Respiratory and Ocular Symptoms among Employees at an Indoor Waterpark Resort — Ohio, 2016

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Hazard Evaluations and Technical Assistance Branch

2017 Expanding Research Partnerships: State of the Science

June 22, 2017

The request — August 2015

- Municipal health department received complaints about an indoor waterpark in a resort

- Initiated an online survey of patrons and employees
  - Eye burning
  - Nose irritation
  - Difficulty breathing
  - Vomiting

- Requested technical assistance from the NIOSH health hazard evaluation (HHE) program

Outline

- Background
- Objectives
- Methods
- Results
- Conclusions
- Recommendations

Indoor waterparks and the potential for illness

- Indoor waterparks are an expanding U.S. industry
  - As of 2015, 192 parks
  - Millions of visitors each year

- Air and water quality problems can lead to respiratory or irritation symptoms
  - Infectious
    - *Legionella*
    - Mycobacteria
  - Chemical
    - Endotoxins
    - Chlorine disinfection byproducts

Chlorine disinfection byproducts

Disinfection byproducts

Chlorine disinfection byproducts

+

=

Chloroform
Chloramines

Chlorine disinfection byproducts

+

=

Chloroform
Chloramines

“Chlorine smell” in pools
Mucus membrane irritants

Background on the facility

- Waterpark is part of a resort hotel
- Resort (hotel) open 7 days a week, 24 hours a day
- Waterpark hours vary by season, day of the week
- Operated by the same company since 2013
- Approximately 110 employees, some < 18 years old

Regulation of the facility

- **Ohio Department of Agriculture**
  - Water features
- **Municipal health department**
  - Whirlpool spa
  - Restaurant

Waterpark features with potential for water agitation

Waterpark features with potential for water agitation

- Rain Fortress with splash area

Waterpark features with potential for water agitation

- Rain Fortress with splash area
- Children's activity pool

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- Water slides

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- Lazy river
- Whirlpool spa

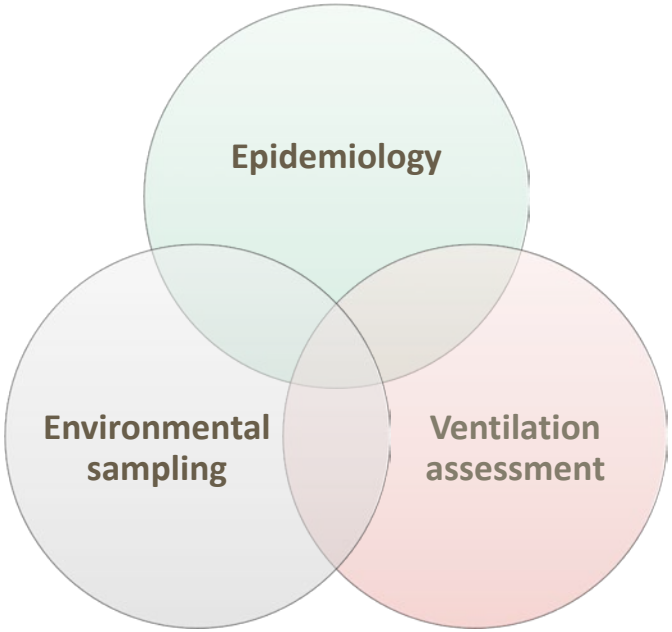
More aerosolization

Objectives

- Characterize and assess the prevalence of symptoms among waterpark employees versus employees in other resort areas
- Determine the etiology of work-related symptoms
- Recommend ways to improve working conditions

Methods

Multidisciplinary approach



- On-site evaluation (3 days)
- Martin Luther King Jr. holiday weekend in January 2016

Questionnaires

Main questionnaire

- Work history and practices
- Medical history
- Demographics
- Symptoms related to work over the past 4 weeks
  - Began while at work and improved away from work
  - Not associated with a cold or upper respiratory infection

End-of-workday symptom questionnaire

- Each day of site visit
- Work-related if symptom began at work that day

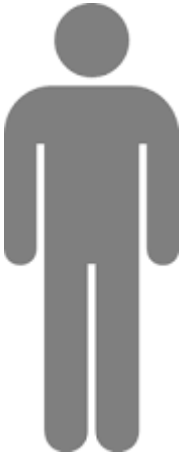
Case definition

3 or more

work-related symptoms

- Eye irritation
- Nose irritation
- Cough
- Wheeze
- Shortness of breath
- Chest tightness
- Sore throat

