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# The "Middling" Tendency

William Keith C. Morgan MD [a], Martin R. Petersen [a] & Robert D. Reger MS [a]
[a] Appalachian Laboratory for Occupational Respiratory Disease, National Institute for Occupational Safety and Health and the Department of Medicine, West Virginia University Medical Center, Morgantown, W Va., USA
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# The "Middling" Tendency

## A Possible Source of Bias in the Interpretation of Chest Films for Pneumoconiosis

William Keith C. Morgan, MD; Martin R. Petersen; Robert D. Reger, MS

**The UICC/ILO Classification of pneumoconiosis divides each of the three major categories of simple pneumoconiosis into three subcategories. Although it is often assumed that the relative widths of the central and marginal subcategories, eg, 1/0, 1/1, and 1/2, that compose a major category are equal, the original describers of the elaboration did not subscribe to this view.**

**It is well known that the percentage of subjects with the major categories of simple pneumoconiosis decreases with increasing category. Similarly it might be inferred that the percentage of subjects with each subcategory would decline as one proceeds up the scale from 0/0 to 3/4. In practice this phenomenon is not seen and more subjects are placed in the middle subcategories.**

The National Coal Board's elaboration of the International Labour Organization Classification of Pneumoconiosis and its UICC/Cincinnati equivalent are used extensively as means of assessing progression of pneumoconiosis. Progression is determined by comparing two films placed side-by-side with the dates known to the interpreter. Because side-by-side comparison of paired films may introduce bias,[1] some advocate that each film should be interpreted independently in the absence of any knowledge of either the appearance or the category of the other film of the pair. Although it is accepted widely that the independent method shows more variation, it is assumed to be relatively free of bias. We have recently observed some "peculiar reading habits" among our interpreters that lead us to believe that both methods may be susceptible to a form of bias that is not generally considered.

It is well known that the percentage of miners with the major categories of simple coal workers' pneumoconiosis decreases as the severity of the disease increases.[2] Hence, there are more miners with category 1 than with category 2, and more with category 2 than category 3. Such a distribution of disease is to be expected since in general it is only those miners who are exposed to high dust concentrations who develop the higher categories of simple coal workers' pneumoconiosis. Similarly, it might be inferred that the percentage of miners who fall into each subcate-

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From the Appalachian Laboratory for Occupational Respiratory Disease, National Institute for Occupational Safety and Health and the Department of Medicine, West Virginia University Medical Center, Morgantown, W Va.

Reprint requests to the Department of Medicine, West Virginia University Medical Center, Morgantown, WV 26506 (Dr. Morgan).

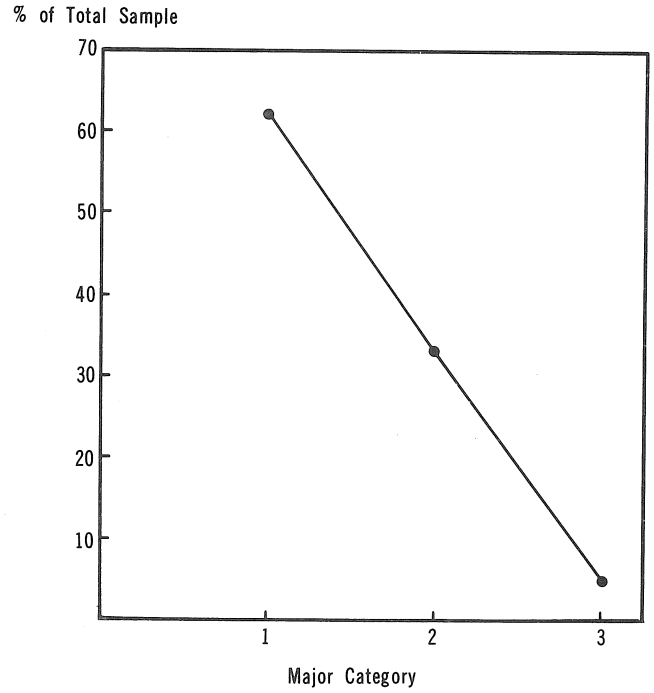
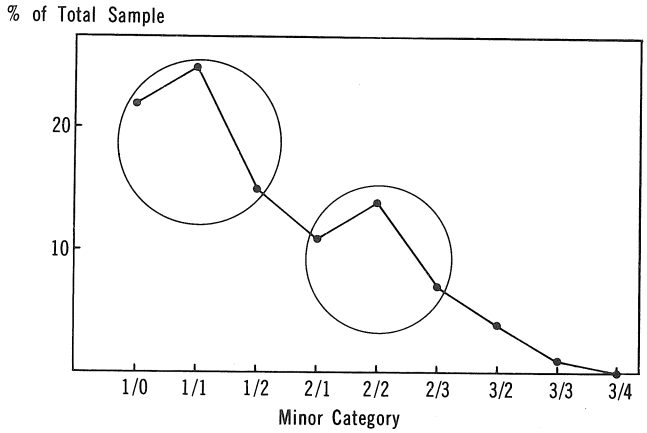



Fig 1.—Percentage distribution of major categories in miners with simple coal workers' pneumoconiosis (25 readers).

