

## SURVEY OF VISUAL STATUS OF FACTORY EMPLOYEES IN ELECTRONICS INDUSTRIES IN SINGAPORE \*

By K. H. Lim, W. P. Wan and P. K. Chew

### SYNOPSIS

As it has been suggested that there was a heavy incidence of "eye-strain" among workers employed in the electronics industries to the extent that their eye sight were adversely affected by their work, a survey was designed to gauge the extent of visual defects and to provide an indication of possible associated factors whether arising out of work or inherent in the workers, or in the factories.

Results of the survey carried out on a stratified random sample of workers from six electronics factories in Singapore provided sufficient evidence to indicate that working in electronics industries does give rise to eye complaints but that many of the complaints arising are non-specific which can occur with equal frequency among persons not doing similar work. Of other complaints—headaches, "eye-strain", blurring of vision—most are associated with improper correction of refractive errors, and in all with ocular muscle imbalance. Many of the complaints have a large psychogenic causative component. Progressive visual deterioration is a hazard which is not confirmed by this survey.

### INTRODUCTION

In view of certain reports that workers in electronics industries in Singapore were having their eyesight adversely affected by their work, it was decided that a survey should be jointly conducted by the Industrial Health Unit of the Ministry of Labour and the Ophthalmic Unit of the Ministry of Health.† Because of the very recent existence of these electronics industries locally, a similar survey had not been done before.

To put the problem in perspective, it must first be stated that workers in electronics industries make intensive use of their eyes at work, the work being very fine and requiring minute manipulation. Workers in these factories are therefore much

more sensitive about the functioning of their eyes than most other workers, and are more likely to complain of small changes, whether transient or permanent, which others might not even notice.

All electronics factories conduct pre-employment vision screening of prospective employees, and the larger firms provide medical nursing care to workers on all shifts, besides the services of medical practitioners retained by the firms.

### ELECTRONICS INDUSTRIES IN SINGAPORE

The electronics industries‡ have only recently come into Singapore. The first international electronics company started operations in 1968. Only two local electronics firms assembling television sets were operating at that time. Since then, the number has increased from about 20 in 1969 to about 40 in 1971. Concomitantly the number of employees has also increased from about 7,500 in 1969 to about 15,500 in 1971. The electronics industry as a whole was the second largest employer in the manufacturing sector employing about 10.5% of the total number of workers. The labour force consists largely of young females, constituting 90% of the total employed and they are in the unskilled or semi-skilled category doing repetitive work. Most firms work on a 3 shift system.

### OBJECTIVE OF SURVEY

A pilot survey was designed mainly to gauge the extent of visual defects and to provide an indication of possible associated factors, whether arising out of work or inherent in the workers, in elec-

---

† Survey team: P. K. Chew, W. P. Wan, S. J. Ngui, J. M. Lang (from the Industrial Health Unit); K. H. Lim, G. L. Voon (from the Ophthalmic Unit).

‡ The electronics industry consists of firms producing transistor radios, T.V. sets, stereograms, semiconductor components, electro tubes, resistors, capacitors, cells, transformers and relays.

---

Ophthalmic Unit, Outram Road General Hospital, Singapore.

K. H. LIM, M.B., B.S., D.O., F.R.C.S.I., A.M., Ag. Senior Ophthalmic Surgeon and Head.

Industrial Health Unit, Ministry of Labour.

W. P. WAN, M.B., B.S., D.P.H., M.Sc., Ag. Senior Registrar. (Now: Senior Registrar, Environmental Health Department)

P. K. CHEW, M.B., B.S., D.P.H., D.I.H., D.I.H.S.A., Chief Medical Adviser.

---

\* From a Report to the Ministry of Labour and Ministry of Health, Singapore, dated February 1, 1972.

tronics factories. The results would indicate whether certain reports currently in circulation were founded, and so would determine (i) whether a subsequent definitive survey needed to be carried out and if so (ii) the specific lines along which such a definitive survey would have to be conducted.

It has been suggested that there was a heavy incidence of "eye-strain" among these workers, and their eyesight gradually deteriorated to the point of eventually resulting in blindness.

## METHOD

### 1. Sampling

A random sample of six electronics factories (three with more than 1,000 employees and three with less) was taken from a total of 20 such factories then known to be in existence in Singapore.

From these factories, 105 subjects were selected using random numbers according to their "employee numbers". Only subjects using microscopes or doing very fine work were included in the sampling.

