to answer 'yes' or 'no,' but if you do not understand a question then ask me about it. Your answers will be treated confidentially."

Cough

Do you cough when you get up or first thing in the morning? Yes/No 1

Do you cough during the rest of the day—I don't mean at the end of the shift? Yes/No 2

(If the answer to 1 or 2 is "yes" go on to 3. If both are "no" go on to 4)

Do you cough like this on most days for as much as three months in the year? Yes/No 3

Phlegm

Do you bring up phlegm when you get up or first thing in the morning? Yes/No 4

Do you bring up phlegm during the rest of the day? Yes/No 5

(If the answer to 4 or 5 is "yes" go on to 6. If both are "no" go on to 7)

Do you bring up phlegm like this on most days for as much as three months in the year? Yes/No 6

Breathlessness

Do you have to walk slower than other people on the level? Yes/No 7

Wheezing

Do you ever have wheezing or whistling in your chest?—I don't mean when you have a cold Yes/No 8

Weather

Does the weather affect your chest? Yes/No 9

Smoking

Do you smoke? Yes/No 10

If yes: Cigarettes a day 11

Ounces of tobacco per week 12

If no: Have you ever smoked as much as 10 cigarettes a day for 10 years? Yes/No 13

Chest Illness

In the last three years have you had a chest illness that has kept you off work for more than a week? Yes/No 14

If yes: What did the doctor say it was? 15

We thank the men at the eight collieries for their excellent co-operation. We are grateful for the assistance which we received from officials of the Board and of the Unions in the industry. We also thank Dr. J. G. Scadding and Mr. D. Hicks for helpful criticism and advice. Finally, we wish to acknowledge the valuable work of our technical staff.

REFERENCES

- Ashford, J. R., *et al.* (1961). To be published.
 — Forwell, G. D., and Routledge, R. (1960). *Brit. J. industr. Med.*, **17**, 114.
 Beckmann, H. (1951). *Beitr. Silikose-Forsch.*, No. 11, p. 11.
 Böhme, A., and Lent, H. (1951). *Ibid.*, No. 11, p. 1.
 Carpenter, R. G., Cochrane, A. L., Gilson, J. C., and Higgins, I. T. T. (1956). *Brit. J. industr. Med.*, **13**, 166.
 Chapman, P. J. (1960). *Symposium on Industrial Pulmonary Diseases*, edited by E. J. Kline and C. M. Fletcher, p. 78. Churchill, London.
 Coates, E. O., *et al.* (1961). *Proceedings of XIIIth International Congress on Occupational Health*. In press.
 Cochrane, A. L., Davies, I., Chapman, P. J., and Rae, S. (1956). *Brit. J. industr. Med.*, **13**, 231.
 Fay, J. W. J. (1957). *Nature (Lond.)*, **180**, 309.
 — and Ashford, J. R. (1960). *Brit. J. industr. Med.*, **17**, 279.
 — and Rae, S. (1959). *Ann. occup. Hyg.*, **1**, 149.
 Fletcher, C. M., Elmes, P. C., Fairbairn, A. S., and Wood, C. H. (1959). *Brit. med. J.*, **2**, 257.
 Foubert, P., Nadiras, P., and Batique, L. (1954). *Rev. méd. minière*, **7**, No. 25, p. 3.
 Gaensler, E. A. (1951). *Amer. Rev. Tuberc.*, **64**, 256.
 Gilson, J. C., and Hugh-Jones, P. (1955). *Spec. Rep. Ser. med. Res. Coun. (Lond.)*, No. 290.
 Gough, J. (1959). *Modern Trends in Pathology*, edited by D. H. Collins, p. 273. Butterworth, London.
 Hart, P. D'A., and Aslett, E. A. (1942). *Spec. Rep. Ser. med. Res. Coun. (Lond.)*, No. 243.
 — and Cochran, J. B. (1958). *Tubercle (Lond.)*, **39**, 296.
 — Cochrane, A. L., Gilson, J. C., and Wood, C. H. (1959). *Brit. J. industr. Med.*, **16**, 255.
 — Oldham, P. D., Cochrane, A. L., and Gilson, J. C. (1956). *Brit. med. J.*, **2**, 904.
 International Labour Organization (1953). *Proc. 3rd Int. Conf. Experts on Pneumoconiosis, Sydney, 1950*. Geneva.