In a resort employee



In the past

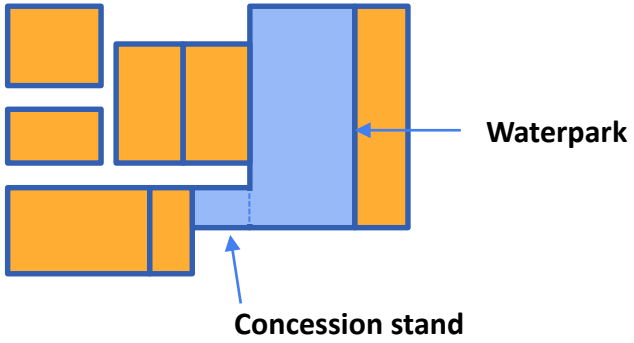
4

weeks

Waterpark vs. non-waterpark employees

Waterpark

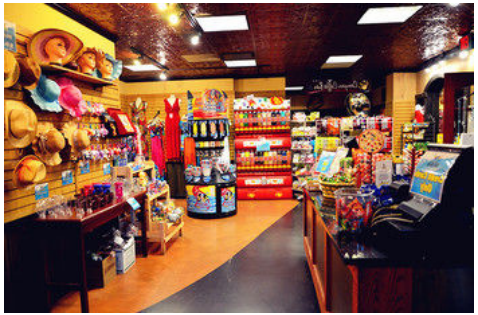
- Aquatics department
- Concession stand employees



Non-waterpark

- Other resort areas

- Hotel
- Arcade
- Gift shop



Data analysis

- Summarized descriptive statistics
- Compared characteristics of waterpark and non-waterpark employees using the Mann-Whitney *U* test or χ^2 test
- Calculated prevalence ratios (95% confidence intervals) using 2x2 tables to identify factors associated with meeting the case definition
- Calculated adjusted prevalence ratios (95% confidence intervals) using log-binomial regression

Air sampling and testing

- Collected areas samples at 6 waterpark locations for
  - **Chlorine**
  - **Chloroform**
  - **Endotoxin**

- Logged **temperature** and **relative humidity** each minute

Water sampling and testing

- Tested water samples using a color-matching test kit for
  - **Total chlorine**
  - **Free chlorine**
- Collected samples from the whirlpool spa, which were cultured for
  - ***Legionella***
  - **Mycobacteria**

Ventilation assessment

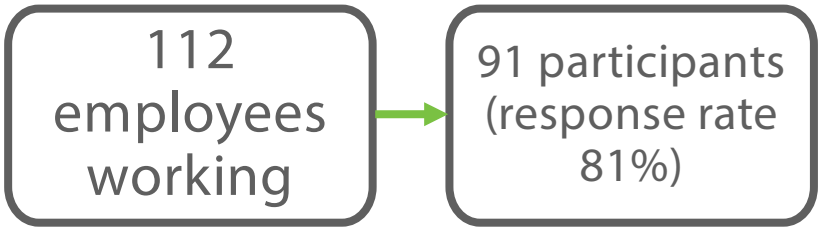
- Visually assessed HVAC* equipment
- Estimated air supply and return flow rates using blueprints
- Compared design air supply rate to consensus standards

* HVAC = heating, ventilation, and air conditioning

Results

Resort employees flow diagram

Resort employees flow diagram



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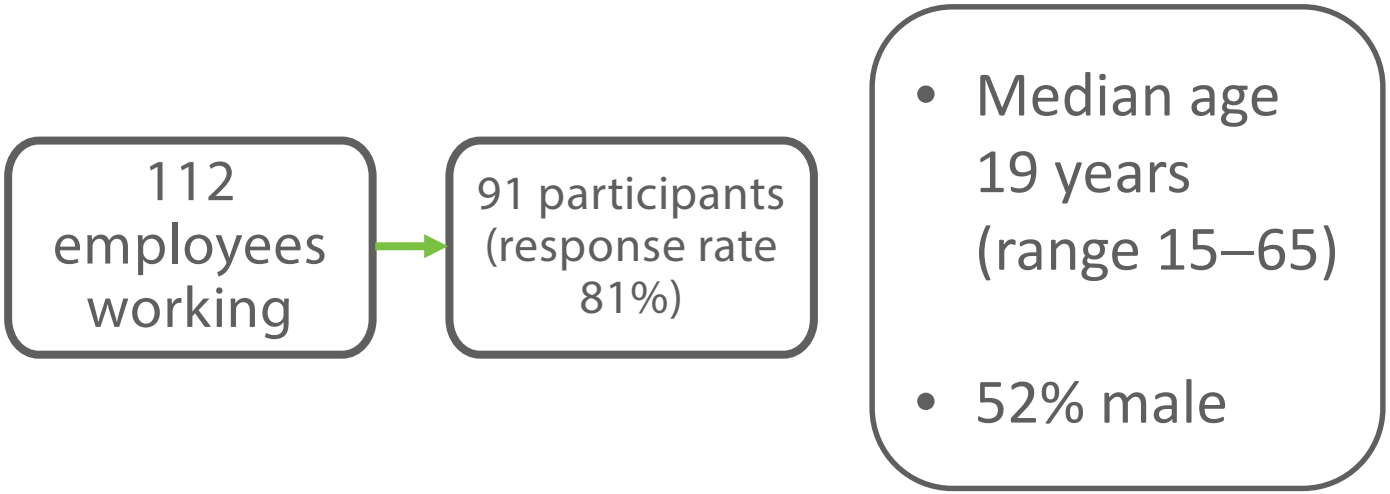

