and apply admission and discharge criteria more effectively than at present. Such a criteria-based system, however, might necessitate the frequent transfer of patients in order to function efficiently, and this is not considered to be a reasonable or acceptable policy.

As our findings indicate, the range of nursing needs of the elderly is basically similar regardless of their place of care. Thus a preferable solution to the problems of misplacement would be to provide the elderly with the type of care they need, wherever they are placed. This would not necessarily mean an increase in overall manpower requirements; merely a more flexible and integrated approach to their allocation and use.

As the nursing needs for the elderly in residential homes will vary at different times the community nursing service should provide care rather than the home. This agrees with the recommendations of the working party on collaboration between the NHS and local government.²⁶ Much can be gained from closer integration of the services²⁷ and more flexibility rather than further specialisation in deploying those in the health and social services who care for the elderly.

The total number of elderly people needing maximum care at home, however, was small in proportion to the large majority who required little or no nursing help. Some low and medium care patients may well have benefited from day-care facilities, with which the area is well provided. Unfortunately, in this study we could not examine this increasingly important facility. Most of the patients at home needing nursing care did not need clinical or technical services, but only basic nursing care at differing levels of intensity or social support, or both. Measures such as providing advice and help to caring relatives must be a fundamental consideration.²⁸

We have drawn attention to these needs and facilities in an area with a high proportion of residents over retirement age. In many similar places elsewhere in the country the needs of the elderly are already high or likely to rise substantially as the "young old" become older, with consequent increasing pressure on all services. This increased demand will primarily affect the community nursing service, which already encompasses many of the elderly and is often the first to provide help for an elderly person. Nevertheless, clearly the increased demand will have substantial implications for all the other health and social services.

We are grateful to the North-east Thames RHA and the Health and Social Services Authorities of Essex for sponsoring and financing this study.

References

- ¹ Abrams, M, *New Society*, 1975, **33**, 777.
- ² Ashley, J S A, and Klein, R E, *Modern Geriatrics*, 1971, **1**, 320.
- ³ Department of Health and Social Security, *Statistics and Research Report*, No 10. London, HMSO, 1975.
- ⁴ Moseley, L G, *Social and Economic Administration*, 1968, **2**, 168.
- ⁵ Evans, G J, et al, *Lancet*, 1971, **2**, 539.
- ⁶ Parnell, P W, *British Journal of Hospital Medicine*, 1972, **7**, 801.
- ⁷ White, D M D, *Lancet*, 1975, **1**, 27.
- ⁸ Kay, D W K, et al, *British Journal of Psychiatry*, 1964, **110**, 146.
- ⁹ Parsons, P L, *British Journal of Preventive and Social Medicine*, 1965, **19**, 43.
- ¹⁰ Brothwood, J, in *Recent Developments in Psychogeriatrics*, ed D W K Kay and A Walk, p 99. Ashford, Royal Medico-Psychological Association, 1971.
- ¹¹ Department of Health and Social Security, *Services for Mental Illness Related to Old Age*. London, DHSS, 1971.
- ¹² Scottish Health Services Council, *Services for the Elderly with Mental Disorder*. Edinburgh, HMSO, 1970.
- ¹³ World Health Organisation, *Psychogeriatrics*, Technical Report Series No 507. Geneva, WHO, 1972.
- ¹⁴ Andrews, J, et al, *Gerontologica Clinica*, 1972, **14**, 100.
- ¹⁵ Carstairs, V, and Morrison, M, *The Elderly in Residential Homes*, Scottish Health Services Studies, No 19. Edinburgh, Scottish Home and Health Department, 1971.
- ¹⁶ Shepherd, M, et al, *Psychiatric Illness in General Practice*. London, Oxford University Press, 1966.
- ¹⁷ McKeown, T, and Cross, K, *British Journal of Preventive and Social Medicine*, 1969, **23**, 24.
- ¹⁸ Mezey, G, Hodgkinson, H M, and Evans, G J, *British Medical Journal*, 1968, **3**, 16.
- ¹⁹ Macguire, P, et al, *British Medical Journal*, 1974, **1**, 268.
- ²⁰ Harwin, B, in *Roots of Evaluation*, ed J K Wing and H Hafner, p 269. London, Nuffield Provincial Hospitals Trust, 1973.
- ²¹ Barr, A, *Measurement of Nursing Care*, Operational Research Project, No 9. Oxford Regional Hospital Board, 1967.
- ²² Pasker, P, and Ashley, J S A, *Community Medicine*, 1971, **126**, 272.
- ²³ Grad, J, and Sainsbury, P, *British Journal of Psychiatry*, 1968, **114**, 265.
- ²⁴ Cresswell, J, and Pasker, P, *New Society*, 1971, **20**, 407.
- ²⁵ Sanford, J R A, *British Medical Journal*, 1975, **3**, 471.
- ²⁶ Department of Health and Social Security, *Reorganisation of the National Health Service and Local Government in England and Wales. A Report from the working party on collaboration between NHS and Local Government on its activities to the end of 1972*. London, HMSO, 1973.
- ²⁷ Leopoldt, H, et al, *Nursing Mirror*, 1975, **141**, 54.
- ²⁸ Hodgkinson, H M, *British Medical Journal*, 1975, **2**, 23.

