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The epidemiology of the common cold. I

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INTRODUCTION

This paper is the first of a series describing a 6-year study of the common cold among office workers undertaken with the aim of tracing, by epidemiological methods, the modes of spread of the common cold through the population. We hoped to be able to estimate the proportion of colds acquired within the working environment and hence to assess the effect of protective measures applied to this environment. A number of such methods, viz. two chemical air disinfectants, ultra-violet irradiation of the upper air, and increased ventilation were studied.

In this paper we describe the offices in which these studies were carried out and the methods that we used. We then present an analysis of the nature and frequency of the colds suffered by the staff and their families in relation to such factors as age, sex and family size.

In subsequent papers we shall analyse cross-infection within the office and the family, present some epidemiological evidence of immunity to the disease, and report on the trials of the environmental preventive measures. We hope also to present the results of an analysis of the relationship between weather and the incidence of the common cold.

MATERIALS AND METHODS

Description of the offices

During the investigation four different groups of offices were observed. Three were in the London area and one in Newcastle upon Tyne, near to the east coast and about 300 miles north of London.

The Newcastle offices were studied over the whole 6 years of the investigation, i.e. from September 1951 to May 1957. These offices, which form the central executive office of the Ministry of Pensions and National Insurance, consist of a considerable number of single-storey buildings arranged as lateral spurs branching off long corridors. Most of the rooms are about 72 ft. long by 36 ft. wide and average 10 ft. high and housed about forty persons, but there are also a number of rooms double this size or half of it, with proportionate numbers of occupants.

From six to ten rooms with between 350 and 500 persons were included in our study each winter.

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During the 3 years from September 1951 to May 1954 observations were made in some offices of Shell Petroleum Company in Central London. The individual rooms housed up to 400 people in a single open space about 200 ft. each way and about 12 ft. high. The only subdivisions were formed by groups of filing cabinets which did not reach more than about 4 ft. above the floor. Two or three of these rooms were included each winter with a study population of between 600 and 1100 persons.

In the following winter, 1954–55, records were kept in two small government offices, one at Stanmore in the north-west suburbs of London and one at Hinchley Wood in the south-west suburbs. The rooms in these offices were of various sizes housing between seven and fifty people each. The number of persons included were about 250 and 120, respectively.

Method of collecting the records

We invited all the members of the staff working in the chosen set of rooms to collaborate in the study and in almost all cases this invitation was given in a personal talk by one of us. The percentage of staff unwilling to collaborate was about 3 % on average and never reached more than 10 %. A personal record form was filled in by each volunteer at the start of each year, giving details such as age, home address, mode of travel to work, family, etc.

The incidence of colds was recorded by nurses from the staff of our laboratory who paid a personal visit to each member of the staff each week and asked for a history of any cold or other respiratory illness during the past week; from any who replied affirmatively she gathered further details of symptoms, day of onset, etc. She also recorded absence from work due to factors other than the common cold.

At Newcastle we also invited the families of a number of the members of the office staff to collaborate. These families had to be chosen from those living within a reasonable distance of the office and in general we chose a larger proportion of those with children in the family than of those without, since we were interested in the part played by the school child in spreading infection. The families were visited in exactly the same way as the office staff by the same nurses and information on the colds suffered by members of the household was obtained from the housewife. The family study did not commence fully until Christmas 1953 and we have full records only for the three winters 1954–55 to 1956–57.

During most of the investigation at Newcastle and part of the investigation at Shell, members of the scientific staff of the laboratory paid regular visits to the offices for bacterial air sampling or for testing the ventilation, air disinfectant concentration, etc.

In each year the study ran from the end of August to the end of May; we collected no records during the summer months.

There were always transfers of staff from one room to another, and as we limited our investigation to the staff in the chosen rooms, there were each year a number of people who were observed for less than the whole winter. For many of the analyses presented in this paper we have used the data only from people in the office

throughout the winter, the criterion being that they were not absent for more than 4 weeks.

