Bedford Glaucoma Survey

J. L. K. BANKES,* M.B., B.S., F.R.C.S., D.O. ; E. S. PERKINS,* M.D., PH.D., F.R.C.S.

S. TSOLAKIS,* M.D., D.O. ; J. E. WRIGHT,* M.D., F.R.C.S., D.O.

Numerous glaucoma surveys have been reported from North America and a few European countries since 1950, when Berens and Tolman screened 10,500 persons (see Posner and Fogland (1964) for a review of the literature up to 1962). The first survey in this country was carried out at Oxford by Luntz et al. (1963), and several other surveys are in progress (Hunt, 1966). The survey of a defined population carried out in Wales by Hollows and Graham (1966) is of particular interest, as it covered 91.9% of this population.

In this paper we wish to report the results obtained from 5,941 persons screened at Bedford, with particular reference to the effect of age, sex, and other factors on ocular tension and the diagnostic problems encountered in the assessment of borderline cases of glaucoma. Some preliminary findings have been published (Wright, 1966).

The aims of the survey, which was initiated by the Medical Officer of Health for Bedford, the late Dr. C. L. Sharp, and financed by the Ministry of Health, were as follows: (1) to determine the prevalence of glaucoma in individuals over the age of 40 years ; (2) to determine the distribution of ocular tensions in the population screened and to attempt to relate the ocular tension to various factors, such as age, sex, menstrual cycle, and time of day ; (3) to assess the relative merits of various diagnostic methods for the detection of glaucoma ; and (4) to investigate the early stages in the development of glaucoma.

Method

The survey was held under the auspices of the local authority health department, and after a preliminary publicity campaign cards requesting an appointment for the tests were distributed to the general public. Appointments were offered only to those over the age of 40, though 66 people under 40 attended and were screened. On registration at the screening clinic the secretary recorded, in addition to the name, address, age, and sex, whether there was a family history of glaucoma, and the time of day. In the case of women a note was also made of the time of the last menstrual period.

Novesine (oxybuprocaine hydrochloride) 0.5% was used for topical anaesthesia followed by one drop of 0.5% sodium fluorescein. The ocular tension was measured first in the right and then in the left eye with the Goldmann applanation tonometer, recording the mean of three readings for each eye.

The patients were then seen by the ophthalmologist, who took a brief ocular and family history, always inquiring for a history of haloes or transient blurring of vision, and carried out an external examination and ophthalmoscopy. The criteria used for asking the patient to return to the assessment clinic for further tests were: (1) applanation reading of 21 mm. Hg or above, (2) difference of 5 mm. Hg between the two eyes, (3) suspicious discs, (4) history of haloes or attacks of blurred vision, and (5) family history of glaucoma. Patients in whom the findings were normal were discharged. Those found to have ocular abnormalities other than glaucoma that required treatment were referred with a report to their family doctor.

* Institute of Ophthalmology, University of London.
Address for reprints: E. S. Perkins, Institute of Ophthalmology, Judd Street, London W.C.1.

At the assessment clinic a routine examination of the patient's peripheral and central fields was made with the Lister perimeter and the Globuck semi-automatic field recorder. After three applanation readings on each eye the patient had a thorough ophthalmological examination, including gonioscopy, and was referred for tonography. In those cases suspected of angle closure, dark-room or mydriatic tests were carried out, a rise of 8 mm. Hg or more being accepted as a positive result.

Distribution of Applanation Tensions

Results

The age and sex distribution of the 5,941 persons screened are given in Table I. The mean tension of 11,849 eyes was 16.29 mm. Hg, with a standard deviation of 3.43. Study of the distribution of tension readings in the entire sample suggests that the curve has a skew to the right in favour of high tension readings (Fig. 1). This is confirmed when the results are plotted on a probability scale as a cumulative percentage frequency ; this shows both the size and the site of any deviation from a Gaussian distribution (Fig. 2). It can be seen that there is agreement with the Gaussian distribution for tensions below approximately 21 mm. Hg, but that above this level there is a progressive divergence from the Gaussian curve. As Hollows and Graham (1966) also found, this skewness to the right, or the tendency for more readings to be higher than in a normal distribution, increases with age. This is demonstrated by the cumulative percentage frequency graphs for different age groups (Fig. 3).

