

CONTROL CHARTS FOR THE STANDARD MORTALITY RATIO

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The Registrar General for England and Wales tells us not only how fast our species is killed, but what kills it, and the preference a specified disease has for different age-groups and for different occupations. The selectivity in the action of the various killers of our species with regard to social status and occupation has found expression in the so-called Standard Mortality Ratio (S.M.R.) which is the index the Registrar General uses for the purpose of describing the selective action of diseases.

The S.M.R. may be briefly explained thus. The Registrar General calculates "standard deaths," which are the numbers obtained by applying the general mortality rates of Table 3 of the *Registrar General's Decennial Supplement England and Wales, Part IIA, Occupational Mortality, 1931*, for all males, all married women, or all single women, as the case may be, at the appropriate age-groups, 20-25-35-45-55-65, to three times the census population of the occupational group as given in Table 4 of the Report, and summing the products. They represent the deaths which would result in an occupation group if that group were exposed at each age to the standard mortality risks. The S.M.R. is the percentage ratio of the deaths actually registered for the group to the calculated standard deaths.

There is, however, apart from systematic and accidental errors of diagnosis, a type of error to be taken into account in comparing S.M.R.s. This is the error due to the fact that the people following a certain occupation form only a comparatively small sample of the total population. Such a sample, if taken at random, may include a greater or smaller number of persons sensitive to the disease in question, or to disease in general. That number, provided the sample is truly random, is due to chance only. Any increase in the S.M.R. due only to the inclusion of a greater number of sensitive persons must not be put down as due to the occupation or social status. We must, therefore, allow for chance fluctuations in the S.M.R. of a population group before judging its S.M.R. for significance.

There will be a certain probability for a deviation of a specified magnitude to occur due to chance only.

The deviation of the S.M.R. from 100 per cent. must be considered in the light of these chance deviations (Yule, 1934). The Registrar General's method of doing this is described in his *Decennial Supplement; Part IIA*. A table is given from which to read the limits within which a difference in the S.M.R. cannot be considered significant or highly significant. These limits vary with the number of deaths in the population group, and thus with its size. In his discussion of the various S.M.R.s the Registrar General takes the standard error into account. But since the report of the Registrar General comprises 176 great folio pages of text and 228 similar pages of tables, some measure of condensation would appear desirable for doctors, and particularly for medical officers, who either cannot spare the time for study, or have not the mathematical stamina for wading through large numerical tables and at the same time applying the criterion of the multiples of the standard errors to every S.M.R. in which they happen to be interested. It is with this in mind that the following charts have been constructed. The quality control chart (Herdan, 1948) is here introduced as a device for facilitating the use of the standard error in judging the significance of S.M.R.s.

The general structure of these charts is as follows.

A straight line represents the S.M.R. for the total population (all males, all married women, all single women, as the case may be) for all causes or for specified diseases. The curved lines are drawn at distances representing 1.5 and 2.5 of the standard error of the S.M.R., (adhering to the practice of the Registrar General) and thus including its chance variation in about 14 out of 15 and 160 out of 161 cases respectively on the basis of an assumed normal distribution of the chance variations. According to the size of the random sample (more precisely, according to the number of deaths in the population group) these lines are at different distances from the mean line. Again adhering to the practice of the Registrar General, they represent the "probable" and "highly probable" border lines between chance variation and true or real differences in the S.M.R., according to sample size. They can also be regarded as a sort of mathematical gauge by which the

