PROGRESSIVE MASSIVE FIBROSIS AND THE INFLUENCE OF BODY SHAPE

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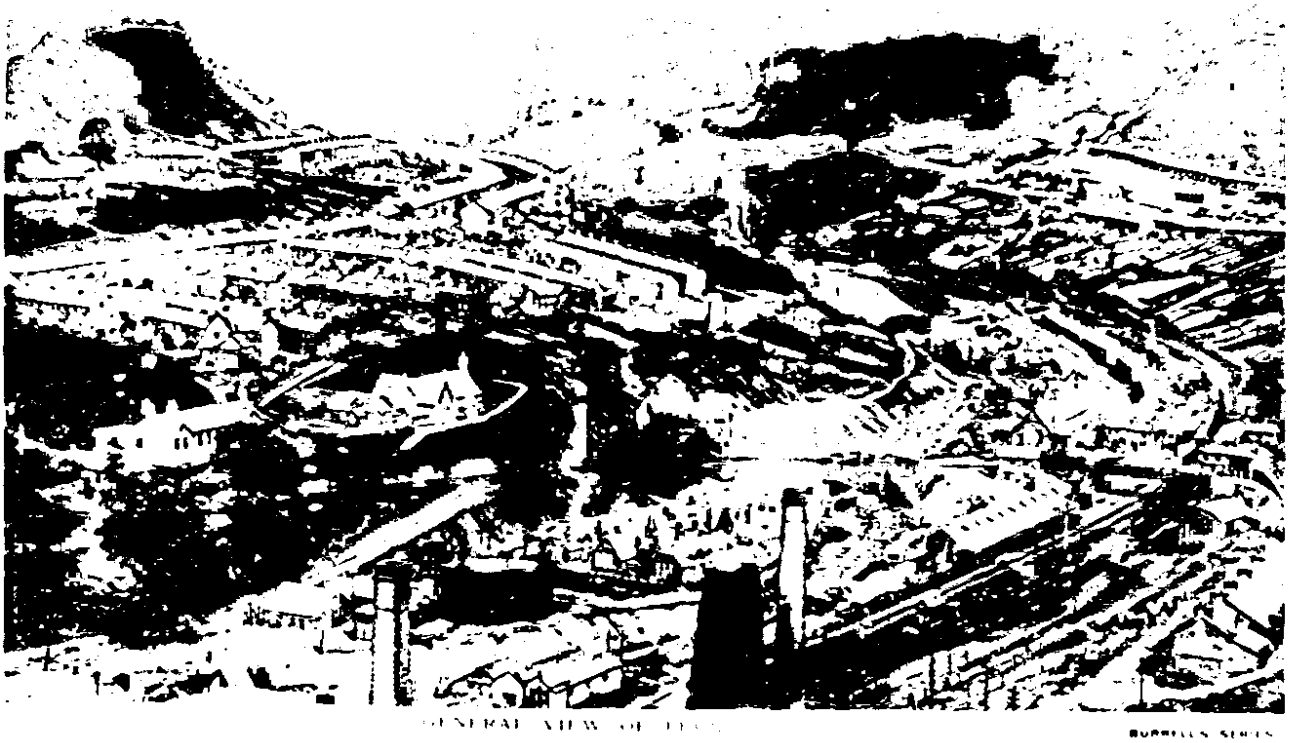
ABSTRACT

New evidence is presented of the increasing risk of attack with reduced body weight. Unlike the recently reported case control study by British Coal[1] there is only alight evidence of an association with Body Mass Index. For the first time it has been possible to use logistic regression models to assess the influence of individual-identifying information such as age, height, and weight in analysis of these prospective data. This has been achieved by employing enhanced computational methods to process the multi-punched records of Cochrane.[2]

Investigation of the cross-sectional data from the twenty-year follow-up of the men of the Rhondda Fach in South Wales[3] provides strong evidence of a lower mean weight of those with Progressive Massive Fibrosis (PMF) category A than in those unaffected. These findings were consistent across categories 2 and 3 background Simple Pneumoconiosis and nearly every age-group.

Little support was found for the hypothesis that pulmonary tuberculosis has a role in the development of PMF.

There is clear evidence that higher grades of Simple Pneumoconiosis are strongly associated with an increased probability of developing PMF.