The results of the various environmental treatments will be discussed in detail in a subsequent paper but, since there was no demonstrable effect due to any of them, records from both treated and untreated rooms have been combined for the epidemiological analysis.

It is appropriate at this point to express our gratitude to the members of the office staff who collaborated with us so fully throughout the years of our investigations.

RESULTS

Diagnosis and symptoms

In this investigation we have been concerned to study the affection generally described as the 'common cold'. This is a symptomatic diagnosis which we were not able to control by laboratory tests, so that it would seem desirable first to examine the symptoms of the colds reported to the nurses who collected the

Table 1. *The distribution of various combinations of symptoms, the duration of symptoms and associated absence from work*

Combination of symptoms	Relative frequency (%)	Median duration of symptoms (days)	% leading to absence from work	Average duration of absence in those absent (days)
a. Running nose and/or sneezing with neither sore throat, cough nor fever	38·2	6·3	5·6	2·6
b. Running nose and/or sneezing with cough but without sore throat or fever	13·9	9·7	12·9	2·2
c. Running nose and/or sneezing with sore throat and cough but without fever	15·1	10·6	12·3	2·6
d. Running nose and/or sneezing with sore throat but neither cough nor fever	29·1	7·0	11·6	2·6
e. Any combination of symptoms which include fever	2·6	10·0	43·0	4·0
f. Any other combination	1·1	7·0	(0)	—
All together	100	8·1	10·3	2·6

This Table is derived from the records of 1398 colds reported in the Newcastle offices over the three years 1951–54, involving 701 person-years.

records. Seven symptoms were reported with approximately the following frequency: sore throat in 50 %, running nose in 90 %, sneezing in 90 %, cough in 40 %, headache in 30 %, malaise in 15 % and fever in only 5 %. In addition some other symptom was recorded in nearly 40 % of colds. Examination of the records suggested that six combinations of symptoms might be usefully examined to see

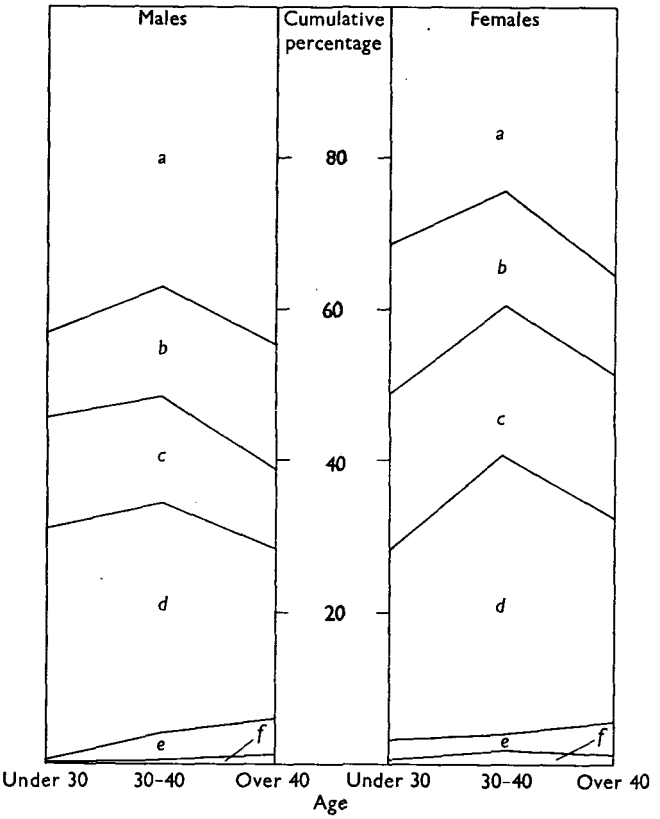

Fig. 1. The relative frequency of the occurrence of various combinations of symptoms according to age and sex. *a*. Running nose and/or sneezing with neither sore throat, cough nor fever. *b*. Running nose and/or sneezing with cough but without sore throat or fever. *c*. Running nose and/or sneezing with sore throat and cough but without fever. *d*. Running nose and/or sneezing with sore throat but neither cough nor fever. *e*. Any combination of symptoms which include fever. *f*. Any combination of symptoms not included in the above.

