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OCCUPATIONAL VARIATION IN BIOLOGICAL VARIABLES

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ABSTRACT

A study was undertaken of 1141 employees of a research institution (93% of the available staff) to resolve claims that health was being affected by exposure to a large range of hazardous laboratory and industrial chemicals including radioisotopes. The data obtained in the study comprised environmental observations; absence and separation records; information from self--administered biographic questionary and from medical interview and examination; chest X-ray, cardiography and spirometry; and haematology and blood chemistry. This paper reports only the biological differences noted between the four main occupational groups in the institution – professional, technical, trade and administration. About half (48%) of administration staff, 7% of technicians, 4% of professionals, and no tradesmen, were female.

The four groups differed widely in many biological variables, differences inexplicable on sex and age grounds alone. These variables included for example drug habits (smoking, drinking and other), physical activity and physical dimensions, other physical measurements such as ventilatory capacity, blood pressure, grip strength and skinfold thickness, blood items, mainly neutrophils, haemoglobin and erythrocyte sedimentation rate, serum chemistry, and personality (extraversion and neuroticism). Generally, and allowing for sex and age differences, there was a gradient in these variables from professional through technical and administration to trades groups, the tradesmen faring worst in a health and fitness sense. There was a related gradient also in social variables and in respiratory symptoms and disease and hearing loss. An attempt to identify work environmental associations of these differences by cross tabulations with occupational history and work exposures and by multivariate analysis was generally negative with respect to biological variables. It was concluded that generally the often marked biological variation noted between broad occupational groups reflected social differences, including differences in life style, rather than occupational variation in exposure to hazardous substances.

Differences between occupational groups in the distribution not only of disease and its precursors but also of biological variables – anthropometric, biochemical, haematological and behavioural – have long been noted. Mostly reports have concerned quite restricted numbers of variables, even only one or two, chosen for a particular purpose such as investigation of an occupational disease. The occupational comparison then tends to deal with populations exposed to a particular hazardous agent (e.g. silica) in a particular work and social environment (e.g. a mine), both of which may heavily influence the comparison. Diverse populations of similar occupational status working under the same roof in non-toxic environments such as offices have shown great differences in sickness absence experience, neurosis, chronic ill health and biological variables[4,5]. As always in such comparisons, the question arises to what extent differences are the result of personal and personnel selection for and out of the job; all worker groups are survivor populations. A health survey of a population working together within the same four walls but having three main tiers of educational background provided an opportunity to examine occupational difference in health status.

SUBJECTS AND METHOD

The survey was conducted among employees of a research establishment at the request of unions because of a series of disconnected incidents involving exposure to various chemical agents and causing mostly short-lived health effects. The establishment undertakes a wide range of basic and applied research in physics, mathematics, engineering, metallurgy and chemistry fields. Accordingly employees are exposed to a wide diversity of physical and chemical agents including radioisotopes, and to the diverse workshop and technical assembly and maintenance procedures associated with such laboratories.

The population of the establishment is normally divided for personnel purposes into professional, technical, trade and administration groups, which provided a convenient basis for comparison in this study. People in each of the first three groups are reasonably homogeneous in occupational status, and thus the groups can be graded in socio-economic level. Most males in the administration group were clerks or administrators but several small subgroups such as drivers, cleaners and gardeners were also included; this group is less homogeneous than the other three. Within each major group subgroups had clearly different occupational environments, for example draughtsmen and chemical and computer technicians (Table 1). However, the wide range of these occupational subgroups; the absence of any toxic hazard common to all, the

TABLE 1
Composition of broad occupational groups, all subjects.

Occupation	N	%	Occupation	N	%
Professional	322	100	Technician	384	100
Engineer	109	34	Fitter	120	31
Chemist	81	25	Chemical	52	14
Physicist	67	21	Draughtsman	39	10
Other	65	20	Electronics	46	12
			Other	127	33
Administration	225	100	Trades	209	100
Clerical	111	49	Fitter's asst.	95	45
Secretarial	48	22	Other	114	55
Other	66	29			

general lack of evidence of toxic effects in particular subgroups; and the tendency generally for occupations to share experimental work across major groups – all meant that any unidentified health effects peculiar to particular occupations would be greatly diluted in major group pooling. The establishment had an attractive garden setting in a bush environment isolated from community air pollution.

The 1 141 subjects examined in the study comprised 93% of the available workforce. Except in administration (52%), the population in each group was largely (professional 96%, technical 93%) or exclusively (trade 100%) male. Females have therefore been omitted from comparisons.

