RELATIONSHIP OF THE LOOSE COUGH SIGN TO DAILY SPUTUM VOLUME OBSERVER VARIATION IN ITS DETECTION

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Evidence of overproduction of sputum, the essential diagnostic feature of chronic bronchitis, is usually sought in epidemiological surveys by questionnaire. This approach is inevitably subjective. A valid objective sign of sputum production would be of value, both as an independent index of chronic bronchitis and as a supplement to the history. Elmes, Dutton, and Fletcher (1959) introduced the measurement of morning sputum volume, but this technique requires co-operation from the subject, may have a high lapse rate, and is open to falsification. Various sources of bias, social, political, and economic, may influence the results obtained from either the history or sputum collection, particularly in occupational surveys. For the past 12 years it has been the practice in this unit to supplement the information obtained from questionnaires by asking the subject to take a deep breath and cough; the cough is recorded as 'loose' (productive) or 'dry' (unproductive) as judged by ear. This paper describes two studies of the relationship between the presence of a loose cough, as defined above, and the daily sputum volume, and provides information on inter-observer variation in the detection of the sign.

PROCEDURE AND METHODS

In the first study, four physicians listened together to the coughs of 111 patients, previously unknown to them, in the general wards of a teaching hospital. The series comprised 53 females and 58 males ranging in age from 15 to 91 (mean 49) years. Sputum mugs and ashtrays were removed before the visit. All patients were asked by the same observer to 'take a deep breath and cough hard'; the sound was recorded independently by each observer as 'loose' (moist or productive) or 'dry' (unproductive) as judged by ear; if the observer was in doubt as to its nature the cough was recorded as dry. If the

cough was feeble or not preceded by full inspiration, the patient was asked to cough again once, or at most twice, usually after a demonstration. Shortly afterwards, each patient was visited by a physiotherapist and encouraged to produce sputum by postural coughing and chest pressure. She left a sputum jar with each patient, instructed him in the importance of using it, and recorded the volume of sputum produced during the next 24 hours.

The second study was conducted primarily to familiarize school medical officers with the loose cough sign before employing it in a large-scale survey of the respiratory status of school children (Gibson, Silverstone, Gandevia, and Hall, 1969), and also to obtain estimates of inter-observer variation. Ten observers listened as above to the coughs of 68 hospital inpatients. A record of the sputum production from the previous 24 hours was available for 54 of the patients as part of their routine observation in the ward. One observer (B.G.) took part in both studies and was responsible for the instructions given to all patients.

The standard deviation agreement index (SDAI) (Armitage, Blendis, and Smyllie, 1966) was calculated as a measure of observer variation. This involves calculating the standard deviation over a series of subjects of the proportion of positive findings by the different observers for each subject. The SDAI is largest when agreement is maximal, that is, when either all or none of the observers' findings are positive for each subject. This maximal value of the index can be calculated using the overall proportion of positives. The minimal value for complete disagreement is zero. Similarly, the value of the index which might arise due solely to chance is calculable.

The data for both sexes have been combined as the prevalence of a loose cough was similar in males and females in each of the sputum volume groups in both studies.

RESULTS

FIRST STUDY

RELATIONSHIP OF LOOSE COUGH TO SPUTUM VOLUME

—Fig. 1 shows the percentage of subjects with a loose cough agreed by three or more of the four observers in each of four arbitrarily graded sputum volumes—nil, less than 2 ml (mean 0.95 ml), 2 to

FIG. 1.—First study: the prevalence of a loose cough for subjects with different 24-hour sputum volumes. (The figures in the columns represent the number of subjects in each group.)

6 ml (mean 3.6 ml), and more than 6 ml (mean 21.7 ml). The percentage of subjects with a loose cough as defined rises progressively from 12% in those recording no sputum during the 24-hour collection period to 49% in those with a daily sputum volume of more than 6 ml.

Table I shows the subjects divided arbitrarily into those producing less than 2 ml of sputum in 24 hours and those producing 2 ml or more. The number of subjects recorded as having a loose cough by each of the four observers, in these two sputum categories, is shown. Coughs were recorded as loose in 46% of

TABLE I
SPUTUM VOLUME IN RELATION TO LOOSE COUGH

	24-hr Sputum Volume	
	< 2 ml	≥ 2 ml
No. of subjects	67	44
No. of loose coughs recorded		
Observer A	11	18
B	12	19
C	11	23
D	12	21
Mean for 4 observers	11.5 (17%)	20.25 (46%)
No. producing sputum		
Physiotherapist	9 (13%)	21 (48%)

those with sputum volumes of 2 ml or more, and in 17% of those producing less than 2 ml. The relationship between a loose cough and a sputum volume of at least 2 ml is highly significant ($\chi^2 = 10.83$, $P < 0.001$). This value for χ^2 is calculated from the mean performance of four observers.