- Lavenne, F. (1961). *C.R. Journées Françaises de Pathologie Minière*. In press.
 — and Belayew, D. (1953). Institut d'Hygiène des Mines, Hasselt. Medical Service Communication No. 106.
 McCallum, R. I., and Browne, R. C. (1955). *Brit. J. industr. Med.*, **12**, 279.
 — and Newell, D. J. (1956). N.C.B. Medical Service Research Report No. 22.
 McKerrow, C. B., McDermott, M., and Gilson, J. C. (1960). *Lancet*, **1**, 149.
 Motley, H. L. (1960). *J. Amer. med. Ass.*, **172**, 1591.
 Newell, D. J., and Browne, R. C. (1955). *J. Fac. Radiol. (Lond.)*, **7**, 20.
 Pemberton, J. (1956). *Arch. industr. Hlth*, **13**, 529.
 Worth, G., and Dickmans, H. (1950). *Tuberk-Arzt*, **4**, 495.
 Zorn, O. (1949). *Beitr. Silikose-Forsch.*, No. 2, p. 1.

NOISY PNEUMOTHORAX OBSERVATIONS BASED ON 24 CASES

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"The patient laughingly said he could reproduce the sound. He turned on his left side, shifted about, and then said 'there it is' . . . ; over the apex of the heart with each impulse, a most amazing sound was heard—crunching is the best adjective—it certainly conveyed the impression of air being churned or squeezed about in the tissues—when the patient turned on his back, the sound at once disappeared." Thus Hamman (1937) described a case with clinical features many would now term "clicking pneumothorax." The chest x-ray picture was normal in this patient and no diagnosis was made. Later he encountered a similar noise in a patient with subcutaneous emphysema and radiological evidence of air in the mediastinum (Hamman, 1939), and, ever since, this sign has been acclaimed, especially in the United States, as diagnostic of mediastinal emphysema. Many contributors have paid little attention to the article by Scadding and Wood (1939) in which they reported four patients with shallow benign left pneumothorax, all of whom had the clicking variety of Hamman's sign. More recently, Chapman (1955), in Texas, and Scott (1957) have defined the condition more accurately by pointing out that shallow left apical pneumothorax is by far the most common cause of Hamman's sign.

Material

In the past 10 years we have encountered 24 patients with clicking, crackling, or crunching sounds at the cardiac apex which followed or accompanied left-sided chest pain. They were all young healthy subjects, all males apart from two, with no significant dyspnoea or systemic upset. The youngest were four youths of 18 and the oldest was a woman aged 36. In some instances the pain was severe initially, but usually it settled within hours while the noise often lasted some days. As in Hamman's original case, these patients sometimes had to assume a certain posture, such as leaning to the left, before the sounds became audible. These were synchronous with the heart beat and varied with respiration, often being louder in expiration. In five

patients the sounds could be heard without a stethoscope, and relatives had heard it. A wife found it disturbing in bed, and in another instance the consultant was greeted by the diagnostic sounds as he entered the patient's room.

Bean (1958) estimates that the sound is heard at a distance from the chest in 10% of cases. On the other hand, one or two patients did not volunteer the information, but admitted the presence of the noise when asked about it, or recognized it later when their attention was drawn to its presence on reclining to the left. Apart from slight diminution of breath sounds over the left upper lobe in several cases, no other abnormal signs were detected. None had subcutaneous emphysema, and when the initial pain had vanished they all felt perfectly well.

Radiological Signs

Eighteen patients had an obvious shallow, left apical pneumothorax. Four other films were reported normal initially by the radiologist, but on further scrutiny, sometimes with the help of a film taken in full expiration, a shallow pneumothorax at the left apex was seen. In a further two patients no abnormality was seen, but no expiratory films were taken. Mediastinal air was never demonstrated. Occasionally a pleural line parallel to the left heart border suggested localized air-pocketing, as did air seen in the region of the lingula in a left lateral view. Air was never demonstrated in the costal or diaphragmatic pleural space. It is of importance to note that some of these shallow pneumothoraces may be very easily missed, or even impossible to delineate on a standard inspiratory x-ray film, but become quite obvious on a film taken in full expiration (Figs. 1 and 2).