CONTROL CHART OF S.M.R., MALES, ALL CAUSES. PART I

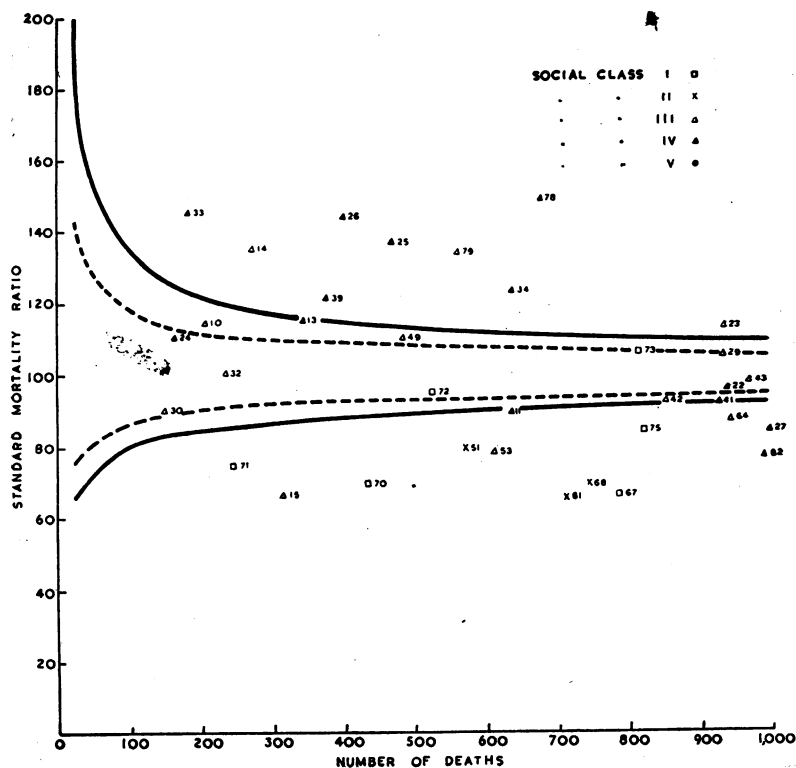


FIG. 1.

TABLE I

KEY TO FIGS. 1 AND 2 GIVING LIST OF OCCUPATIONS FOR WHICH S.M.R. IS SIGNIFICANTLY HIGH AND LOW

High			Low		
Social Class	No.	Occupation	Social Class	No.	Occupation
I	—		I	67 70 71 75	Bank and insurance officials Clergymen (Anglican Church) Ministers of religion (excluding R.C.) Professional engineers
II	28 77	Employers and managers in Occupation Orders VIII-XXI, XXXI Inn-, hotel-keepers	II	1 12 51 63 64 68 74 81	Farmers and their relatives Employers and managers: gas, bricks chemicals, etc. Railway officials Commercial travellers Retail salesmen, grocery Civil Service and Local Authority administrative, executive Teachers (not music) Draughtsmen, costing clerks, etc.
III	4 14 16 17 23 46	Coal hewers and getters Potters, ware-makers, etc. Furnacemen, rollers and skilled assistants Metal moulders and die casters Boiler-makers, platers and iron shipwrights Masons	III	2 15 27 35 38 40	Gardeners, nurserymen, florists Workers in chemical processes Plumbers (not chemical plumbers) Makers of textile goods Bakers and pastrycooks Carpenters

significance of a difference in S.M.R.s is quickly ascertained. All we have to do is to plot the S.M.R. for the occupation group in question as the vertical ordinate against the total number of deaths in that group during the time under consideration as the horizontal ordinate or abscissa for the cause or causes in question. If the point falls beyond the outer control line (2.5 times the standard error) we can be satisfied of a real difference and may use it as a reliable pointer to further investigation. If the point falls beyond the inner control limit (1.5 times the standard error) but not beyond the outer control limit, the difference is probably significant and well worth investigating further.

As an illustration of the method the following control charts have been prepared to show in males the S.M.R. for all causes (Figs. 1 and 2); influenza (Fig. 3); respiratory

CONTROL CHART OF S.M.R., MALES, ALL CAUSES. PART II

tuberculosis (Fig. 4); cancer (Fig. 5).

For each chart the occupational groups have been listed for which the S.M.R. falls beyond the outer control limits, and thus signifies that the mortality, due to all causes or to the specified diseases, exceeds or is less than that of the total population by an amount which must be regarded as significant.