Fig 2.—Percentage distribution of minor categories in miners with simple coal workers' pneumoconiosis (25 readers).



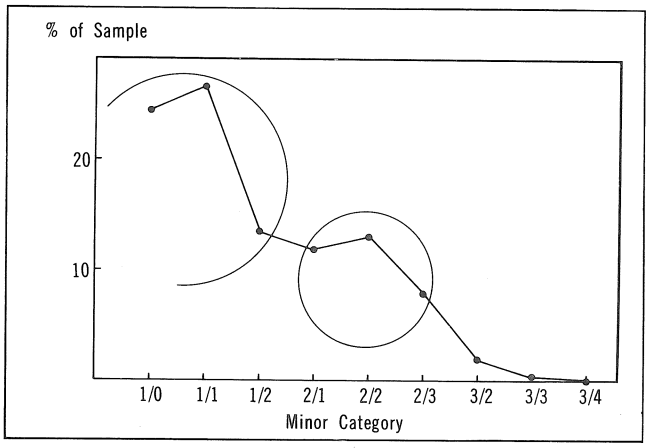




Fig 3.—Percentage distribution of miners with simple coal workers' pneumoconiosis (reader 1).

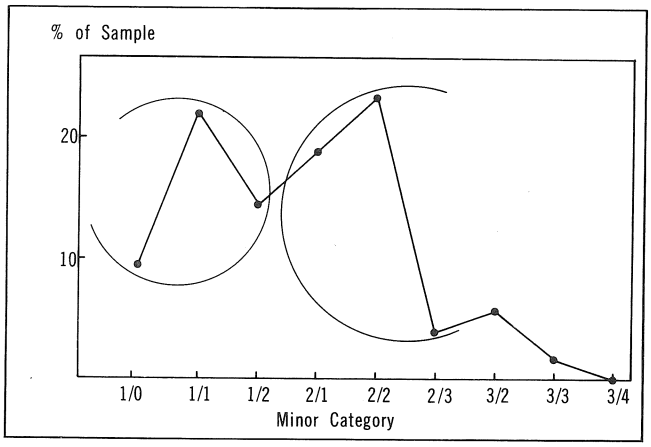



Fig 4.—Percentage distribution of miners with simple coal workers' pneumoconiosis (reader 2).

gory, viz, 0/1, 1/0, 1/1, or 1/2, might decrease as one proceeds up the scale from 0/0 to 3/4.

When Liddell first described the National Coal Board elaboration, he discussed the relative widths of the central and marginal subcategories that compose a major category.[3] He suggested that the central subcategories (1/1, 2/2, and 3/3) would contain approximately half of the total subjects in the major category and the marginal subcategories, viz, 1/0, 1/2, 2/1, or 2/3, would contain a quarter of the subjects. We, therefore, thought it might be of interest to ascertain the distribution of readings for a series of US interpreters.

## METHODS

As of December 1972, over 60,000 chest roentgenograms had been taken as a result of the first round of the Federal Coal Mine Health and Safety Act of 1969. Approximately 7,500 of this total were diagnosed as category 1, 2, or 3 simple pneumoconiosis. In addition, a sample of nearly 1,300 films from the interagency study with positive evidence of coal workers' pneumoconiosis was added to this sample, making a grand total of nearly 8,800 roentgenograms that had been read as showing simple coal workers pneumoconiosis. The percentage of films that fell into each major category was first determined. Next, for the category 1 roentgenograms, we determined the distribution of the various subcategories, viz, 1/0, 1/1, and 1/2. Similar analyses were performed for categories 2 and 3.