With the criteria previously described, 708 patients (11.9% of the total) were referred for assessment. In addition, 71

TABLE I.—Age and Sex of Total Population Screened

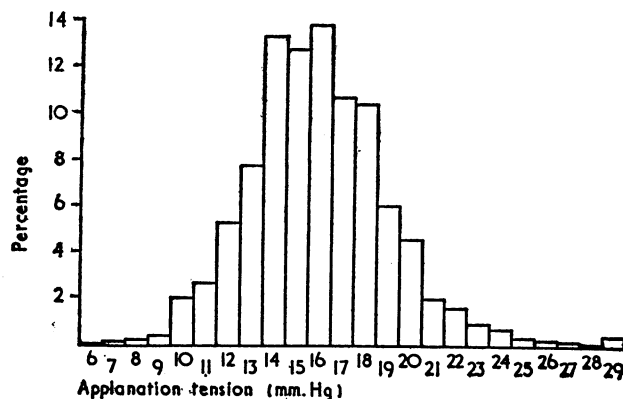| Age Group	Men	Women	Total
20–29	3	3	6
30–39	39	21	60
40–49	861	1,077	1,938
50–59	806	1,158	1,964
60–69	454	883	1,337
70–79	207	359	566
80+	23	47	70
Total	2,393	3,548	5,941

FIG. 1.—Frequency distribution of ocular tensions of all subjects.

patients (1.19%) were found to have ocular conditions other than glaucoma which required immediate attention, and they were referred to their general practitioners. The remaining 5,162 were thought to represent a normal population, and the following statistics refer to this group.

The mean tension of all 10,297 normal eyes was 15.66 mm. Hg, with a standard deviation of 2.49. The means, standard deviations, and standard errors for male and female right and left eyes are shown in Table II. The mean tension of the female eyes was significantly higher than that of the male eyes, and the mean tension of the right eyes in both sexes was significantly higher than that of the left eyes. The difference between the right and left eyes is presumably due to the fact that the right eye was always measured first.
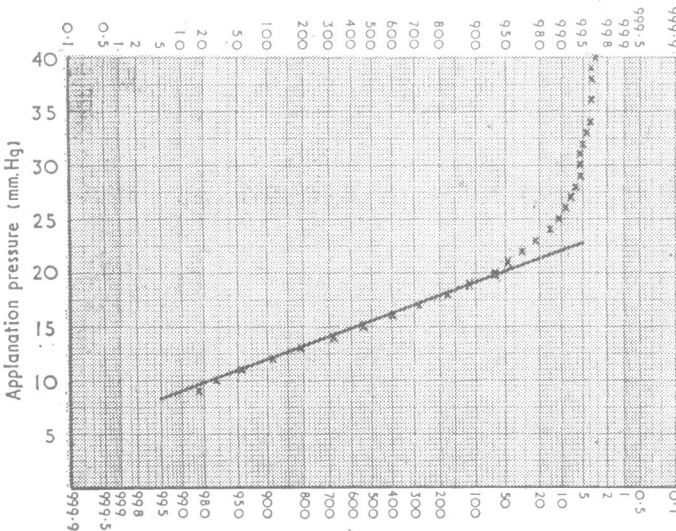
The mean tension showed a steady rise with increasing age except in the small group of people over the age of 80 (Table III). However, further analysis showed that the rise in tension with age was more pronounced in women than in men (Table IV). The differences in ocular tension between men and women observed in this survey were similar to the findings of Armaly (1965) and Graham and Hollows (1964). The former found that in people over 40 years of age the increase in the mean value with age was greater in women, and he inferred that this was due to the hormonal changes of the menopause. In the rather small under-40 age group in our series the mean tension of female eyes was lower than that of male eyes—as was found by Hollows and Graham (1966)—but in the older age groups the mean tension was always higher in female eyes except in the 50-59 age group.

FIG. 2.—Cumulative percentage frequency of ocular tensions of all subjects.

TABLE III.—*Mean Tension in Different Age Groups*

Age Group	No. of Cases	Mean Tension (mm.Hg)	S.D.	S.E.
30-39	50	15·06	2·67	0·37
40-49	1,753	15·49	2·42	0·06
50-59	1,721	15·72	2·49	0·06
60-69	1,137	15·78	2·52	0·07
70-79	446	15·81	2·55	0·12
80+	49	15·41	2·81	0·40

TABLE IV.—*Mean Tensions in Male and Female Eyes in Different Age Groups*

Age Group	Males			Females		
	No. of Eyes	Mean Tension (mm.Hg)	S.D.	No. of Eyes	Mean Tension (mm.Hg)	S.D.
Under 40	74	15·33	2·48	38	14·91	2·87
40-49	1,535	15·43	2·50	1,964	15·54	2·35
50-59	1,390	15·73	2·56	2,043	15·72	2·44
60-69	749	15·63	2·57	1,519	15·85	2·49
70-79	321	15·42	2·57	568	16·02	2·51
80+	34	15·06	3·20	62	15·43	2·60