In this way we are not misled by the great number of S.M.R.s, differing from 100 by greater or smaller amounts, which very often mean nothing since they may be due to sampling fluctuations only. The comparison between

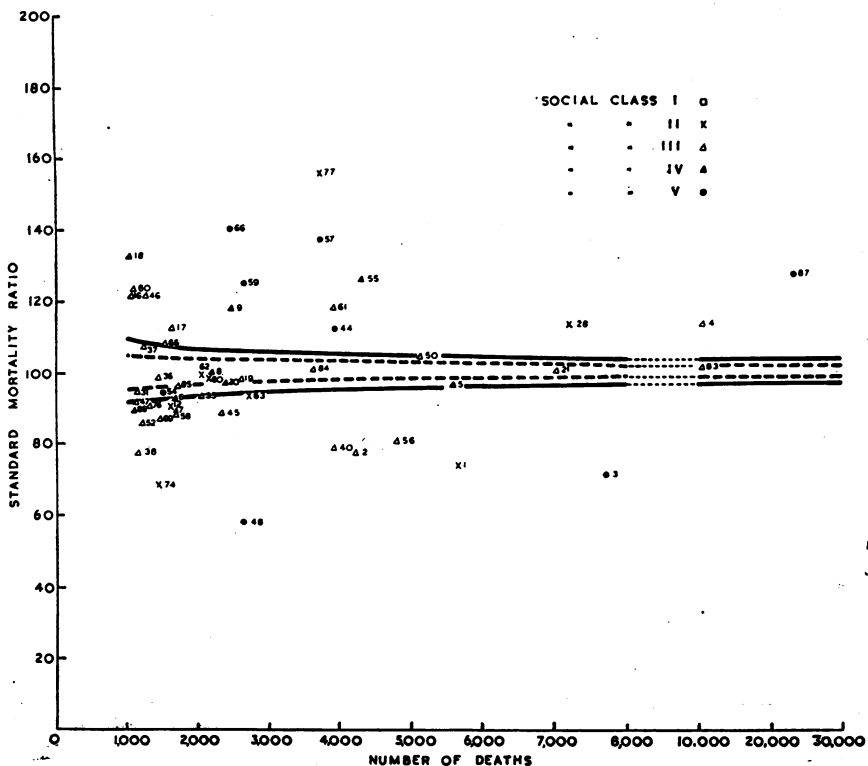


FIG. 2.

TABLE I—Continued

	61 Retail proprietors: dairy, meat, fish, greengrocery		45 Bricklayers
	65 Retail salesmen: dairy, meat, fish, greengrocery		47 Platelayers
	79 Waiters		52 Railways: engine drivers
	80 Hairdressers		53 Railways: signalmen
			56 Road transport: motor drivers
			58 Postmen and sorters
			69 Police
			76 Domestic servants (indoor)
			82 Typists and other clerks
IV	9 Coal mines: workers above ground	IV	6 Coal mines: conveying material to shaft
	18 Iron and steel foundry furnacemen		7 Coal mines: making and repairing roads
	25 Metal grinders		11 Stone miners, quarriers
	26 Metal glazers, polishers, etc.		86 Boiler firemen and stokers
	33 Textile strippers and grinders		
	34 Textile dyers		
	39 Makers of alcoholic drinks		
	55 Road transport: horse drivers		
	78 Barmen		
V	44 Builders, masons, and labourers	V	3 Agricultural and gardeners' labourers, etc.
	57 Water transport: dock labourers		48 Navvies in building trade, etc.
	59 Messengers and porters		
	66 Costermongers, newspaper sellers		
	87 General labourers		
	88 General labourers and other unskilled workers		

