OCULAR EFFECTS OF AIRBORNE PARTICLES IN THE WORKING ENVIRONMENT

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Very little can be found in the literature regarding the specific effects of airborne particles in the working environment on ocular tissue. Hence, I have designed a simple study to determine whether or not ocular tissue is indeed affected by adverse environmental conditions. The environment chosen is the Ferris State College Printing Department. The subjects are students in the Ferris State College Industrial Graphics program. Acute ocular signs and symptoms involving the anterior segment following exposure to airborne particles are the variables being investigated.

METHODS AND INSTRUMENTATION

Three distinct groups of information are gathered in this study. The first deals only with population characteristics. Each subject was required to fill out a questionaire indicating whether or not he/she wears contact lenses, has a current eye infection, or is using a prescribed or over-the-counter medication. Those individuals whose responses were positive to contact lense wear or an ocular infection were dropped from the test population. Those individuals using a medication remained in the study, providing the medication did not have a known ocular side effect.

The next two groups of information deal directly with the adverse effects of airborne particles on ocular tissue in the

working environment. Data collected are of two types. First are the subjective symptomatic responses given by each subject in the test population. Second are the objective findings, or signs, of the anterior segment examination through biomicroscopy. Symptoms and signs were evaluated prior to, and following exposure to airborne particles in the working environment. Data was collected in a check-list fashion to facilitate ease in tabulation. Please refer to appendix A for the actual questionaire and examination form used.

Biomicroscopy was performed with an American Optical slit lamp. Examined were the lids, conjunctiva, cornea, tear film quality, tear break-up-time, and the corneal fluorescein staining pattern. Those individuals having abnormal slit lamp findings during the "prior exposure" examination were also dropped from the test population.

The following summarizes the sequence of events for each subject in the test population. First, the questionaire indicating contact lens wear, ocular infection, and use of medications was filled out by each subject, along with a check-list of descriptive terms regarding present ocular symptoms. Second, the biomicroscopic examination was performed. Third, the subjects entered the working environment where airborne particles were known to exist. Immediately upon leaving the working environment, the subject again filled out the check-list of present ocular symptoms. Then, the final biomicroscopic examination was performed.

TEST POPULATION AND ENVIRONMENT

Twelve subjects, students at Ferris State College in the Graphic Arts program, volunteered to take part in this study. Six of the twelve were dropped from the test population for one or more of the following reasons: current contact lens wear, known diagnosis of conjunctivitis, demonstrated corneal staining, an abnormally low tear break-up-time, failure to return for the "following exposure" examination. The remaining six test subjects ranged in ages 18 to 23 years, with a mean age of 19 years. Two were female, and four were male.

The environment containing airborne particles is a single floor with classrooms and large work areas containing machinery for the various stages of the printing process. Chemicals used in these work areas include: developing solutions, blanket wash, fixer solutions, plate gum, plate cleaners, activating solutions, and printing inks. A majority of these solutions have labels which display health warnings regarding the inhalation of fumes and direct dermal contact. Some labels display warnings specific for contact with ocular tissue.

METHODS USED FOR STATISTICAL ANALYSIS

By using the null hypothesis, H_0, as our premise, we state that no significant difference exists between the group of data "prior exposure," and the group of data "following exposure" to the adverse environmental conditions.

A p-value is used to establish significance. The Z-test is used to determine a p-value for each area being statistically analyzed. If the p-value are greater the .05, the differences between the two groups of data is not significant. A p-value

less than .05, but greater than .01, denotes a difference which is significant. A p-value less than .01 denotes a diference which is highly significant. P-values which are equal to .05 or .01 are considered right on the boaderline; the decision regarding significance is arbitrary.

The formula for the z-score is as follows:

$$z = \frac{\bar{X}_p - \bar{X}_f}{\sqrt{\frac{s_p^2}{n_p} + \frac{s_f^2}{n_f}}},$$

n= the number of eyes examined.
X= a piece of data.
$\bar{X}$= the mean, or average value of the sample data.
S= the standard deviation of $\bar{X}$.

The subscripts "p" and "f" refer to data collected "prior exposure" and "following exposure," respectively.

Once a z-score is calculated, the p-value which correlates can be found in the table of appendix B. Below summarizes the relative significance of the p-values:

if p > .05, not significant;
if .01 < p < .05, significant;
if p < .01, highly significant.

DATA AND ASSIGNED VALUES

Only the positive responses and findings are listed in the tables below. Values are assigned to those slit lamp findings which are to be analyzed statistically. Assignment of values was done arbitrarily; tear quality and break-up-time could take on positve and negative values, where the normal condition was equal to zero. Values for fluorescein staining of the cornea begin at zero, indicating no staining, and take on only positive values depending upon the amount of staining observed.