The number of days since the beginning of the last menstrual period was recorded for all women screened, and an analysis of the tension readings at different phases of the menstrual cycle is shown in Table V. The lowest mean tension was found to coincide with the twenty-first to the twenty-fourth days of the cycle, and the highest mean tension occurred from the ninth to the twelfth day. There is another peak during the twenty-fifth to the twenty-eighth day. The mean tension in the post-menopausal women was higher than that in women who were still menstruating, even when only those women in the age group 40-49 were compared. The mean tension in 383 pre-
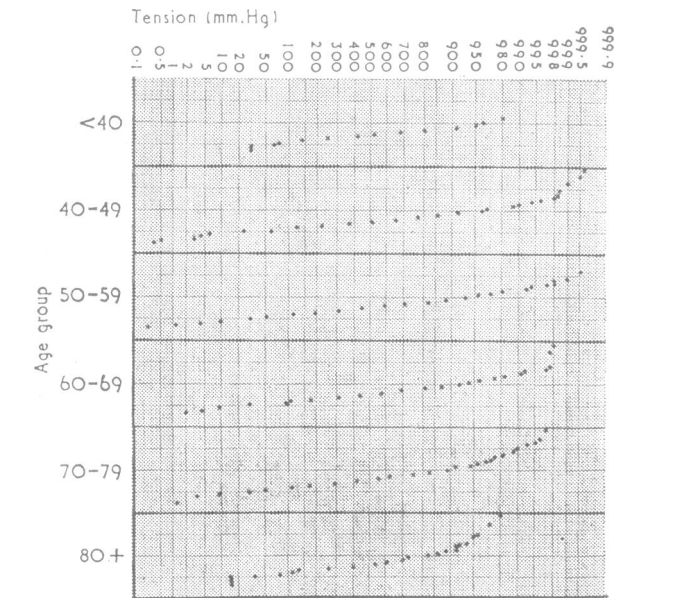

FIG. 3.—Cumulative percentage frequency of ocular tensions in different age groups.

TABLE II.—*Comparison of Mean Tensions in Right and Left Eyes*

	Male Eyes				Female Eyes			
	No.	Mean Tension (mm.Hg)	S.D.	S.E.	No.	Mean Tension (mm.Hg)	S.D.	S.E.
All eyes ..	4,103	15·57	2·55	0·04	6,194	15·71	2·44	0·03
Right eyes	2,053	15·73	2·54	0·055	3,098	15·88	2·44	0·039
Left eyes..	2,050	15·40	2·55	0·051	3,096	15·55	2·43	0·039

TABLE V.—*Variation in Mean Tensions During Menstrual Cycle*

Days	No. of Cases	Mean Tension (mm.Hg)	S.D.	S.E.
0-4	145	15·31	2·5	0·21
5-8	115	15·45	2·29	0·21
9-12	99	15·85	2·49	0·25
13-16	153	15·77	2·44	0·20
17-20	61	15·65	2·25	0·29
21-24	95	15·12	2·06	0·21
25-28	100	15·60	2·42	0·24
Over 28	2,335	15·77	2·46	0·05

TABLE VI.—*Variation in Mean Tensions with Time of Day*

Hour of Day	No. of Cases	Mean Tension (mm.Hg)	S.D.	S.E.
10.00-11.00	272	15·63	2·44	0·15
11.00-12.00	715	15·96	2·45	0·09
12.00-13.00	485	15·87	2·42	0·11
13.00-14.00	15	16·38	2·19	0·57
14.00-15.00	504	15·40	2·60	0·12
15.00-16.00	940	15·51	2·49	0·08
16.00-17.00	1,061	15·65	2·45	0·08
17.00-18.00	588	15·67	2·52	0·10
18.00-19.00	499	15·58	2·51	0·11
19.00-20.00	71	15·46	2·31	0·27
20.00-21.00	10	14·98	2·56	0·81

menopausal women in this age group was 15.39 mm. Hg (S.D. 2.73), compared with a mean of 15.45 mm. Hg (S.D. 3.37) for 140 postmenopausal women in the same age group.

As was to be expected, the time of day at which tensions were measured had some influence on the results (Table VI). Tension readings were higher in the morning than in the afternoon and evening. The same trend was reported by Graham and Hollows (1964).

Comment

The mean applanation tensions obtained in this survey correspond well with those of other reported surveys, and the manner of the distribution of tension readings confirms the previous reports of a skewness in favour of higher readings (Armaly, 1965 ; Hollows and Graham, 1966). Leydhecker (1967) contends that ocular tension has a normal distribution and that those people whose tension falls outside the limits of such a distribution are abnormal, and he has presented evidence that a high proportion of people with tensions above the normal range develop glaucomatous field defects. Davanger (1965) has postulated that a skew distribution of ocular tension is to be expected when " assuming a normal distribution of ' effective ' pore diameter of the aqueous outflow paths." Hollows and Graham (1966) feel that their results show only a continuum of tonometric data and that the dividing line between health and disease is difficult to place according to tonometric data alone.

