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BEDROOM VENTILATION: ATTITUDES AND POLICIES

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SUMMARY

A behavioural study by Brundrett in 1977 indicated that in the U.K. a substantial number of persons slept with their bedroom windows open. Such a habit, if it prevailed during cold weather, could lead to considerable energy losses. However Brundrett's sample was small and the data, which were gathered in the summer, might reflect behaviour which varied with the seasons and so were biased. The present investigation questioned a larger sample during the winter. The questionnaire also invited respondents to cite the ill-effects from which they might suffer if their bedroom window were closed all night. The results generally confirmed Brundrett's indications regarding the prevalence of window opening. The reasons for it appear to be related to beliefs regarding ventilation and health. These could have their origins in the writings of Florence Nightingale.

KEY WORDS Ventilation Attitudes Bedrooms Hygiene

INTRODUCTION

Energy, ventilation and health

To conserve energy in domestic buildings the exchange of warmed internal air with cold external air should be minimized. Yet there is a belief that a lack of fresh air, i.e. air imported from the outside, is unhealthy. The present study is concerned with beliefs about the need for fresh air in bedrooms at night.

Data on window opening in the U.K. have been reported by Brundrett (1977). As a supplement to a day-time observational study undertaken during summer, 101 householders were questioned about their general window opening habits. This revealed that 34 per cent slept with their own bedroom windows open, and 14 per cent opened their childrens' bedroom windows at night. Answers to another question indicated that 28 per cent kept their own bedroom windows open continuously, and 11 per cent their childrens' bedroom windows open continuously. If these habits were maintained throughout the year, the energy losses they incur could be substantial.

The aim of the questionnaire prepared for the present investigation was to obtain additional data on window opening habits and, more importantly, to seek reasons for them. It was anticipated that these reasons would be related to ideas about health. For this reason respondents were invited to state what ill-effects they thought might arise if bedroom windows were not opened.

The importance of bedroom ventilation is stressed in folk medicine in the U.K. Mrs Beeton in her famous *Book of Household Management* (1889) strongly emphasizes the importance of adequate ventilation. She asserts that 3000 cubic feet of perfectly pure air each hour are required by every adult man. One popular home medical guide (Gomez, 1970), in listing the causes of headaches, includes carbon dioxide and poor ventilation, although it does not specially mention bedrooms. The idea that ventilation, and bedroom ventilation specifically, is conducive to good health is stated very strongly and directly by Florence Nightingale in her guide to nursing originally published 100 years ago (Nightingale, 1980). She writes, 'The very first canon of nursing is this: to keep the air he (the patient) breathes as pure as the external air'. This is done by arranging a supply of: 'Air from the air without, and that, too, through those windows, through which the air comes

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freshest' (p. 6). But fresh air is also held to be important for general hygiene. She elaborates: 'Do you ever go into the bedrooms of any persons . . . before the windows are opened in the morning, and ever find the air anything but unwholesomely close and foul? During sleep, the human body, even when in health, is far more injured by the influence of foul air than when awake' (p. 9). And at a later point she hints of dire consequences if bedroom ventilation is inadequate: 'What will they (most people) say if it is proved true that fully one-half of all the disease we suffer from is occasioned by people sleeping with their windows shut?' (p. 11).

Ms Nightingale firmly believed that foul air provided a breeding ground for the diseases which were then contagious, such as smallpox, scarlet fever and diphtheria. In the wards and bedrooms of the time hygiene was poor. Inhabitants needing to evacuate in the night used slop pails or 'chamber pots', so the foul smells of which she complains are not surprising. Nor is it surprising that measures which would discourage airborne carriers of disease should improve health. What is questionable is whether these measures are necessary now that toilet habits have changed and excreta are no longer to be found in bedrooms.

Present-day attitudes to bedroom ventilation may be mediated by general ideas relating fresh air to hygiene, especially ideas about school-room ventilation. These in turn can be traced back to the medical sources. Terman and Almack (1914), in a treatise on school hygiene, recommend liberal doses of fresh air in schools, preferably supplied by well-placed windows. They claim that a failure to ventilate will result in 'headache, drowsiness, lassitide, faintness, dizziness, and nervousness'. In addition they go on to assert that 'Bad ventilation is a factor in the production of nearly all kinds of diseases which have their seat in the respiratory passages', and 'The imperfect aeration of the blood (which occurs) causes general debility. This means lowered resistance to fatigue, to disease, and probably also to *temptation*.' (*sic*).