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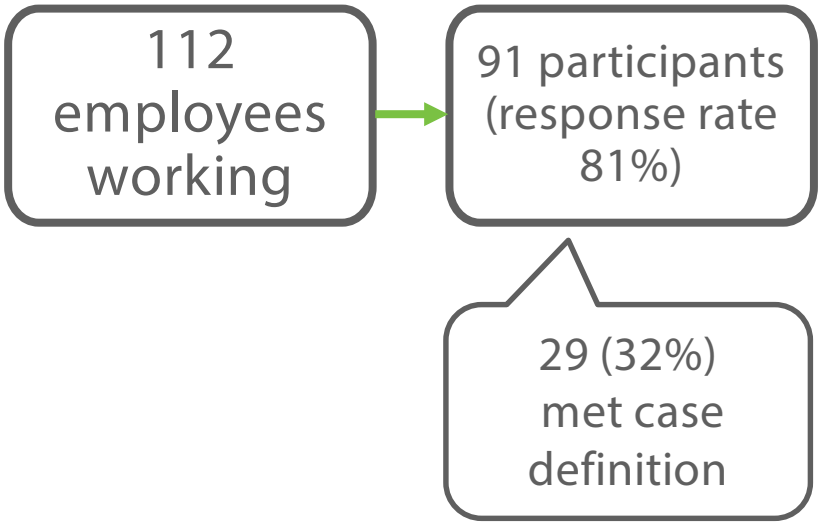

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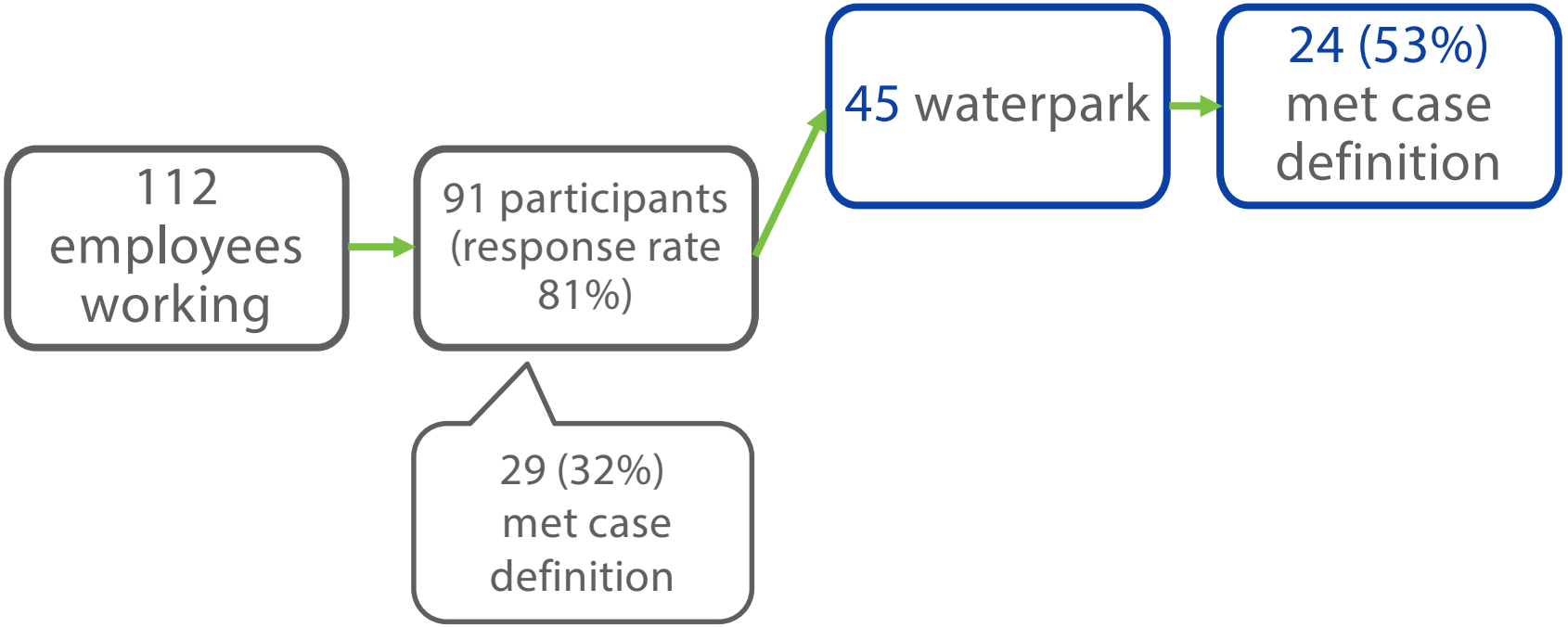

