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The Incidence of the Common Cold in Relation to Certain Meteorological Parameters

by

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INTRODUCTION

The influence of various meteorological parameters on the incidence of the common cold has not received the attention it deserves. This infection is by far the most common condition which is experienced by the individual. Furthermore, the 'cold' and the sequelae therefrom, are the most frequent reasons for seeking advice and treatment from the general medical practitioner.

Literature on the epidemiology of the common cold includes very few family studies of subjects in their home environment. Van Loghem (1928) in The Netherlands found that colds increased and decreased synchronously throughout that country and that the periods of increase and decrease coincided with decrease and increase of temperature respectively. Large and small families in his study had similar cold incidence suggesting low contact rate. On the other hand Lidwell and Sommerville (1951) investigating the incidence of colds in a small Wiltshire village concluded that school children played a major role in the introduction of colds into the household.

Hope-Simpson (1958) in a further family study identified a close relationship between 'cold' incidence and mean monthly 30 cm earth temperature. Tyrell (1965) at the Cold Research Unit, Salisbury, Wiltshire, working with comparatively small numbers of adult volunteers, found that the percentage of colds occurring after nasal inoculation varied only slightly with the season of the year. He recorded 52% April to September and 41% January to March. Andrewes (1951) and Jackson et al (1960) found that chilling volunteers after nasal inoculation with virus, gave the same incidence of colds as controls who had been maintained in comfort.

The effect of relative humidity seems to be doubtful but Hope-Simpson (1958) considered the low levels attained in heated rooms in winter played a significant part in cold morbidity.

There seemed therefore to be a need for further investigation into the natural morbidity of the common cold in relation to weather and so bring to a finer point the long held conclusion that cold weather induced more colds. This field study was undertaken with this object in view.

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METHODS

COMMON COLD DATA

The village of Wingerworth (population 3, 000) is a dormitory area 5 km south of the industrial town of Chesterfield (population 60, 000) in Derbyshire, and 21 km south of Sheffield. Patients of the medical author (I.R.D.P.) were selected, and numbered 758 from 195 families. The age of the sample ranged from a few months to 50 years and were mostly from socio-economic group III. The criterion for selection was that families were those most likely to make accurate returns. This was more important in the study than random sampling. The investigation extended from 1 October 1970 to 30 September 1971 and all dates shown on the figures relate to this period.

All families were visited and instructed on the compilation of the form (Fig. 1).

INVESTIGATION: INCIDENCE OF COMMON COLD AND METEOROLOGICAL CONDITIONS

NAME SMITH

CHRISTIAN NAME(S) William John

ADDRESS 16 Central Avenue
Wingerworth, Chesterfield,
Derbyshire

AGE (If under 16 yrs) ____ years

PRIMARY SCHOOL HUNLOKE / DEER PARK

(If at either of these Schools please delete one NOT applicable)

Please use ONE sheet for EACH Quarter (i.e. October to December, January to March etc.) and DELETE those months NOT applicable.

OCTOBER / ~~JANUARY / APRIL / JULY~~

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Midnight to 6 a.m.																															
6 a.m. to 12 noon										X	X	X	X	X																	
12 noon to 6 p.m.																											X	X	X	X	X
6 p.m. to Midnight																															

NOVEMBER / ~~FEBRUARY / MAY / AUGUST~~

DATE	1	2	~~3~~	~~4~~	~~5~~	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Midnight to 6 a.m.								X																							
6 a.m. to 12 noon																												X	X	X	
12 noon to 6 p.m.	X																				X	X	X	X	X	X					
6 p.m. to Midnight																															

DECEMBER / ~~MARCH / JUNE / SEPTEMBER~~

NOTES

1. Please put an 'x' in the square indicating the exact time of onset of the cold, and continue the 'x's (only ONE for each day) along the line you have started, until the nose stops running.
2. If you are away from Wingerworth for more than twenty four hours would you please draw a line through the dates when you are absent. For example: 1 2 ~~3 4 5~~ 6 7 8. This is useful as we will know the exact size of the 'sample' but please carry on recording 'X' should you have symptoms, - although you are away.
3. Please let us know if you are in any doubt as to how to record any particular symptom. Everyone will receive a personal visit when any queries may be raised.
4. Please return the used sheet on the 1st of the month following the end of the Quarter, i.e. 1st January 1971, 1st April 1971, etc.
5. Thank you once again for your help.