## RESULTS

The distribution of the various major categories is shown in Fig 1. It is apparent that as the category of pneumoconiosis increases, the number of miners affected decreases. Thus, 62% of the total were diagnosed as category 1, 30% as category 2, and

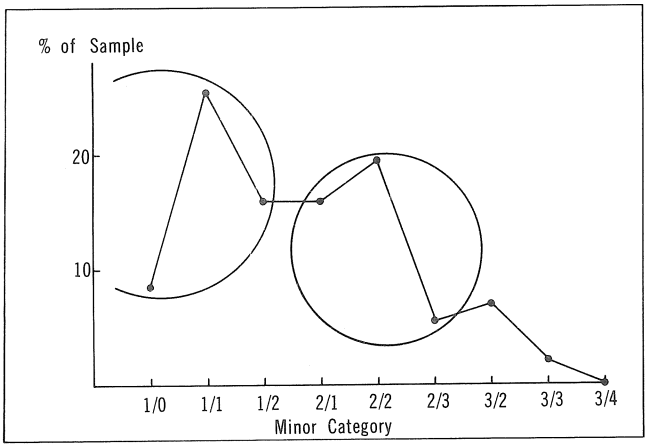



Fig 5.—Percentage distribution of miners with simple coal workers' pneumoconiosis (reader 3).

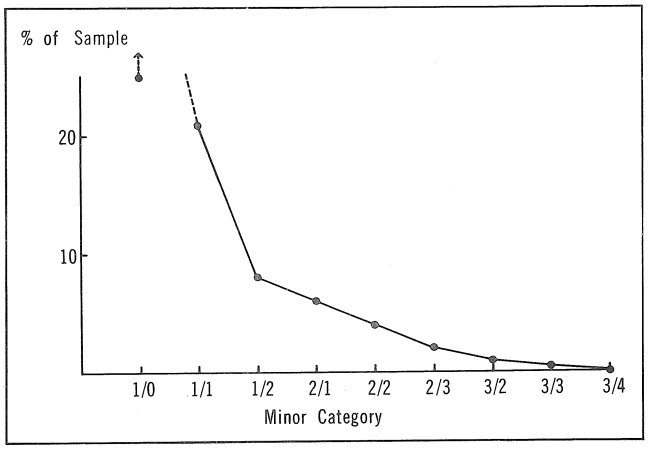



Fig 6.—Percentage distribution of miners with simple coal workers' pneumoconiosis (reader 4).

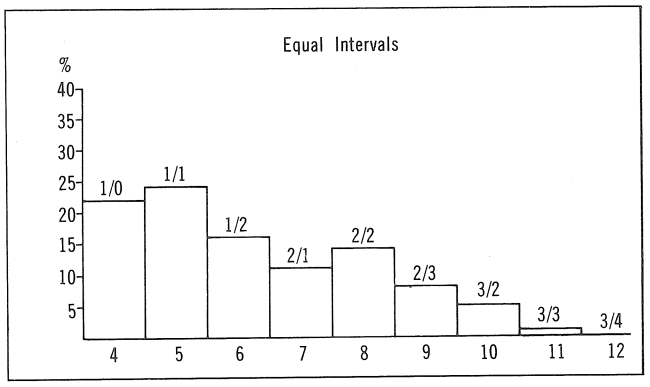
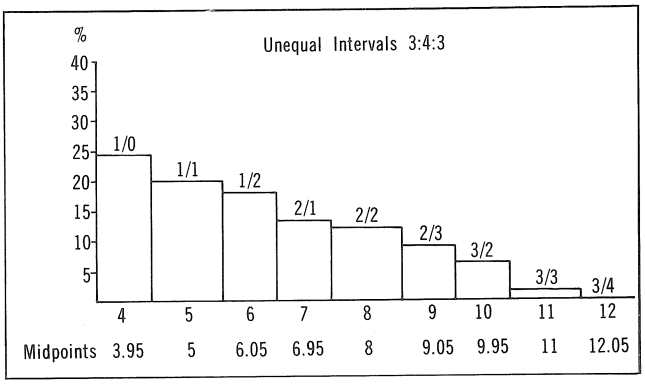



Fig 7, Left.—Histogram of minor categories in miners with simple coal workers' pneumoconiosis (equal intervals). Right,




Histogram of minor categories in miners with simple coal workers' pneumoconiosis (3:4:3 ratio within major categories).

only 4% as category 3. When the distributions for the various subcategories were plotted (Fig 2), an entirely different phenomenon became apparent. A tendency to place relatively more films in the middle of the category was evident; namely, more films were placed in categories 1/1, and 2/2 than were placed in subcategories 1/0, 1/2, 2/1, and 2/3. Such an analysis may not be valid for individual readers because the number of observations per reader may be small, and hence, inferences relative to the proposition that a monotonic downward trend within a major segment of the disease continuum might be erroneous. We, therefore, analyzed the interpretations of those readers who had interpreted 500 films or more. Observations on the reading habits of some of these readers are shown in Fig 3 to 6. For some readers, the "middling" tendency was more obvious for category 1, while for others, it was more apparent for category 2. Its absence in category 3 may well be a consequence of relatively few films placed in this category. Figure 6 depicts the only reader who did not show a tendency "to middle."