Belief in the wide-ranging effects of ventilation was maintained well beyond the time of the first world war. Excessive exposure to the elements was a major feature of schools specially constructed for children with either physical or mental disability. In the U.K. special school buildings such as the 'Staffordshire', or 'Pavilion' type were constructed. These had windows pivoted at the mid-point top and bottom (Chaddock windows) which could be opened to 90 degrees and so provide unimpeded access to the outside (Davies, 1935). In Switzerland, sanatoria for tuberculous children took things to the extreme. They glazed windows with 'vita' glass which transmitted UV light more freely, and established regimes of fresh-air activity such as snowballing when dressed only in boots and loin-cloths (see Davies, 1935, p. 90).

These ideas relating ventilation to hygiene, which had such an influence on the planners of schools, may well have permeated through to the children themselves. If so, these children will have been led to believe that generous levels of ventilation are beneficial. Moreover they will expect a lack of ventilation to result in headaches, feelings of lassitude and possibly diseases of both mind and body of even greater severity.

Carbon dioxide concentration and well-being

Since the normal respiratory process involves the uptake of oxygen in exchange for carbon dioxide, it might be supposed that in the absence of ventilation ill effects arise from a lack of oxygen or build-up of carbon dioxide, or both. Nineteenth-century nursing practices such as the removal of flowers from sick-rooms at night, were based upon this assumption. Early physiological studies failed to support such simple theories (see Kerr, 1926). Haldane had showed that the CO_2 level in the alveoli of the lungs was 6 per cent, vastly higher than that in the atmosphere (0·03 per cent). This level is not altered by the atmospheric variation of the CO_2 breathed. He asserted that the physical effects of CO_2 in atmospheric contamination were nil. Much more important were heat and humidity. Hill and others reinforced these views, '. . . the problem of ventilation, the promotion of comfort and a sense of well-being, was not primarily associated with the chemical composition of the air, for comparatively high concentration of carbon dioxide, e.g. 3 per cent could be tolerated provided there was adequate air movement and no excess of moisture in the air' (Roberts and Shaw, 1966).

In these early studies the theoretical models were understandably crude, as were the physiological indices employed. The criteria for making general statements regarding the quality of the atmosphere are also questionable. The investigator undertook the role of sole judge in these matters, since it was before the days of systematic psychological investigation. We may doubt, therefore, whether what was decreed to be a 'tolerable'

work or school environment in these investigations bears on what would be considered desirable in a domestic setting today.

Relatively recent physiological studies have revealed a high degree of complexity in the homeostatic mechanisms associated with pulmonary function. They still tend to be concerned with relatively massive levels of CO_2 contamination. They seek to establish the limits for survival or for the maintenance of efficiency in some form of activity, rather than for comfort levels. Much of this research has been sponsored by the military, since they employ personnel in confined conditions such as submarines where ventilation may be extremely restricted. Thus Schaefer (1958) exposed submariners to CO_2 concentrations varying from 1·5 to 7·5 per cent for 15 minute periods. His main dependent variables were physiological, but he did also quote clinical symptoms such as headache, stomach-ache, restlessness, irritation and lassitude. These were obtained from invited self-reports. Few symptoms were reported at 5 per cent levels and none at all at lower levels. At 7·5 per cent, 18 of the 42 subjects complained of headache, 10 of restlessness, 6 of dizziness, 27 of dyspnea (difficulty with breathing). Schaefer divided his subjects into two groups in terms of whether they responded to the stress by raising their ventilation rates markedly. The group that did this was more susceptible to ill-effects.

The straightforward interpretation of Schaefer's observations is that massive CO_2 concentrations are needed to induce any reports of symptoms. We may doubt, however, whether this implies that equivalent levels would be needed before unselected individuals in a domestic environment would notice discomfort. Military personnel who have volunteered for special duties are young, fit, keen and reluctant to complain, especially as they may well believe that evidence of a susceptibility to symptoms could disbar them from their chosen speciality.