The influence of age, sex, menstruation, and time of day on tonometric readings is considerable, and if any upper limit of normal tension were proposed it would have to be modified for each individual, taking these factors into account.

The divergence of tension readings from a Gaussian distribution increases with age. Armaly (1965) found that the distribution was Gaussian in people under the age of 40, and in our series the distribution of tensions in the relatively small number of people under the age of 40 showed the smallest deviation from a normal distribution. The deviation increases in each decade above this age.

There are significant sex differences in mean applanation tensions, and in premenopausal women the menstrual cycle is accompanied by significant variations in tension. Paterson and Miller (1963) observed that the coefficient of outflow was decreased at the time of ovulation in healthy volunteers, and this finding fits in well with our observation that the mean applanation tension was highest in mid-cycle.

The difference between the tensions in the first and second eye to be measured confirms many previous observations, though the reason for the lower reading in the second eye is still uncertain* (Perkins, 1959). It has been attributed to such factors as a fall in systemic blood pressure, muscular relaxation, and evaporation of fluid from the cornea (Grant and English, 1963) ; though the latter factor is unlikely to be as important in tonometry as in tonography.

Assessment of Patients Referred from Screening Clinic

The following definitions have been used in the classification of patients referred for assessment.

(1) *Ocular Hypertension.*—An ocular tension of 21 mm. Hg or above by applanation tonometry, in the absence of glaucomatous field defects and with no evidence of angle closure.

(2) *Chronic Simple Glaucoma.*—Ocular tension of 21 mm. Hg or above by applanation tonometry on two or more occasions, glaucomatous cupping of the disc, and visual field defects typical of glaucoma, and with no evidence of angle closure.

(3) *Low-tension Glaucoma.*—As for (2) except that the ocular tension is persistently less than 21 mm. Hg by applanation tonometry.

(4) *Closed-angle Glaucoma.*—A clear history of haloes typical of corneal oedema with gonioscopic evidence of a narrow angle capable of closure ; or ocular tension of 21 mm. Hg. or above in the presence of obstruction of the angle by the root of the iris.

Of the 5,941 persons screened, 708 (11.9%) were referred for assessment, and this number is made up by the groups shown in Table VII. An additional 71 (1.19%) were found to have ocular conditions requiring treatment and were referred direct to their own doctors from the screening clinic.

TABLE VII.—*Patients Referred for Assessment*

Failed to attend or complete assessment	78
Diagnosed as primary glaucoma	67
Discharged, no evidence of glaucoma	351
Still on follow-up	212
	708

Of the 708 persons referred for assessment on suspicion of glaucoma by means of the criteria previously mentioned, 78 failed to attend or complete the investigations ; these included five probably having chronic simple glaucoma, two probably having early closed-angle glaucoma, and two with secondary glaucoma. The reasons for failing to complete assessment included death (7), removal from the district (8), and preference for consulting own ophthalmologist (6).

Sixty-seven cases of primary glaucoma were detected on screening and confirmed by assessment, but five of these were referred to the clinic by ophthalmologists as glaucoma suspects and have been excluded from the subsequent analyses, as they constitute a highly selected group. The people who attended for screening do not in any case represent a true random sample of the population, but the inclusion of patients already suspected of having glaucoma would introduce a still greater bias into the sample. Seven patients with glaucoma gave a history of treatment for glaucoma and though they had received or were still receiving treatment they were all inadequately controlled. These seven cases have, however, been excluded from analysis and only 55 cases of primary glaucoma were therefore thought to have been detected as a result of the survey—0.93% of those screened. The diagnostic categories of these 55 cases are shown in Table VIII.

