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Impact of Uncorrected Vision on Productivity-A study in an Industrial setting a Pair of Spectacles

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Abstract

Background**:** According to the World Health Organization (WHO) around one billion people worldwide in developing countries need vision correction. Uncorrected vision is believed to be responsible for a widespread loss of labour productivity and quality, reading and literacy problems, and other problems such as road and domestic accidents.

There is however, a lack of data on both the prevalence and the effects of uncorrected vision. As a result, governments and funding agencies have been hesitant to prioritise vision correction in their health and social development agenda.

This acute lack of access to vision correction across the developing world is primarily due to inadequate number of eye care professionals, facilities and the high cost of providing spectacles.

Objective of the study: As there are not any studies in the area of uncorrected vision and impact on productivity, this study was undertaken as a pilot study with an intention of understanding the impact of productivity among employees needing vision correction in comparison with those not needing correction but doing identical work, and to measure subsequent changes in productivity following vision correction among the former group through the supply of prescription spectacles.

Method*:* The research was undertaken among a group of 238 workers engaged in spinning and winding function at a cotton spinning and textile factory in Madurai. The productivity data was collected for 30 working shifts for each employee. Then the eye test was done by a team comprising of Ophthalmologist and Optometrist from Aravind Eye Hospital (WHO Collaborating Centre) and given the corrective glass to those who were prescribed the correction. Then after a month of gap given to get used to the glasses, again the productivity data was collected for 30 working shifts for all the samples in the first phase and analysed.

Results: Out of the 238 (111 Spinners + 127 Winders) workers undergone eyesight testing, 187 (90 Spinners + 97 Winders) workers needed vision correction which is around 80% of the total test done. Of these 187 needing vision correction, 169 (75%) were presbyopic and needed glasses for near vision correction. All those who were identified as needing vision correction were given spectacles. In terms of productivity measurement, though there were problems in tracking the data each employee wise due to various reasons as the industry was undergoing a transition at that point of time. With the best available data, the spinners showed an average improvement of 9.5% (with a standard error in the mean of 1.6); 44% improved their productivity by more 10% on previous output levels whilst 23% exceeded them by 20%. The winders showed less change after the provision of spectacles with 23% increasing their productivity by 10% of the factory standard, demonstrating that this task made less demand on workers visual acuity.

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Conclusion: A significantly higher proportion of industry workers having poor vision due to Refractive error. They never try to correct this error unless the vision problem is a major hurdle in their work and social life. The ignorance may be due to, not a painful problem, access to immediate services in eye care, cost of services, inconvenience in using a foreign object, cosmetic value, no realization of quality and performance attached to work.

***Constraints*:** The study could have been better if these following constraints were not there

Industry was undergoing a transition from Manual to Automation processes. There was drive of Voluntary Retirement scheme (VRS). If the study team could have got more time to think over the strategy and methodology.

***Policy Issues*:** The sight test result showed a high percentage of uncorrected refractive error in a high profile industrial setting. This could mean some percentage of loss of productivity and also a stake in quality of the product due to sight problem. This gives an impression to study on subjects who are involved in products linked to productivity and quality like export products, jewellary, thread work, handicrafts, textiles, manual industrial works and also life threatening workers like driving and food products industries, where good sight means a lot. As a policy the industrial settings should include eye testing in to their regular health screening programmes as this has direct implications to the work and outcome of the industry.

INTRODUCTION

Significant visually disabling refractive error affects a large proportion of the world's population, affecting both genders and all age and ethnic groups. Many have permanent low vision (less than 6/18 binocularly) that requires rehabilitation services. Refractive error can be simply diagnosed, measured and corrected with spectacles. Their provision (distance spectacles for myopia and near spectacles for presbyopia) is extremely cost-effective.

There are currently a number of barriers to the effective correction of refractive error. In many areas, the eye care personnel and/or the equipment needed to perform refraction are unaffordable to the community in need. There may be a lack of public awareness of the importance of eye care and the availability of vision correction. In the delivery of effective refractive services, all of these barriers must be removed and long-term sustainable solutions and infrastructure put in place. The aim of refraction camp programmes for correction of refractive error should be the delivery of equitable affordable eye care, so that all those who can benefit from refractive services get the correction and support they need.