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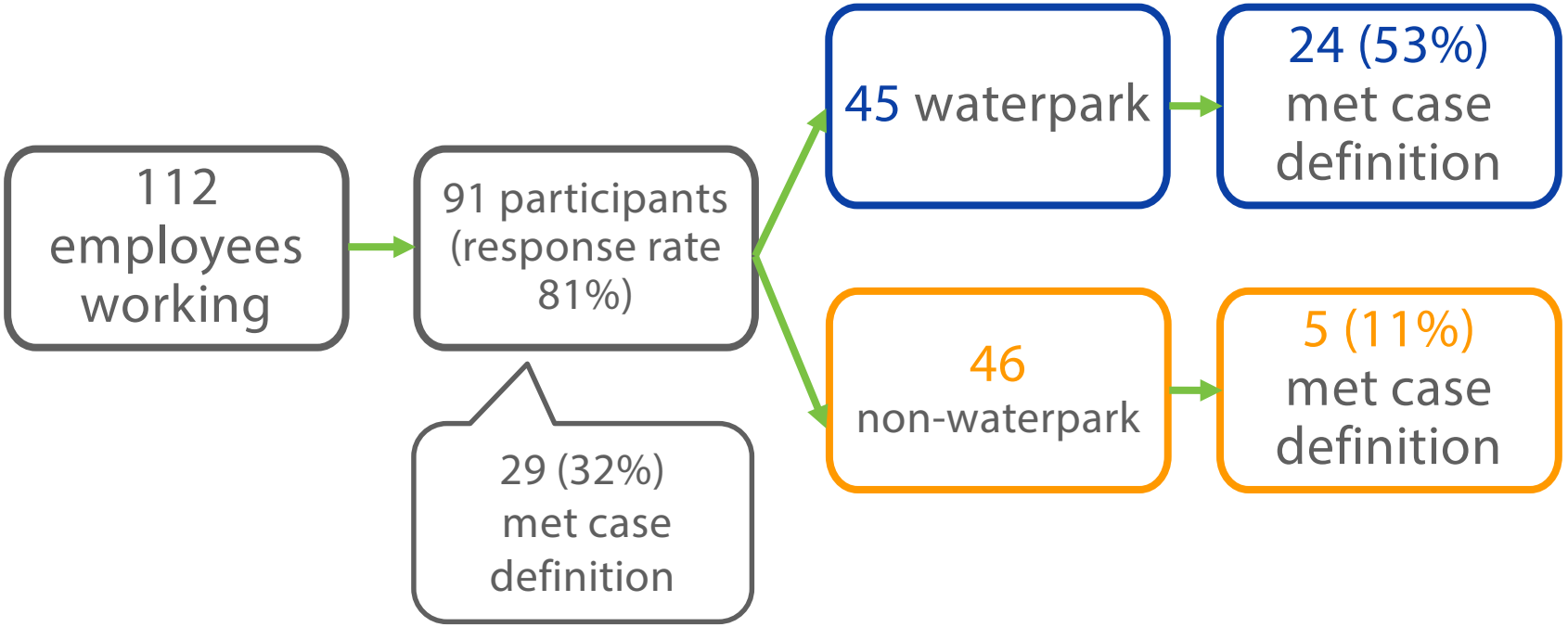

Characteristics of waterpark and non-waterpark employees

Characteristic	Waterpark employees N = 45	Non-waterpark employees N = 46	*P* value
Age <18 years, no. (%)	26 (58)	2 (4)	< 0.001
Male sex, no. (%)	23 (51)	24 (52)	0.92
Job tenure, months; median (range)	7 (<1–78)	14 (<1–150)	0.005
Hours worked over past 4 weeks, median (range)	72 (15–204)	86 (14–240)	0.24
Current asthma, no. (%)	10 (22)	3 (7)	0.33
Current smoker, no. (%)	3 (7)	8 (17)	0.20

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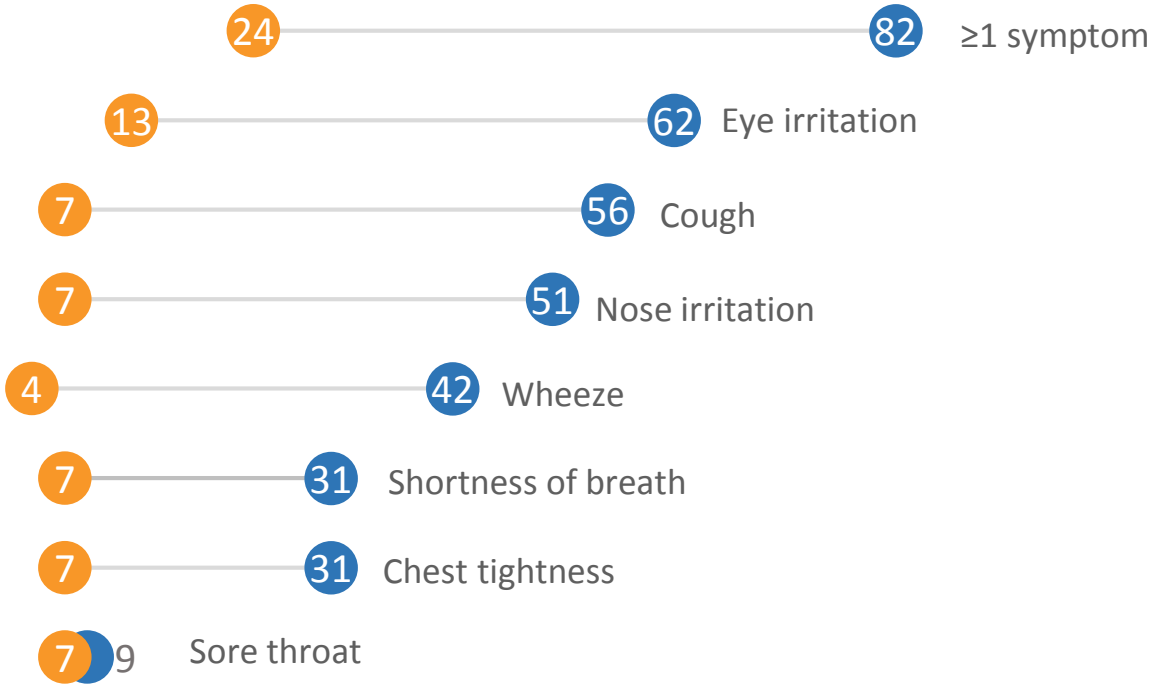
Percentage of non-waterpark and waterpark employees with work-related symptoms in the past 4 weeks