The physiotherapist at her visit shortly after the physicians recorded the production of sputum in nine of the 67 subjects (13%) who produced less than 2 ml in the subsequent 24 hours and in 21 of the 44 subjects (48%) who subsequently produced 2 ml or more, results very similar to those obtained with the loose cough sign.

VARIATION BETWEEN OBSERVERS—The total number of loose coughs recorded by each observer ranged from 29 to 34 for the 111 subjects. The small 'range' of variation within each sputum volume group is shown in Table I. Fig. 2 shows that in 74% of subjects all four observers agreed on the nature of the cough, three agreed in 22%, and they were evenly divided in the remaining four subjects (4%).

FIG. 2.—First study: the percentages of the 111 subjects for whom 4, 3, and 2 observers respectively were in agreement on the nature of the cough.

The SDAI for the data shown in Fig. 2 was 1.56, which is 86% of its maximum value, reflecting a high degree of inter-observer agreement; its maximal and chance values were 1.81 and 0.90 respectively. Table II shows the χ^2 analysis for differences between observers and interaction between observers and sputum volumes. There were no significant differences between observers in the overall series or at different sputum volumes.

TABLE II

ANALYSIS OF χ^2 : RELATIONSHIP BETWEEN LOOSE COUGH, SPUTUM VOLUME, AND OBSERVER VARIATION

Effect Measured	Degrees of Freedom	χ^2	Probability
Sputum volume	1	40.056*	$P < 10^{-7}$
Differences between observers	3	0.703	$0.9 > P > 0.8$
Interaction between observers and sputum volumes	3	0.712†	$0.9 > P > 0.8$

*This applies to all four observers' results combined. The average judgement would be measured by a χ^2 of one quarter of this.

†Appropriate adjustments were made for the inequalities in numbers tested at the different volumes.

SECOND STUDY

RELATIONSHIP OF LOOSE COUGH TO SPUTUM VOLUME

—There were more subjects producing large volumes of sputum in this group, and no volume between zero and 5 ml was found. The seven subjects producing more than 50 ml/24 hours were unanimously recorded as having 'loose' coughs.

Table III shows the number and percentage of loose coughs in the two sputum groups—nil, and 5 ml or more. The mean of 10 observers is shown, i.e., 97 loose coughs were recorded by 10 observers among the 33 subjects who produced no sputum. The association between loose cough and sputum production is significant ($\chi^2 = 7.24$, $P < 0.01$). Of the 13 subjects about whom less than eight observers agreed, only 2 of the 12 in whom there was some record had produced sputum, supporting the suggestion that when in doubt the sign should be recorded as negative.

VARIATION BETWEEN OBSERVERS—Of the 68 subjects, the number recorded as having a loose cough by each observer ranged from 26 (38%) to 34 (50%). Fig. 3 shows that all 10 observers were in agreement as to the nature of the cough in 32 subjects (47%) and nine observers in 16 subjects (24%); eight or more observers agreed in relation to 55 of the 68 subjects (81%). The SDAI was 4.06, 81.5% of its maximum value of 4.98, the chance value being 1.56. There were no significant differences between the observers ($\chi^2 = 3.6$, $P > 0.90$, with 9 degrees of freedom).

TABLE III

NUMBER OF LOOSE COUGHS RECORDED (MEAN FOR 10 OBSERVERS) ACCORDING TO SPUTUM VOLUME

Sputum Volume	No. of Subjects	No. of Loose Coughs
Nil	33	9.7 (29%)
≥ 5 ml	21	14 (67%)

FIG. 3.—Second study: the numbers and percentages of the 68 subjects for whom the stated number of observers were in agreement on the nature of the cough.

DISCUSSION

In view of the difficulties of sputum collection, a reliable objective sign of sputum production would be of value both in clinical practice and in occupational and epidemiological surveys. The hypothesis underlying the loose cough sign is that a normal subject with a normal bronchial mucosa will have a dry or unproductive cough upon request at any time; as a corollary, a random loose cough implies bronchial hypersecretion. It has been shown above that the sign can be used with an acceptable degree of observer error, but the demonstration of its validity is a more complex matter. Occasional subjects are observed with an unequivocally loose cough who produced no sputum according to ward estimation of sputum volume or questionnaire replies. Conversely, one patient with a measured daily sputum volume of 50 ml was judged by 10 observers on one occasion to have a dry cough on request.

It is impossible to define a specific sputum volume which, recorded over periods of up to 24 hours, necessarily implies the diagnosis of chronic bronchitis. The history of cough and sputum, an audibly loose cough, and measurements of sputum volume are all best regarded as indices of excessive sputum production whose validity can be determined only by their results in practice. It is interesting that a standard index of sputum production—whether or not a patient can produce sputum with the assistance of a physiotherapist—gave results very similar to those obtained with the loose cough sign (Table I).