I.R.D. Proctor, Belfit House, Wingerworth.

Fig. 1. Example of 'Cold' Return Form.

Each form covered one quarter of the year and comprised three one-month grids in which each day was divided into 6-hr periods, 00:00 to 06:00 hr etc. It was felt this 6-hr breakdown would encourage accurate recording, in addition to allowing comparable alignment with 6-hr meteorological observations.

When visited, the head of the household was advised of the symptoms to be observed and it was stressed that an "X" be placed in the box corresponding to the six hourly period during which the first cold symptoms occurred. The occurrence of an attack of afebrile rhinorrhoea (a running nose without a fever) was the only condition required to be recorded. This specifically eliminated tonsillitis (sore throat and pyrexia) and influenza (acute febrile upper respiratory tract infection); these being the other most common upper respiratory tract infections liable to be confused with the common cold. Therefore it was anticipated that infections by rhinovirus would account for the majority of recorded episodes of illness.

METEOROLOGICAL DATA

All meteorological data was collected from a climatological station maintained and situated in Wingerworth by the meteorological author (D.S.B.F.). The station is fully instrumented, including barograph, thermograph and hygrograph. Summaries of the observations are reproduced in the Monthly Weather Report of the Meteorological Office. Wingerworth lies at a height of about 100 m with moorland rising to 400 m to the West; making valley conditions a major climatic consideration. By virtue of its situation in the Midlands, the climate is less prone to maritime influences.

ANALYSIS OF COLD DATA

Colds recorded, varied in duration from 1 day which could represent an abortive cold or a short period of allergic rhinitis, up to 34 days.

These long periods of rhinorrhoea were recorded by subjects of known allergic or catarrhal tendency. The average duration of colds, excluding single days and colds over 14 days was 5.7 days. Returns were carefully marked up and no 'spoiled' papers were received. Inevitably the number of returns diminished with each succeeding quarter. With appropriate correction for this factor, the mean colds per person per year was 2.7. The total number of colds recorded was 1683 (Table 1).

TABLE 1. Numerical return of colds - 1 October 1970 to 30 September 1971

Period etc.	Autumn quarter			Winter quarter			Spring quarter			Summer quarter			Year	
	October	November	December	January	February	March	April	May	June	July	August	September	Annual total	% of total
00:00 to 05:59 hr	76	50	58	36	36	51	15	24	21	7	4	30	408	24
06:00 to 11:59 hr	73	53	112	42	68	82	32	56	32	9	5	36	600	36
12:00 to 17:59 hr	38	36	68	47	42	43	13	26	19	2	4	29	367	22
18:00 to 23:59 hr	59	37	45	23	33	36	10	19	19	3	2	22	308	18
Monthly totals	246	176	283	148	179	212	70	125	91	21	15	117	1683	100
Colds as rate per thousand	324	232	374	224	272	321	147	263	191	46	33	256	2673	-
Quarterly correction factor		0			1.2			1.6			1.7		Mean colds	
Quarter: Family population		195			166			130			122		were 2.7	
Patient population		758			659			475			458		per person	
Total colds		707			542			283			151		per annum.	
Colds per thousand		930			827			601			335			

RESULTS

The 6-hr analysis showed that 58% of the colds commenced in the two periods, 06:00 to 18:00 hr when subjects could be expected to be outside at some time, whereas 42% occurred during the evening and night periods, 1800 to 06:00 hr. Colds first noted in the daytime in April and July, both months of quiescent weather, showed a marked reduction. Colds commencing at weekends (Saturday or Sunday) were no greater in number than might be expected by selecting any other two random days of the week.