TABLE VIII.—*Cases of Primary Glaucoma Detected*

Chronic simple glaucoma	42
Low-tension glaucoma	3
Closed-angle glaucoma	10
	55

A total of 351 cases were discharged from the assessment clinic as not having primary glaucoma ; over half of those referred were therefore false positives of the screening process. The reasons for their referral are shown in Table IX. The largest group consisted of 182 people who had a tension of 21 mm. Hg or more on screening. Investigations showed no other evidence of glaucoma, and in many of them subsequent tension readings were less than 21 mm. Hg. None had tensions of more than 24 mm. Hg on subsequent tests. The mean values of tension on screening and at the first assessment for 170 of these cases are shown in Table X. The difference between the first and subsequent tension readings is so marked and consistent that it is unlikely to be due to errors in the method and is probably due to an elevation of tension induced by un-

TABLE IX.—*Cases Discharged after Assessment*

Reason for Referral	No.	% of Referred Cases
Tension of 21 mm.Hg or over	182	51·9
Family history of glaucoma	68	19·4
Suspicious discs	59	16·8
History of haloes	18	5·1
Family history and tension of more than 21 mm.Hg.	4	1·1
Suspicious disc and tension of more than 21 mm.Hg	3	0·9
Family history and suspicious disc	1	0·3
Other causes, including secondary glaucoma	16	4·6
	351	

familiarity with the test. In the rather calmer conditions of the assessment clinic the patients were more relaxed and less apprehensive.

TABLE X.—*Means of Applanation Readings Taken on Two Occasions*

	Right Eyes			Left Eyes		
	Mean Tension (mm.Hg)	S.D.	S.E.	Mean Tension (mm.Hg)	S.D.	S.E.
First reading ..	21·48	1·62	0·12	20·84	2·08	0·16
Second reading ..	19·39	2·68	0·21	18·93	2·19	0·17
Difference in means	2·09			1·91		

The next largest group (68) consisted of people who gave a family history of glaucoma but were found to have no evidence of glaucoma on assessment. In 59 cases in which the disc was thought to be suspicious at the screening clinic subsequent investigations failed to show any pathological changes indicative of glaucoma. In the 18 cases with a history of haloes there was no evidence of glaucoma, and the symptoms were due to other causes (lens opacities) or were not typical of glaucomatous haloes.

The 212 cases still being followed up can be divided into the categories shown in Table XI.

TABLE XI.—*Cases Still on Follow-up*

Ocular hypertension	180
Suspected closed-angle glaucoma	4
Suspected secondary glaucoma	1
Family history and borderline tension	16
Suspicious discs	11
	212

Comment

The 5,941 people who attended the screening clinic cannot be regarded as a random sample of the population of Bedford. The vast majority attended of their own accord in response to publicity in the press and on notices, etc. It would not be surprising, therefore, if the sample contained a number of people who had ocular symptoms that may have been the result of glaucoma. In fact seven of the 10 cases of closed-angle glaucoma gave a history of haloes and 22 of the 42 cases of simple glaucoma had experienced some symptoms.

On the other hand, many older members of the population, in whom the incidence of glaucoma is highest, may have been unable to attend the clinic because of other infirmities. A small number of people with known glaucoma attended the clinic in search of a second opinion, but these have been excluded from the analyses.

The prevalence rate for all types of primary glaucoma (0.93%) is lower than that reported in most population surveys, and this is probably due to a more rigid definition of chronic simple glaucoma than that which other workers have used. There were seven cases of possible primary glaucoma (five chronic simple, two closed-angle) among those who failed to attend for follow-up, and of those still under review there are four cases of suspected closed-angle glaucoma. In addition 80 patients had Po/C ratios of 120 or more and would be considered to have glaucoma by some ophthalmologists. If these and the suspected cases are added to those fulfilling our diagnostic criteria a much higher prevalence of glaucoma is obtained.

Hollows and Graham (1966) used similar criteria to ours in a glaucoma survey on over 90% of a defined population and found a prevalence of all types of glaucoma of 0.84%. The prevalence rate for chronic simple glaucoma was 0.43% as compared with our rate of 0.71%. The prevalence rate of 0.08% for closed-angle glaucoma found by Hollows and Graham (1966) is considerably lower than our figures from Bedford (0.17%). This may represent a true difference in incidence in the two populations studied.

Six cases of secondary glaucoma detected in our survey gave a definite history of trauma ; none had a field defect but all had raised tension and reduced outflow facility in the affected eye. Four of the six showed traumatic recession of the angle, a condition first clearly recognized by Wolff and Zimmerman (1962) and further described by Pettit and Keates (1963), Rodman (1963), and Alper (1963).

The age incidence of the 45 cases of open-angle glaucoma was:

40–49	50–59	60–69	70–79	80+
4	6	12	16	7

It will be seen that 78% of the cases were over 60 years of age, suggesting that glaucoma detection programmes should concentrate particularly on people over the age of 60. The incidence of cases of chronic simple glaucoma in the separate age groups was as follows:

40–49	50–59	60–69	70–79	80+
0.02%	0.31%	0.9%	2.82%	10.0%

Comparable figures for closed-angle glaucoma were:

40–49	50–59	60–69	70–79	80+
0.06%	0.25%	0.07%	0.53%	0%

Screening Methods

One of the objects of the survey was to determine the value of tonometry, examination of the optic disc, a history of haloes, and a family history of glaucoma as screening techniques. In the following discussion only cases of primary open-angle and closed-angle glaucoma are considered. All cases of secondary glaucoma had raised tension on screening.