Magnitude of refracive error blindness

With blindness defined as a presenting distance visual acuity < 3/60 in the better eye, the prevalence of blindness due to refractive error has been reported to be as high as 0.20% in India[1] for all age groups in the population considered together. If blindness is defined as presenting distance visual acuity <6/60 in the better eye, the prevalence of blindness due to refractive error in an Indian population was reported to be 0.36%, including 0.06% from amblyopia resulting from high uncorrected refractive error[1]. These data suggest that about 1 of every 280 people in the study population were blind from uncorrected or inadequately corrected refractive error or from refractive error-related amblyopia. In 1999 Dr. Dandona et al made a study on "Blindness in the Indian State of Andhra Pradesh", in the prevalence of refractive errors in India is as mentioned below:

Prevalence of refractive errors

The correction of refraction errors to eliminate this form of avoidable disability has been included as a priority component within the planned areas of action under ***Vision 2020: the Right to Sight***, the Global Initiative for the Elimination of Avoidable Blindness.

Country	Author	Year	Age range	*Myopia		*Hyperopia	
				Definition	Prevalence %	Definition	Prevalence %
India	Dandona	1999	< 16	< - 0.50	5.0	> 0.50	5.84
			16 – 39		14.6		2.7
			>39		28.2		27.4

*__Myopia__ - < or equal to – 0.50D and **Hyperopia** - > or equal to 2.00D (particularly in children)

Reference: 1. *Rakhi Dandona and Lalit Dandona, Refractive error blindness, Bulletin of the World Health Organization, The International Journal of Public Health, Volume -79, No.3, 2001, page -238*

SUBJECTS & METHODS

The research was undertaken among a group of 238 employees at a cotton spinning and industrial textile factory in Madurai owned by Madura Coats Limited (MCL), a subsidiary of Coats Viyella PLC UK.

This factory was selected on the basis that (a) it was located in the same city as Aravind Eye Hospital, thus simplifying the logistics of collecting data and working with the factory management, and (b) that it was a relatively large factory, thus providing a large enough sample size of employees to enable statistically significant trends to be calculated. From a total of around 2,000 employees, those selected for productivity measurement were those engaged in the processes of spinning (113 employees) and winding (125 employees). At the MCL factory the spinning and winding operations combine the following features, which made them suitable for productivity research:

- the work, although largely mechanised, is not automated and relies on a high degree of manual dexterity and visual acuity among the operatives, principally in identifying and repairing breaks in the cotton yarn as it passes through rows of mechanical spindles;

- the work is divided into shifts of equal duration (eight hours), enabling comparison of output as between employees on different shifts;
- the work is uniform, both within and between shifts, and employees do not normally move between spinning and winding or vice versa, enabling comparison of individuals' outputs over time for each operation;
- employees are grouped into "batches", which work a single shift (for example, 3.00-11.00 p.m.) during one week, another shift (for example, 7.00 a.m.-3.00 p.m.) another week, etc. Over the period of output measurement this would normalise for differences in lighting conditions which might affect productivity;
- the employees' ages spanned the range 24 to 54 years, with 69 aged under 40 and 169, 40 and over, enabling a comparison of productivity and eyesight based on age;
- very few of the employees already used spectacles. Those who did so could be identified, and in practice none of these wore spectacles at work;
- the management of MCL was prepared to cooperate in the research by giving Aravind Eye Hospital personnel access to the spinning and winding sections of the factory and the output records and standards, and by allowing independent observation of the recording process.

In the case of winding, employees are responsible for the operation of spindles on a single machine winding an identical thickness (count) of yarn. In the case of spinning, employees are responsible for spindles on several rows and several machines, which may be spinning several counts of yarn.

In each process, production "standards" in kg are set by MCL management for each shift, taking into account the machine(s) in question and the count of the yarn being wound or spun. Each employee's output on each shift is recorded against this standard. Thus, over time, it is possible to measure each employee's productivity as a ratio of the actual output versus the standard, expressed as a percentage. Any differences between machines, which would affect the productivity of employees against standards, would be eliminated over time, as employees are moved between machines.