FIRST COLDS IN THE FAMILY

The total colds for the period October to December were plotted against the first cold starting in each family (Fig. 2). This method eliminated all colds occurring in the family for the seven days following the onset of the first cold. Thus it could be reasonably assumed that contact colds within the family were ignored.

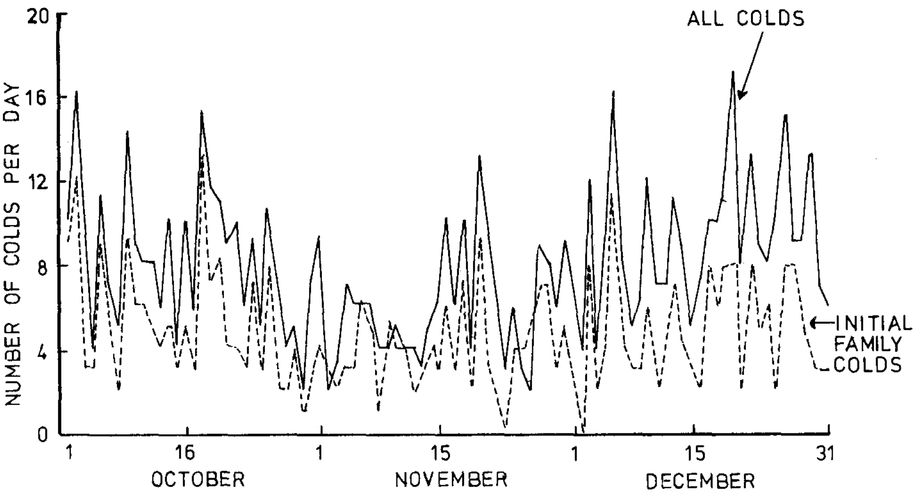

Fig. 2. Total daily colds and initial family colds.

The two graphs corresponded well with only 8% of the total records being at variance. It can be concluded therefore that regardless of the time of inoculation with virus, onset symptoms occur under the influence of an external factor, the most likely being weather, the sole universal variable.

WEEKLY COLDS AND SCHOOL TERMS

The curve of weekly total colds showed the customary autumn peak in September and spring peak in March, with winter peaks in December and February (Fig. 3). May which was sunny but changeable also showed a high cold incidence. The school terms are shown to have a marked effect on morbidity. The beginning of each term coincides with a sharp increase. Even the ten day mid-summer term holiday aborts a rise in colds which is immediately resumed on return to school.

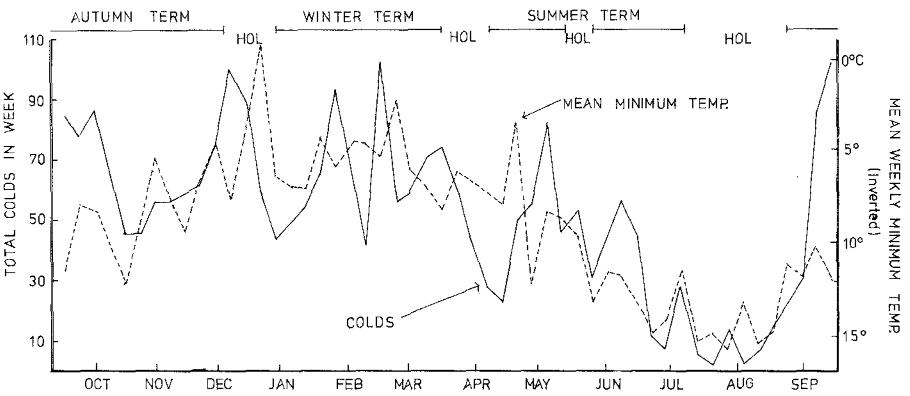

Fig. 3. Total weekly colds in relation to mean weekly minimum temperature and school terms.

It can be concluded that the epidemiology of the common cold is sensitive to the dates of school terms. The close crowding of school children in what to many of them constitutes a stress situation, promotes the occurrence of many infections.