The normal level of CO_2 in the atmosphere is very low, only 0·03 per cent. A person lying in bed produces about 12 litres of CO_2 per hour (Lambertsen, 1971). A simple calculation reveals that even in a very small sleeping chamber, say 2 m × 2 m × 3 m, the CO_2 level which will be built up over an 8 hour period is less than 1 per cent with zero ventilation. Extrapolation from Schaefer's study would make it doubtful whether any ill-effects could be expected at such low concentrations, but, as we have noted above, his criteria may be inappropriate.

Lambertsen (1971, pp. 1146–1147) states that the maintenance of internal CO_2 levels within very fine limits is highly critical since it determines pH levels, which in turn influence essential metabolic and electrical reactions. Despite massive increases in oxygen uptake during exercise, there is '. . . a normal state at rest of precarious balance on the brink of respiratory insufficiency. The adequacy of oxygenation at rest is sustained in man by the extreme sensitivity of the respiratory centers to effects of CO_2 . . .' This statement provides some grounds for believing that the body is sensitive to small shifts in CO_2 concentration, hence there may be some related if diffuse sense of awareness of these changes.

The standard technique used in physiological studies is to expose subjects to precisely measured conditions for relatively short periods of time, usually of 15 min or less. Extrapolation to normal sleeping conditions presents some problems. The much longer periods of exposure persons experience during sleep may mean that they have an opportunity to adapt and hence become less susceptible to ill-effects. On the other hand, the longer period of exposure may provide an opportunity for the gradual accumulation of effect, so that a condition which can be tolerated over a short period becomes relatively more distressing.

Apart from physiological considerations, we may speculate that while resting, especially at night when distracting stimuli are absent, persons are aware of slight discomforts which they would ignore in the daytime. Dissatisfaction with sleep quality would appear to be widespread, to judge from the sales of sleeping pills and those bedtime drinks reputed to have sleep-enhancing qualities. So we might expect ritual and 'superstitious' behaviour relating to sleep. Any slight doubts regarding the adequacy of ventilation are therefore likely to be resolved by indulging in excess.

Previous studies of bedroom ventilation

Research into the bedroom ventilation requirements of normal persons is extremely limited. As noted above, Brundrett (1977) had obtained evidence indicating that approximately 30 per cent of U.K. householders sleep with their bedroom windows open. Subsequently, a student undergraduate project sponsored by the ERC

pointed to a possible build-up of high CO_2 levels in sleeping accommodation where windows were closed (Kelly, 1980). This in turn led to another student field study in which window opening was controlled so that CO_2 levels could be monitored during the night (Kuba, 1980).

Kuba measured the CO_2 levels at 10 different points in the bedroom, some close to the head of the sleeping subject and one right in the bedclothes. He used a Gas-o-mat analyser designed for industrial monitoring which had an upper limit of 0·5 per cent on its scale. He reported that with the window closed the mixing of the air in the room was reduced. Local concentrations of CO_2 close to the head of the subject went off the scale of the analyser in some instances, i.e. exceeded 0·5 per cent. Quality of sleep was assessed by a questionnaire adapted from De Diana (1976). The correlation between sleep quality and CO_2 level suggested that the higher the CO_2 concentration, the poorer was sleep, although this result was not statistically significant. (Lack of significance might be attributed to the low power of the experiment, since only 16 subjects were employed, and also to the low power of the non-parametric statistical test employed.)

THE QUESTIONNAIRE

The design of the questionnaire

Since it is possible that window opening habits are related to school hygiene practices of earlier generations, subjects were asked their age. Sex was the other demographic question, the reason being a suspicion that the females would place more emphasis on keeping warm.

Window opening habits were probed in two ways: first with a specific question relating to the previous night, secondly with an abstract question about general practice. This second question asked whether the respondent opened the bedroom window 'never', 'sometimes' or 'always'. For those who answered 'sometimes' a further question was set to try to discover what circumstances determined whether the window would be opened or closed.

It was thought that attitudes to fuel economy, which might have a bearing upon window opening practices, would depend upon whether or not the respondent's home had central heating. So they were asked about this.

If the bedroom were normally kept warm, heat losses would be greater and therefore energy wastage would be greater, so respondents were asked directly about bedroom temperature.