Employees' output was measured and recorded against standards in two phases. Phase I winding measurement took place between 4 February and 10 March 2001. Spinning measurement took place between 20 February and 24 March. Between 7 and 24 March all 238 employees being measured underwent eyesight testing, resulting in 187 of them requiring and being prescribed and supplied with spectacles. 49 employees were found not to require vision correction, and two were referred for other eye conditions.

Following a period of some four weeks to allow the former group to become accustomed to wearing spectacles, Phase II output measurement of all 238 employees took place during May and up to 2 June, in which those prescribed spectacles were required to wear them. Section 4 of this report summarises the analysis of productivity in both phases.

Research activities undertaken

Design of methodology

The following factors were taken into account in design of the research methodology and data recording procedures:

- Originally it had been anticipated that only a sample of employees would be selected, however to achieve sufficient numbers for statistical accuracy all spinning and winding employees (totaling 238) were selected;
- It was decided that in Phase II the productivity of all employees (i.e. including those not prescribed spectacles) should be measured, to allow for the effects of externalities on changes in productivity between phases;
- It had been anticipated that the length of experience of individual employees would have an effect on their productivity, but this was found not to be a significant factor since all employees had been engaged on this work for several months at least;
- It was decided to measure output by shift rather than by hour, since all shifts are of equal (eight hours') duration;
- Since all the factory employees were male, no gender breakdown was applicable;
- MCL reported that no employees had been laid off or retired for reasons of poor eyesight, therefore no sight testing of former MCL employees was considered necessary for purposes of comparison.

Spreadsheets were prepared to record the following data for each spinning and winding employee:

- name
- age
- employee ID number
- for each shift: date, standard output (kg), actual output (kg), percent (actual/standard)
- totals: standard (kg), actual (kg), percent (total actual/total standard)
- number of days worked

In the case of winding, a single figure for each of the standard output and the actual output was shown for each shift. In the case of spinning (where employees are responsible for several machines), outputs and standards on each shift were to be taken from each machine and aggregated.

It was agreed with MCL management that the process of recording and responsibility for entering data on outputs and standards would be as follows:

- MCL supervisors at shop floor level would complete spreadsheets manually on a daily basis;

- LAICO would input this data into Excel spreadsheets;
- LAICO would regularly oversee and crosscheck the data to ensure that it was being collected and recorded accurately by MCL.

Phase I productivity measurement

Measurement of output was recorded between 4 February and 10 March 2001 (winding) and 20 February and 24 March (spinning). The start of the spinning measurement was delayed due to problems in collecting data, as explained below.

The collection of winding data presented no significant problems. In this department, approximately 10 per cent of employees' wages are based on their productivity, and productivity standards are clearly determined under agreements between MCL and the trade unions. For each employee and each shift, output for each employee is measured by weighing the cones of yarn and recorded against his name. Furthermore, the arrangement of machines in the winding section means that a given employee on a shift produces yarn of only one count; thus, only one set of output figures has to be recorded.

The recording of spinning data however presented a number of practical problems, which emerged only after data collection was under way. Despite earlier assurances by MCL that measurement and recording of spinning output were accurate, it transpired that in practice the way in which output was recorded made it difficult to attribute it accurately to individual employees. Furthermore, since wages in the spinning section are not tied to productivity there was little incentive on the part of MCL or employees to measure productivity in the same way as applied in the winding section. The problems arose as follows:

- the output of each frame, containing several hundred spindles, is measured by a hank meter, a counter driven by a roller, which is in turn driven by the yarn passing over it. The speed of the roller, and hence the reading on the hank meter, is the same regardless of the number of broken threads. Thus, the hank meter does not accurately measure actual output of a frame;
- the spun yarn is collected on "cops", which are collected when they are full. This activity, which is undertaken by different employees, does not necessarily coincide with the ending of a shift, therefore the number of cops completed cannot be attributed to a single employee;
- during a shift the yarn count may be changed on one or more of the frames. Although the standard for that shift will be adjusted, there is nevertheless a period of "down time" while the changeover takes place;
- output is determined not only by the speed with which employees mend broken threads (i.e. the task for which visual acuity would be expected to be important), but also by how promptly they replace empty bobbins (from which yarn passes through spindles on to the cops);

- LAICO staff, who visited the factory on an almost daily basis to collect the spinning data discovered that MCL supervisors were not recording it correctly or in a form that LAICO could use. Therefore, a delay occurred in recording spinning output while LAICO redesigned the data recording forms;
- there was some turnover among MCL supervisors responsible for recording data.