INTRODUCTION

To facilitate study of factors relating to the development of Progressive Massive Fibrosis, in 1950 the Pneumoconiosis Research Unit of the British Medical Research Council initiated a survey of the smaller of the two Rhondda Valleys in mid Wales—the Rhondda Fach.[4] This total population epidemiological and intervention study was designed to investigate the importance of exogenous tuberculosis infection in the occurrence of PMF. Through extensive hospitalization, the environment was made as tuberculosis-free as possible. The adjacent Aberdare valley was used as an untreated reference.

At the time of initial survey, the eight towns of the Rhondda Fach were grouped around four collieries, which provided employment for most of the men. A view of the valley is given above. The total population was approximately 19,000; pneumoconiosis was commonplace amongst the numerous miners and ex-miners.

RESULTS FROM THE TWENTY-YEAR FOLLOW-UP

All Miners and Ex-miners

Comparison of mean Heights for all men alive at the start of study indicates little difference between radiographic categories 0, 1+2+3, and A+BC. Marked differences exist between the mean Weights of the PMF (A+BC) and SP groups (Figure 1).

Miners and Ex-miners with Category 2, 2A, and 3,3A

The men with PMF category A were sub-divided on the basis of their background SP category. The youngest age-group was omitted since few of these men have PMF. The oldest age-group was omitted to reduce the confounding influence of advanced age. Mean Weights of men with PMF category A and those of corresponding SP groups free from PMF at the time of the first survey are presented in Figure 2; all groups are large (> 20), except for the oldest 3A's. For nearly every age-group and within each background SP category, the mean Weights for those with category A are much lower than those for men without category A (Figure 2). The between-group differences in mean Height are small.

COMPARATIVE STUDY

As a test of the hypothesis that men who were initially free from Progressive Massive Fibrosis and who subsequently developed it (i.e. were attacked) do not differ appreciably in their physical characteristics from those not attacked, having allowed for their background category of simple pneumoconiosis, the prospective eight-year incidence of PMF in miners and ex-miners of the Rhondda Fach was compared with that of miners in the Aberdare valley.[2] The radiographs were read in chronological order independent of any other knowledge about the individual; the average of the radiographic categories of simple pneumoconiosis at time of survey and follow-up was used. This is henceforth referred to as "simple pneumoconiosis (SP) category."

The Data

Of the 1853 men originally seen in the surveys, 1226 men had complete data: 581 in the Rhondda Fach, and 645 in the Aberdare valley. A binary indicator of PMF status at time of follow-up was established—not attacked: 0, attacked: 1.

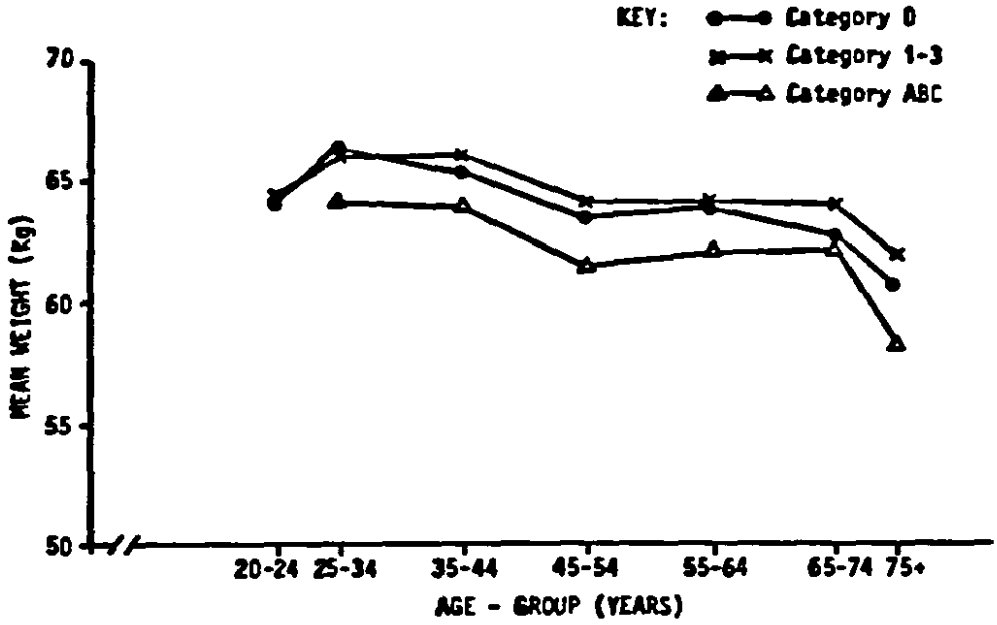


Figure 1. Mean weights by age-group for total initial Rhondda Fach population of miners and ex-miners.