The four major groups varied somewhat in age distribution (Table 2) which may affect comparisons of strongly age-related variables. All groups had a preponderance of older subjects; turnover of males in the establishment has been low.

TABLE 2
Distribution by main occupational group, males.

Broad age group (years)	Occupational group %				All % (993)
	Professional (306)	Technical (364)	Trade (207)	Administration (116)	
20–39	48	38	44	34	42
40+	52	62	56	66	58

The data presented here are all derived from medical interviews and any consequent specialist referrals. The method included self-administration of a long take-home questionary that comprised sections on biography, past and present health, attitudes to work, habits and extraversion stability rating. Examination included some anthropometry, cardiography, sphygmomanometry, audiometry, spirometry, haematology and blood chemistry.

This paper deals more with differences observed between main occupational groups in certain biological variables than with disease prevalence. The study is still largely at a descriptive stage. Analysis is proceeding.

RESULTS

Occupational comparisons to control for various personal and social influences as sources of confounding of observed differences possibly attributable to occupation showed a consistent variation by broad employment group (Table 3). With scarce an exception, fewer professionals than technicians, and technicians than tradesmen, had the higher order values of the items listed in the table, whether physical measurements or haematology or blood chemistry analyses. The same consistent gradient appeared in the behavioural and social attributes listed and in the respiratory symptoms. In the case of most attributes the gradient implied increasingly unfavourable health status. In the case of

TABLE 3
Occupational differences, selected attributes, males, all ages.

Attribute*	Broad occupational group %				Age ratio % young (<40 yrs) vs old (40+) (413:580)
	Professional (306)	Technical (364)	Trade (207)	Administrative (116)	
Physical measurement					
Stature < 165 cm	7	7	16	8	6:11
FVC/Predicted VC < 80%	2	8	15	17	3:13
FEV_1/FVC < 70%	6	7	12	14	4:12
Grip < 40 kg	10	7	19	13	6:15
Hearing loss 35 dB + at 4 kHz	9	19	29	16	2:22
Mean skinfold 20 mm +	15	16	21	22	15:19
Systolic pressure 160 mm +	4	8	15	7	2:13
Diastolic pressure (4th phase) 100 mm +	7	12	11	14	3:16
Haematology					
Haemoglobin 16g/100 ml +	20	29	27	34	20:26
Neutrophils 5 000/mm^3 +	8	13	19	20	9:16
Lymphocytes 3 000/mm^3 +	10	16	23	15	16:15
Monocytes 600/mm^3 +	9	12	14	19	11:13
ESR 6 mm +	7	12	18	20	4:18
Blood chemistry					
Sodium 144 mmol/l +	10	17	15	16	10:17
Potassium 5.2 mmol/l +	7	16	9	20	9:15
Phosphate 3.5 mg/100 ml +	14	15	30	23	26:13
Cholesterol 250 mg/100 ml +	13	14	16	24	7:21
Fasting glucose 120 mg/100 ml +	7	15	14	17	5:18
Alkaline phosphatase 60 U +	16	26	37	41	21:31
Aspartate transferase 20 U +	16	21	20	23	17:18
GGT 35 U +	9	10	13	21	8:24
Creatinine 1.2 mg/100 ml +	7	10	8	14	7:11
Urate 8 mg/100 ml +	4	8	6	10	4:8

Behavioural, social					
3 + drinks daily	13	16	26	40	16:23
15 + cigarettes daily	7	12	17	21	11:14
Regular drug taking	5	11	12	11	4:13
Low exercise outside work (<3 on 11 point scale)	30	34	42	39	24:43
Extraversion (15 + on 24 point scale)	3	4	14	15	10: 6
Instability (15 + on 24 point scale)	3	7	8	5	7: 6
Birth: Australia	61	65	70	83	73:63
United Kingdom	25	23	24	12	
North Europe	7	10	3	2	
Respiratory symptoms					
Short of breath	9	17	21	25	7:23
Regular cough	13	19	30	17	14:23
Regular sputum	11	18	27	20	18:18
Recurrent wheeze	9	12	16	16	9:14
Elicited loose cough	5	6	15	9	6: 9
Chronic respiratory disease	2	3	11	5	2: 8

*The items listed were selected, from cross-tabulations with occupation, as the appropriate ends of the distributions of relevant independent variables and nominal attributes. In the text, statistical significance relates to the χ^2 test on the full tables. Only significant comparisons are listed, out of over 100 tested. With three exceptions (urate, birthplace, and wheeze) the probability was for each item less than 0.01, and mostly less than 0.001. Some consequential associations with occupation (for example, weight and home ownership), though significant, have been omitted.