Table 2. *Duration of colds and associated absence, by month*

Month	Median duration of symptoms (days)	% leading to absence from work	Average duration of absence in those absent (days)
September	6·2	9·8	1·8
October	8·5	13·7	2·9
November	6·9	9·2	2·5
December	7·8	8·7	2·7
January	9·2	13·3	3·2
Feburuary	8·9	9·5	2·7
March	8·9	11·4	2·1
April	9·4	6·7	2·2
May	5·8	5·0	2·5

This Table is based on the same data as Table 1.

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how far each behaved as a separate entity, i.e. whether the colds recorded could be consistently divided into groups on diagnostic criteria. Table 1 and Figs. 1 and 2 show the relative frequency of these different combinations both overall and with respect to age, sex and season of the year. Table 1 together with Tables 2 and 3 also show the median duration of symptoms, the fraction of colds causing absence

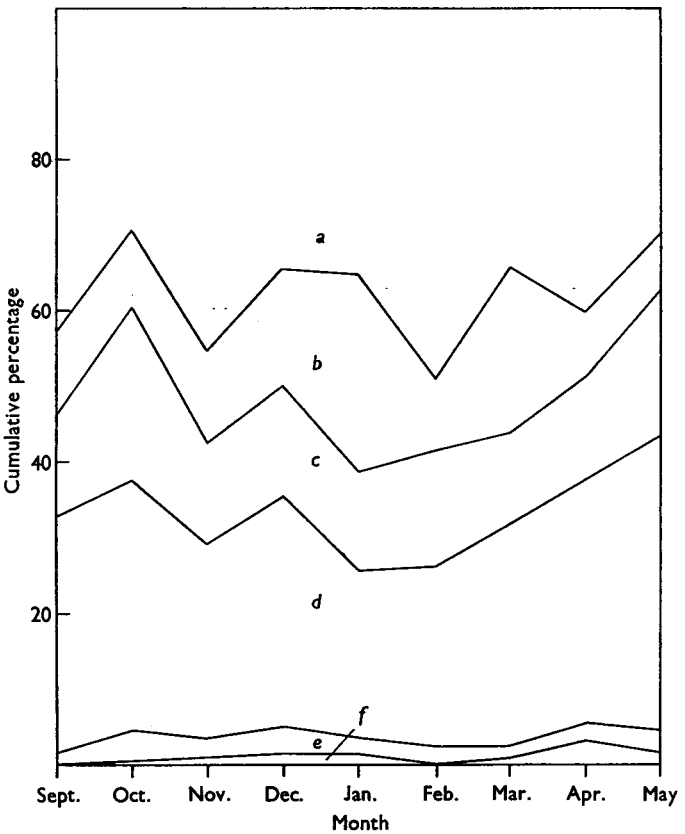

Fig. 2. The relative frequency of the occurrence of various combinations of symptoms according to the time of year. The combination of symptoms are the same as those given in Fig. 1 and Table 1.

Table 3. *Duration of colds and associated absence, by age and sex*

Age	Sex	Median duration of symptoms (days)	% leading to absence from work	Average duration of absence in those absent (days)
Under 30	Male	7·7	8·5	3·0
	Female	8·1	9·2	2·8
Between 30 and 40	Male	8·1	9·1	2·0
	Female	8·8	10·9	3·3
Over 40	Male	8·6	12·3	2·4
	Female	7·0	17·4	2·7

This Table is based on the same data as Tables 1 and 2.

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and the average duration of absence from work as a result of the cold. Fig. 3 shows the distribution of duration of symptoms and of absence from work due to a cold. A single year of the family experience (1956–57) has also been analysed to see how far the symptom combinations might differ in respect of their ability to produce secondary cross-infection when introduced into the family and how far these secondary cases showed a similar combination of symptoms to the introducing case. The results of this analysis are given in Table 4.