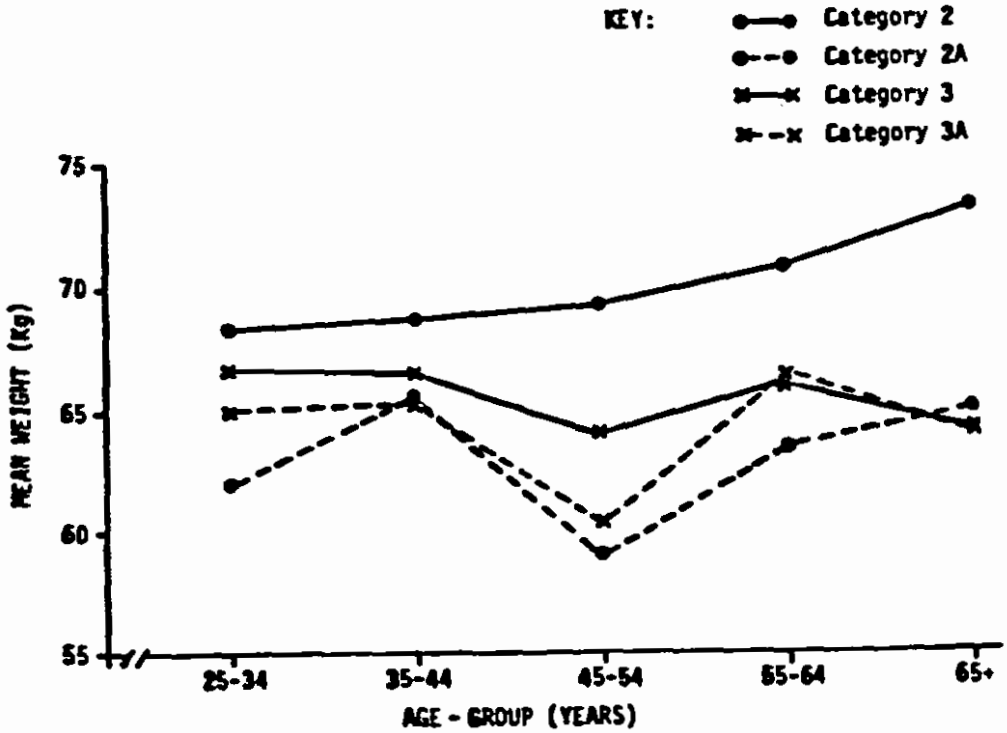


Figure 2. Mean weights by age-group for miners and ex-miners with category A PMF and those without: for background SP categories 2, 3

Simple Pneumoconiosis category was noted on a five-point scale: 1, 1.5, 2, 2.5, 3. The arithmetic mean of chest width at full inspiration and at full expiration was denoted Mean Chest Diameter (MCD). The Body Mass Index (BMI = Weight/Height^2) of Quetelet,[6] and the index of Body Type, i.e. Height^2/(10 * MCD) due to Rees and Eysenck[7] were calculated. Age at time of survey was grouped: 1 = 25–34, 2 = 35–44, 3 = 45–54, 4 = 55–64, 5 = 65+ years.

Preliminary Results

Table I displays the summary description of these data. The percentage and number attacked for each Valley, together with the number at risk, are shown in Table II.

Due to the similarity of corresponding cell entries for Weight and BMI amongst those attacked and those not attacked for each valley, tables were combined across the Valleys. Those attacked have consistently lower mean Weight than those who did not develop PMF (Table III); little such difference is found for the Body Mass Indices (Table IV).

Tabulation of percentage attacked by Age-group and Grouped Weight for SP category 2.5 suggested that the group of men weighing 60-69 Kg are at particular risk of attack by PMF. However, interpretation poses problems since there are a large number of cells which are either empty or are based on small numbers.

Logistic Regression Analysis

To further investigate the role of anthropometric indices in the probability of attack by PMF, logistic linear models were used to analyse the data.[8] The outcome variable being a binary indicator of attack by PMF, regression coefficients with a positive sign indicate variables associated with increased probability of attack, and conversely for a negative sign. Variables Age, SP category, and Valley were included as factors (dummy variables).

Model development. A variety of models were fitted in the development of a parsimonious model that adequately described the data. Models were compared by referring the change in Deviance, as terms are added or removed, to tables of Chi-squared. The Deviances do not have an "absolute" meaning, only differences between them may be safely treated as Chi-squared variables.[9] The importance of individual regressors was considered both in terms of the size of their contribution to the regression equation and their atandard Normal Deviate (SND).