Our results suggest that prior experience with the sign is of little importance for medical observers. In the first study the findings of a first-year resident

did not differ significantly from those of the most experienced observer (B.G.), and in the second study none of the nine school medical officers differed from him significantly in their first use of the sign. This does not necessarily apply to observers with different backgrounds. Dr. Charles Fletcher (personal communication) found that while a trained nurse with thoracic experience, and a technician with no relevant experience, recorded a similar proportion of dry coughs (94% and 92% respectively) in subjects producing no sputum, the nurse reported more loose coughs (83% by comparison with 44%) in those with 'first hour morning sputum volumes' of over 2.5 ml.

The present studies indicate that the sign may be used to define groups with different prevalences of sputum production as estimated by daily sputum volume. In occupational and epidemiological surveys the presence or absence of a loose cough has been shown to define groups which can be distinguished by other differences in behaviour: a highly significant association between a loose cough and smoking has been demonstrated in Australian patients attending both general practitioners (Gandevia, 1969) and a hospital outpatient department (Hong, Gandevia, and Lovell, 1967) for non-respiratory complaints. Hong *et al.* found a loose cough to be related both to a current history of cough and sputum and to previous acute bronchitis, but not to previous pneumonia. Cullen *et al.* (1969) used the loose cough sign in a comprehensive survey of 1,638 men from Busselton, a rural community in Western Australia. They found a highly significant relationship between the presence of a loose cough and reduced values for the forced expiratory volume in one second (FEV₁), the forced vital capacity, and the ratio between these two indices. There was also a significant association between the presence of a loose cough and positive answers to the questions from the Medical Research Council questionnaire on cough, phlegm, recent episodes of productive cough, previous chest illnesses, breathlessness, and wheezing. Their finding of a loose cough in 11% of the non-smokers, similar to that found in non-smokers attending general practitioners for non-respiratory complaints (Gandevia, 1969), is further evidence of the reliability of the sign when used by different observers in comparable populations. Finally, on exposure to certain occupational inhalants, greater decreases in FEV₁ have been found in those subjects with a loose cough; the sign proved more successful in predicting such decreases than either a history of cough and sputum or a history of symptoms on exposure to the inhalant concerned (Gandevia and Milne, 1965; Gandevia and Ritchie, 1966).

The advantages of the loose cough sign are that it is rapid, simple, objective, independent of language barriers (Gandevia, 1967), and applicable to young children (Chia *et al.*, 1971). As few subjects find the procedure objectionable, the refusal rate in our studies has been less than 1%. In our view, the sign offers an effective method of describing a population in terms of the prevalence of bronchial hypersecretion.

SUMMARY

Inter-observer variation in the detection of a loose (productive) cough upon request and the relationship between it and daily sputum volume were studied in 111 hospital inpatients by four observers and in a further 68 patients by 10 observers. The association between the presence of a loose cough and 24-hour sputum volumes of 2 ml or more was significant in both studies ($P < 0.001$ and $P < 0.01$ respectively). Inter-observer variation was assessed by the standard deviation agreement index, which was 86% and 81.5% of its maximum values respectively in the two studies. Published experience of the sign in occupational and epidemiological surveys is reviewed. The reliability of the sign and its validity as an index of abnormal bronchial function are supported by the results obtained in epidemiological surveys.

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REVISION OF THE INTERNATIONAL CLASSIFICATION OF DISEASES

The World Health Organization has started its 10-yearly process of revision of the International Classification of Diseases, Injuries and Causes of Death (ICD) to bring it into line with current needs. The classification is the one used throughout the world in official statistics of mortality and morbidity and is also widely used for indexing records such as hospital case notes.

Although the next revision, the ninth, will not come into use until 1978, the Revision Conference which will decide its details will be convened by the World Health Organization in 1975, and the end of 1972 is the last date for national proposals to reach them.

The World Health Organization has decided that the basic structure of the ICD shall remain the same at this revision (though a more fundamental revision is not ruled out for the future) and that the numbering system shall

not be disturbed without good reason, such as when part of the classification is so out of date as to warrant complete restructuring of that part. But it is recognized that extra detail must be provided by subdivision for those who need it in applications such as hospital indexing.

The Director and Registrar General has appointed a subcommittee of his Medical Advisory Committee to advise on the United Kingdom proposals and also to advise the WHO Centre for the Classification of Diseases, in this department, on tasks which it has been allotted in connexion with the revision. The subcommittee will appoint working groups of specialists in the various fields.

The committee would welcome comments or proposals from anyone with an interest in the subject and would be glad to know, early, of any proposed work.

We have been asked to publish the above note by Dr. A. M. Adelstein, Chief Medical Statistician at the Office of Population Censuses and Surveys, Somerset House, London, W.C.2.