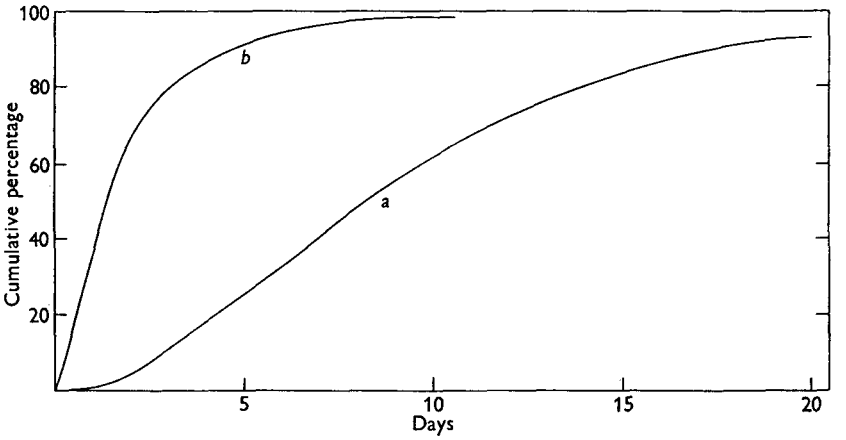

Fig. 3. The duration of symptoms and absence from work. Curve *a*, duration of symptoms. Curve *b*, duration of absence in those absent from work on account of a cold.

Table 4. *Infectivity of various symptom combinations and persistence of type*

Combination of symptoms for introducing case	No. of introductions	No. leading to secondary cases	Expected no.
a	91	29	30·7
b	78	32	26·3
c	38	11	12·8
d	44	13	14·8
e	30	10	11·5
f	4	1	
All together	285	96	

$\Sigma\chi^2 = 1{\cdot}82$ on 4 degrees of freedom, whence $P \simeq 0{\cdot}7$.

Total number of secondary cases	127
Number showing identical symptom combination to the introducing case	42
Expected number showing identical symptom combination	30

$$\chi^2 = \frac{12^2 \times 127}{30 \times 97} = 16{\cdot}3 \text{ for 1 degree of freedom, whence } P \simeq 0{\cdot}01$$

The combinations of symptom are the same as those given in Table 1. This table is based on the experience of 191 individuals in 49 households during the year 1956–57.

The expected numbers are calculated on the assumption of a random distribution of secondary cases.

The method of assessing introducing and secondary cases is described in the second paper of this series.

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Seasonal variation in the numbers of colds reported

The overall seasonal distribution and the way in which this is built up of 1st, 2nd, 3rd, etc., colds in the given season is given for the Newcastle data in Fig. 4. The London data are generally similar but the early autumn peak is more pronounced and rises above the highest mid-winter levels.