Finally, an open-ended question invited respondents to specify the ill-effects which might arise if their bedroom window were closed all night. This provided an opportunity for them to express their beliefs and fears.

A replica questionnaire is provided in Figure 1, augmented by data showing the overall response rates for each question.

Subjects

The questionnaire was originally planned as a supplement to an experimental study of CO_2 and sleep quality, but since the numbers involved would be small and the questions were of general interest in their own right, additional subjects were recruited: 28 of these were undergraduate psychology students from the University of Hull; 55 were teachers attending an educational conference at the university in January 1983; 149 were patients waiting in a GP's surgery in Newcastle upon Tyne. The students and the patients were recruited during the period January–March 1983, so all respondents completed the questionnaire during the winter months and most were resident on the North East coast, which is cold.

The composition of the sample in terms of sex and age is shown in Table I.

RESULTS

Overall responses

The questionnaire is reproduced in Figure 1 along with a gross indication of the responses. The figures show the percentage in each category, or the percentage of affirmative responses, whichever is appropriate. These are

Question			%
1.	Did you have your bedroom window open last night?		26
2(a)	Do you have your bedroom window open:		
	(1) always		13
	(2) sometimes		71
	(3) never		17
(b)	If 'sometimes', then does this depend upon:		
	(1) the outside temperature		58
	(2) the room temperature		42
	(3) the room size		8
	(4) any other reason—give details below.		
	.....		
	.....		
3.	Is your home centrally-heated?	YES/NO (Yes)	79
4.	Is your bedroom usually:		
	(1) hot		7
	(2) warm		37
	(3) cool		32
	(4) cold		24
5.	If your bedroom window were closed all night, from what ill effects might you suffer?	(No ans)	29
		(None)	28
		(One)	31
		(Two)	9
		(Three)	2
		(Four)	1

Figure 1. The questionnaire (generally the numbers are the overall percentage of affirmative answers, see text)

Table I. Composition of the questionnaire sample

Sex	Source	Age group						
		10–19	20–29	30–39	40–49	50–59	60+	Total
Male	Teachers	0	1	7	5	2	0	15
	Students	4	14	1	1	0	0	20
	Patients	2	4	7	5	11	16	45
	Total	6	19	15	11	13	16	80
Female	Teachers	0	6	1	3	1	0	15
	Students	12	19	4	0	0	0	35
	Patients	11	23	26	12	17	15	104
	Total	23	48	31	15	18	15	150
Both	Teachers	0	7	8	8	3	0	26
	Students	16	33	5	1	0	0	55
	Patients	13	27	33	17	28	31	149
Grand total		29	67	46	26	31	31	230

Note: two respondents failed to state their sex and have had to be omitted. One was in the 30–39 age group. The other was in the 50–59 group.

based upon the number who responded. The total N was 232. Nearly all of them completed the whole questionnaire. Omissions are as follows;

Age : 3 (who put 60+ instead of their precise age)
Sex : 2
Q1 : 1
Q2(b) : 1 (of those who had answered 'sometimes' to Q1)
Q3 : 1
Q5 : 41

Consistency checks

A number of the questions are interrelated. Examination of these indicates the care with which the questionnaire was answered.

In the case of Question 2(b), answers were required only from those respondents who asserted in 2(a) that they had their bedroom windows open 'sometimes'. The total number of responses to 2(b) was 171. Of these, 163 had answered 'sometimes' to Q2(a). So there were only 8 who had overlooked the precise wording of the (b) part of the question.

Other checks on consistency revealed few lapses. Thus answers to Q2 were generally consistent with answers to Q1. Of the 192 who had their bedroom window closed last night (Q1), 39 indicated on Q2 that they never opened it, 146 sometimes did, and just 6 inconsistently reported they always did. Of the 39 who had it open, 16 said they sometimes opened and the remaining 23 always did.

Another consistency check involved Q2(a) and Q5, since it might be expected that habitual behaviour would be related to reports of symptoms. There were just 9 respondents who claimed to have a policy of never opening their bedroom window, yet listed one or more ill effects this practice produces. Six were female. Seven had central heating. One respondent, who was married, commented that the couple's window opening policy was dictated by the respondent's spouse. So there are circumstances in which pairs of responses such as these are not inconsistent.