POPULATION CHARACTERISTICS.

test subject	ocular injury	present CL wearer	previous CL wearer	ocular infection/ irritation	allergies	medications
JD						
SF						
DY					(hay fever)	
SG						
KM						
CS						(thyroid pills)

SYMPTOMATIC RESPONSES.

	prior exposure										following exposure										
test subject	scratchy itchy	stinging	gritty	burning	dry	watery/teary	sensitive to light	discharge	red	other	scratchy itchy	stinging	gritty	burning	dry	watery/teary	sensitive to light	discharge	red	other	hours of exposure
JD										fine										fine	1
SF					+					fine										fine	2
DY										fine										fine	3
SG										foggy			+							foggy	3
KM									+	tired				+ (slight)						tired	2.5
CS										tired										—	2.5

BIOMICROSCOPIC EXAMINATION FINDINGS.

Tear Film Quality: no findings listed indicate a tear film quality which is within normal limits.

test subject	prior exposure OD	prior exposure OS	following exposure OD	following exposure OS	assigned values prior exposure OD	assigned values prior exposure OS	assigned values following exposure OD	assigned values following exposure OS
JD					0	0	0	0
SF			↑w	↑w	0	0	+1	+1
DY			↑w ↑d	↑w ↑d	0	0	+2	+2
SG	↑d	↑d	↑d	↑d	+1	+1	+1	+1
KM					0	0	0	0
CS	↑o	↑o	↑o	↑o	-1	-1	-1	-1

↑w ≡ ↑ water content
↑o ≡ ↑ oil content
↑d ≡ ↑ debris

Tear Break-Up-Time: no findings listed indicate a break-up-time of > 10 seconds.

test subject	prior exposure OD	prior exposure OS	following exposure OD	following exposure OS	assigned values prior exposure OD	assigned values prior exposure OS	assigned values following exposure OD	assigned values following exposure OS
JD					0	0	0	0
SF								
DY								
SG								
KM								
CS								

Corneal Staining With Fluorescein: no findings indicate no staining observed.

test subject	prior exposure OD	prior exposure OS	following exposure OD	following exposure OS	assigned values prior exposure OD	assigned values prior exposure OS	assigned values following exposure OD	assigned values following exposure OS
JD				+	0	0	0	+1
SF							0	0
DY							0	0
SG							0	0
KM							0	0
CS			+				+1	0

DATA ANALYSIS

The subjective portion, containing symptomatic responses, does not easily lend itself to statistical analysis. However, it should be noted that two of the six subjects reported an adverse change following exposure. One reported stinging, and the other reported slight burning. Also, two subjects reported redness and tearing prior exposure, but did not report the same symptoms following exposure. Please refer to table of symptomatic responses for a summary of subjective data collected.

Of the data collected through biomicroscopic examination, three areas were analyzed for statistical significance. These

areas examine the subtle acute changes that may occur over a short period of time: tear film quality, break-up-time, and corneal fluorescein staining. Other areas also examined were the lids, conjunctiva,and cornea with white light. Examination findings for these latter groups of data revealed no differences between the "prior exposure" and the "following exposure" groups of data. Thus, these areas were not statistically analyzed.

Tear Film Quality:

$n = 12$

$\bar{X}_p = 0$ $S = .5773503$

$\bar{X}_f = .5$ $S = .7905694$

z-score = -1.769301 p-value = .04

Tear Break-Up-Time:

No difference was found between the "prior exposure" and "following exposure" data; therefore no statistical analysis was done.

Corneal Staining With Fluorescein:

$n = 12$

$\bar{X}_p = 0$ $S = 0$

$\bar{X}_f = .1666667$ $S = .372678$

z-score = -1.5491936 p-value = .064

CONCLUSION OF STATISTICAL ANALYSIS

Statistical analysis of the tear film quality shows a significant difference between the data collected prior, and following exposure to airborne particles. The p-value for this variable is .04. Thus the null hypothisis, H_0, has been disproved.

The null hypothesis for tear break-up-time remains true, as no difference between the data collected prior and following exposure was found. The null hypothesis for corneal staining with fluorescein also remains true. However, the p-value found for this variable approaches the boundary between non-significant and significant.

DISCUSSION AND SUMMARY

Three variables of the biomicroscopic examination were statistically analyzed to determine if adverse environmental conditions cause acute ocular changes. Of the three, tear film quality rendered a p-value demonstrating a significant difference between the observed ocular conditions prior and following exposure.

More research in this area is needed, for a variety of reasons. First, this study only begins to identfiy possible acute ocular conditions which may occur as a result of exposure in the work environment. The subjects of this study were in the environment for an average of 2.5 hours; this is not the normal exposure period in a realistic working situation. The actual productivity demands of a realistic working situation were also absent. With an increased use of machinery, surely the air would show a greater concentration of fumes, dusts, and particles.

Second, the chronic effects of exposure need to be investigated. The amount of time required for ocular tissue to recover from an acute insult, the number of repeated exposures required for a chronic condition to develop, and whether or not a type I hypersensitivity reaction evolves are some of the questions that

need to be answered.

Furthermore, if a chronic condition develops, will the condition hinder the worker's ability to perform satisfactorily on the job? If so, what measures can be taken to either prevent the chronic condition, or decrease the severity of symptoms associated with the chronic state?

