethylene is not regulated in the dry cleaning industry as stringently as in other industries with respect to the number and frequency of inspections. The qualitative portion of my study reflected the presence of a standard for perchloroethylene exposure set by both federal and state agencies. However, the industrial hygienists and technical consultants from the Cal/OSHA Consultation Service Offices outlined an inspection process that allows for long periods of time to pass before any inspection or regulation of the PEL is conducted. Under the current guidelines of Cal/OSHA, the inspection only occurs after an employee complaint or an employer request. Due to this request dependent system of regulation, it is possible that a dry cleaning facilities could have longer periods of time between inspections as opposed to an industry with regularly scheduled inspections or unannounced spot inspections. This may be a possible explanation for the dry cleaning industry on a nationwide scale reflecting high values for the average months between inspections as compared to other industries. The request dependent system of regulation also makes it possible for the time between inspections to be variable and unpredictable, despite trends that this system consistently results in more infrequent inspections.

Comparing the dry cleaning industry to other perchloroethylene industries on a nationwide level through data obtained from the Environmental Protection Agency revealed trends supporting my hypothesis that the number of inspections and the inspection frequency of the dry cleaning industry are lower than that of the other industries.

The positive correlation between the average months between inspections and the number of facilities in the search indicates that those industries with a greater number of facilities, such as dry cleaners, are more likely to have longer intervals between inspections. This positive correlation corresponds to comments made by the industrial hygienists and technical consultants of Cal/OSHA that regular inspections or inspections not requested by dry cleaning employees or employers are rarely done due to the great amount of dry cleaning facilities in any given area. While it cannot be determined if the qualitative data regarding one regulation in only the state of California can be applied to nationwide data concerning all the EPA regulations on the industry, the comments of Cal/OSHA adds weight to the positive correlation between length of time between inspections and number of facilities.

The positive correlation between the number of inspections and the number of facilities in the search seems intuitive in that the more facilities capable of being searched, the greater the chance of inspection. The aspect of interest in this correlation, however, is not that the correlation is positive but rather that the dry cleaning data point lies far below the regression line. Similar to the previous correlation, this correlation emphasizes the lack of inspection in the dry cleaning industry in comparison to other industries using the same solvent. Likewise, the same rationale of industries with many facilities are difficult to regulate applies to this correlation.

The negative correlation between the average number of months between inspections and the ratio of facilities inspected to facilities in search further supports my hypothesis of less frequent regulation of the dry cleaning industry. This correlation combines the first two in that it reflects both the low ratio of inspections to number of facilities and the infrequent regulations. As a combination of the two previous correlations, this trend can also be explained by the possible difficulties that arise with a limited staff of inspectors and a large amount of facilities to inspect.

In addition to these correlations, further conclusions can be drawn based on the data on enforcement actions and enforcement to inspection rate. However, drawing conclusions based on this data is difficult because it cannot be determined whether a low enforcement value is indicative of lack of enforcement or a lack of violations requiring enforcement actions. Based on

phone interviews with Cal/OSHA Consultation Offices, I would speculate that the low enforcement to inspection rate is due to the policy of inspection only based on employee complaint or employer request. A likely explanation of this low rate would be that inspections are largely a result of employer request, which would be instances in which the dry cleaning employer would be likely to pass all inspections and, if violations occur, may be more likely to avoid enforcement due to Cal/OSHA's encouragement of self-regulation and compliance.

A low dry cleaning rate of enforcement to inspection rate is also of great interest considering the results of the correlations based on the EPA data. The correlations illustrated a low inspection rate indicating that any enforcement would be very minimal in order to maintain a low enforcement to inspection rate. However, due to the lack of sufficient information regarding what constitutes enforcement and basic information on how this data was obtained, any speculation on the dry cleaning industry's relatively low record of enforcement actions and relatively low enforcement to inspection rate may lead to incorrect conclusions.

The drawing of incorrect conclusions is also possible in my analysis of my correlations. This study could only draw on two aspects: the quantitative data obtained for one regulation in the state of California and the qualitative data obtained through the EPA Sector Notebook Project. Due to the differences in scope of these two data sets, there is much room for error in concluding that trends seen in one data set is a result of information obtained from the other. Many other explanations are possible other than the inability to inspect industries with large numbers of facilities. Further studies are necessary before more definite explanations for dry cleaning trends can be established.

In further studies, I would look at more regulations and on a nationwide scale in attempts to obtain data to compare with the EPA Sector Notebook data. I would also look at different metrics such as looking at the inspections per worker. It is possible that the dry cleaning industry is being regulated at the same level as other industries with respect to a ratio of inspections to workers. It is known that while dry cleaners are abundant, each facility has a smaller number of workers than other industries. Therefore, it would be of interest to see if looking at amount of workers would yield different conclusions. Other possible studies that may be of use in expanding this study would be a comprehensive study on another industry that share some properties with dry cleaning. These studies would help in determining if dry cleaning was

unique in its regulation trends or if the trends are a result of a certain aspect of the industry such as number of facilities.

Conclusion In conclusion, the dry cleaning industry's 8-hour PEL enforced by Cal/OSHA is not enforced regularly rather by request from either an employee or employer. The large amount of dry cleaning facilities in any given area is a likely cause for the significantly lower inspection frequency and lack of regular inspections. The dry cleaning industry compared to other industries on a national level is consistently exceptional in its regulation frequency, amount of inspection, and facilities inspected. The dry cleaning industry, while regulated correctly in accordance to California state and federal law, is often under regulated in comparison to other industries. The results indicate that to the best extent of my study, my hypothesis of less stringent regulation in regards to number of inspections and frequency of inspections of the dry cleaning industry was correct. Further study is needed to fully explain the reasons behind the trends seen in this study,

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