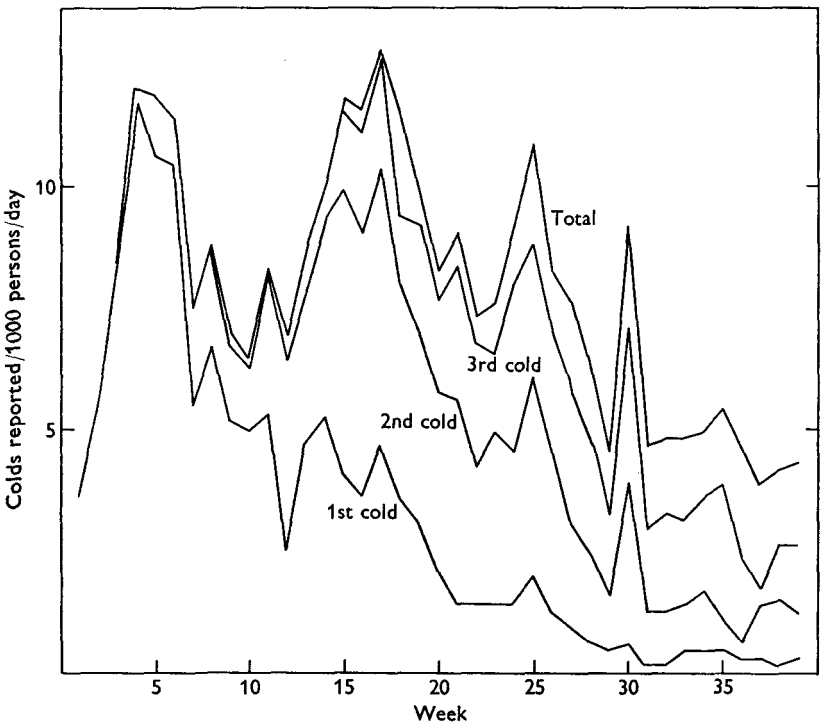

Fig. 4. Seasonal distribution of incidence of colds. The data are derived from the records of the Newcastle offices over the four 40-week periods 1952–53, 1953–54, 1955–56, 1956–57.

Frequency of colds in relation to various factors

Where any particular quantity, in this case the number of colds experienced by an individual in a year, may be dependent on a large number of factors which are themselves highly intercorrelated, the most convenient form of analysis is a multiregression analysis based on a simple linear regression equation (Lidwell, 1961). The form of equation which we have used is

$$Y = A + b_1 x_1 + b_2 x_2 + \ldots,$$

where Y = the number of colds, A, b_1, b_2, etc., are constants and x_1 and x_2, etc., are parameters which take the values 1 or 0 according as the factors 1, 2, 3, etc., are present or absent in the case of the individual concerned in that year. The results of an analysis carried out in this way are given in Table 5 for the data collected in the offices and in Table 7 for the data collected from the families at Newcastle. The office data were also examined for the possibility of interaction

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between the factors of age, sex and household type. No evidence of any interactions was found. Nor could evidence be found of any differences in frequency of colds experienced associated with residence in any of seven different areas of Newcastle and the surrounding districts.

Table 5. *The effect of various factors on the number of colds experienced by members of the office staffs*

Coefficients, $b_1 b_2 b_3$, etc., of the regression equation $Y = A + b_1 x_1 + b_2 x_2 + \ldots$, where Y is the number of colds experienced in a year (40 weeks).

Factor	Person-years	Newcastle (6 yr.) 1311	London (3 yr.) 2218	All data 3765
1. Sex	Female	0·173 (0·088)	**0·252** (0·085)	**0·279** (0·058)
2. Age	Under 20	**0·575** (0·181)	**0·427** (0·120)	**0·431** (0·095)
3.	21–30	**0·245** (0·097)	**0·360** (0·082)	**0·321** (0·060)
4.	Over 40	**−0·523** (0·087)	**−0·265** (0·085)	**−0·358** (0·059)
5. Household	With infant	−0·086 (0·124)	0·069 (0·101)	−0·006 (0·076)
6.	With schoolchild	0·171 (0·092)	0·162 (0·077)	**0·181** (0·057)
7.	With infant and schoolchild	−0·179 (0·151)	**0·302** (0·121)	0·151 (0·092)
8.	Hostel	0·313 (0·210)	**−0·422** (0·202)	−0·088 (0·141)
9. Transport	Private	−0·080 (0·080)	**0·551** (0·155)	0·096 (0·067)

The constant A varies according to year and place from about 1·5 to 2·2 with a mean value of 2·00. Coefficients which exceed twice their standard error are in bold figures. The predicted number of colds for any individual is obtained by substituting the appropriate values in the regression equation. The parameter x_1 takes the value 0 for males and 1 for females, x_2 takes the value 1 for age 20 or under and 0 for any other age, x_3 takes the value 1 for age 21 to 30 and 0 for any other age, x_4 takes the value 1 for age over 40 and 0 for any other age, x_5 takes the value 1 for individuals living in households with infants under school age but without schoolchildren and 0 for any other type of household, x_6 takes the value 1 for households including schoolchildren but not infants and 0 for any other type of household, x_7 takes the value 1 for households including both infants and schoolchildren and 0 for any other type of household, x_8 takes the value 1 for those individuals living in hostel and 0 for all others, x_9 takes the value 1 for those who did not use public transport to get to work and 0 for all others. The standard errors of the coefficients are given in brackets after each value.