To provide a baseline for assessing subsequent models, a null model (ϕ) containing only the Grand Mean (%GM) was fitted.

Main effect and first order interaction terms were added to form model I. The regression estimates for these and the other models fitted are summarized in Table V.

Table I

PMF Attack Study: Ranges, Means and Standard Deviations of Explanatory Variables

VARIABLE	V A L L E Y			
	Rhondda Fach	Aberdare	Rhondda Fach & Aberdare	
	Mean (SD)	Mean (SD)	Range	Mean (SD)
Valley	0	1	0 - 1	0.526
Proportion Attacked	0.189	0.127	-	0.157
SP category	2.419 (0.445)	1.869 (0.652)	1 - 3	2.130 (0.627)
Age group	2.336 (1.089)	2.386 (1.033)	1 - 5	2.362 (1.060)
Height (M)	1.679 (0.061)	1.679 (0.067)	1.29 - 1.94	1.679 (0.064)
Weight (Kg)	65.06 (8.94)	64.03 (9.16)	44.40 - 107.0	64.52 (9.07)
Body Mass Index	23.07 (2.87)	22.68 (2.66)	16.73 - 44.42	22.87 (2.76)
Mean Chest Diameter (cm)	27.30 (2.09)	27.40 (2.00)	20.0 - 38.5	27.35 (2.05)
Body Type	103.8 (9.2)	103.4 (9.2)	61.63 - 141.12	103.56 (9.20)

During model development, it was clear that SP terms were dominant, with their regression coefficients increasing monotonically with increasing category of SP. The contributions made by the Age terms were small and non-significant. There appeared to be little contribution made by the Valley term, either directly or through associated interaction terms.

Little evidence was found to reject the null hypothesis of a true value of zero for the coefficients for MCD, Body Type, or BMI (QI). Coefficients for Height, though consistently negative suggesting reduced probability of attack amongst taller men never attained anywhere near a conventional level of significance ($P > 0.2$). The contribution made by the Weight term was consistently negative, with generally strong evidence to reject the null hypothesis of a true value of zero. Thus indicating reduced probability of attack amongst heavier men.

Additional support for inclusion of the Weight term was provided by further models which omitted this term (VIII), included a Height term (IX), or replaced the Weight term by the BMI (X). The results from model IX indicated a true effect of Weight rather than an effect of overall 'size'. Little improvement in fit resulted from the adoption of any of these models.

Many other models were assessed. In particular, SP. Weight interaction terms were included but none of these models showed any useful improvement in fit.

Predictive Value of Model VII

Using the inverse logistic transform and three categories of Weight: Low (50 Kg), Medium (65 Kg), and High (80 Kg), the percentage probabilities of a miner being attacked by PMF were evaluated as a function of SP category. The estimates are shown in Table VI.

Table VII was formed by applying these predicted percentage attacks to the numbers at risk.

Although changes in Deviance indicate that the explanatory ability of the model VII incorporating Weight and SP is much greater than that of model VII using SP alone, further investigations indicate that the main contribution of Weight to the predictive ability of the model is due to its smoothing-out of perturbations in the predicted numbers corresponding to SP category 2. Simple pneumoconiosis is the dominant factor in the attack process.

Table II

Percentage and Number Attacked by PMF, and Number at Risk for Each Valley by Age-group and SP Category

KEY: in each cell) Percent attacked
figures) Number attacked
arranged as) Number at risk

Age Group	Rhondda Fach					Aberdare					Total				
	Category of Simple Pneumoconiosis					Category of Simple Pneumoconiosis					Category of Simple Pneumoconiosis				
	1	1.5	2	2.5	3	1	1.5	2	2.5	3	1	1.5	2	2.5	3
20 - 34	-	(0.0)	14.6	13.5	29.3	0.0	4.5	9.1	19.4	35.3	0.0	3.9	12.2	15.7	31.0
	0	0	6	7	12	0	2	3	6	6	0	2	9	13	18
	0	7	41	52	41	12	44	33	31	17	12	51	74	83	58
35 - 44	-	(0.0)	13.2	15.4	30.2	0.0	11.0	18.0	5.9	35.3	0.0	11.3	25.4	19.7	43.7
	0	0	9	12	19	0	8	9	2	12	0	8	18	14	31
	0	6	68	78	63	46	73	50	34	34	46	79	118	112	97
45 - 54	-	(0.0)	17.8	21.7	24.4	0.0	7.7	3.2	26.9	43.5	0.0	6.5	11.8	23.6	31.3
	0	0	8	10	10	0	4	1	7	10	0	4	9	17	20
	0	9	45	46	41	39	52	31	26	23	39	61	76	72	64
55 - 64	-	(0.0)	17.9	38.5	16.7	0.0	5.6	20.0	45.5	(11.1)	0.0	4.5	18.8	41.7	14.3
	0	0	5	5	2	0	1	4	5	1	0	1	9	10	3
	0	4	28	13	12	27	18	20	11	9	27	22	48	24	21
65 +	-	(0.0)	26.7	(0.0)	(25.0)	(0.0)	(20.0)	(0.0)	(20.0)	(0.0)	(0.0)	(12.5)	23.5	10.0	(20.0)
	0	0	4	0	1	0	1	0	1	0	0	1	4	1	1
	0	3	15	5	4	2	5	2	5	1	2	8	17	10	5