CONTROL CHART OF S.M.R., MALES, INFLUENZA

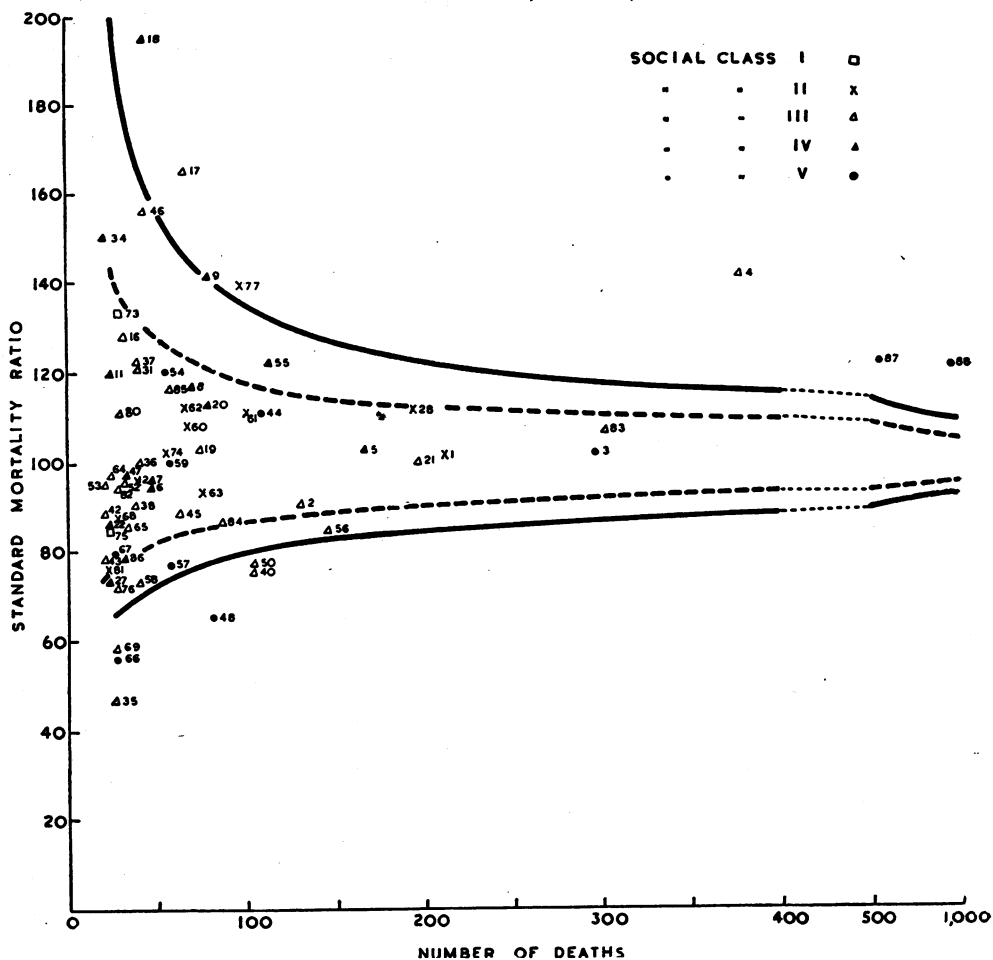


FIG. 3.

TABLE II

KEY TO FIG. 3 GIVING LIST OF OCCUPATIONS FOR WHICH S.M.R. IS SIGNIFICANTLY HIGH AND LOW

High			Low		
Social Class	No.	Occupation	Social Class	No.	Occupation
I	—		I	—	
II	77	Inn-, hotel-keepers	II	—	
III	4 17	Coal hewers and getters Metal moulders and die casters	III	35 40 50 69	Makers of textile goods Carpenters Paper hangers, painters, etc. Policemen
IV	18	Iron and steel foundry furnacemen	IV	—	
V	87 88	General labourers General labourers and other unskilled workers	V	48 66	Navvies in building trade, etc. Costermongers, etc., newspaper sellers

CONTROL CHART OF S.M.R., MALES, RESPIRATORY TUBERCULOSIS

the graphs for influenza and respiratory tuberculosis is very instructive in this respect. Although even in the former the S.M.R.s often differ widely from one another and from 100, yet most of them are comprised between the outer control limits, thus affording no clue whether influenza is an occupational disease to a high degree.

Respiratory tuberculosis, on the other hand, shows a very great scatter of S.M.R.s, extending considerably beyond the outer control limits, and thus characterizing the disease as highly "occupational" in the wider sense of