A "control" group of 25 student nurses was also randomly selected to provide a crude comparison with persons of similar age and sex. However, it must be noted that whereas test subjects have all been screened during recruiting for good eyesight, control subjects have not and this must be borne in mind in any comparison of the two groups. To the best of the knowledge of the investigators, no other group of females of similar age (except woman police constable recruits) is screened for good eyesight in Singapore.

### 2. History and Examination

Subjects included in the sample were instructed to report to the Eye Clinic at the Outram Road General Hospital where their personal, work and clinical histories were taken (see Appendix) by the staff nurses of the Survey Team and, their vision tested by the ophthalmologists without knowledge of their histories. Subjects were given staggered dates for these during the month of November 1971.

### 3. Visual Examination

#### *Vision:*

Visual Acuity for distance and near was assessed (1) unaided, (2) aided with subjects' own spectacle glasses, and (3) determined whether it could be improved further with a pin-hole. Refraction was performed whenever indicated. Visual Acuity for distance was assessed by standard non-serif test types internally illuminated (Weiss model) placed at 6 metres. Visual Acuity for near vision was assessed by N reading charts.

*Manifest hypermetropia* when present was ascertained.

*Dominance* of subjects' eyes was also ascertained.

*Accommodation* was measured with an R.A.F. Near Point Rule for each eye. The same instrument was also used to measure convergence.

*Ocular movements* in all directions of gaze were tested.

*Cover test* was performed at 1 metre and 6 metres to demonstrate heterophoria or squint.

*Muscle Balance:* Muscle balance was measured with Maddox Wing for near and Maddox Rod for distance and, in subjects in whom muscle imbalance was detected this was confirmed with a synoptophore to ascertain the state of binocular vision.

*Examination of the eye* including the ocular fundi for evidence of disease completed the visual examination.

### 4. Statistical Analysis

The significance test used is the Chi-square test and significance is taken at the  $p = 0.05$  level.

## FINDINGS

### 1. Non-response

Out of the originally selected 105 persons, two did not respond despite repeated attempts at persuasion. The reason for non-response was stated to be inconvenience and loss of earning time.

### 2. General

In general, no real basis was found for the various rumours but a few facts emerged. Among the test subjects about 44.5% had refractive errors, while among the 25 control subjects, 64% had refractive errors. This illustrates one point. It does not mean that working in electronics factories improves eye-sight, but merely demonstrates that workers have been selected during pre-employment examinations for good vision.

While 40% of the test subjects had eye complaints, only one control subject (or 4%) had similar complaints, (See Table I).

### 3. Age-sex Distribution

All subjects in both Test and "Control" groups were female.

Fig. 1. shows the age distribution of Test subjects. The majority of subjects come within the age group 17-22, with the peak at age 19-20.

TABLE I  
PREVALENCE OF REFRACTIVE ERRORS  
AND EYE COMPLAINTS AMONG TEST  
AND "CONTROL" SUBJECTS

| Finding                | Test |      | Control |    |
|------------------------|------|------|---------|----|
|                        | No.  | %    | No.     | %  |
| With refractive errors | 45   | 44.5 | 16      | 64 |
| With eye complaints    | 41   | 40   | 1       | 4  |

#### 4. Positive Findings

- An unexpectedly high proportion of test subjects (52%) with refractive errors had eye complaints. Probability level was between 0.05 to 0.01. Conversely, subjects with no abnormal finding had 'unexpectedly' low incidence of eye complaints (27.5%).
- Analysis of age of subject against prevalence of refractive errors showed just significant results ( $p \approx 0.05$ ). Subjects under 17 years of age had unexpectedly low prevalence of refractive errors and subjects aged 19 to 20 had an unexpectedly high prevalence, the percentages being 15.5% and 60% respectively.
- Accommodation was found to be significantly related to age. This is a known medical fact confirmed in this survey.
- Subjects with accommodation better than (i.e. within 11 cm.) had low prevalence of eye complaints while subjects with poorer accommodation (i.e. 11 cm. or more) had a significantly higher prevalence (48%).
- The prevalence of refractive errors among subjects with accommodation better than 14 cm. was 38% while that among subjects with poorer accommodation (14 cm. or more, in this case) was significantly higher, at 78%. The probability level here is less than 0.01.