where ( ) indicates percentage based on number at risk < 10.

Table III

Weights (Kg) of Men—Combined Valleys

SP Category	Total Group Mean (SD) Range	Not attacked No.	Not attacked Mean	Attacked No.	Attacked Mean	No. at Risk
1	64.94 (10.02) 46.70 - 97.10	126	64.94	0	-	126
1.5	64.32 (9.46) 45.80 - 107.00	205	64.44	16	62.84	221
2	64.93 (9.35) 47.20 - 98.40	284	65.06	49	64.53	333
2.5	64.76 (9.14) 44.40 - 106.10	246	65.50	55	61.47	301
3	63.55 (7.59) 46.70 - 87.10	172	64.09	73	62.26	245

Linear regression analyses for men attacked by PMF provide some slight evidence of a trend of decreasing average Weight with increasing average category of SP. By contrast, the evidence for the Body Mass Index is somewhat stronger.

DISCUSSION

Strong evidence of the importance of weight in the aetiology of PMF category A is provided by the cross-sectional data shown in Figures 1, 2. However, by their very nature, it is not possible to make inferences about the prognostic value of SP or Weight in determining the probability of a man being attacked by PMF.

There is a strong influence of SP category on the probability of attack by PMF throughout all the models considered. The (independent) influence of reduced Weight on the probability of attack is also obvious. There was however no evidence of B relation between probability of attack and Age. This is similar to the finding of Cochrane.[2] The logiatic regression analyses provide strong evidence of increasing risk of attack with reduced weight. There is only slight evidence of an influence of the Body Mass Index.

The consistent but slight trend of decreasing Weight (BMI) with increasing Lung Dust content as found in the final regression analyses supports the idea that lighter men are preferentially selected for attack.

Model VII provided the best parsimonious description of the data; it was able to predict well the number of men attacked.

In terms of the hypothesis of Cochrane et al[4] that pulmonary tuberculosis has a role in the development of PMF, the consistently small and non-significant coefficient for Valley and the corresponding terms for interaction with SP suggest little support for this idea. Cochrane[2] noted that despite the efforts of the field experiment, there may have been no real difference in the level infection in the two valleys. However, his further work comparing the attack rate during different periods following the initial survey was regarded as undermining the 'tuberculosis hypothesis'.

CONCLUSION

Further study of the prognostic value of these indices, in particularly weight, would be useful. In view of the great variability of the attack rate of PMF in different coal-fields, consideration pf datasets based on other types (ranks) of coal would be informative.

If the importance of weight as a predictive factor in attack by PMF can be validated, the use of a weight-monitoring procedure might lead to further improvements in the health of miners.

Table IV

Body Mass Indices of Men—Combined Valleys

SP Category	Total Group Mean (SD) Range	Not attacked No.	Not attacked Mean	Attacked No.	Attacked Mean	No. at Risk
1	23.26 (3.00) 17.80 - 34.39	126	23.26	0	-	126
1.5	22.80 (2.86) 17.37 - 36.60	205	22.85	16	22.23	221
2	23.01 (2.89) 17.32 - 33.86	284	23.00	49	23.05	333
2.5	22.91 (2.89) 16.73 - 44.42	246	22.94	55	22.80	301
3	22.48 (2.11) 17.88 - 30.32	172	22.68	73	22.02	245