Reasons

The number of respondents offering other reasons for opening or closing windows other than temperature and room size was 36. Most could be classified under the headings of 'season' (2); 'ventilation' (4); 'condensation' (3); 'wind' (3) and 'security' (4); leaving 10 odd-ball cases. Some specific comments were rather surprising. One young lady kept her window open to allow free access to her cats whereas another felt forced to keep her window closed to keep unwanted feline visitors out. Two respondents attributed their policy to the poor structural condition of their property. They did not need to open windows because in one case the window frame fitted the brickwork so poorly that permanent ventilation was provided around the window rather than through it, and in the other the window sash was so warped that the window could not be closed. Some of those with condensation problems dried washing in their room which suggests that for some respondents their bedroom was also their living room.

Ill-effects attributed to sleeping with closed windows

Figure 1 shows that 43 per cent of the respondents offered one or more instances of ill-effects; 28 per cent specifically stated 'none'; 29 % failed to offer a positive response. There is good reason to infer that nearly all of this last group feel that no ill-effects result. These reasons are (i) the high level of co-operativeness indicated by the rate of responding to the other questions and (ii) the wording of the question, which only invited responses from those who had symptoms to specify. The majority therefore, by a slender margin, think that sleeping with the window closed will not be harmful.

Although the question was open-ended, the ill-effects specified by the respondents fall into a relatively small number of classes. These are listed in Table II together with the total number of instances in each.

The data in Figure 1 showed that 12 offered two or more symptoms. Much of the overlap was between categories D and E. Complaints of stuffiness and of heat seem to go together, not surprisingly.

Interrelations between factors

For analysis, all records were entered into the SPSS facility on the University mainframe computer and cross-tabulated. Thus it was possible to explore interrelations between responses to different questions and correlations between responses and the individual differences registered (age and sex).

One hypothesis examined was that window opening policy would be related to the presence of central heating. It was expected that respondents who had central heating would be more likely to have a policy of

Table II. Ill-effects from sleeping with closed bedroom windows

	Symptom	Frequency
A	Headache (headache, thick head, muzzy, fuzzy)	33
B	ENT (sore throat, thick tongue, stuffed-up nose, sore or wheezy chest, 'flu)	31
C	Lethargy (lethargy, sleepiness, inability to awaken)	13
D	Stuffiness (stuffiness, lack of air, claustrophobia, stale air, condensation)	32
E	Heat (too hot, sweaty, clammy)	16
F	Poor sleep (poor sleep, no sleep, unrefreshed, bad dreams, restlessness)	12
G	Mood (bad-tempered, depressed, unmotivated)	3

keeping their window closed. This expectation was false. The analysis showed no influence of central heating upon policy.

Policy was related to bedroom temperature, as can be seen in Table III. (The cells have been collapsed so that the expected numbers are sufficiently large for statistical analysis.) Those who describe their bedrooms as 'cold' are likely to keep the window shut, whereas those calling it 'cool' are likely to keep it open ($P < 0{\cdot}01$, chi-square with 4 d.f.).

Individual differences

The data on individual differences in sex and age have been examined for connections with window opening behaviour. Sex made no substantial difference. Age, however, did.

From the introductory remarks, it may be supposed that window opening is influenced by changing cultural factors. An obsession with the health-giving benefits of fresh air prominent in the early decades of this century is possibly being replaced by an emphasis upon energy conservation now that energy costs have increased markedly. If window opening is influenced by the dominant ethos of the respondents' childhood, these changes can be expected to show up as a correlation between behaviour and age.

Table IV shows how responses to the questionnaire relate to the respondent's age. These show that the older respondents are less likely to have the policy of never opening their bedroom window. ($P < 0{\cdot}05$ on a chi-square test, which is conservative since it does not take the smoothness of the trend into account.) This result is reinforced by the replies to Q1 which show a tendency for fewer of the youngest group to have had their window open last night, although this result is less clear-cut and obviously not statistically significant.