WEEKLY COLDS AND METEOROLOGICAL PARAMETERS

Looking at the weekly weather and the high levels of cold incidence, the consistent factors were the occurrence of either cooler weather or a fluctuating temperature pattern. Conversely the weeks of low cold incidence were characterised by either warmer weather or a steady temperature pattern, typical of quiescent weather.

The graph of weekly colds and mean minimum temperature (Fig. 3) shows an excellent correlation except for one week in February, which happened to be a week of steady temperature; April, coinciding with the school Easter holiday and a month of steady weather; and September when the school autumn term commenced. Mean minima were lower at Wingerworth than in adjacent areas. This is due to the 'valley' conditions previously mentioned, but there is agreement in fluctuations at nearby stations.

Mean minimum temperature gave a better relationship than the 30-cm earth temperature. The 30-cm earth temperature was the component found by Hope-Simpson (1958) to be the most acceptable.

MONTHLY COLDS AND MONTHLY METEOROLOGICAL DATA

Here the monthly colds (rate per thousand) were plotted against monthly mean minimum temperature and monthly hours of dry air (relative humidity below 60%), (Fig. 4). The mean minimum curve is convincing except in January when the weather was cold at first, then mild and finally steady; and April, when the temperature was slowly and consistently rising. In both these months school holidays contributed to the depression of cold levels. Dry air is uncommon from November to February but the curve relates well for spring and early summer.

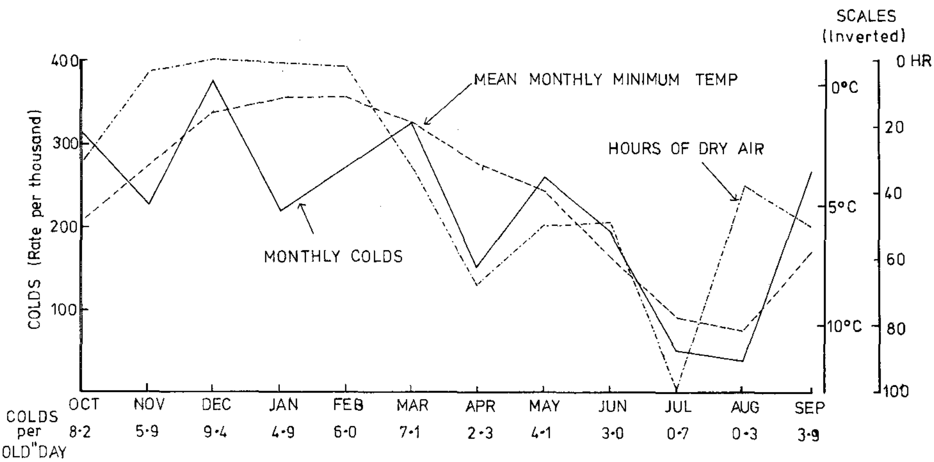

Fig. 4. Monthly colds (rate per thousand) in relation to mean monthly minimum temperature and total hours of dry air (rh < 60%).

It is worthwhile to note here that a dull and wet August was not accompanied by an increase in colds.

DAILY COLDS AND DAILY METEOROLOGICAL PARAMETERS

After experiment, it was decided to use three day running cold totals in order to smooth out the minor cold oscillations and to allow for the delay of cold onset. These were then plotted against actual minimum daily temperatures and equivalent effective temperature. In this instance the equivalent effective temperature was the mean air temperature corrected for mean wind speed. There was good correlation in 'blocks' for both temperature interpretations. Spells of cold weather tended to produce high cold levels and the converse is well illustrated in October and May. The springtime trend to warmer weather parallels the trend to fewer colds. Sudden warming can be seen to coincide with an increase of colds in May and at other times, e.g. late November, mid December and early February.

RELATIVE HUMIDITY

Attempts were made to relate daily cold variation to both 09:00 hr relative humidity and lowest relative humidity and also to humidity and temperature minima in a single factor but no significant correlations were obtained. An analysis was then made of mean colds occurring at 10% levels of minimum relative humidity (Table 2). There was a surprisingly constant common cold level both in summer and winter. Taken over the whole year however there was a very slight tendency for more colds at higher humidity levels. The figures do show an increase in winter in the 46 - 55% minimum humidity level but this low value was only reached on ten occasions during the study period. It is of significance that in the United Kingdom winter humidity levels of this order are uncommon and are often preceeded by nights with high radiation and therefore low minimum temperatures. Thus we may be recording the effects of cold nights rather than very dry days.