In practice, MCL management is interested principally in the output of the spinning section as a whole rather than that of individual employees, and output targets are set accordingly. Employees are spot-checked several times during each shift by supervisors, and if more than one per cent of the spindles for which they are responsible are found to be broken the employee is likely to be disciplined.

Excel spreadsheets showing winding and spinning data were sent to EAG in late April and early May respectively for preliminary analysis.

Eyesight testing and dispensing of spectacles:

Testing of the eyesight of the 238 employees took place over a period of three weeks in March 2001. It was conducted by a team from the Aravind Eye Hospital including a senior Ophthalmologist and a senior Optometrist, who visited the factory and conducted tests at the end of shifts. An external expert observer was also present to have sample checks on quality of the eye screening test. The test was found to be of high quality and the spectacles given to the employees were also of very good quality.

The Grades of Vision were determined based on the printouts of sight test data prepared by LAICO.

Grade 1 (perfect vision) = reading for both eyes is zero

Grade 2 (mild near vision correction required) = reading for one or both eyes is >0 but <1

Grade 3 (medium near vision correction required) = reading for one or both eyes is 1-2

Grade 4 (severe near vision required) = reading for one or both eyes is >2

Grade 5 (distance vision correction required) = reading for on or both eyes is <0

Table 1: Eyesight Test Results (no. of workers and vertical %)

Quality of vision	Spinning	Winding	Total
Grade 1: perfect vision	21 (18.6%)	17 (13.6%)	38 (16.0%)
Grade 2: mild near vision correction required	9 (8.0%)	15 (12.0%)	24 (10.1%)
Grade 3: medium near vision correction required	69 (61.1%)	70 (56.0%)	139 (58.4%)
Grade 4: severe near vision correction required	6 (5.3%)	10 (8%)	16 (6.7%)
Grade 5: distance vision correction required	8 (7.1%)	13 (10.4%)	21 (8.8%)

TOTALS	113 (100%)	125 (100%)	238 (100%)

A breakdown of grades according to age showed the following:

Table 2: Eyesight By Age Group (no. of workers and vertical %)

Quality of vision	Under 40	40 & over	Total
Grade 1: perfect vision	35 (50.7%)	3 (1.8%)	38 (16.0%)
Grade 2: mild near vision correction required	18 (26.1%)	6 (3.6%)	24 (10.1%)
Grade 3: medium near vision correction required	5 (7.3%)	134 (79.3%)	139 (58.4%)
Grade 4: severe near vision correction required	0	16 (9.4%)	16 (6.7%)
Grade 5: distance vision correction required	11 (15.9%)	10 (5.9%)	21 (8.8%)
TOTALS	69 (100%)	169 (100%)	238 (100%)

Following testing, prescription bifocal spectacles were provided to all employees requiring them, a total of 187. The spectacles are dispensed by an experienced opticians team from Aravind Eye Hospital with prior measurements of size and angle in relation to face and also with proper counselling. 49 employees were not prescribed spectacles, either because they had perfect vision (grade 1) or because their refraction error was small and they were aged below 40.

Phase II productivity measurement

This measurement covered both employees who had been prescribed spectacles and those not requiring them.

Although the project Terms of Reference had originally envisaged measuring the Phase II productivity only of those prescribed spectacles, it was decided to include all employees, both in order to enable as broad a comparison as possible between Phase I and Phase II data, and also to allow for externalities which might affect the productivity of all employees but would not be reflected in output standards, for example, changes in the quality of the raw cotton or the ambient temperature. Although data would be collected for 238 employees, the number for which both Phase I and II data would be available for comparison would be limited to a maximum of 206 and might be less if some of these took voluntary redundancy in the course of the Phase II productivity measurement period.