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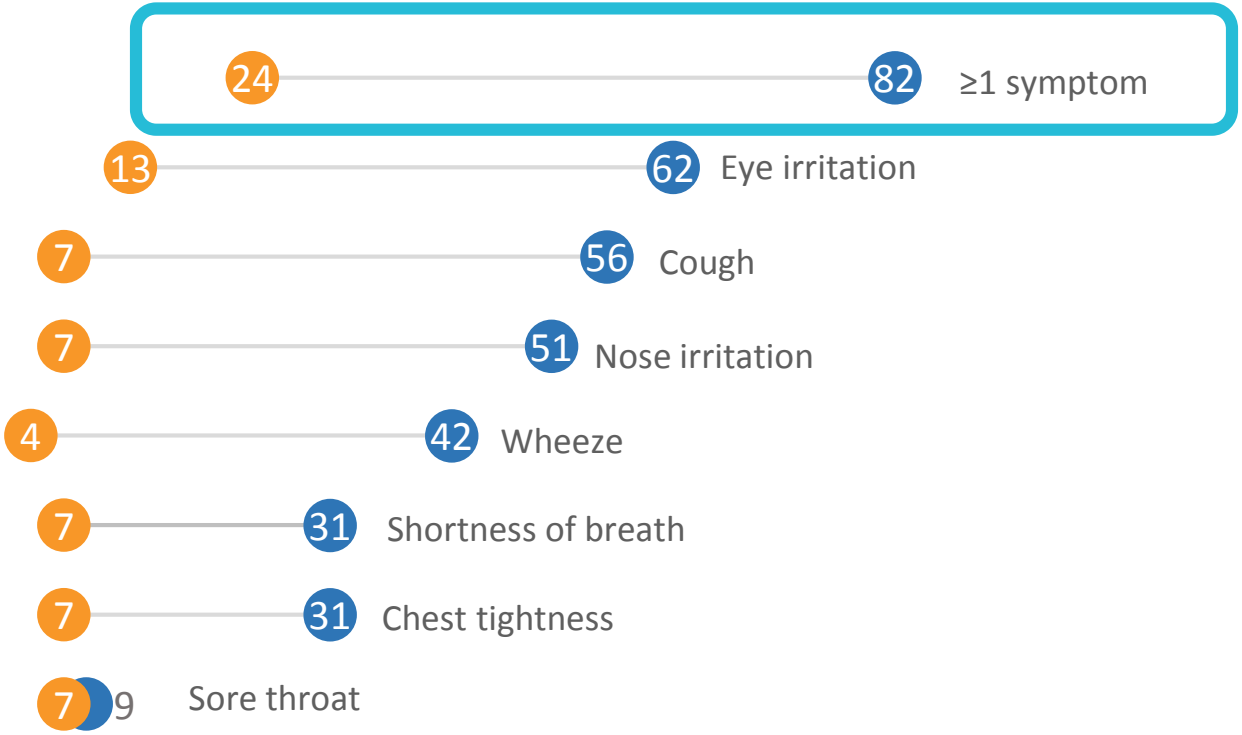