TABLE 4

Correlations of selected variables with other measurements, all males. (Only values of r = 0.10 or more are listed. At r = 0.10, P is <0.002).

Haematology	All males (993) r
Neutrophils:	
Smoking	0.23
FEV_1/VC	−0.12
Lymphocytes	−0.84
Monocytes	−0.21
Lymphocytes:	
Smoking	−0.21
FEV_1/VC	0.11
Grip	0.10
Neutrophils	−0.84
Monocytes	−0.14
Monocytes:	
Neutrophils	−0.21
Lymphocytes	−0.14
ESR:	
Smoking	0.11
Cholesterol	0.19
FVC/Predicted VC	−0.21
FEV_1/FVC	−0.18
Grip	−0.15
Haemoglobin	−0.30
Haematocrit	−0.26
Systolic blood pressure	0.13
GGT	0.11
Haemoglobin:	
Smoking	0.13
Cholesterol	0.10
FVC/Predicted VC	−0.17
Haemoglobin	0.14
Haematocrit	0.12
Mean skinfold	0.25
Systolic pressure	0.18
Diastolic pressure	0.23
Aspartate transferase	0.10
Creatinine:	
Weight	0.11
Mean skinfold	0.12
Diastolic pressure	0.11
GGT:	
Alcohol	0.13
Smoking	0.10
Cholesterol	0.13
Systolic pressure	0.12
ESR	0.11
Aspartate transferase	0.30

Physical measurements	All males (993) r
Mean skinfold:	
Cholesterol	0.26
Urate	0.25
FVC/Predicted VC	−0.23
Haemoglobin	0.14
Haematocrit	0.16
Systolic pressure	0.12
Diastolic pressure	0.30
FEV_1/FVC	0.13
Lymphocytes	0.10
Systolic pressure	−0.12
Diastolic pressure	−0.10
ESR	−0.15
Exercise outside work	0.11
Systolic pressure:	
Cholesterol	0.16
Urate	0.18
Stature	−0.16
FVC/Predicted VC	−0.20
FEV_1/FVC	−0.17
Grip	−0.12
Haemoglobin	0.10
Haematocrit	0.10
Mean skinfold	0.12
Diastolic pressure	0.69
ESR	0.13
GGT	0.12
Diastolic pressure:	
Cholesterol	0.24
Urate	0.23
FVC/Predicted VC	−0.16
FEV_1/FVC	−0.16
Grip	−0.10
Haemoglobin	0.18
Haematocrit	0.21
Mean skinfold	0.30
Systolic pressure	0.69
Exercise outside work	−0.14
Creatinine	0.11

Urate	0.14
Mean skinfold	0.14
Systolic pressure	0.10
Diastolic pressure	0.18
ESR	−0.30
Haematocrit:	
Smoking	0.16
Cholesterol	0.13
Urate	0.12
Mean skinfold	0.16
Systolic pressure	0.10
Diastolic pressure	0.21
ESR	−0.26
Exercise outside work	−0.10

Blood chemistry	All males (993) r
Cholesterol:	
Alcohol	0.10
Urate	0.16
Stature	−0.15
FEV_1/FVC	−0.12
Grip	−0.11
Haemoglobin	0.10
Haematocrit	0.13
Mean skinfold	0.26
Systolic pressure	0.16
Diastolic pressure	0.24
ESR	0.19
GGT	0.13
Urate:	
Alcohol	0.15
Cholesterol	0.16
Creatinine	0.12
Exercise outside work	−0.16
Stature:	
Cholesterol	−0.15
FVC/Predicted VC	0.11
Systolic pressure	−0.16
Exercise outside work	0.12
FVC/Predicted VC:	
Coffee	0.10
Smoking	−0.18
Uric acid	−0.17
Stature	0.11
FEV_1/FVC	0.15
Grip	0.26
Mean skinfold	−0.23
Systolic pressure	−0.20
Diastolic pressure	−0.16
ESR	−0.21
FEV_1/FVC:	
Tea	−0.11
Smoking	−0.20
Cholesterol	−0.12
FVC/Predicted VC	0.15
Grip	0.13
Neutrophils	0.12
Lymphocytes	0.11
Systolic pressure	−0.17
Diastolic pressure	0.16
ESR	−0.18
Exercise outside work	0.11
Grip:	
Cholesterol	−0.11
FVC/Predicted VC	0.26