The Sounds

When not wrongly labelled "spontaneous mediastinal emphysema," the syndrome has been most often termed

"clicking pneumothorax," and the original contribution of Scadding and Wood referred to "systolic clicks due to left-sided pneumothorax." Only in some patients, however, and only at times in the same patient, has the sound heard been of "clicking" quality. At one time or another in this condition we have heard sounds which could be described as clicking, crunching, crackling, bubbling, and grating. Our phonocardiogram in Case 19 (Fig. 3) illustrates the variations which may occur even in the same patient. Tracing A, taken in the erect position, shows no definitely abnormal sound; tracing B shows the sound as a regularly recurrent "click" in systole (patient here was still erect but inclined towards the left side); while tracing C shows a series of abnormal sounds of a more complex nature both in systole and in diastole (the patient here was lying on his left side). Draper (1948) talked of sounds in one such patient being like "pebbles dropped in a metal bucket," and Miller (1945) spoke of a "grinding" sound. For this reason we feel that "noisy pneumothorax" is a more satisfactory descriptive term.

It is salutary to add the syndrome to the list of chest conditions which at times may be diagnosed by the stethoscope with greater certainty than by x-ray examination.

Mechanism of Production of the Sounds

From Figs. 1 and 2 it is seen how the air pocket in a small pneumothorax changes its size and shape with alteration of intrapleural pressure during the respiratory cycle. In these patients air-pocketing seems to occur on the medial aspect of the left lung, where forcible changes in shape of the ventricles can produce sudden changes in intrapleural pressure. One or more bubbles of air may be flattened, expanded, and moved in position between the viscous layers of parietal and visceral pleurae, producing sounds of varying quality, much as the consonant "t" and allied popping sounds can be formed between the tongue and palate (Scadding and

FIG. 1.—Routine film taken on inspiration, showing small left apical pneumothorax. FIG. 2.—Film taken on full expiration; pneumothorax now very obvious.

Wood, 1939). When rather more than a bubble of air is present tapping sounds may be produced by the action of the ventricle touching the lung surface in systole. We know that spontaneous pneumothorax is almost as common on the right side as on the left, and so we must assume that such localized air-pocketing on the right side either does not occur or, as seems more likely, is not affected to the same extent by the less forcible action of the right atrial surface of the heart.

Illustrative Case Histories

Our first patient was a most interesting example of the condition, in view of his five attacks in less than a year and the erroneous diagnoses made during his earlier admissions.

FIG. 3.—A. Normal phonocardiogram—in erect position. B. Systolic "click"—patient lying reclining to left. C. Complex sounds—patient lying on left side.

Case 1.—A clerk was first admitted to hospital in March, 1949, at the age of 18, with precordial pain of several days' duration. Three weeks previously he had been punched heavily on the praecordium. The pain was absent on lying flat. A harsh rasping sound was heard at the apex in diastole when he sat up or lay on the left side. He seemed otherwise well and the chest x-ray picture was reported normal. A presumptive diagnosis of traumatic pericarditis was made and he was discharged feeling fit after three weeks. A month later he was readmitted with a recurrence of identical symptoms and signs, which disappeared rapidly; he was allowed home in one week. Two months after this he had a recurrence of the pain and felt a "bubbling" in his chest when he lay on his left side. On this occasion "coarse pericardial friction" was heard in the left lateral position. A presumptive diagnosis of "pneumopericardium with mediastinal emphysema" was made, but on this occasion we were able to demonstrate a left apical pneumothorax radiologically. Once more his symptoms and signs quickly subsided. Two weeks after his discharge he had a further attack, which cleared in four days, but five months later he was admitted to hospital for the fifth time with identical findings, the only abnormal sign being the presence of "clicking" sounds at the apex on sitting up or when lying on his left side. A recurrence of the left apical pneumothorax was noted on x-ray examination, and a week or two later, in February, 1950, left pleurodesis was performed. Since then he has reported at regular intervals and has had no recurrence.

Case 6.—In March, 1956, a man aged 36 was admitted to hospital with pain in his left chest and marked shortness of breath of several hours' duration. He had had a spontaneous pneumothorax on the left side 18 months and three years previously. Clinically he presented the features of a large left-sided pneumothorax, and this was confirmed radiologically. The acute symptoms rapidly subsided after a week's rest in bed, and he was allowed home though radiologically the pneumothorax was not completely absorbed. When seen about a month later he stated that he felt almost normal apart from the occurrence in the previous two weeks of a peculiar "clicking" sound in his chest; this sound was most obvious while he was lying in bed or on his left side. His wife had often heard it when he adopted this posture. On examination loud systolic "clicks" were audible internal to the apex. X-ray examination showed considerable re-expansion of his lung with only a shallow apical air-collection remaining. In view of his three attacks of left-sided pneumothorax, he had a left pleurodesis performed in July, 1956, and since then has had no recurrences.