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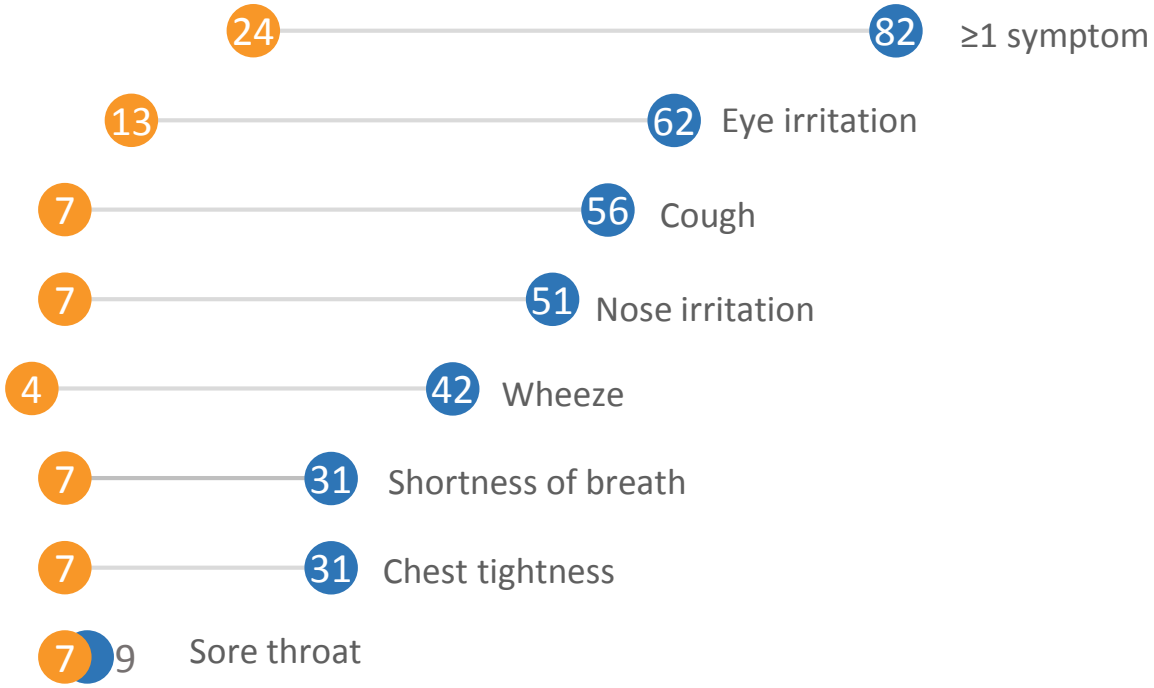

Factors associated with meeting the case definition (n = 91)

Characteristic	No. (%) of employees meeting case definition	Prevalence ratio	95% confidence interval
Waterpark employee			
Yes	24 (53)	**4.91**	**(2.05, 11.73)**
No	5 (11)		
Current asthma			
Yes	9 (31)	**2.70**	**(1.60, 4.56)**
No	20 (26)		

Factors not associated with meeting the case definition (n = 91)

Characteristic	No. (%) of employees meeting case definition	Prevalence ratio	95% confidence interval
Age			
<18 years	11 (39)	1.38	(0.75, 2.51)
≥18 years	18 (28)		
Sex			
Male	16 (34)	1.15	(0.63, 2.11)
Female	13 (30)		
Smoking status			
Current smoker	1 (9)	0.26	(0.04, 1.72)
Never or former smoker	27 (35)		

Assessing for potential confounders

	Crude prevalence ratio	95% confidence interval
Waterpark employee	4.91	(2.05, 11.73)

- Assessed age, current asthma, and current smoking status
- Final model adjusted for age

Assessing for potential confounders

	Crude prevalence ratio	95% confidence interval	Adjusted prevalence ratio	95% confidence interval
Waterpark employee	4.91	(2.05, 11.73)	3.99	(1.46, 15.91)

- Assessed age, current asthma, and current smoking status
- Final model adjusted for age

Daily symptom questionnaire findings in waterpark employees

Work-related symptoms, n (%)	Day 1 (n = 38)	Day 2 (n = 32)	Day 3 (n = 22)
≥1 work-related symptom	25 (66)	25 (78)	15 (68)
Eye irritation	23 (61)	22 (69)	9 (41)
Cough	20 (53)	20 (63)	12 (55)
Nose irritation	17 (45)	15 (47)	9 (41)
Wheeze	5 (13)	5 (16)	1 (5)
Shortness of breath	5 (13)	6 (19)	1 (5)
Sore throat	3 (8)	2 (6)	0 (0)