Behavioural	All males (993) r
Extraversion:	
Alcohol	0.11
Instability	0.10
Exercise outside work	0.15
Instability:	
Extraversion	0.10
Exercise outside work:	
Smoking	−0.13
Haematocrit	−0.10
FEV_1/FVC	0.11
Grip	0.11
Mean skinfold	−0.16
Diastolic pressure	−0.14
Extraversion	0.15
Alcohol:	
Smoking	0.17
Cholesterol	0.10
Urate	0.15
Extraversion	0.11
GGT	0.13
Smoking:	
Alcohol	0.17
FVC/Predicted VC	−0.18
FEV_1/FVC	−0.20
Haemoglobin	0.13
Haematocrit	0.16
Neutrophils	0.23
Lymphocytes	−0.21
Exercise outside work	−0.13
ESR	0.11
GGT	0.10

others, such as electrolytes and extraversion the implication is not necessarily or less directly unfavourable or is not obvious. The differences between professionals and technicians are affected partly by age but not those between technicians and tradesmen.

The relationship of the administration group's findings to those of the other groups was much less consistent. In proportion of staff with high levels of some attributes the administration men clearly exceeded the others. Allowing for their smaller group size, they were generally more likely to have poor lung ventilation, high values of most blood chemistry variables and unfavourable habits. Such pre-eminence was not by any means entirely attributable to the older age distribution of the administration group; and in many attributes where clearly age affects values the group was not outstanding, whereas in others where age has no or little effect they had the highest proportion affected of any group.

Multivariate analysis is proceeding in order to dissect the relative contribution of and interactions between attributes inherent in the occupational differences. Simple product-moment correlation analysis revealed generally low order interactions (Table 4), omitting those to be strongly expected such as that between stature and grip or between systolic and diastolic blood pressure. In many cases age explains some of the association noted.

TABLE 5
Chronic fixed airways disease vs selected attributes, all subjects.

Attribute	All subjects % (1 141)	Fixed airways disease % (57)
Origin:		
Australia	68	58
United Kingdom	22	35
North Europe	6	5
Drug habit:		
3 + drinks daily	30	39
6 + cigarettes daily	22	54
Other drug taking	11	26
Physical findings:		
Stature 180 cm +	15	7
FVC/Predicted VC <70%	3	28
FEV_1/FVC <65%	4	45
Systolic pressure 140 mm +	28	54
Diastolic pressure 90 mm +	32	44
Skinfold 17 mm +	34	28
Blood findings:		
Leucocytes 7 000/mm^3 +	29	46
ESR 6 mm +	16	37
Bicarbonate 28 mmol/l +	35	44
Urate 7 mg +	19	32
GGT 35 +	10	28

The associations of the biological attributes subject of occupational differences with a partly environmentally determined disorder, chronic fixed airways disease, are shown in Table 5. Generally, the subjects with airways disease more often indulged in drinking, smoking and other drug habits; were shorter and thinner; had values towards the upper limits of normal in the distributions of blood pressure and certain blood variables; and ventilated as poorly as the diagnosis dictates.

DISCUSSION

The many and often marked occupational differences, consistent across a wide range of personal, social and biological attributes, and effectively grading the groups in a health sense, are likely to have been multifactorial in origin. The complex interrelationships between most of the attributes need further analysis, but already any contribution to the findings from the physico-chemical work environment seems to be minimal in view of the lack of association of the attributes with the many work items tested. This is not to deny that tradesmen, say, generally work in a dirtier ambience than professionals, which may have some effect undetected against the environmental background or by the method used. Nor did the method test the possible indirect contribution from psychosocial elements in the work, although it is likely that the climate and opportunity for indulgence in smoking and drinking varied across the occupational groups studied[5].

The proneness of certain occupations to death from work disease and injury has been long recognized, and quantitated perhaps first by William Farr in the nineteenth century. The often grossly inequitable distribution of mortality by social class (and thus occupational status), also recognized by Farr, regrettably still continues[11]. Even within broad occupational groups of similar social standing much variation in mortality occurs, for example between types of medical practitioner[3].

Similar occupational differences in mortality, and in morbidity from such disorders as hypertension, ischaemic heart disease, peptic ulcer and arthritis, have been demonstrated by Arnoldi and Mockbee between different occupations employed in the same organization[1]. As in the present study their professionals fared better than their technicians and administrators. Occupational differences in health experience have been shown also for such indices as sickness absence[6], though social and industrial influences cloud the issue here. However, a literature search revealed no comparable study of occupational variation in a range of biological variables, although there are many studies of groups exposed to particular risk, for example occupational lung disease or metal poisoning; of occupational variation in risk factors of coronary heart disease; and of occupational variation in social habits such as drinking and smoking. Similarly, bodies of data analysed by occupation and suitable for comparison have been difficult to find in Australia, except in respect of limited variables such as lung ventilation or factors associated with risk of hypertension.