Statistics at Square One

IX—Percentages

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British Medical Journal, 1976, **2**, 166-167

Standard error of difference between percentages

Just as a mean and a difference between two means can have standard errors so can a percentage and a difference between two

percentages. Again both the size of the sample and the amount of variation in the population from which it is drawn affect the size of the standard error.

For example, Mr Black is a senior surgical registrar in a large hospital in Edinburgh. He is investigating acute appendicitis in people aged 65 and over. As a preliminary study he examines the hospital case notes over the previous ten years and finds that of 120 patients in this age group, with a diagnosis confirmed at operation, 73 were women and 47 were men. The percentages are: women 60.8%, men 39.2%.

If p represents one percentage, 100 - p represents the other. Then the standard error of each of these percentages is obtained

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by (1) multiplying them together, (2) dividing the product by the number in the sample, and (3) taking the square root:

$$\text{SE percentage} = \sqrt{\frac{p(100-p)}{n}}$$

Mr Black's figures are as follows: SE percentage =
$$\sqrt{\frac{60.8 \times 39.2}{120}} = 4.46.$$

With this standard error we can get 95% confidence limits on the two percentages:

$$60.8 \pm (1.96 \times 4.46) = 52.1 \text{ and } 69.5$$

$$39.2 \pm (1.96 \times 4.46) = 30.5 \text{ and } 47.9.$$

There is a probability of 95% that the percentages of men and women in the population from which the sample came fall within these confidence limits.

Mr Black wonders whether the percentages of men and women in his sample differ from the percentages of all the other men and women aged 65 and over admitted to the surgical wards during the same period. After excluding his sample of appendicitis cases, so that they are not counted twice, he makes a rough estimate of the number of patients admitted in those 10 years and finds it to be about 12 000 to 13 000. He therefore selects every twentieth case and so obtains a sample of 640 patients. Of these, 363 were women and 277 men, giving percentages of 56.7 for women and 43.3 for men.

The percentage of women in the appendicitis sample differs from the percentage of women in the general surgical sample by $60.8 - 56.7 = 4.1\%$. Is this difference of any significance?

There are two ways of calculating the standard error of the difference between two percentages. One is theoretically more soundly based for the problem we are considering—testing a null hypothesis. The other is in practice more readily calculated and usually gives almost the same result.

The following formula gives the theoretically preferable method:

$$\text{SE diff \%} = \sqrt{\frac{p \times (100-p)}{n_1} + \frac{p \times (100-p)}{n_2}}$$

To obtain p we must amalgamate the two samples and calculate the percentage of women in the two combined; $100-p$ is then the percentage of men in the two combined. n_1 and n_2 are the numbers in each sample.