In sum, this study has shown that indeed some ocular tissues are affected by airborne particles in the working environment. Additional research is needed to distinguish acute from chronic effects. Also needed is the identification of those chronic effects which may lead to debilitation of workers, and thus affect the indivduals ability to remain a productive member of the work force.

APPENDIX A

STUDENT QUESTIONAIRE

1. Have you ever had any injury to your eyes?
   - ☐ Yes. If so, please explain: _____
   - ☐ No.

2. Do you wear contact lenses?
   - ☐ Yes.
   - ☐ No.

3. Have you ever worn contact lenses?
   - ☐ Yes.
   - ☐ No.

4. Do you have any type of eye infection or eye irritation, at the present time?
   - ☐ Yes. If so, please explain: _____
   - ☐ No.

5. Do you have any allergies?
   - ☐ Yes. If so, please explain: _____
   - ☐ No.

6. Are you taking any medications, including over-the-counter store bought medications, at the present time?
   - ☐ Yes. If so, please list these: _____
   - ☐ No.

7. How would you describe the way your eyes feel or look <u>at this very moment</u>?

   - ☐ Scratchy.
   - ☐ Itchy.
   - ☐ Stinging.
   - ☐ Gritty.
   - ☐ Burning.
   - ☐ Dry.
   - ☐ Watery/Tearing.
   - ☐ Sensitive to light.
   - ☐ Draining with a discharge.
   - ☐ Red/"Blood-shot."
   - ☐ Other: _____

1. How would you describe the way your eyes feel or look at this very moment?

- ☐ Scratchy.
- ☐ Itchy.
- ☐ Stining.
- ☐ Gritty.
- ☐ Burning.
- ☐ Dry.
- ☐ Watery/Tearing.
- ☐ Sensitive to light.
- ☐ Draining with a discharge.
- ☐ Red/ "Blood-shot."
- ☐ Other: _____

2. Have you ever noticed that your eyes continue to be irritated, or continue to bother you, later in the evening, or even into the next day?
   - ☐ Yes. If so, which ones: _____
   - ☐ No.

3. How long have you been in the working environment today?
   ____ hours.

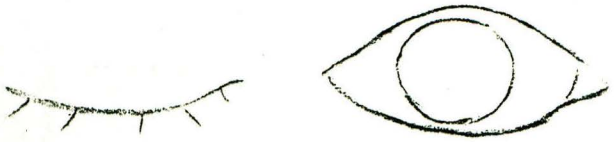
4. What type of chemicals or solutions do you work with?
   _____
   _____
   _____
   _____

BIOMICROSCOPY  Prior environmental exposure
Following environmental exposure

LIDS

OD
___WNL
___edema
___gland abnormality
___lashes
___other:

OS
___WNL
___edema
___gland abnormality
___lashes
___other:



CONJUNCTIVA

OD Bulbar:
___WNL
___injection
___chemosis

Palpebral:
___WNL
___injection
___chemosis
___follicles
___papillae
___retention cysts
___concretions
___discharge
___other:

OS Bulbar:
___WNL
___injection
___chemosis

Palpebral:
___WNL
___injection
___chemosis
___follicles
___papillae
___retention cysts
___concretions
___discharge
___other:

TEAR FILM

OD
___WNL
___increased oily component
___increased water component
___debris
___other:

OS
___WNL
___increased oily component
___increased water component
___debris
___other:

CORNEA

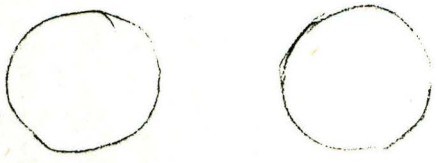
OD
___WNL
___edema
___epithelial defect
___vessel invasion
___other:

OS
___WNL
___edema
___epithelial defect
___vessel invasion
___other:

FLUORESCENE STAINING

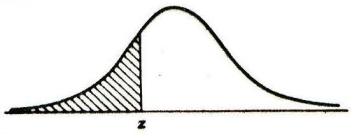
OD
_____tear B.U.T.
___corneal staining

OS
_____tear B.U.T.
___corneal staining



APPENDIX B

Percentiles of the Standard Normal Distribution.



$P(Z \leq z)$	z
.001	-3.0902
.005	-2.5758
.01	-2.3263
.02	-2.0537
.03	-1.8808
.04	-1.7507
.05	-1.6449
.10	-1.2816
.15	-1.0364
.20	-.8416
.25	-.6745
.30	-.5244
.35	-.3853
.40	-.2533
.45	-.1257
.50	0
.55	.1257
.60	.2533
.65	.3853
.70	.5244
.75	.6745
.80	.8416
.85	1.0364
.90	1.2816
.95	1.6449
.96	1.7507
.97	1.8808
.98	2.0537
.99	2.3263
.995	2.5758
.999	3.0902

REFERENCES

Elementary Statistics. Lindgren, B.W., Berry, D.A., Macmillan Publishing Co., Inc., 1981.