TABLE 2. Relationship between common cold incidence and lowest daily relative humidity (10% ranges) for winter, summer and the whole year. Wingerworth, Derbys, October 1970 to September 1971

10% Lowest humidity ranges	Winter			Summer			Year		
	No of days	Total colds	Mean colds	No of days	Total colds	Mean colds	No of days	Total colds	Mean colds
86 to 95	27	177	6.6	8	15	1.9	35	192	5.5
76 to 85	55	381	6.9	23	66	2.9	78	447	5.7
66 to 75	53	364	6.9	40	90	2.3	93	454	4.9
56 to 65	34	236	6.9	47	101	2.1	81	337	4.2
46 to 55	10	77	7.7	55	139	2.5	65	216	3.3
36 to 45	1	6	6.0	6	14	2.3	7	20	2.9
26 to 35	-	-	-	2	9	4.5	2	9	4.5
All humidities	180	1241	6.9	181	434	2.4	361	1675	4.6

OTHER METEOROLOGICAL PARAMETERS

The many other daily parameters investigated included solar radiation, wind speed and direction, dew point, vapour pressure, 10 cm soil temperature, cooling indices, daily temperature range, maximum temperature, and synoptic changes. On all graphs in which temperature was a factor it could be demonstrated that at times of maximum parameter fluctuation (which was often coincident with air mass change) there was a marked tendency towards an increase in cold incidence.

SIX HOURLY DATA

Small temperature fluctuations were associated with low cold incidence and conversely large temperature fluctuations produced high cold levels after a 24 hour time lag. Gradual continuous warming resulted in gradual 'cold' reduction.

The cold weather, (around freezing point), at the end of December gave a high 'cold' level but this fell after a few days of stabilization, even at the low temperature. This demonstrates that stabilization, even at low temperatures, is accompanied by low 'cold' incidence. Conversely, the fluctuation of temperature, even at times to higher levels (e.g. mid December), can upset the ability of the subject to resist invasion of the mucous membrane by the rhinovirus with the onset of 'cold' symptoms.

It is notable that a single large fluctuation was less likely to give a 'cold' increase than a double or multiple oscillation. This finding agrees with the work of Smith, Hugh-Jones and Jackson (personal communication) concerning the effect of temperature on respiratory disease in kittens in which a double thermal stress, falling in the incubation period of the virus, gave epidemics in a cattery.

DISCUSSION AND HYPOTHESIS

From the evidence enumerated it appears that of all the meteorological parameters, temperature alone is related to the incidence of the common cold; and that temperature fluctuation rather than temperature level is the more significant. The site of action of the temperature factor must surely be the site of entry of the virus, - the nasal mucosa.

It is tempting to look upon this effect as a local cooling of the nasal mucosa by inspired air. This may be partly true, but it would not explain the onset of colds due to anxiety stress which physicians will have often recognised at times of bereavement and examinations for example. Nor can it explain why warmer temperatures at times promote infections.

The Equivalent Effective temperature findings suggest that peripheral cutaneous cooling is also significant. It is known that cutaneous cooling and anxiety stress produce a reflex cooling of the nasal mucosa; furthermore cutaneous warming has the same cooling effect initially, with subsequent warming (Ralston and Kerr, 1945). Here then is a possible explanation of the production of colds by cutaneous cooling, and warming and anxiety stress all of which produce reflex cooling. Van Loghem (1928) assumes that colds occur as a result of a meteorologically determined disturbance of the thermoregulation of the population. This would seem to be the most plausible explanation of the synchronicity of cold morbidity. It is now suggested that the reflex cooling may be the mechanism involved in this phenomenon.

