

**HEALTH EFFECTS  
EVALUATION OF THEATRICAL  
SMOKE, HAZE, AND PYROTECHNICS**

**Jacqueline M. Moline, M.D., M.Sc.**

**Anne L. Golden, Ph.D.**

**Mount Sinai School of Medicine**

**Joseph H. Highland, Ph.D.**

**Alan S. Kao, Ph.D.**

**ENVIRON International Corporation**

**HEALTH EFFECTS  
EVALUATION OF THEATRICAL  
SMOKE, HAZE AND PYROTECHNICS**

**EPIDEMIOLOGICAL  
ASSESSMENT**

**Phase 1:  
Baseline Questionnaire**

**Phase 2:  
Daily Checklists**

**Phase 3:  
Medical Evaluations**

**EXPOSURE  
ASSESSMENT**

**Preliminary  
Exposure Assessment**

**Detailed  
Exposure Assessment**

**FINAL REPORT**

# Phase 1

- The baseline questionnaire was distributed to all Actors and Stage Managers in a current Broadway musical.
- The questionnaire collected background, symptom, and medical information from 439 participants, as well as information on their activities onstage and their theatrical experience.

# Phase 2

- Phase 2 was designed to collect longitudinal data on daily symptoms over the course of the study.
- Actors completed daily checklists describing their activities and symptoms for three one-month periods.
- 554 daily checklists were collected.

# Phase 3

- The medical evaluation consisted of vocal quality assessments, pulmonary function tests, and direct visualization of the vocal cords.
- The medical evaluation is a unique aspect of this study. It allowed for a direct assessment of both acute and chronic effects on the upper airway, voice, and respiratory tract.
- 95 Actors participated in the medical evaluations.

# Exposure Assessment

- A preliminary exposure matrix was developed using time and activity data from the baseline questionnaires and stage-wide average concentration measurements.
- The purpose of this exposure matrix was to provide preliminary estimates of exposure so that initial analyses of all 439 of the Actors participating in the study could be conducted.

# Exposure Assessment

- A detailed exposure matrix was developed to provide a more accurate characterization of exposure on a subset of 218 Actors for the epidemiological analysis.
- Use of the detailed exposure matrix provided data to distinguish between integrated and peak exposures.

# Participating Shows

- Beauty and the Beast
- Cats
- Chicago
- High Society
- Jekyll and Hyde
- The Life
- The Lion King
- Les Miserables
- Miss Saigon
- The Phantom of the Opera
- Ragtime
- Rent
- The Scarlet Pimpernel
- Smokey Joe's Cafe
- The Sound of Music
- Titanic

# Theatrical Effects Used During Study

Show	Theater	Effect		
		Glycol	Oil	Pyro
Beauty & the Beast	Palace	U		U
Cats	Winter Garden		U	U
Chicago	Shubert		U	
High Society	St. James			
Jekyll & Hyde	Plymouth	U	U	U
Les Miserables	Imperial	U		
The Life	Barrymore	U		
The Lion King	New Amsterdam		U	
Miss Saigon	Broadway	U		
The Phantom of the Opera	Majestic	U	U	U
Ragtime	Ford Center		U	U
Rent	Nederlander		U	
The Scarlet Pimpernel	Minskoff			
Smokey Joe's Café	Virginia		U	
The Sound of Music	Martin Beck	U	U	
Titanic	Lunt-Fontanne	U		

# Conclusions

- No evidence of serious health effects was found to be associated with exposure to any of the theatrical effects evaluated in this study.

# Conclusions

- Peak exposures to elevated localized air concentrations following a release of glycol smoke are associated with increased reporting of respiratory, throat, and nasal symptoms and findings of vocal cord inflammation.

# Conclusions

- Elevated exposures to mineral oil haze are associated with increased reporting of throat symptoms.

# Conclusions

- No health effects were associated with the current use of pyrotechnic effects from any of the productions included in the study.

# Conclusions

- There was no evidence of an additive or multiplicative increase in effect from exposure to more than one of the types of theatrical effects evaluated in this study.

# Conclusions

- Other factors besides theatrical effects were also found to be associated with increased symptom reporting.
  - ⊕ Perceived levels of stress (at work and away from work)
  - ⊕ Performance schedule
  - ⊕ Physical demand of the role(s) played.

# Guidance

- Exposures to theatrical effects should not exceed peak or ceiling concentrations of
  - ⊕ 40 mg/m<sup>3</sup> for glycols
  - ⊕ 25 mg/m<sup>3</sup> for mineral oil.
- Time-weighted average exposures to mineral oil should be kept below 5 mg/m<sup>3</sup>.
- Based on the results of this study, no change in the current use of pyrotechnics is necessary.

# Guidance

- As long as peak exposures are avoided, the health, vocal abilities and careers of Actors should not be harmed.