#### 5. Negative Findings

The duration of work was not found to have a significant bearing on the prevalence of eye complaints, nor on the prevalence of refractive errors. Note, however, that a high labour turnover rate is a common feature among electronics industries, and self-selection could have occurred, with "affected persons" (i.e. those with eye complaints or with refractive errors) leaving their jobs and thus not being covered in this survey at all.

Similarly, neither the age of the subject nor the power of microscope magnification used was a

significant factor affecting the prevalence of the eye complaints.

Significance tests of results of visual acuity examination could not be done because the numbers involved were too small. However, Fig. 2 shows, among the visual acuity groups, the percentages of subjects with eye complaints. There appear to be two peaks in this figure—among subjects with visual acuity of 6/6-6/9 and 6/12-6/18.

Among test subjects, the adequacy of correction of refractive errors is categorised as in Table II and the proportions of those with complaints shown.

Of the 19 subjects classified as normal (no refractive error), but with eye complaints, 8 had minor (probably unrelated) complaints such as occasional migraine, rare headaches, itchy eyes, tired eyes, red eyes and conjunctivitis; one had marked muscle imbalance; six were "borderline normal" cases with minimal myopia or poor accommodation; and the remaining four had no abnormality detected.

TABLE II  
PROPORTIONS OF SUBJECTS WITH  
EYE COMPLAINTS AMONG VARIOUS  
CATEGORIES OF CORRECTION FOR  
REFRACTIVE ERROR

| Category                        | Total No. | No. with Complaints | %         |
|---------------------------------|-----------|---------------------|-----------|
| Uncorrected Refractive Error    | 23        | 12                  | 52        |
| Glasses prescribed but not used | 3         | 3                   | 100       |
| Inadequate correction           | 7         | 3                   | 43        |
| Adequate correction             | 10        | 4                   | 40        |
| Overcorrection                  | 1         | 0                   | 0         |
| No Refractive Error             | 59        | 19 (11)             | 32 (18.6) |
| TOTAL                           | 103       | 41                  | —         |

Figures in brackets are the number and percentage respectively excluding those with minor and probably unrelated complaints (see text).

APPENDIX

Serial No: .....

SURVEY OF WORKERS IN ELECTRONIC INDUSTRIES

PERSONAL

Name: ..... Sex: Female  
 I.C. No: ..... Spectacles: Yes No  
 Race: ..... Occasionally .....  
 Birthday: ..... Always .....  
 Age: ..... At work .....  
 At microscope .....  
 Wearing spectacles since (age) .....  
 Last change (date) .....

WORK

Factory: .....  
 Description of present work: .....  
 .....  
 Microscope magnification: .....  
 Date of joining present factory: .....  
 Previous factories: ..... Duration .....  
 .....  
 .....  
 .....  
 .....

HEALTH

General Health: Good Moderate Poor  
 Any significant medical history: .....  
 Presently on any drugs (Specify): .....  
 Any history of eye complaints: Yes/No  
 If yes: Nature .....  
 When .....  
 Duration .....  
 Frequency .....

EYE EXAMINATION

VISION

|                        | Distant   |       | Near      |       |
|------------------------|-----------|-------|-----------|-------|
|                        | R         | L     | R         | L     |
| Unaided                | .....     | ..... | .....     | ..... |
| Aided                  | .....     | ..... | .....     | ..... |
| Aided with pin-hole    | .....     | ..... | .....     | ..... |
| Power of glasses       | .....     | ..... | .....     | ..... |
| Manifest hypermetropia | .....     | ..... | .....     | ..... |
| Accommodation:         | R.....cm. |       | L.....cm. |       |

APPENDIX (contd.)

**Maddox Wing**

Unaided:                   Eso       .....       Exo       .....       Vertical       .....  
 Aided: .....  
 Maddox Rod:            R:       o       L:       o .....Prisms.  
 Convergence .....cm.       Divergence .....cm.  
 R .....L .....Both .....       R .....L .....Both .....  
 Handedness:            R .....L .....       Dominance:       R.....L.....Mixed.....

**Cover Test**

Near: NAD .....       Exo .....       Eso .....  
 Far:       .....       .....       .....

**Binocular Vision**

Simultaneous perception: .....  
 Fusional range: Horizontal .....  
   Vertical .....  
 Stereopsis: .....

Any Ocular Pathology: .....  
 .....  
 Diagnosis: NAD/ .....