Case 10.—A tobacco-factory worker aged 27 developed sudden catching pain in the left pectoral region and some dyspnoea on rising in the morning. He went to work, and his condition gradually improved. He reported to his doctor that evening and attended hospital next day. Slight hyperresonance and distant breath sounds were detected at the left apex and, just internal to the apex beat, systolic grating sounds were heard. X-ray examination confirmed a small left apical pneumothorax. When seen three days later the abnormal sounds had disappeared but the pneumothorax was still just visible on an x-ray film. He returned to work a week later.

Case 15.—A man aged 32 developed a dull precordial pain at his work and was short of breath at the onset. He went home to bed, but resumed work the next day and felt well apart from slight dyspnoea on exertion. When seen on the third day the only abnormality detected was reduction of air entry at the left apex and systolic "clicking" when he lay on his left side. On questioning he stated that he had been aware of his heart beating and had heard it "clicking while sitting upright." X-ray examination confirmed the presence of a shallow left apical pneumothorax.

Case 17.—A youth of 19 had developed a sudden tightness in his chest while at work but not while doing anything

strenuous. He was brought into the casualty department slightly short of breath and aware of a "rumbling" in his left chest. He was not distressed and no abnormality was found except for a harsh rasping sound heard internal to the cardiac apex, chiefly systolic, but also heard in early diastole and loudest in expiration while lying on his left side. X-ray examination showed a small left apical pneumothorax. When seen four days later no abnormal sounds were present and he was no longer breathless.

Case 21.—This patient, aged 19, complained of the sudden onset of aching pain in his left lower chest and over the praecordium of 24 hours' duration. He stated that his parents had heard a "clicking" sound coming from his chest when he went to bed. His doctor referred him to hospital labelled "coronary thrombosis in a lad of 19 years." On examination he was not obviously distressed. Blood-pressure was normal. A systolic "clicking" sound was audible internal to the cardiac apex in the left lateral position. X-ray examination showed a shallow left apical pneumothorax. He was not admitted to hospital, and when seen four days later he was symptom-free and repeat x-ray films showed that the pneumothorax had been absorbed. He was seen three months later; he had no complaints and an x-ray film of the chest was normal.

Differential Diagnosis

Most of our patients were seen as suspected cardiac cases. The usual initial diagnosis was "myocardial infarct with a peculiar type of pericardial friction sound." Our first patient was variously labelled "traumatic pericarditis," "mediastinal emphysema," and "pneumopericardium" before a left pneumothorax was demonstrated during his third attack. In the literature one finds these patients initially diagnosed as dissecting aneurysm, pulmonary embolism, mediastinitis, and ruptured heart valve; indeed, when we remember that these patients are not ill, it is surprising how often lethal labels have been attached. Patients never fail to recognize a recurrence, and doctors seldom have difficulty in diagnosing a subsequent case. If the noise is not obvious the pain may be ascribed to pleurisy, intercostal neuralgia, muscle strain, or Bornholm disease (Draper, 1948).

In our series (apart from recurrences) the only patients who came to us correctly diagnosed were the second and third examples of the condition from one practice. A fourth patient from the practice was referred as a possible case of myocardial infarction as he did not volunteer that he had in fact experienced the peculiar sensation and noise. Hamman's sounds may occur with spontaneous and traumatic mediastinal emphysema, but such patients are usually ill or at least distressed. Similar sounds may be heard occasionally with bullous emphysema, pneumoperitoneum, and dilated lower oesophagus (Chapman, 1955).

Discussion

It has been estimated (Wynn-Williams, 1957) that about 2,500 cases of spontaneous pneumothorax occur annually in Great Britain, and that a family doctor with an average list might expect to meet one such case every 10 years or so. Only a proportion of these, perhaps a sixth (Chapman, 1955), will be of the noisy type. Yet, either by coincidence or because of increased awareness, we have seen four of our series from one practice of three doctors in these 10 years. Recurrence and male predominance is found in this type as in spontaneous pneumothorax in general. We have no evidence that the initial mechanism is different from the usual bursting of

a visceral pleural blister with accompanying alveolar air leakage. It seems to be the small volume of air leak that is important in producing the noise, as the syndrome can be produced experimentally by inducing a left pneumothorax with less than 150 ml. of air (Scadding and Wood, 1939) and may also occur when a larger pneumothorax is almost completely expanded (as in Case 6). We have also heard the characteristic sounds in the early stages of a left pneumothorax, disappearing with further air leakage. Thomson (1947) described three similar cases.