Tonometry

How effective was tonometry in detecting glaucomatous patients ? Of all 55 primary glaucomas, 49 (89%) had a tension in excess of 21 mm. Hg on the applanation tonometer. Of the six with normal tension on initial screening, two were cases of intermittent angle closure, three were diagnosed as having low-tension glaucoma, and one had a raised tension on a later occasion.

It was interesting to note that 8 of the 10 cases of closed-angle glaucoma had a raised tension on screening. Tonometry failed to detect four (8.9%) cases of open-angle glaucoma (three of which remained low-tension glaucoma) and two (20%) of closed-angle glaucoma. The total false-negative rate for all primary glaucomas was 10.9%.

The true false-positive rate for tonometry alone cannot yet be assessed, but, using the criterion of 21 mm. Hg and above, there were about six patients referred for assessment and found not to have definite glaucoma for every one referred and found to have definite glaucoma. It is unlikely that the figure of six to one will be reduced to less than five to one by development of glaucoma in patients with ocular hypertension being followed up. The number of false positives from tonometry falls very rapidly if higher values than 21 mm. Hg are used as the cut-off point. Of all glaucomas diagnosed 32 (58%) had tensions over 25 mm. Hg on screening. There were only 12 cases with initial tensions of 25 mm. Hg or over not diagnosed as primary glaucoma ; six of these patients refused or failed to attend for complete assessment, one had secondary glaucoma, and in only five did assessment result in discharge from the clinic.

A cut-off point of 25 mm. Hg therefore greatly reduces the number of false positives, but at the expense of increasing the number of false negatives. A method of increasing the sensitivity and specificity of tonometry by using a variable critical level has been suggested (Perkins, 1967).

Ophthalmoscopy

The optic disc was thought to be suspicious or pathological on screening in 21 (38%) of 55 cases of primary glaucoma. In four this was the only abnormality on screening, though one of these subsequently showed a raised tension.

Of the open-angle (chronic simple+low-tension) cases, 20 out of 45 (44.5%) had a suspicious or pathological disc. One of 10 cases of closed-angle glaucoma had abnormal discs.

Fifty-nine cases referred for assessment because of suspicious discs alone were found not to have glaucoma. Other cases are still being followed up.

The false-negative rate for screening on disc appearances alone was 62.5%. Judgement of the optic disc depends greatly on the experience of the observer and on such factors as ambient lighting, size of pupil, and brightness of the ophthalmoscope.

History of Haloes

Six (60%) of the patients with closed-angle glaucoma gave a history of haloes. Sixteen others with a history of haloes were found not to have glaucoma.

Family History

Only two patients with a family history of glaucoma were found to have definite glaucoma, and the tension was raised in both. Two further patients with a family history and raised tension refused further assessment and may have had glaucoma. Sixty-eight people with a family history but without raised tension were discharged with no evidence of glaucoma. Sixteen are still on long-term follow-up.

Field Defects

Though field testing was not carried out as a screening procedure it was performed on all assessment cases. By definition all cases of chronic simple glaucoma (42) had field defects, and in addition five of the closed-angle cases also had them. An additional 27 cases of 274 tested showed field defects not due to glaucoma. In a few cases it was impossible to record a reliable field. If the Globuck screen had been used as a screening method about 10% of those tested would have given false-positive results. It is impossible to assess the false-negative rate.

Tonography

Tonography was carried out whenever possible on all cases referred for assessment. All but three of the cases of open-angle glaucoma tested had outflow facilities of less than 0.18, with a mean of 0.11. The mean value of outflow facility for those with no other evidence of glaucoma was 0.216, but some had values as low as 0.10. However, the differentiation between glaucomatous and normal eyes was fairly good.

Unfortunately in the case of ocular hypertensives no clear differentiation into normal and abnormal resulted from the tonography finding. The mean coefficient of outflow was 0.21, with a range from 0.05 to 0.39. We had hoped to find a bimodal distribution suggesting two main groups—glaucomatous and normal. However, the distribution suggests a single population with a range of values from abnormal to normal.

The ratio $P_o/C \times 100$ has been considered of diagnostic importance and a value of over 120 is thought to indicate glaucoma. We found that this criterion had about the same value as tonography—that is, the normal eyes gave low values and the glaucomatous eyes gave values above 120, but the ocular

hypertensive group gave values between 50 and 450 and appear to comprise a single population. These results are shown in Figs. 1 and 2.