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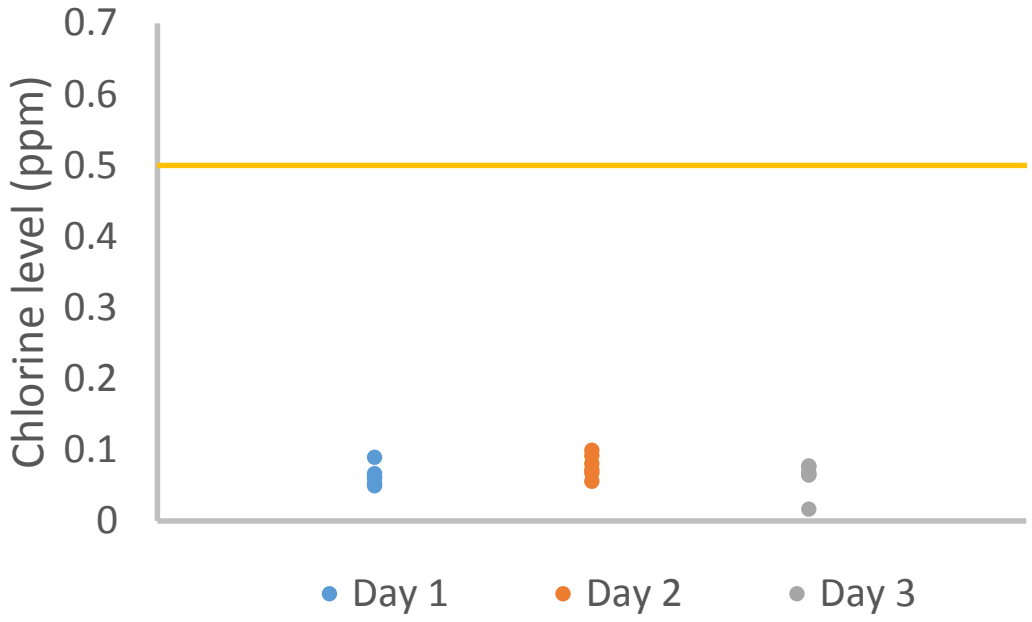
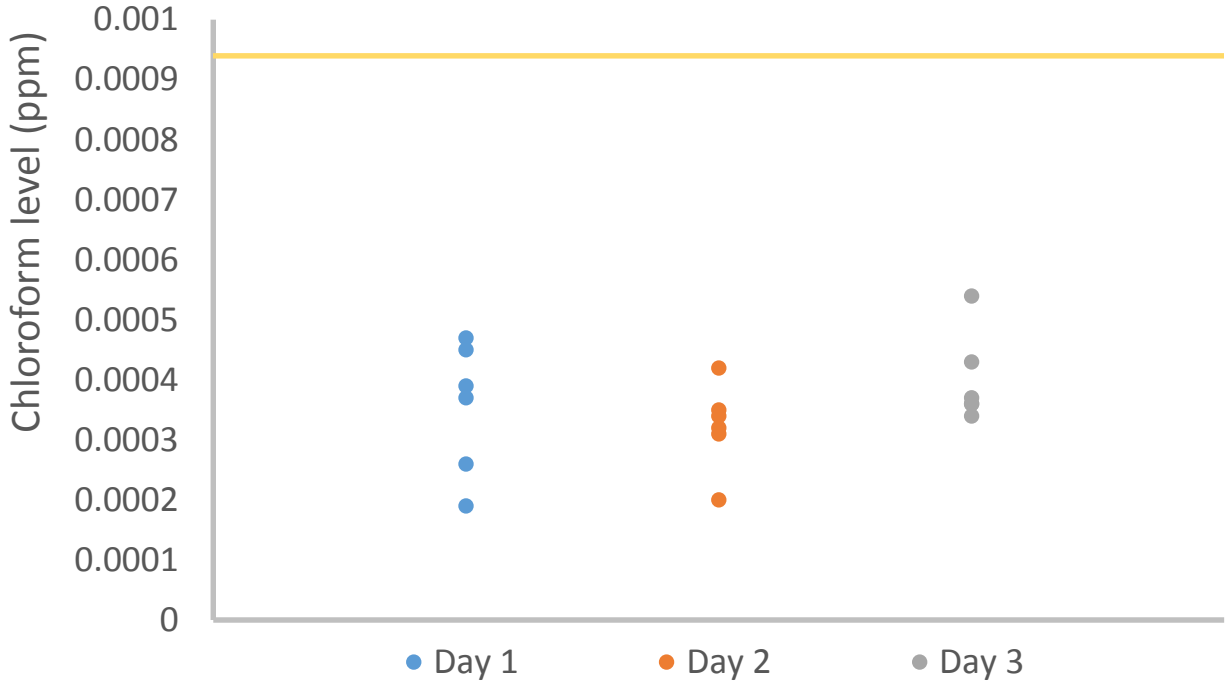
Air chlorine levels were LOW



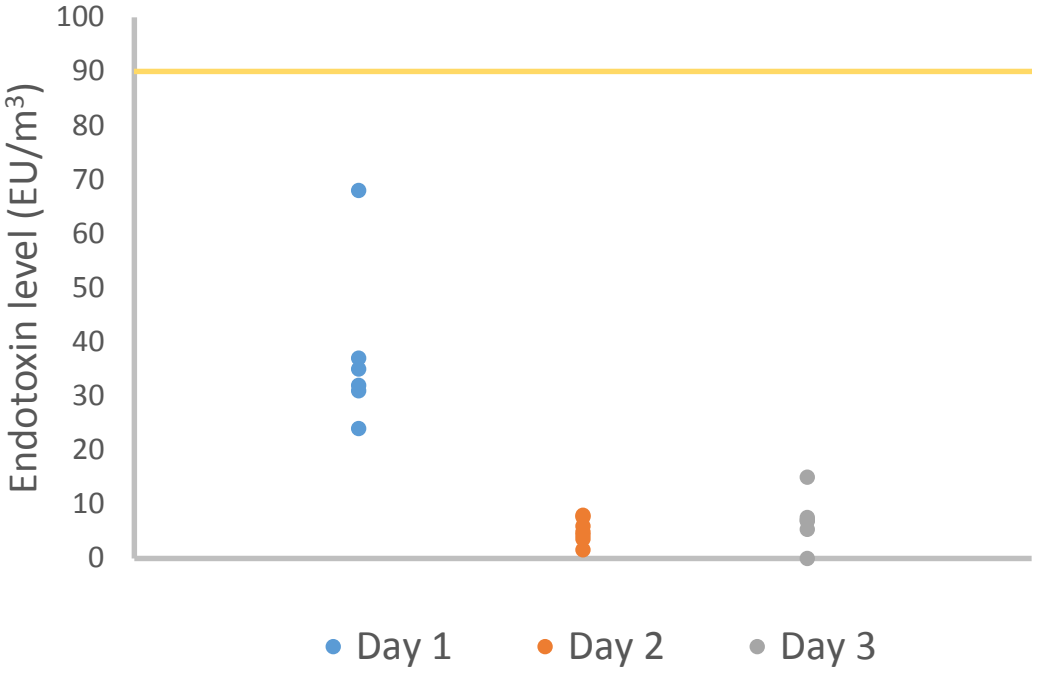
Occupational exposure limit
(NIOSH, ACGIH)
0.5 ppm