## COMMENT

As more and more dust is retained in the lungs, so the roentgenographic category increases; however, the changes both in regard to dust and x-ray category are part of a continuum with seemingly clear-cut incremental steps. It may be argued that the tendency for the majority of readers to place more films in the "middle" of a category than at either end confirms Liddell's[3] original hypothesis regarding the relative widths of the subcategories. But before we accept this, we should ask whether such a distribution of the various subcategories could be artifactual and if the middling that we have observed in most interpreters could be a form of observer bias. We incline to the view that we are observing at least a partial middling bias because we are aware that at least three of the expert interpreters—and we suspect more—included in this study did not and probably still do not use standard films when they are interpreting unknown roentgenograms.

It is generally assumed that the UICC classification forms a discrete scale. Alternatively, one can assume a continuous scale with the reading being "rounded" to the center of the interval. If we assume the intervals to be of the same width, then we get a histogram corresponding to the relative frequency polygon of Fig 2 (Fig 7, left). To produce a monotonically decreasing trend, we need only to widen the intervals for 1/1 and 2/2. In using this approach, it seems that 1/1, 2/2, and 3/3 should be 1⅓ times as wide as each of the other cate-

gories. For statistical analysis, each category may be assigned to the midpoint of its interval. Figure 7, right, shows that these values are not neatly spaced integers as illustrated previously.

If the process is continued further by widening the first four or five intervals, and narrowing the last four or five intervals so that the first is increased more than the second, the second more than the third, and so on, and the ninth decreased more than the eighth, the eighth more than the seventh, the curve can be made to fit a horizontal line. Indeed it can be made to show a monotonic increase or even a gaussian distribution.

The fact that more films are classified in one interval than another, has three possible explanations: (1) The intervals are not of equal width. (2) There are truly more subjects in the midcategories than in the marginal categories. (3) There is a bias that leads to films being placed in an incorrect category.

Liddell (personal communication) favors the first hypothesis. As stated previously, all coal miners are not exposed to heavy dust concentrations, so that a downward trend is to be expected. Thus, one of the patterns shown in Fig 7 can be assumed to be correct. However, there is an infinite number of possible patterns with unequal intervals. Figure 7, right, represents an unequal interval width with a 3:4:3 ratio. This might be expected to be a correct unequal interval because of our automatic usage of base 10, and such a ratio is the closest we can get to equal integers that sum to 10. Although this must be a reason for assuming the unequal model of Fig 7, right, it by no means proves that this model is correct.

The second explanation for the inclusion of unequal numbers of subjects in the subcategories can be eliminated because we are measuring a continual increase of disease, and it does not seem likely that certain miners would show disease progression for a while, then remain stationary for a period, then show further progression and so on. Hence, the explanation must be either that: (1) some intervals are wider than others (Fig 7, right) or (2) there is a reading bias (Fig 7, left). At this time there is no way to determine whether some intervals are wider than others, because we cannot measure the true dust level in the lungs during life.

From a mathematical standpoint, the same problem exists with either model. In Fig 7, left, the excess in category 1/1 is most likely due to values that should have been classified as 1/0 or 1/2. Thus, some values that were greater than 5.5 and some that were less than 4.5 have been rounded to 5. In Fig 7, left, some values greater than 5.5 were rounded to 5 (namely values between 5.5 and 5.6), as were some values less than 4.5. However, the advantage to using the equally spaced model is that the integers are easy to remember. The use of the 3:4:3 unequal intervals scheme adjusts the curve only so that it is monotonically decreasing. It does not remove bias and, in fact, causes problems in remembering what values to assign the categories for statistical purposes.

It may be that the proposition that the number of subjects with category 1, 2, or 3 carries over to well-defined segments of the continuum of abnormality is false and that the patterns being observed are real. On the other hand, if our supposition concerning the distribution of the subcategories is correct, we are observing a middling tendency on the part of most interpreters that is a form of observer bias. Interestingly enough, the only interpreter in whom the middling tendency was absent is not a radiologist. It is known that this interpreter always referred to standard films while categorizing unknowns. Perhaps when the other readers routinely use the standards, their middling tendency will likewise disappear.

## References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## CORRECTION

**For "E," Read "C."**—In the article, "Pressor Activity in Bovine Kidney Homogenate: Enhancement by Cadmium and Zinc Ions," published in the August ARCHIVES (29:110-114, 1974), an error occurred on page 113. In column 3, line 5, the substance presented parenthetically should be "Zn-CDTA," not Zn-EDTA.