Other Ocular Conditions Detected During Screening

A note was made of other ocular abnormalities encountered during screening. As the fundus was viewed through an undilated pupil many minor degrees of macular degeneration and similar lesions were probably missed, so that the figures represent minimal incidences. The results for the first 3,000 cases are presented in order of frequency of disease (Table XII).

TABLE XII.—*Conditions Other than Glaucoma*

	No. of Cases		No. of Cases
Cataract	90	Iris atrophy	2
Myopia with degenerative changes	22	Vitreous detachment	2
		Retinal detachment	2
Uveitis (inactive 16, active 3)	19	Diabetic retinopathy	2
Vascular disease of retina	19	Amblyopia	2
Corneal scarring	13	Exophthalmos	1
Injuries to globe	11	Enucleation	1
Macular degeneration	9	Ptosis	1
Known glaucoma	7	Coloboma of iris	1
Optic atrophy	5	Neoplasm of iris	1
Squint	4	Vitreous haemorrhage	1
Congenital abnormality of disc	3	Old contusion injury of retina	1
Neoplasm of lid	2	Retinitis pigmentosa	1
Corneal dystrophy	2		
			224 (7·2%)

It is of interest to note the large number of cases of cataract. The lens changes were senile in type in 82 patients (59 women and 23 men). The mean age of the women was 70 and of the men 77.

Conclusions

It is generally accepted that successful treatment of chronic simple glaucoma can prevent further deterioration of visual field and that peripheral iridectomy is highly successful in avoiding the catastrophe of an acute attack in closed-angle glaucoma. Early diagnosis of both types of glaucoma by population screening is therefore worth while provided that it is practical and economically feasible.

This survey has confirmed that glaucoma screening is practical if good facilities and trained personnel are available. There is no doubt that presymptomatic diagnosis appeals to the general public, though voluntary schemes tend to attract particularly those people who are " health conscious " and likely to seek advice at a relatively early stage of an illness. Many of the glaucoma cases detected in this survey had ocular symptoms, so that the diagnosis was not truly presymptomatic ; however, in most cases the disease was not far advanced, and there is no doubt that the screening programme has been worth while for these people and for those with other ocular conditions requiring treatment.

Screening programmes are expensive in time and money, and if directed to the detection of only one disease are uneconomic in medical manpower. Having persuaded people to attend a screening clinic it is more logical to screen for as many pathological conditions as is practicable during one visit.

With the rather strict criteria for assessment described here, about 10% of those screened would require further investigation—a proportion which would create a large demand on the ophthalmological resources if mass screening were carried out. Many of the false positives resulted from tonometry using a single critical level of tension (21 mm. Hg applanation). A more sophisticated approach in which the ocular tension of each individual is assessed in the light of the probability of glaucoma occurring in a person of that particular age and sex would greatly reduce the number of false positives without significantly increasing the risk of failing to detect glaucoma. Cases of low-tension glaucoma cannot be detected by tonometry, but they constitute a very small group in which treatment is notoriously difficult. In spite of its defects, tonometry does have very great

advantages as a screening method, and remains the best single test which does not require an experienced ophthalmologist to perform it.

All surveys produce the problem of borderline cases, and this problem with glaucoma surveys has been previously discussed by one of us (Perkins, 1966). No easy solution can be proffered, and only further research will provide clearer indications of methods of reducing the number of patients requiring long-term follow-up.

Summary

A glaucoma screening survey using applanation tonometry was carried out on 5,941 persons in Bedford. The distribution of ocular tensions showed a divergence from a Gaussian curve for tensions of 21 mm. Hg and above. Age, sex, time of day, and menstruation were found to influence the tonometric readings. Fifty-five cases of primary glaucoma (0.93% of those screened) were detected as a result of the survey ; these included 42 cases of chronic simple glaucoma, 3 cases of low-tension glaucoma, and 10 cases of closed-angle glaucoma. An additional 180 persons (3% of the population studied) were found to have applanation tensions of 21 mm. Hg or more but without other evidence of glaucoma. Nearly 80% of the patients with glaucoma were over 60 years of age, suggesting that glaucoma detection programmes should concentrate on the older age groups. As over 10% of the population screened required further investigation, large-scale screening of the population would throw a heavy burden on the ophthalmological services of the country. In spite of the difficulty of interpreting tonometric results, tonometry is the most reliable

screening procedure which does not require an experienced ophthalmologist to perform it.