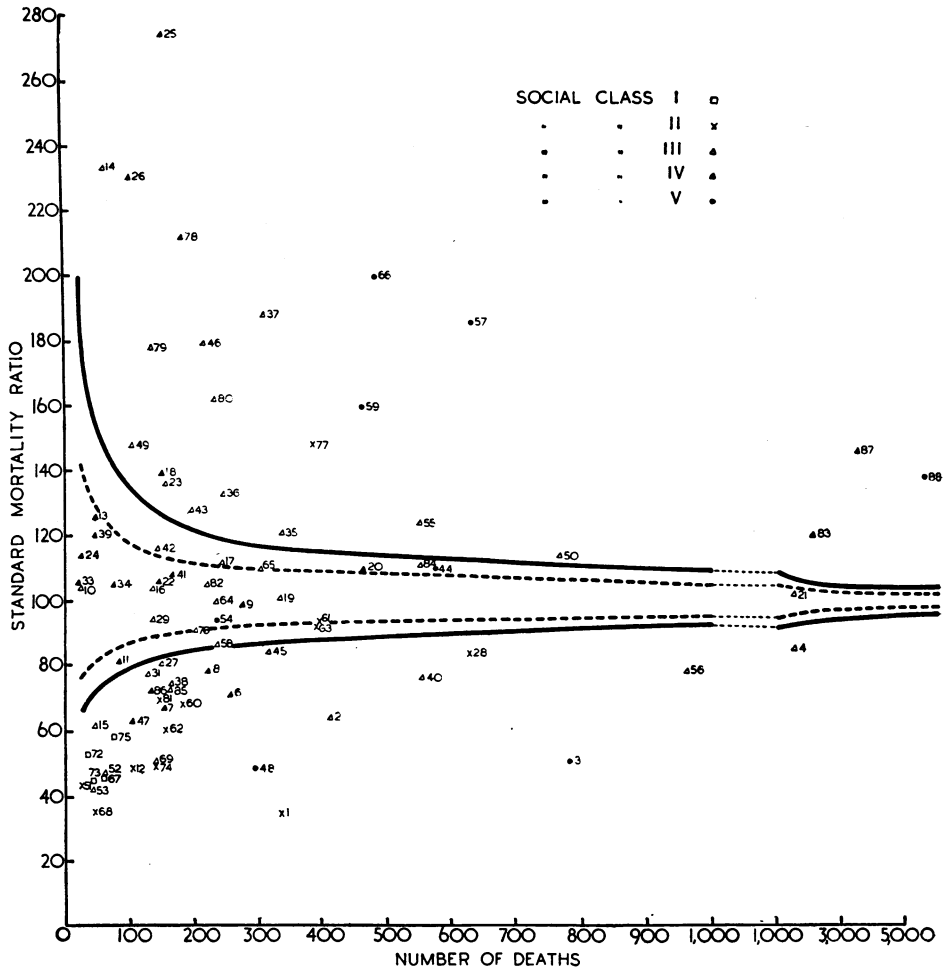


FIG. 4.

TABLE III

KEY TO FIG. 4 GIVING LIST OF OCCUPATIONS FOR WHICH S.M.R. IS SIGNIFICANTLY HIGH AND LOW

High			Low		
Social Class	No.	Occupation	Social Class	No.	Occupation
I	—		I	67	Bank and insurance officials
				72	Judges, barristers, solicitors
				73	Physicians, surgeons
				75	Professional engineers
II	77	Inn-, hotel-keepers	II	1	Farmers and their relatives
				12	Employers and managers: gas, bricks, chemicals, etc.
				28	Employers and managers in Occupation Orders VIII-XXI, XXXI
				51	Railway officials

TABLE III—Continued

				60	Retail proprietors, etc., e.g. grocery
				62	Wholesale proprietors, etc.
				68	Civil Service and Local Authority: administrative and executive
				74	Teachers (not music)
				81	Draughtsmen, costing clerks, etc.
III	14	Potters, ware-makers, etc.	III	2	Gardeners, nurserymen, florists
	35	Makers of textile goods		4	Coal hewers and getters
	36	Boot and shoe makers, repairers		15	Workers in chemical processes
	37	Boot and shoe workers and factory operatives		27	Plumbers (not chemical plumbers)
	43	Printing machine minders, printers, etc.		31	Textile weavers (cotton)
	46	Masons		38	Bakers and pastrycooks
	49	French polishers		40	Carpenters
	50	Paper hangers, painters, etc.		45	Bricklayers
	55	Road transport: horse drivers		52	Railways: engine drivers
	79	Waiters		53	Railways: signalmen
	80	Hairdressers		56	Road transport: motor drivers
	83	Typists and other clerks (other than Civil Service)		69	Police
				85	Stationary engine drivers not underground in mines
IV	18	Iron and steel foundry furnacemen	IV	6	Coal mines: conveying material to shaft
	25	Metal grinders		7	Coal mines: making and repairing roads
	26	Metal glazers, polishers, etc.		8	Coal mines: other workers below ground
	78	Barmen		47	Platelayers
	87	General labourers		86	Boiler firemen and stokers
V	23	Boiler-makers, platers and iron shipwrights	V	3	Agricultural and gardeners' labourers, etc.
	57	Water transport: dock labourers		48	Navvies in building trade, etc.
	59	Messengers and porters			
	66	Costermongers, newspaper sellers			
	88	General labourers and other unskilled workers			