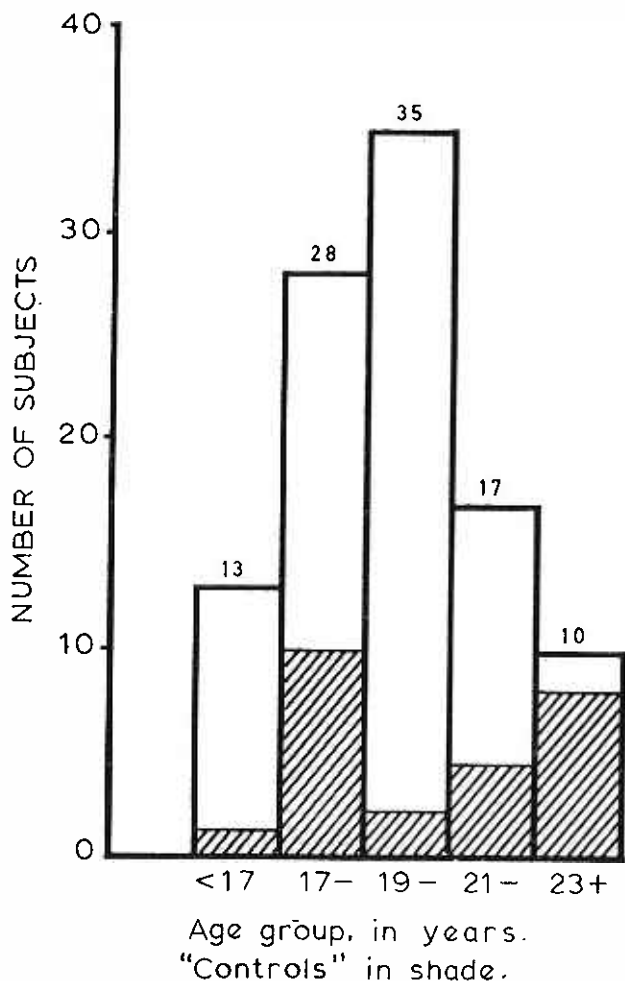


Fig. 1: Age Distribution of Test Subjects.

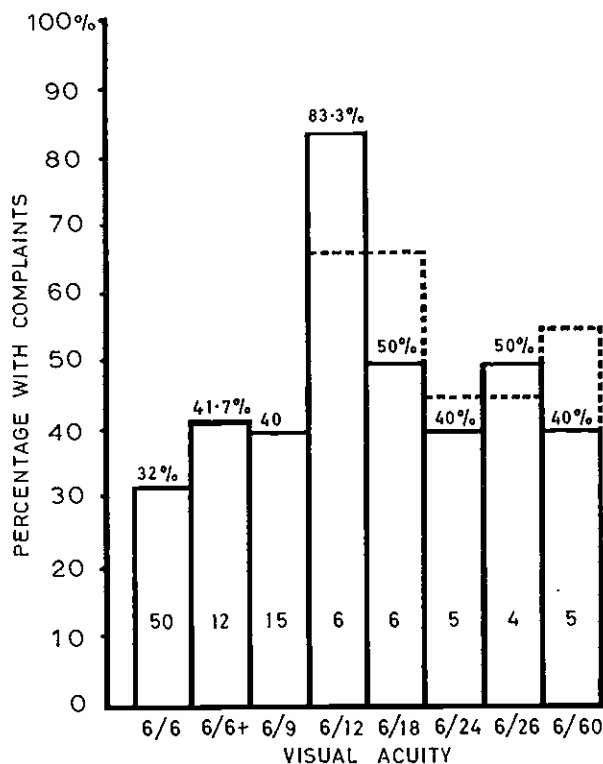


Fig. 2: Percentages of subjects with eye complaints among the various visual acuity groups.

Visual Acuity (Combined, bilateral). Numbers within the columns are the total numbers of subjects (with and without complaints) in each visual acuity group.

Of the 26 subjects with uncorrected refractive errors (whether glasses had been prescribed or not) 15, or 50%, had eye complaints. Percentages were lower for those with adequate glasses or those with no refractive error.

One feature noted was that 7 out of the 41 subjects with eye complaints stated that they felt the effects only while on night shift.

#### 6. Muscle Imbalance

The prevalence of subjects with ocular muscle imbalance was found to be low—3 out of 103.