Finally, the MCL Industrial Relations head confirmed that supervisors were under instructions to monitor the wearing of spectacles at work by those supplied with them.

Measurement of output was recorded between in May and up to 2 June. Similar spreadsheets and input procedures were used as for the Phase I measurement.

ANALYSIS OF PRODUCTIVITY RESULTS

Winders: Phase I Productivity

The average (mean) of each worker's actual output versus the standard output has been calculated as a percentage. This mean takes account of the number of shifts worked by each worker, so it represents an "average difference versus standard output per shift".

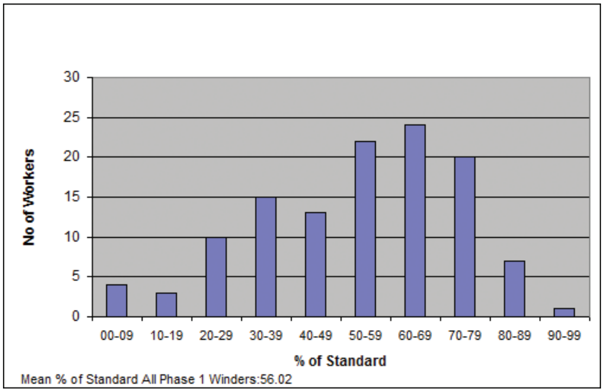

Figure 1: Distribution of Winders Phase 1 Productivity

The overall average percentage of standard output produced by all Winders in Phase I is 56%. However, the distribution around the average is quite broad. Figure 1 below

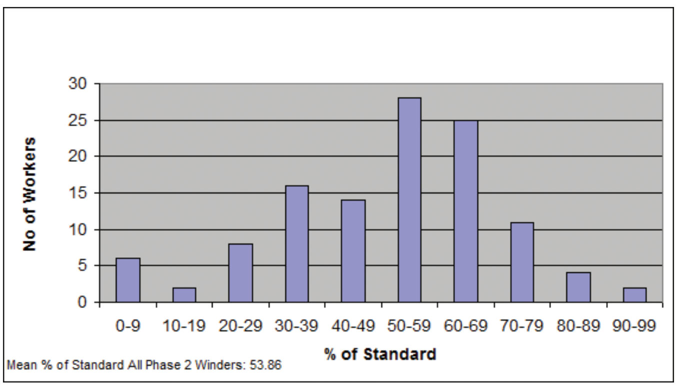

Figure 2: Distribution of Winders Phase 2 Productivity

shows that the largest number of workers produced between 56% and 80% of the standard, but 19 workers (16%) produced less than 30% of the standard.

Winders: Phase II Productivity

In phase II the average percentage of standard output fell to 54% overall.

Spinners: Phase I Productivity

The overall average percentage of standard output produced by all the Spinners in Phase I is 86%, and hence considerably higher than that for Winders. The distribution in Figure 3 below shows that no spinners produced less than 40% of standard, and 17 produced more than 100% of the standard.

Spinners: Phase II Productivity

In Phase II the average percentage of standard output rose to 92%. Figure 4 below shows that only one worker produced less than 70% of the standard (compared to 25 workers in Phase I).