These examples indicate that the costal pleura is not adherent. Similar sounds may be heard after penetrating wounds of the left chest, having been termed "pericardial knock" (Smith, 1918), and after left thoracotomy; here it is more difficult to exclude pneumomediastinum or pneumopericardium as the cause, although it seems to occur only in the case of left chest involvement. It is perhaps not surprising that Hamman's sign has often been accepted as indicating benign spontaneous pneumomediastinum, as routine x-ray examination may fail to demonstrate a pneumothorax. Also it is difficult to be certain whether an air pocket on the medial aspect of the left lung or lying anteriorly in the left lateral film is intrapleural or lying between the parietal pleura and pericardium, in the mediastinum.

It is known from clinical experience (Heichman *et al.*, 1958) and from experimental work (Macklin, 1939) that air under tension in the mediastinum may burst into both pleural spaces or into either side with equal frequency. It is not surprising, then, to find contributors to this syndrome of supposed "benign spontaneous pneumomediastinum" (Miller, 1945) wondering why a pneumothorax, when demonstrable, is always on the left side. We feel, nevertheless, that a young healthy adult who develops sudden chest pain, who has characteristic sounds at the cardiac apex, and who yet remains apparently well has almost certainly a shallow spontaneous left pneumothorax.

While Hamman's sounds do occur in traumatic and severe mediastinal emphysema (as in oesophageal rupture), nevertheless we submit that "benign cases" have no mediastinal air leak, but only a shallow left pneumothorax which may or may not be easily demonstrated on a routine chest film. Further evidence of this belief is provided by Draper (1948), who, on studying the literature, finds that the recurrence rate of 25% is common to this benign syndrome and spontaneous pneumothorax in general.

Summary

Hamman's sign (crunching, crackling, or clicking sounds near the cardiac apex) may be heard in traumatic or severe spontaneous mediastinal emphysema, but shallow left pneumothorax is a much more frequent cause. Hamman's sounds associated with left chest pain are often thought to indicate serious heart disease, and in the present series of 24 cases the following conditions were initially suspected: benign and traumatic pericarditis, coronary thrombosis with pericarditis, pneumopericardium, and ruptured heart valve; while other authors mention dissecting aneurysm, pulmonary embolism, mediastinitis, pleurisy, intercostal neuralgia, muscle strain, and Bornholm illness in differential diagnosis.

Noisy pneumothorax is a benign condition, usually occurring in young healthy males, and is invariably left-sided. The mechanism of production of the sounds is related to a localized collection of air in the pleura being compressed and moved on the medial aspect of the left lung by the forcible action of the ventricles.

In the past the condition has often been reported as "benign spontaneous mediastinal emphysema," but there is considerable room for doubt about this diagnosis as a clinical entity.

Shallow spontaneous pneumothorax presumably occurs as often on the right side, but it is rarely recognized because of the absence of Hamman's sign and lack of proximity of the pain to the praecordium. In a healthy patient with sudden chest pain this diagnosis cannot be excluded without an x-ray film taken in full expiration.

ADDENDUM.—Since this paper was accepted we have encountered an example of right-sided shallow apical pneumothorax accompanied by a faint crackling noise down the right border of the sternum. So far as we can ascertain, this is the first recorded example, although Black (1948) did describe the case of a patient with a complete right pneumothorax who experienced a clicking sound while walking. In such a case the presence of a small quantity of fluid may have been responsible for the production of the sounds, and the example is scarcely comparable. Our patient was Case 23 in the above series, who had had a typical left noisy pneumothorax 11 months before. It would appear that in the case of an active heart the right atrial surface may occasionally disturb an air pocket sufficiently to produce at least a faintly audible sound.