Table 6. *Partition of variance for the number of colds experienced by an individual in one year* (40 *weeks*)

	Newcastle	London	Together
Mean number of colds per year	2·00	2·22	2·13
Mean variance about this mean	1·81	2·11	2·00
Residual mean variance on regression (year differences are included in the regression)	1·66	1·88	1·78
Absorbed by factors correlated (see Table 5)	0·15	0·23	0·22
*Mean variance between same individuals in different years	1·21	1·43	1·34
Absorbed by individual characters other than those correlated	0·45	0·45	0·44

* $1/2N\,\Sigma\,(y_1 - y_2)^2 - \frac{1}{2}a^2$, where y_1 and y_2 are the number of colds experienced by an individual in any pair of years, N is the number of individuals for whom the summation is made and a is the mean difference between the number of colds experienced by an individual in the 2 years.

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In order to see how far individual characters, other than the recorded factors of age, sex and environment, might be responsible for the differing experience of the various individuals, an analysis was made of the variance in the number of colds experienced by the same individual in two different years. This variance is compared with the gross variance and the residual variance on the regression, in Table 6.

Table 7. *The effect of various factors on the number of colds experienced by members of the families of the Newcastle office staff*

Coefficients, $b_1 b_2 b_3$, etc, of the regression equation

$$Y = A + b_1 x_1 + b_2 x_2 + \ldots,$$

where Y is the number of colds experienced by an individual in a year (40 weeks).

	Factor		Adults excluding non-working wives and mothers	Non-working wives and mothers	School-children	Infants
		Person-years ...	223	131	152	58
		A	2·22 (0·30)	1·14 (0·48)	2·37 (0·27)	4·18 (0·47)
1.	Sex	Female	0·30 (0·28)	—	0·29 (0·32)	0·52 (0·50)
2.	Age	Under 20	0·15 (0·37)	—	—	—
3.		21–30	**1·28** (0·28)	**1·04** (0·47)	—	—
4.		Over 40	−0·30 (0·20)	0·20 (0·30)	—	—
5.	Household	With infant	−0·12 (0·34)	**0·97** (0·52)	—	—
6.		With schoolchild	−0·01 (0·24)	**0·87** (0·39)	—	—
7.		With infant and schoolchild	−0·34 (0·34)	**0·90** (0·49)	**0·90** (0·28)	−0·44 (0·52)
8.	Work	M.N.I. *not* in office survey	−0·18 (0·20)	—	—	—
9.		Other work	**−0·60** (0·28)	—	—	—
10.		At home	−0·36 (0·35)	—	—	—

Coefficients at or about twice their standard error or more are in bold figures.

The effect of family size was explored but this was not consistent and, overall, only small.

The predicted number of colds for any individual is obtained by substituting the appropriate values in the regression equation. Parameters x_1, x_2, x_3, x_4, x_5, x_6, and x_7 have the same significance as in Table 5, x_8 takes the value 1 for those working in the Newcastle offices but not included in the office survey and 0 for all others, x_9 takes the value 1 for those going out to work but not in the Newcastle offices and 0 for all others, x_{10} takes the value 1 for those not going out to work and 0 for all others.

A further point with reference to the statistics exhibited in Tables 5 and 7 may conveniently be referred to here since it is not apparent from the tables as presented. Those members of the office staff who took part in the family survey have, when account is taken of the factors included in the regression, including the year of observation, a consistently lower experience of colds than the other members of the staff. The deficit is of the order of 12% and is statistically significant, from which we must draw the inference that these individuals are not entirely representative of the office staff as a whole, although the discrepancy is unlikely to have any serious consequence in the subsequent evaluation.

DISCUSSION

The data on the nature and duration of the symptoms and the distribution of the several symptom combinations presented in Tables 1–4 and Figs. 1 and 2 do not in any way suggest that a useful subdivision of cases is possible on the basis of symptomatic criteria. The data on cross-infection within the family given in Table 4 are particularly relevant here. The number of secondary cases showing an identical symptom pattern to the initial case is indeed significantly greater than that to be expected on a purely random basis, but the overall magnitude of this excess, one-third of secondaries identical instead of the one-quarter expected, is only small and no more than might reasonably be expected from constitutional similarities among members of the same family and the tendency of individual informants to emphasize particular symptoms.