In this connection the work of Tromp (1964) is of interest. He found that after cooling of the hand at 10°C for 2 min, the normal temperature was regained within 6 min in the healthy subject but was delayed in patients with a wide variety of conditions, including asthma, cancer, pregnancy - and even the common cold. This finding Tromp attributes to the failure of the normal thermoregulation of the body through the hypothalamus. The delayed rewarming, if controlled centrally, must logically apply also to the reflex effect on the mucosa. Assuming that cooling of the mucosa allows virus penetration or development, delay in rewarming would give more time for the process to take place. This prolongation of the reflex cooling period might account for the widely accepted theory that colds occur more readily in subjects who are fatigued, or below their normal standard of fitness.

The continuation of cold weather, as has been shown, can result in a diminishing level of 'colds' - demonstrating that the thermoregulation mechanism can adapt to any given temperature if maintained for a sufficiently long period.

Arising from this premise it would appear that the thermo-regulating centre can be programmed to accommodate to a certain degree of variation in thermal stress. Most people have a fairly regular routine of work and travel and home environment to which the body mechanism becomes accustomed and it is only when confronted by a sudden large temperature oscillation, preferably repeated on two or more occasions, that failure of thermo-regulation results in a 'cold'.

The operation of the foregoing systems must of course assume the presence of virus in sufficient numbers and an antibody titre low enough to allow the development of overt infections.

CONCLUSION

It would appear that marked temperature oscillation, especially towards cooler weather, is the main meteorological factor in the incidence of the common cold. The periods of school terms make a further considerable contribution to the morbidity level.

The education system is immutable but many of the exacerbations of chronic chest disease are initiated by a 'cold'. It might be helpful therefore to recommend these subjects to remain indoors and maintain their "milieu extérieur" as far as possible under certain meteorological conditions, especially large changes in temperature.

It should be possible, for example, to forewarn patients of major synoptic changes, especially to cooler weather, which would be likely to upset their thermoregulatory pattern.

ACKNOWLEDGEMENTS

Our thanks are due to the patients who so conscientiously recorded their colds over the months. Also to our families who helped in so many ways, not least their patience during so many hours when we were working on this paper.

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ABSTRACT.- The effect of various meteorological parameters on the incidence of the common cold in 198 families was studied from October 1970 to September 1971 at Wingerworth, Derbyshire. Temperature fluctuation, particularly when repeated, was found to be the most significant factor, with school terms contributing markedly to the morbidity. Outdoor relative humidity levels were not found to be significant. The failure of the thermoregulation of the body, and more specifically of the nasal mucosa, in response to temperature stress is suggested as a possible mechanism which facilitates the development of virus to produce a common cold infection.

ZUSAMMENFASSUNG.- Es wurde die Wirkung verschiedener meteorologischer Parameter auf die Häufigkeit von Erkältungen in 198 Familien von Oktober 1970 bis September 1971 in Wingerworth, Derbyshire, untersucht. Lufttemperaturschwankungen, besonders wenn sie wiederholt auftraten, hatten den stärksten Einfluss. Die Schulperiode trug erheblich zur Morbidität bei. Die relative Feuchtigkeit der Luft war ohne Bedeutung. Ein Versagen der Wärmeregulation des Körpers insbesondere im Bereich der Nasenschleimhäute bei Temperaturbelastung wird als mögliche Reaktion angesehen, die die Entwicklung des Virus erleichtert und zur Erkältung führt.

RESUME.- On a étudié les effets de différents paramètres météorologiques sur la fréquence du rhume commun dans 198 familles de Wingerworth, Derbyshire. Cette étude a été effectuée d'octobre 1970 à septembre 1971. Les fluctuations de température, spécialement si elles se répètent, se sont révélées le facteur déterminant. Quant à la fréquence de l'atteinte du mal, c'est surtout en périodes scolaires que la transmission du virus a lieu. Par contre, l'humidité relative de l'air est sans signification. On en conclut qu'une défaillance de la régulation thermique du corps, principalement dans la région des muqueuses nasales, s'il y a contrainte thermique, doit être considérée comme une réaction possible facilitant le développement du virus et conduisant au refroidissement.