Number of women in the samples: $73 + 363 = 436$

Number of people in the samples: $120 + 640 = 760$

% of women: $(436 \times 100)/760 = 57.4$

% of men: $(324 \times 100)/760 = 42.6$

Putting these numbers in the formula, we find the standard error of the difference between the percentages is

$$\sqrt{\frac{57.4 \times 42.6}{120} + \frac{57.4 \times 42.6}{640}} = 4.92.$$

In practice it is generally simpler to use the percentages in each sample as in the following formula:

$$\sqrt{\frac{p_1 \times (100-p_1)}{n_1} + \frac{p_2 \times (100-p_2)}{n_2}}$$

With Mr Black's figures we have:

$$\sqrt{\frac{60.8 \times 39.2}{120} + \frac{56.7 \times 43.3}{640}} = 4.87.$$

The results obtained by these two methods differ in this case by only 0.05, which is negligible.

The difference between the percentage of women (and men) in the two samples was 4.1%. To find the probability attached to this difference we divide it by its standard error (obtained by the second, more convenient method above): $4.1/4.87 = 0.84$. As this ratio is less than one standard error, the difference between the percentages in the two samples could have been due to chance alone.

Standard error of a total

The total number of deaths from a particular disease varies from year to year in a town. When the population of the town or the area where they occur is fairly large, say, some thousands, and provided the deaths are independent of one another, the standard error of the number of deaths from a specified cause is given approximately by its square root, $\sqrt{n}$. Further, the standard error of the difference between two numbers of deaths, n_1 and n_2 , can be taken as $\sqrt{n_1 + n_2}$. This can be used to estimate the significance of a difference between two totals by dividing the difference by

$$\text{its standard error: } \frac{n_1 - n_2}{\sqrt{n_1 + n_2}}$$

It is important to note that the deaths themselves must be independently caused; for example, they must not be the result of an epidemic such as influenza. And the reports of the deaths must likewise be independent; for example, the criteria for diagnosis must be consistent from year to year and not suddenly changed in accordance with a new fashion or test.

Despite its limitations this method has its uses. For instance, in Carlisle the number of deaths from ischaemic heart disease in 1973 was 276. Is this significantly higher than the total for 1972, which was 246? The difference is 30. The standard error of the difference is $\sqrt{276 + 246} = 22.8$. We then take $30 \div 22.8 = 1.313$. This is clearly much less than 1.96 times the standard error at the 5% level of probability. Reference to table 7.1 shows that in fact $P > 0.1$. The difference could therefore easily be a chance fluctuation.

This method should be regarded as giving no more than approximate but useful guidance, and is unlikely to be valid over a period of more than very few years owing to changes in diagnostic techniques. An extension of it to the study of paired alternatives will be described next week.

Exercise 9. In an obstetric hospital 17.8% of 320 women were delivered by forceps in 1975. What is the standard error of this percentage? *Answer:* 2.1%. In another hospital in the same region 21.2% of 185 women were delivered by forceps. What is the standard error of the difference between the percentages at this hospital and the first? *Answer:* 3.7%. What is the difference between these percentages of forceps delivery and what is its significance? *Answer:* 3.4%; $0.5 > P > 0.3$.

El Greco's style of painting is with monotonous regularity attributed to astigmatism. But if you see a vertical line as a sloping one or rounded objects elongated, would the same thing not happen with the outlines of the canvas so that things cancel out?

This theory, that El Greco's tendency to elongate his figures along a meridian 15° off the vertical, was proposed in 1913, and has been argued tediously. There is, of course, little truth in it for stylistic and historical reasons, quite apart from this obvious riposte—that the subject should correspond to the rendering, however much they are both altered by the misshapen eye into a distorted percept within the artist's brain. This objection was countered, during the prolonged German-Spanish controversy, by the observation that if one covers one eye by an astigmatic lens (the fellow eye being closed) and attempts to draw a circle "out of one's head" it will come out as an oval, whereas if one tries to copy a circle already on the page, although both the circle and its "copy" will appear oval through the lens, the latter will in fact emerge on paper as a circle. Hence (argued the Germans) the greater elongation of the angels that El Greco depicted as opposed to the humans, who were often portrayals of his contemporaries. The whole issue has been recounted, and properly disposed of, in a recent analysis of the influence of eye disorders on personality and imagery.¹ But such a hoary theory will not readily be laid to rest. Astigmatism can, incidentally, affect an artist's rendering by giving him an incentive to avoid his least clear meridian, but that is another story.

¹ Trevor-Roper, P D, *The World through Blurred Sight*. London, Thames and Hudson, 1970.