Table V
Summary of Models

Regression coefficient
Standard error
SND

Model	Grand Mean	Valley(2)	Age(2)	Age(3)	Age(4)	Age(5)	Staple Pseudocontrasts category 1.5	2	2.5	3	Weight	Weight	Mean Chest Diameter	Body Type	Quetelet Index	Vol(2) - (SP = 1.5)	Vol(2) - SP = 2	Vol(2) - (SP = 2.5)	Vol(2) - Weight	Vol(2) - Weight	Deviance
0	-1.678 0.07638																				1868 on 1725 df
1	-0.636 5.111	-0.3833 0.517 -0.88	0.1158 0.2186 0.53	0.08888 0.3618 0.30	0.2297 0.3865 0.15	0.1735 0.4711 0.37	0.7358 0.897 0.83	1.152 1.078 1.06	1.322 1.078 1.08	1.883 1.889 2.00	-1.916 2.057 -0.93	-0.02055 0.01784 -1.21	0.887734 0.85774 0.15			5.966 5.019 0.16	-0.5444 0.4382 -1.24	-0.1768 0.4294 -0.41	0.5131 3.034 0.28	-0.886733 0.62449 -0.25	959.6 on 1268 df
II	-0.319 4.823	0.3293 0.2986 1.13	0.08821 0.2177 0.45	0.1811 0.2354 0.77	0.3482 0.2986 1.15	0.2325 0.4622 0.50	0.3526 1.031 0.84	1.209 1.029 1.06	1.412 1.026 1.06	1.883 1.911 2.00				-73.82 89.19 -0.82		5.852 5.161 0.72	-0.8231 0.4355 -1.43	-0.2012 0.4263 -0.47			868.5 on 1712 df
III	-0.388 4.571	0.2636 0.2939 0.90					0.7247 0.920 0.83	1.165 1.073 1.06	1.386 1.073 1.06	1.868 1.866 2.00	-1.981 1.511 -1.26	-0.02190 0.01436 -1.26	0.884188 0.85261 0.88			5.936 0.956 0.98	-0.5661 0.4372 -1.29	-0.1835 0.4262 -0.43			966.3 on 1714 df
IV	-0.838 4.876	0.3822 0.2913 1.08					0.2565 0.925 0.83	1.208 1.018 1.06	1.318 1.018 1.07	1.873 1.901 2.02			-0.05414 0.04957 -1.20		-0.01882 0.03798 -0.56	5.882 0.946 0.72	-0.8821 0.4355 -1.38	-0.1888 0.4264 -0.43			967.4 on 1215 df
V	-0.862 3.936	0.2598 0.2923 0.89					0.2157 0.964 0.82	1.177 1.078 1.05	1.298 1.075 1.08	1.837 1.870 2.03		-0.02915 0.01815 -2.00				5.827 0.871 0.73	-0.5738 0.4385 -1.31	-0.1954 0.4268 -0.38			961.8 on 1216 df
VI	-0.756 3.920	0.08186 0.1777 0.47					5.998 3.871 1.55	6.045 3.867 1.77	7.185 3.867 1.86	7.774 3.867 2.00		-0.02537 0.01899 -2.91									966.3 on 1319 df
VII	-0.844 3.911						5.979 3.870 1.54	6.757 3.864 1.98	7.853 3.864 1.83	7.670 3.863 1.98		-0.02980 0.01895 -2.97									968.5 on 1220 df
VIII	-0.566 3.946						6.015 3.826 1.53	6.800 3.819 1.96	7.860 3.819 1.88	7.986 3.916 1.93											977.8 on 1221 df
IX	-0.948 4.430						5.999 3.863 1.55	6.815 3.857 1.77	7.872 3.857 1.83	7.688 3.857 2.00	-1.955 1.589 -1.23	-0.02700 0.01171 -1.89									957.0 on 1219 df
X	-7.495 3.977						5.998 3.912 1.53	6.796 3.906 1.76	7.869 3.906 1.88	7.674 3.906 1.96					-0.06613 0.03232 -1.83						895.7 on 1220 df

Table VI

The Percentage Probability of Attack Using Model VII

Category of SP	Category of Weight			% Predicted on Overall Weight
	Low	Medium	High	
1	0.03	0.02	0.01	0.02
1.5	10.4	6.9	4.5	7.2
2	20.8	14.4	9.7	14.7
2.5	25.3	17.8	12.2	18.3
3	38.6	28.7	20.5	29.8

Table VII

The Number of Attacks Predicted by Model VII

Category of SP	Number of men at risk	Number of attacks	
		Observed	Predicted
1	126	0	0.024
1.5	221	16	15.991
2	331	49	49.006
2.5	301	55	55.000
3	245	73	73.002

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