TABLE IV

KEY TO FIG. 5 GIVING LIST OF OCCUPATIONS FOR WHICH S.M.R. IS SIGNIFICANTLY HIGH AND LOW

High			Low		
Social Class	No.	Occupation	Social Class	No.	Occupation
I	—		I	67	Bank and insurance officials
				70	Clergymen (Anglican Church)
				73	Physicians, surgeons, etc.
II	28	Employers and managers in Occupation Orders VIII-XXI, XXXI	II	1	Farmers and their relatives
	77	Inn-, hotel-keepers		68	Civil Service and Local Authority: administrative, executive
				74	Teachers (not music)
				81	Draughtsmen, costing clerks, etc.
III	16	Furnacemen, rollers and skilled assistants	III	2	Gardeners, nurserymen, florists
	17	Metal moulders and die casters		27	Plumbers (not chemical plumbers)
				40	Carpenters
				53	Railways: signalmen
				56	Road transport: motor drivers
IV	13	Skilled workers in gas works service	IV	5	Coal mines: workers below ground other than hewers
	18	Iron and steel foundry furnacemen		6	Coal mines: conveying material to shaft
	39	Makers of alcoholic drinks		7	Coal mines: making and repairing roads
	55	Road transport: horse drivers		8	Coal mines: other workers below ground
	78	Barmen			
V	44	Builders, masons, and labourers	V	3	Agricultural and gardeners' labourers, etc.
	57	Water transport: dock labourers		48	Navvies in building trade, etc.
	59	Messengers and porters			
	87	General labourers			
	88	General labourers and other unskilled workers			