Table III. Window opening and bedroom temperature (the number of respondents in each category; one failed to answer both questions)

Policy	Bedroom temperature: Cold	Cool	Warm or hot	Total
Never open	12	12	15	39
Sometimes	26	46	91	163
Always open	2	15	12	29
Total	40	73	118	231

Table IV. The percentage of responses to each question as a function of age

Q	Response	Age group 10–19	20–29	30–39	40–49	50–59	60+
1	Open last night	10	18	21	12	23	30
2(a)	Never	31	21	17	12	13	3
	Sometimes	66	70	70	76	68	74
	Always	3	9	13	12	19	23
3	C/heat in home	55	69	89	97	87	84
4	Hot or warm bedroom	55	36	60	77	50	45
5	One or more ill effects	52	43	40	50	44	32

DISCUSSION

The data presented here augment those of Brundrett. He questioned 101 persons living in family houses on a new estate in the West Midlands during the summer. The 232 persons in the present sample came from a wide variety of homes, mostly in the North East, and they were questioned during the winter. The proportion who had their bedroom window open the night before they were questioned was 26 per cent, which roughly matches the 34 per cent of Brundrett's sample who asserted that they kept their bedroom window open at night. The great majority adapt their window opening to the weather, keeping closed up if it is too cold or too windy. However, a hard core of 13 per cent claim to sleep with the window open whatever the conditions. Window opening is unrelated to the possession of central heating. It is related to bedroom temperature: those with cold bedrooms being more likely to sleep with the window closed. So there is some indication that persons try to avoid getting too cold at night. The implication for energy conservation is that those opening windows have heat they are prepared to lose. They possibly have excessive heat in the bedroom so that the cooling resulting from opening the window improves their comfort, but such speculation goes beyond the data.

It should be observed at this juncture that neither the present study nor Brundrett's can reasonably claim to present data from a representative sample of the U.K. population. However, the combined results suggest that a substantial proportion of the U.K. population sleep with their bedroom windows open. It might therefore be worth while instigating a proper survey in order to estimate the total energy losses which result from this behaviour.

With Brundrett's family homes the bedrooms were upstairs and were separated from the daytime living spaces. Although such accommodation is common, it is not universal. Many persons live in bed-sitting rooms or small apartments where a common space serves for daytime and night-time activity. The problems of ventilation may well be more severe in the latter. An appropriate survey would need to take this into account.

In order to change persons' habits it is necessary first to understand the basis for them. The reasons given for opening bedroom windows indicated a belief that fresh air in the bedroom is necessary for physical health. If the window were closed all night many persons thought they would suffer in a variety of ways. Poor sleep was expected. In addition, they anticipated symptoms such as those of the common cold, e.g. stuffed up noses and congested lungs. Some even thought they would suffer from influenza. Any experience of symptoms is probably psychogenic. Obviously, anxiety about sleeping conditions will not be conducive to good sleep. So persons who think that they need the window open will worry if it is closed, and this worry will cause them to sleep badly and thus confirm their beliefs.

The basis of these beliefs may well lie with ideas prevalent in folk medicine. These in turn probably originate from 19th century writings, such as those quoted from Florence Nightingale. The poor hygiene of the time is no longer a problem. Excrement is no longer kept in chamber pots under the bed. Furthermore the physiological ideas regarding the ill-effects of high CO_2 levels have been substantially modified as a result of further research, so there is no longer any reason for anxiety about the consequences of leaving a bunch of flowers in a sick-room overnight. It is just possible that these concerns might properly be replaced with concern about timber

preservation treatments and the fumes exhuded by dieldrin, formaldehyde, and agents used in the glues of hardboard and chipboard. *The Guardian* newspaper reports a need for concern over these pollutants (Tucker, 1984).

If at some future time it is thought to be desirable to attempt to change sleeping habits, it will be useful to understand how they are established. From the evidence presented here it would appear that today's habits are attributable to scientific ideas current in the 19th century. These have filtered down through their application to hygiene in schools to the present adult population. It may take a prolonged period of education to change such deeply-rooted ideas.

CONCLUSIONS

The data obtained from this winter-time study in North East England show a rough correspondence with those previously obtained by Brundrett. Most persons adapt their behaviour to the weather, but there is a hard core of 13 per cent who always sleep with the window open. Many persons believe that sleeping with the window closed will result in ill-health and produce symptoms associated either with ear, nose and throat disorders, or chest complaints.

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