The significance for health of the occupational variation in some biological variables tested is unclear. The implications of raised serum cholesterol, urate, glucose, creatinine and enzymes and red cell indices are not all clear but are less ambiguous than those in serum electrolytes and in white cells[14]. It is necessary to decide whether significant occupational differences represent reactions to work exposures, as suggested for haematocrit values in uranium miners[15], and whether they indicate merely physiological homeostatic or compensatory mechanisms or rather minor or major cell damage[18]. Occupational differences in some of the variables probably constitute response to a multiplicity of agents. The response is largely non-specific though it is possible in the group if not always in the individual to relate raised values to exposure history, and thus to be relatively assured of specificity in the particular case.

The values of variables in Table 2 were chosen from two-way tables with occupation to be towards the upper limit of "normal". In none of the interval or ratio items was the distribution in any way bimodal; there was no suggestion of discrete normal and abnormal populations. However, some skewness was generally observed, and a proportion of results, varying in amount with each variable, was found to be "abnormal" (by the standards of the autoanalyser used). This finding is not unexpected when the method of setting normal limits is considered, that is allowance has to be made for the normal (or statistical) abnormal[9].

However, despite rigorous assurance as to the accuracy of the analytical method, the numbers of abnormals went far beyond the statistical expectation for some variables. Many abnormals represented clearcut subclinical disease, for example ventilatory deficit combined with respiratory symptoms, and gross gamma glutamyl transpeptidase (GGT) elevation in heavy drinkers. The matter was less clear with creatinine values of 1.3 to 1.5 mg % where a search of individual files revealed almost no relevant, even subclinical, disease pattern. The range of normal in these biological variables seems greater than the generally stated standards[2], whose use should therefore be questioned in occupational medicine and occupational epidemiology. The limits of normality derived from more general populations may not be representative of those of particular occupational groups, for which special standards may be necessary.

Smoking showed expected diverse (if low) correlations with other items. Alcohol did not to the expected extent correlate with systolic pressure (0.07), skinfold (0.08), aspartate transferase (0.05), haemoglobin (0.05) or ventilatory function[12], though the strength and number of associations were increased by restriction of testing to regular older drinkers, as in the study by Whitehead and co-workers[17]. The occurrence of high values of GGT (9% $>$ 50 in subjects aged 40 and older) in the present study suggests much subclinical hepatic toxicity. The predictive association of raised serum enzyme, urate and red cell volume with drinking noted by Whitehead and co-workers was thus only partly realized. The correlations noted for urate and skinfold tend to support Jeremy and Towson's[10] contention of a common occupational link through weight.

Of the environmental variables tested, and excluding consequential associations of social attributes such as marital state (e.g. with ventilatory function[13]) and housing, only smoking, drinking and low physical exercise outside work showed much correlation with the biological variables most subject of occupational variation. Certainly the work influences studied such as regular exposure to particular hazardous substances did not correlate with these biological findings.

Blood pressure elevation and ventilatory deficit both were common and commonly linked with occupation, and both showed correlations with other variables studied. Both occurred frequently in the range of measurements between upper limit of normality and frank disease. The tradesmen's greater physical exercise at work was no protection to them whereas exercise outside work was favourably linked with these two variables in the professional group. The English (chronic obstructive airways) disease was still manifest in men who mostly had migrated to Australia many years before.

On the evidence at this stage of analysis, life style associated with occupation and its social level was more important than the physico-chemical nature of the work in inducing biological differences between occupational groups that were not created by personal or personnel selection for the job. The psychosocial nature of the work environment may be responsible for mental and physical disturbances, and for occupational differences in indulgence in harmful habits[7], and is currently subject of investigation in relation to occupational differences in risk of coronary heart disease and hypertension[8]. Further study is needed on the health significance of asymptomatic raised values of biological variables[16].

There is in any case a need to determine the unique biological characteristics of particular work populations before the effects of physico-chemical and mental work stress on health are measured, else any findings are confounded. For prevention of disease, greater understanding is needed also of compensatory and subclinical effects of different types of work on the levels of biological variables. It may be possible, as with raised levels of GGT in workers whose drinking habits are accepted as "normal"[17], to use biological values predictively, particularly if changes in combinations of variables can be identified in relation to particular occupations or exposures.

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