The number of persons with colds who reported fever was always small, but varied considerably from year to year and probably reflects the incidence of less frequent but more severe conditions including mild influenza, etc. 'Colds with fever' also, as would be expected, were more often associated with absence from work and this absence was of longer duration than that associated with non-febrile colds.

The overall percentage of colds leading to absence from work was about 10% and the average duration of absence was 2·6 days. Since the average number of colds per year was just over two this resulted in about 60 days absence per year per 100 persons due to colds. The percentage of colds causing absence rose appreciably with increasing age but there was no indication of increased duration of absence or of symptoms. Notably, and in contrast to common impression, female staff had only a moderately greater proportion of colds which led to absence than male staff, and the difference was only significant in the oldest age group. There was little, if any, difference between men and women in the duration of symptoms or the duration of absence, when this was due to a cold.

When we come to consider the influence of the various factors examined on the frequency of colds experienced by different individuals (Tables 5 and 7) it is clear that, unlike an earlier investigation carried out in rural environment (Lidwell & Sommerville, 1951), the presence of schoolchildren in the household led to hardly any excess in the number of colds experienced, except in the case of mothers who did not go out to work. The effect of the use of public transport was small and equivocal. Only a very small number of the staff in the London offices did not use public transport so that no weight can be attached to the apparent disadvantage to them of relying on private means of transport.

Age is the factor which exerts the strongest influence on the incidence of colds; the gradient is consistent all the way from the pre-school infant to the over-40 age group. This trend is, of course, consistent with many previous observations. The difference associated with sex, while consistent, is not large, and amounts to a 10–15% higher incidence among females at all ages.

The partition of variance given in Table 6 shows several features of interest. The gross variance is slightly below that of a Poisson distribution. The factors

correlated reduce this by just over 10 % and other individual characters, which will include constitutional differences as well as environmental factors not included in the analysis, account for about twice as much. The final residual variance, i.e. the variance between the number of colds experienced by an individual in different years, is thus only two-thirds of that appropriate to a Poisson type variable. This would indicate that the colds do not occur in a random time series. Such a reduction in variance would be the result of any effect which limited the number of colds which could be experienced in one season. Our recording process, which did not allow for a cold to be recorded until after the symptoms of any preceding cold had disappeared, itself introduced such an effect but of insufficient magnitude to account for the observed figures. Any appreciable period of effective immunity to the infection following a cold would operate in a similar way and this appears to be the likely explanation of the value of the residual variance found. This point is discussed further in the second paper in this series.

SUMMARY

The number and some characteristics of the colds experienced by office workers in London and Newcastle upon Tyne are described.

Age was the only factor found to be strongly associated with the number of colds experienced by an individual. Female staff suffered only 10–15 % more colds than male staff. The presence of children in the household had little or no effect. The daily use of public transport also appears to be unrelated to the number of colds suffered.

We are grateful to the Ministry of Pensions and National Insurance for affording us the facilities necessary for the carrying out of this investigation, and particularly to the staffs of the offices who collaborated with us in providing the records and to the members of the Establishment Department and to the staff representatives for their help in the organization of the study. We are also indebted to the Medical Department of the Ministry for their interest and advice. We also wish to record our gratitude to the Shell Petroleum Company, its officers and staff, and particularly the chief medical officer, for their assistance and collaboration, to the management and staffs of the two other London offices studied and to the nurses, Mrs E. Hodgson, Miss M. Petts, Miss L. Waddell and Mrs E. A. Wilson, who collected the records.

REFERENCES

LIDWELL, O. M. (1961). *J. Hyg., Camb.*, **59**, 259.
LIDWELL, O. M. & SOMMERVILLE, T. (1951). *J. Hyg., Camb.*, **49**, 365.