REFERENCES

- Bean, W. B. (1958). *Dis. Chest*, **34**, 193.
 Black, A. B. (1948). *Lancet*, **1**, 408.
 Chapman, J. S. (1955). *Amer. J. Med.*, **18**, 547.
 Draper, A. J. (1948). *Ibid.*, **5**, 59.
 Hamman, L. (1937). *Trans. Ass. Amer. Physns*, **52**, 311.
 — (1939). *Bull. Johns Hopk. Hosp.*, **64**, 1.
 Heichman, J., Fialkov, G., and Jungmann, A. (1958). *Dis. Chest*, **33**, 432.
 Macklin, C. C. (1939). *Arch. intern. Med.*, **64**, 913.
 Miller, H. (1945). *Amer. J. med. Sci.*, **209**, 211.
 Scadding, J. G., and Wood, P. (1939). *Lancet*, **2**, 1208.
 Scott, J. T. (1957). *Dis. Chest*, **32**, 421.
 Smith, S. M. (1918). *Brit. med. J.*, **1**, 78.
 Thomson, A. P. (1947). *Lancet*, **1**, 630.
 Wynn-Williams, N. (1957). *Thorax*, **12**, 253.

The two-year mass radiography campaign in Scotland, in which 1,844,268 people were examined, disclosed 12,094 new cases of tuberculosis. There was an exceptional public response, but at least one-third of adults in the survey areas failed to co-operate. Evidence suggests that disease among these people is as high as, if not higher than, among those who did co-operate. A report of the campaign, *The Two-year Mass Radiography Campaign in Scotland 1957-58*, (H.M.S.O., price 7s.), makes the following points: nearly two-thirds of the cases were found in Glasgow; nearly four-fifths were found in Glasgow, Edinburgh, Aberdeen, and Dundee; new cases of tuberculosis were mostly among older men and younger women; about two-thirds of all cases were among men; fewer than expected were recalled for full-size radiography; the total number radiographically examined was some 50% higher than expected. A feature of the campaign was the relatively better support given by women in all age groups. The towns in which the male response was the greater were Edinburgh, Dundee, and Aberdeen. The highest response rates were by both men and women belonging to the 15 to 25 and 45 to 59 age groups. The report adds that the trend of tuberculosis will require continued study over a period of years to determine the long-term influence of this campaign.

MALARIA IN AFRICAN CHILDREN WITH DEFICIENT ERYTHROCYTE GLUCOSE-6-PHOSPHATE DEHYDROGENASE

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It has been recognized for twenty years that some subjects—particularly among populations of African, Asian, or Mediterranean origin—are apt to develop haemolysis when given therapeutic doses of the anti-malarial 8-aminoquinolines (primaquine, pamaquin, etc.), sulphonamides, and certain other drugs. Beutler (1959) and his colleagues showed that sensitivity to primaquine is due to an intrinsic erythrocyte defect. One of the most striking features of the defect is diminished activity of the enzyme glucose-6-phosphate dehydrogenase (G6PD) which catalyses the first and rate-controlling step in the hexose monophosphate shunt metabolic pathway (Carson *et al.*, 1956). It has been suggested that the low G6PD in sensitive subjects may not be the primary defect, but that stromal activation of the enzyme may be at fault (Rimon *et al.*, 1960).

Childs and Zinkham (1959) and others have shown that the defect is inherited as a sex-linked character, with full expression in male hemizygotes (having an X chromosome carrying the mutant gene, together with a normal Y chromosome) and female homozygotes (having two X chromosomes carrying the mutant gene) and partial expression in female heterozygotes (having an X chromosome carrying the mutant gene and a normal X chromosome).

Although the G6PD-deficiency trait is not usually associated with haemolysis, there is no doubt that it is potentially harmful. In Mediterranean countries subjects with the trait develop favism after ingestion of broad beans (see Beutler, 1959), and evidence is accumulating that they suffer from haemolysis when exposed to virus infections (Szeinberg *et al.*, 1960; Marks, 1960). In spite of this hazard, the enzyme-deficiency trait has attained high frequencies in certain areas, including East Africa, where in some tribes it is found in 25% of males (Allison, 1960). As Motulsky (1960) and Allison (1960) have emphasized, the distribution of the enzyme-deficiency trait parallels that of *Plasmodium falciparum* malaria until recent eradication. The question therefore arises whether the trait has become common in malarious regions because carriers are protected to some extent against falciparum malaria, as is the case with the sickle-cell gene (Allison, 1957).

The present investigation was undertaken to test this hypothesis directly by measuring parasite rates and densities in susceptible African children with and without enzyme deficiency, living in a holoendemic area. Young children were selected for analysis, as in an earlier investigation of malaria and the sickle-cell trait (Allison, 1954), because in older children and adults the effects of acquired immunity may be so great as to overshadow inherited resistance to malaria (Allison, 1957).