measure of respirator effectiveness because, in general, it tends to increase as Co increases. This relationship complicates comparisons of WPF values measured at different Co levels. Third, he found no clear evidence that one class of respirator is better than any other class, particularly between elastomeric half-mask and filtering facepiece respirators. In addition, the differing results between CLSAs within the same class of respirators indicated that the outcome of one CLSA may be a poor predictor for another CLSA in the same class.

2. PAPRs and SARs

Dr. Brown analyzed 13 studies to evaluate and compare the effectiveness of PAPRs and SARs. Ten of the studies were conducted with PAPRs, and three with SARs. Brown's analyses divided these ''high-performance'' respirators into seven classes (*i.e.*, five types of PAPR and two types of SAR) based on their design features (*see* Table 2), with subsequent separation of these respirator classes into 14 CLSAs.

Brown used the CLSAs to determine whether any differences in respirator effectiveness existed among the respirator classes. He analyzed the data for trends of WPFs, either upward or downward, as Co increases, and for homogeneity. Brown plotted all of the data, fitted lines to these plots, made comparisons of study results within each respirator class, and developed functions from the fitted lines. (For additional details on these statistical analyses and the data plots, *see* Ex. 5–2.)

On reviewing the data plots, Brown concluded that the data were consistent with a linear relationship between ln(Ci) and ln(Co). Also, the presence of outliers and/or an imbalanced distribution of the observations influenced the results. He recommended further investigation of the outliers, particularly those with unusually high Ci values, to determine if they resulted from characteristics of the respirator or other variables. He also recommended studying the imbalanced distributions to determine if they represented individual study biases caused, for example, by collecting data at different work sites or on different work shifts. Finally, Brown noted that the robust least trimmed squares line may be useful for estimating the relationship between ln(Ci) and ln(Co).

Fifth percentiles are commonly used as a benchmark for respirator performance. Brown's analyses showed that fifth percentile estimates differed considerably within respirator classes that contained more than one CLSA. The range of the fifth percentile estimates was 28–389 for the five CLSAs in Class 2, 17–107 for the two CLSAs in Class 4, 29–1779 for two CLSAs in Class 5, and 74–188 for the two CLSAs in Class 7. The fifth percentile estimates in Classes 3 and 6 were large, while the fifth percentile estimates were small in Classes 1, 4, and 7. Brown believed that, while some of these differences may be attributed to a real difference in respirator performance between classes, the sample sizes were too small and/or the sampling variability too large to obtain reliable estimates at low percentile levels. He noted that the fifth percentile estimates were variable, and were not predictable from one CLSA to another CLSA within the same respirator class. Thus, he concluded that the fifth percentile estimates of WPFs have limited utility for setting assigned protection factors. Table 3 lists the descriptive statistics for WPFs, for each class-study-agent combination.

TABLE 3.—DESCRIPTIVE STATISTICS FOR WPF, BY CLASS, STUDY AGENT

	CL1.26.Cd	CL2.22.Pb	CL2.23.Pb	CL2.24.Si	CL2.3.BAP	CL2.5.Asb	CL3.27.EBZ
Curve Label	1	2a	2b	2c	2d	No curves	3
Median	2,972.97	127.88	155.29	3,553.72	1,788.32	156.00	11,935.87
Range	25,186.05	1,040.75	6,131.76	95,518.07	8,203.89	537.00	4,746,673.83
Minimum	53.70	22.58	28.24	36.31	371.49	66.00	1,152.26
Maximum	25,239.75	1,063.33	6,160.00	95,554.38	8,575.38	603.00	4,747,826.09
No. Observations (N)	33	46	43	59	20	7	58
5th Percentile	280.25	27.82	35.03	92.07	388.70	70.50	1,797.79
10th Percentile	581.87	53.04	43.08	267.60	407.51	75.00	2,365.29
Reject Lognormality?	No	No	No	No	No	No	Yes
Geometric Mean	2,523.49	126.85	184.69	2,765.75	1,408.10	151.95	15,623.81
Geometric Stan. Dev	3.56	2.28	3.21	6.33	2.50	2.54	5.56
	CL4.21.Si	CL4.6.Pb	CL5.18.Pb	CL5.21.Si	CL6.19.Si	CL7.25.Sr	CL7.28.Si
Curve Label	4a	4b	5	No curves	6	7a	7b
Median	48.67	438.60	7,948.14	85.44	9,178.81	3,827.16	2,480.55
Range	176.27	2,310.33	73,081.90	189.92	34,735.48	87,137.82	33,384.67
Minimum	16.40	23.00	579.04	24.75	668.34	41.67	43.33
Maximum	192.67	2,333.33	73,660.94	214.67	35,403.82	87,179.49	33,428.00
No. Observations (N)	7	25	53	4	15	21	52
5th Percentile	17.20	107.06	1,779.12	29.10	1,407.60	74.07	188.14
10th Percentile	18.00	160.95	2,300.18	33.50	2,229.66	79.37	383.47
Reject Lognormality?	No	No	No	N too small	No	No	No
Geometric Mean	49.20	400.34	8,319.09	76.10	7,389.62	2,315.04	2,066.00
Geometric Stan. Dev	23.60	2.81	3.03	25.60	2.92	9.99	4.02

The objective of the review of these 13 WPF studies was to see what can be learned about the performance of each respirator class, and its relative effectiveness, based on the data for Co and Ci. He also attempted to determine how Ci changes as Co changes, and what factors affected this relationship.

Brown found too much unexplained variability between study outcomes, even within the same respirator class and within similar ranges of Co, to make valid and reliable comparisons. He noted that study outcomes for the same class of respirator may differ significantly, which raised concerns about interpreting the outcome for a class from a single study. More specifically, he questioned whether the results from one study would be similar