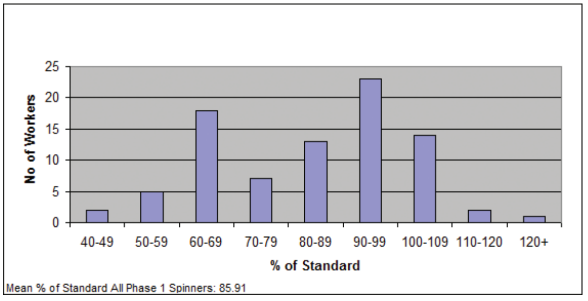

Figure 3: Distribution of Spinners Phase 1 Productivity

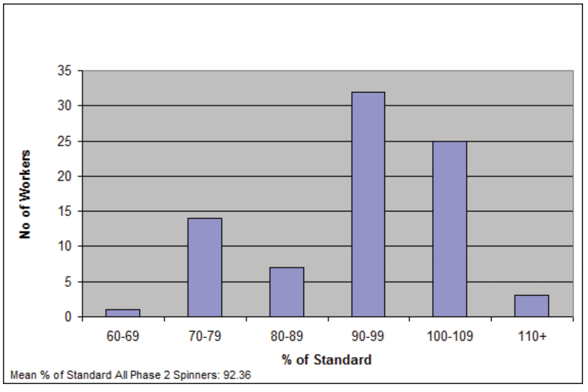

Figure 4: Distribution of Spinners Phase 2 Productivity

Qualitative Research

In addition to collection of the quantitative data on productivity, a discussion meeting, with interpreter, also took place between the GIC consultant and a group of 16 MCL spinning and winding employees. The objective of this was to add some qualitative background to the quantitative analysis of productivity and eyesight data by asking employees to respond to questions on the effects of wearing spectacles. The following was recorded:

- none of the 16 had had an eyesight test before;
- some employees had experienced problems at work due to poor vision (for example, difficulty in seeing broken threads), while others had no such problem;
- in the first few days of wearing spectacles, several had experienced difficulty in adjusting their focus when looking up and down in the course of working with spinning and winding machinery, due to having bifocal spectacles;
- all confirmed that, if supplied with spectacles, they wore them at work unless they happened to leave them at home;
- all stated they wore spectacles at home and found them useful in the home;
- all confirmed that, overall, they could see more clearly with spectacles than without;
- most confirmed that they would continue to wear spectacles at work and that, if their spectacles were damaged, they would immediately replace them at their cost;
- there was a general complaint that it was difficult to wear spectacles in the work place, due mainly to dust and the tendency of spectacles to slip down the bridge of the nose.

Overall, seven of the 16 said they found wearing glasses not to be a problem, but all agreed they expected to become accustomed to wearing spectacles over time.

CONCLUSIONS

- It was an interesting finding to know that almost 80% of the sample subjects were in need of corrective glasses but hardly anyone was aware of this.
- There are significant challenges associated with data collection for research of this type. Reliable measures of production output, as well as sufficiently large sample sizes to demonstrate statistical significance, are difficult to establish. However, important learning has been gained on all aspects of research implementation in the context of eyesight and industrial productivity.
- The Phase I productivity data indicate that there are no significant differences between workers aged under or over 40, or between those not requiring and those requiring vision correction.
- However, eyesight testing at the end of Phase 1 showed that only 16% of all workers tested had perfect vision, and only 3 of these workers (less than 2% of the total) were

aged over 40. 10% required mild near vision correction, 58% medium near vision correction, 7% severe near vision correction and 9% distance vision correction. 79% of those workers aged over 40 required medium near vision correction.

- Amongst winders workers, average productivity declined slightly between Phase I and Phase II (from 56% to 54% of standard), but this difference is not statistically significant.
- Amongst spinners workers, productivity was generally higher, and this improved between Phase I and Phase II (from 86% to 92% of standard).
- Following correction of vision impairment those spinners workers who received glasses for mild–medium near vision correction improved their average productivity by 12% in Phase II. Although workers who did not require glasses also improved their productivity, those with glasses for near vision improved most.
- There are some practical issues associated with wearing spectacles in a humid, dusty work environment. Nevertheless, there are also indications that workers do become used to them and find them helpful at home as well as at work.

Impact of corrected vision at home and social environment*: *Qualitative findings

In order to understand the impact of spectacles use at home and social environment, the research team took a sample of around 10% of the workers who were prescribed and dispensed spectacles under the research and visited their houses and talked to the family members and neighbors besides the user on what observations they have about the individual after the use of spectacle. The common answers which the research team received, on the changes the family and the user experiencing are:

1. He is watching the TV from a distance unlike before where he use to watch from a close distance
2. Reading newspapers regularly
3. Not getting angry, searching for his personal items like Identity card, purse and other items inside the house
4. Able to ride bicycle and motorcycle in the evening
5. Can read the price of the products, which normally written in small letters, in the shop before buying
6. Not coming with cut hands due to sharp edges of the yarn, unlike before where he was not able to see the cut ends clearly and comes home with minor bruises and cuts
7. Feels very confident and higher level of motivation

The researchers can observe the happiness in the family and individual due to improved vision after wearing the spectacles which they had never realized before.

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