REFERENCES

Alper, M. G. (1963). Arch. Ophthal., 69, 455.
Armaly, M. F. (1965). Arch. Ophthal., 73, 11.
Davanger, M. (1965). Intraocular Pressure in Normal Eyes and in Eyes with Glaucoma Simplex. Bergen.
Graham, P., and Hollows, F. C. (1964). Trans. ophthal. Soc. U.K., 84 597.
Grant, W. M., and English, F. P. (1963). Arch. Ophthal., 69, 314.
Hollows, F. C., and Graham, P. A. (1966). In Glaucoma, edited by L. B. Hunt, p. 24. London.
Hunt, L. B. (editor) (1966). Glaucoma. London.
Leydhecker, W. (editor) (1967). Tutzing Symposium on Glaucoma Basel.
Luntz, M. H., Sevel, D., and Lloyd, J. P. F. (1963). Brit. med. J., 2. 1237.
Paterson, G. D. and Miller, S. J. H. (1963). Brit. J. Ophthal., 47, 129
Perkins, E. S. (1959). In Glaucoma, edited by F. W. Newell, p. 143 New York.
Perkins, E. S. (1966). Trans. ophthal. Soc. U.K., 86, 199.
Perkins, E. S. (1967). Atti LI Congr. Soc. oftal. ital. In press.
Pettit, T. H., and Keates, E. U. (1963). Arch. Ophthal., 69, 438.
Posner, A., and Fogland, W. G. (1964). Eye Ear Nose Thr. Mth., 43. No. 6, p. 53.
Rodman, H. I. (1963). Arch. Ophthal., 69, 445.
Wolff, S. MacK., and Zimmerman, L. E. (1962). Amer. J. Ophthal., 54. 547.
Wright, J. E. (1966). In Glaucoma, edited by L. B. Hunt, p. 12. London.

Effects of Two Slimming Drugs on Sleep

IAN OSWALD,* M.A., M.D., D.SC., D.P.M. ; HENRY S. JONES,† M.B., B.S. ; JANENE E. MANNERHEIM,‡

Most slimming pills are also "pep-pills" and invite abuse. Past experience leads to scepticism when claims are made that a new appetite-reducing drug does not affect alertness or mood.

One may take the example of diethylpropion, reported by Seaton et al. (1961) from Edinburgh to be an effective appetite reducer with "no evidence of undue central nervous stimulation or insomnia. . . . No important side-effects." Time, however, showed that diethylpropion, like dexamphetamine and phenmetrazine, was a pep-pill, causing elevation of mood and of the pace of thinking (Jonsson et al., 1965). Despite spirited defence (Roebuck, 1963) it has become recognized as a drug which can lead to tolerance, dependence, abuse, and psychotic manifestations (Clein and Benady, 1962 ; Kuenssberg, 1962 ; Caplan, 1963 ; Jones, 1968), selling in the illicit market at a slightly lower price than amphetamine (Kuenssberg, 1963) and being included in the Drugs (Prevention of Misuse) Act, 1964.

The Edinburgh group have since reported on the effective new slimming drug fenfluramine, again reporting "no evidence of stimulation of the central nervous system" (Munro et al., 1966), while Traherne (1965) and Spence and Medvei (1966) reported no insomnia despite an evening dose.

* Department of Psychiatry, University of Edinburgh, Scotland (to which address reprint requests may be sent) ; formerly Visiting Professor of Psychiatry, University of Western Australia.
† State Mental Health Services, Heathcote Hospital, Western Australia.
‡ Monash University Medical School, Victoria, Australia.

Aims and Methods

Experiments were conducted to determine what effect clinical doses of fenfluramine, and diethylpropion of believed equivalent anorexiant potency, would have on the sleep of paid healthy young adult volunteers when taken in the evening. Volunteers were studied in pairs. Tablets of identical appearance were used containing placebo or diethylpropion 50 mg., or fenfluramine 40 mg., always taken one to one and a half hours before lights-out. Silver disc electrodes were affixed to the scalp and face for recording the electroencephalogram (E.E.G.) and eye movements as in previous drug studies (Oswald and Thacore, 1963 ; Oswald and Priest, 1965). These two previous studies had been of whole-night sleep, but had shown that the essential information could have been gained from the first two hours of sleep. Consequently in the present study only the first two hours and the first three hours of sleep are considered (on two diethylpropion nights sleep totalled less than three hours). Results were not utilized from the first laboratory night of each volunteer. On the later nights the drug sequence used was: placebo, fenfluramine, fenfluramine, placebo, on four nights at weekly intervals for one volunteer, with the reverse order for the other of each pair ; and similarly for the other comparisons. Volunteers undertook to get a good night's sleep for at least two preceding nights and to abstain from alcohol.

In addition we observed the effect of giving nightly for a week phenmetrazine 50 mg. (two volunteers), or diethylpropion