CONTROL CHART OF S.M.R. MALES, CANCER

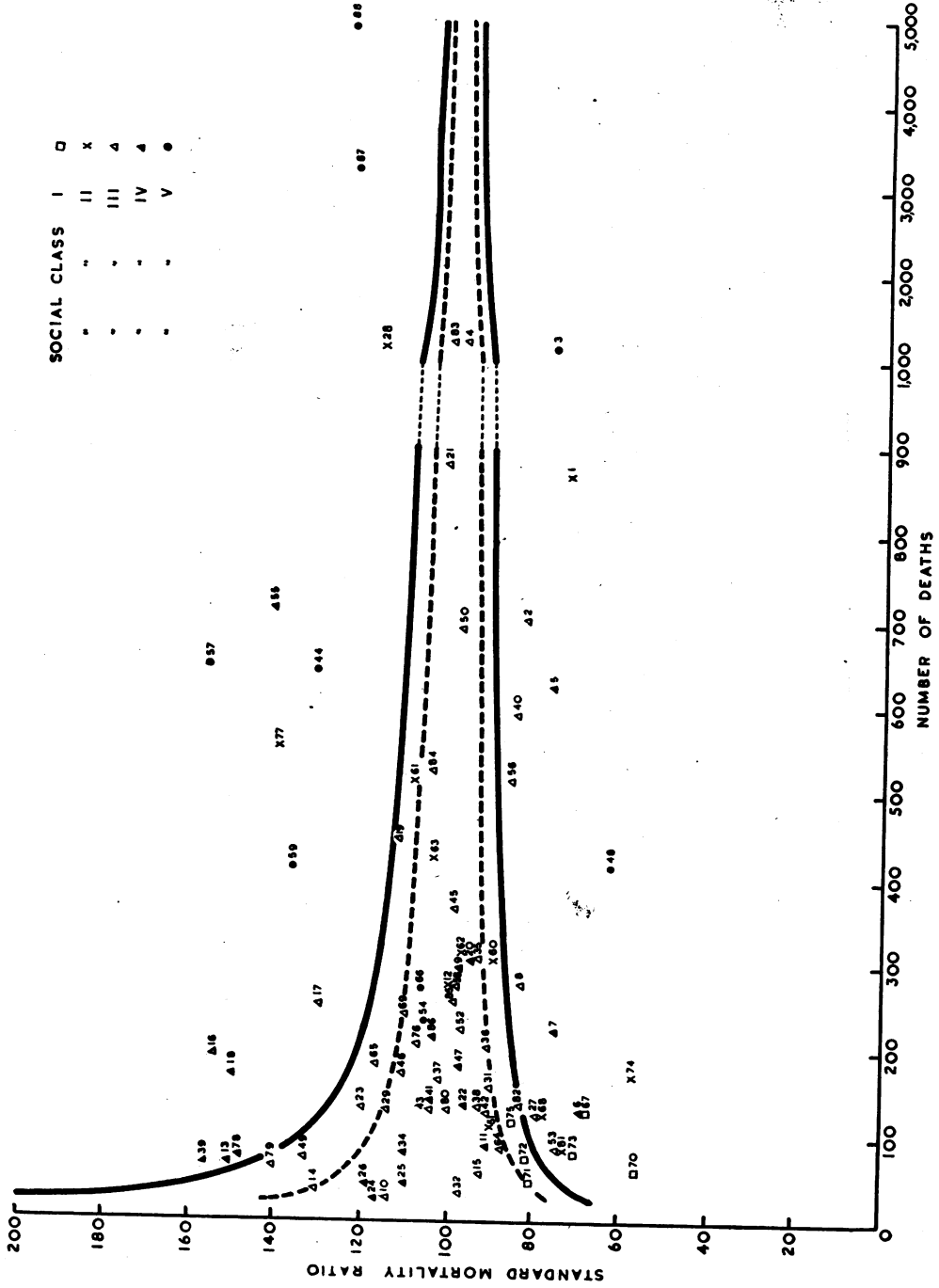


FIG. 5.

the term. That is, either the employees of certain occupational groups are at an increased risk of dying from respiratory tuberculosis, or a sort of selection takes place which makes persons afflicted by the disease gravitate to certain occupations more than to others.

On the basis of the control chart it is possible to express the scatter of the S.M.R. which is characteristic for a given disease in a single figure. One way of doing this is to count the points outside the outer control limits and express their number as a percentage of the total number of points plotted. We thus obtain for

Influenza	12/67	..	18%
Cancer	32/86	..	37.2%
Respiratory tuberculosis	57/84	..	67.85%
All causes	60/88	..	68.2%

For the purpose of comparison between different diseases, or between a specified disease and "all causes," index figures might easily be constructed. Taking for instance the percentage of points outside the control limits for "all causes" as our standard of comparison, i.e. as 100 per cent., the relative scatter for the three specified causes results as:—

Influenza, 26.5 or approximately one quarter of the scatter due to "all causes"; cancer, 54.7 or

slightly more than one half of the scatter due to "all causes"; respiratory tuberculosis, 99.7 or approximately the same as the scatter for "all causes."

Although the Registrar General distinguishes by means of the S.M.R. between occupational groups with regard to a specific cause of death, it seems very desirable to have a method for distinguishing between different causes of death with regard to the extent to which they are selective in their action upon occupational groups. The integrating device which is needed for doing this is provided by the control chart, giving a complete picture and taking at the same time the standard error of the S.M.R. into account. It reveals the degree of significant heterogeneity in the action of a specified lethal agent upon the occupational groups. It also enables us to express that degree of heterogeneity, and the difference between different causes of death in that respect by a single index figure.

REFERENCES

- "The Registrar General's Decennial Supplement. England and Wales, 1931, Part IIA, Occupational Mortality." 1938. London.
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