All 3 have eye complaints—the first subject, with exophoria of 4 prisms and ability to converge to 10 cm., (convergence insufficiency) complained of “painful eyes” when newly employed, not since; the second subject, with esophoria of 9 prisms and ability to converge to 7 cm., (divergence insufficiency) complained of “eye-strain” on night shifts; and the third subject, with exophoria of 6 prisms, ability to converge to 8 cm. but with poor horizontal fusional range of minus 6 to plus 18 prisms, (poor fusional vergence) complained of “watery eyes” and headaches. Complaints in these subjects are not unexpected.

#### 7. Dominance

In subjects with complaints, there were only 2 instances of uncorrected poorer vision in the dominant eye.

### DISCUSSION

As the tennis player will complain of “tennis-elbow”, the writer of “writer’s-cramp” and the labourer of “back-ache”, so complaints of “eye-strain” as an occupational hazard are not unexpected from employees in electronics industries where work involves use of the microscope under factory conditions. But, “eye-strain” as a symptom is difficult to elucidate or ascertain. Broadly speaking, the term may be defined as various forms of distress associated with the use of the eyes. In theory it can be attributed to 4 main factors (Duke-Elder, 1969):—

1. Refractive Errors
2. Ocular Muscle Imbalance
3. Target Difficulties
4. Functional Factors

#### Refractive Error

44.5% of test subjects had refractive errors of whom 52% had eye complaints. These figures are statistically significant but whether it is because subjects with refractive errors tended to complain more often of eye strain cannot be ascertained.

Significance tests of results of visual acuity cannot be done due to small numbers involved, (See Table II).

#### Muscle Imbalance

Of 103 test subjects only 3 had muscle imbalance and all 3 had eye complaints which are not unexpected. The low incidence of muscle imbalance is due to screening off in pre-employment examination.

#### Target Difficulties

Target difficulties, i.e. images seen under magnification by subjects. Statistical tests revealed that microscopic magnification used had no significance to the prevalence of eye complaints. The microscopes were illuminated by side-lighting thus eliminating glare and each had adjustments for individual inter-pupillary distance and correction for subjects’ own refractive errors to a range of 3.00 Dioptres.

#### Functional Factors

These include emotional disorders, general health and anxiety states and are personal to an individual. From the elimination of other factors except refractive errors and muscle imbalance that can contribute to eye strain, it would appear that many of the complaints have a large functional component.

### CONCLUSIONS AND RECOMMENDATIONS

1. This survey has provided sufficient evidence to indicate that working in electronics industries does give rise to eye complaints, largely because of the intensive use of visual discrimination and fine eye-hand co-ordination.
2. Many of the complaints arising are minor, or vague, or non-specific—e.g. migraine, headache, “tired eyes”—which can occur with equal frequency among persons not doing similar work.
3. Of the other complaints—e.g. frequent attacks of headache or giddiness, “eye-strain”, blurring of vision—most are associated with improper correction of refractive errors and in all with ocular muscle imbalance. These are not normally serious conditions and can be corrected with spectacles or eye exercises.
4. Many of the complaints have a large psychogenic causative component. Some complaints of headache are very likely associated with neckache and backache due to bad sitting posture. The work environment, though generally satisfactory from the point of view

of lighting, ventilation, and such physical factors, tends to be boring. Inter-personal relationships between workers or with supervisors and management may loom in the minds of workers with exaggerated importance, and psychogenic maladies are bound to appear, reflecting unsatisfactory morale.

5. Progressive visual deterioration is a hazard which is not confirmed by this survey.
6. Arising out of this survey, the following recommendations should be considered:—
  - (a) The medical services of the factories investigated should be informed of the particulars of persons found to require spectacles or for whom special follow-up would be beneficial.
  - (b) Pre-employment vision screening records should be standardised for all electronics industries.

- (c) A further survey of visual function in electronics industries may be done in greater detail, but this need be given only low priority as the questions remaining to be settled are largely academic in nature.

#### ACKNOWLEDGEMENTS

Grateful acknowledgement is made to the following members of the team who carried out the survey: Miss S. J. Ngui, S.R.N., C.M.B., H.V., Miss J. M. Lang, S.R.N., S.C.M. and Dr. G. L. Voon, M.B., B.S., D.O. We thank the electronics factories involved for their co-operation. We also thank the Permanent Secretary/Commissioner for Labour, Ministry of Labour and the Permanent Secretary/Director of Medical Services, Ministry of Health, Singapore, for permission to publish this paper.

#### REFERENCE

1. Duke-Elder, S.: "The Practice of Refraction." 8th edition, p. 1-12, Churchill, London, 1969.