Air chloroform levels were LOW



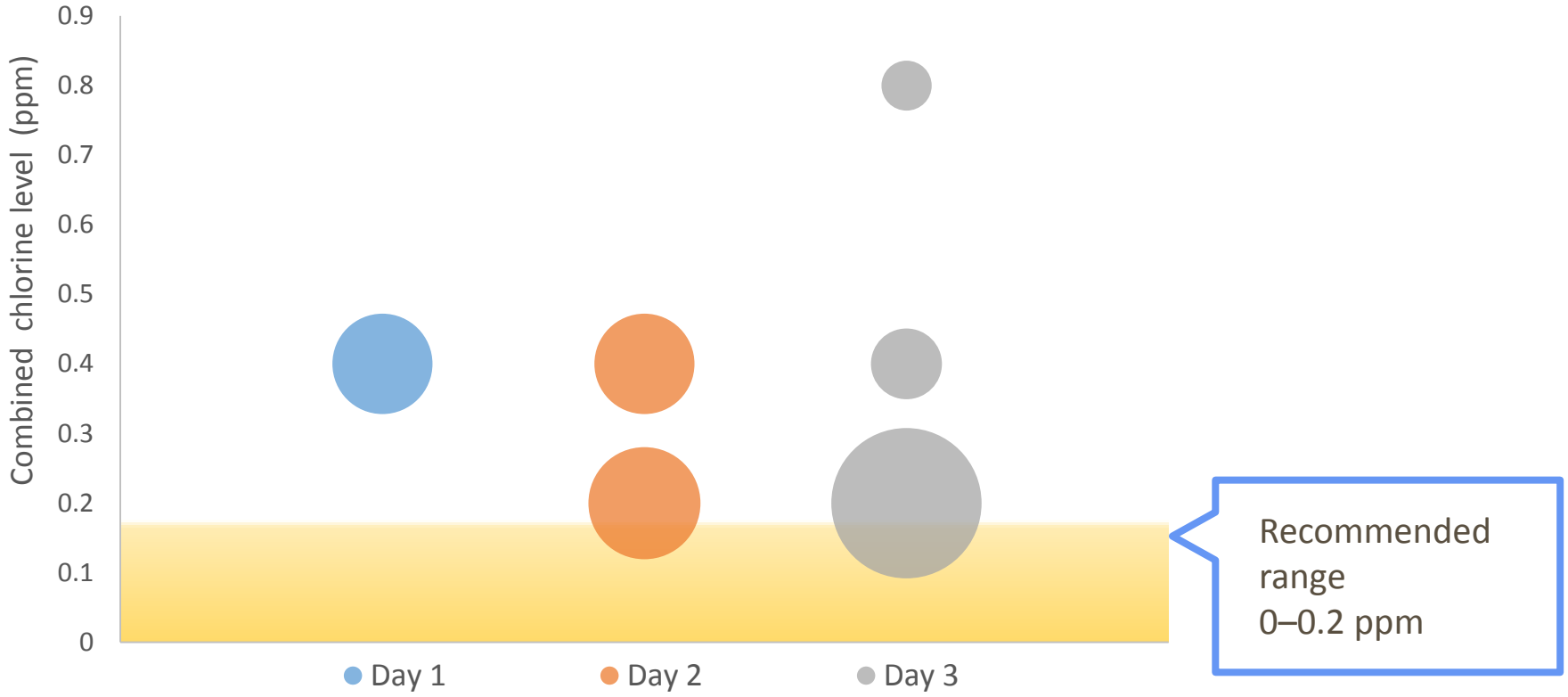
Level associated with symptoms in a previous study
0.00094 ppm

Air endotoxin levels were LOW



Health-based exposure limit (Dutch Expert Committee on Occupational Standards)
90 EU/m^3

Water combined chlorine levels were at or ABOVE the waterpark's internal guidelines



Water microbiology results

No

Legionella or mycobacteria was detected

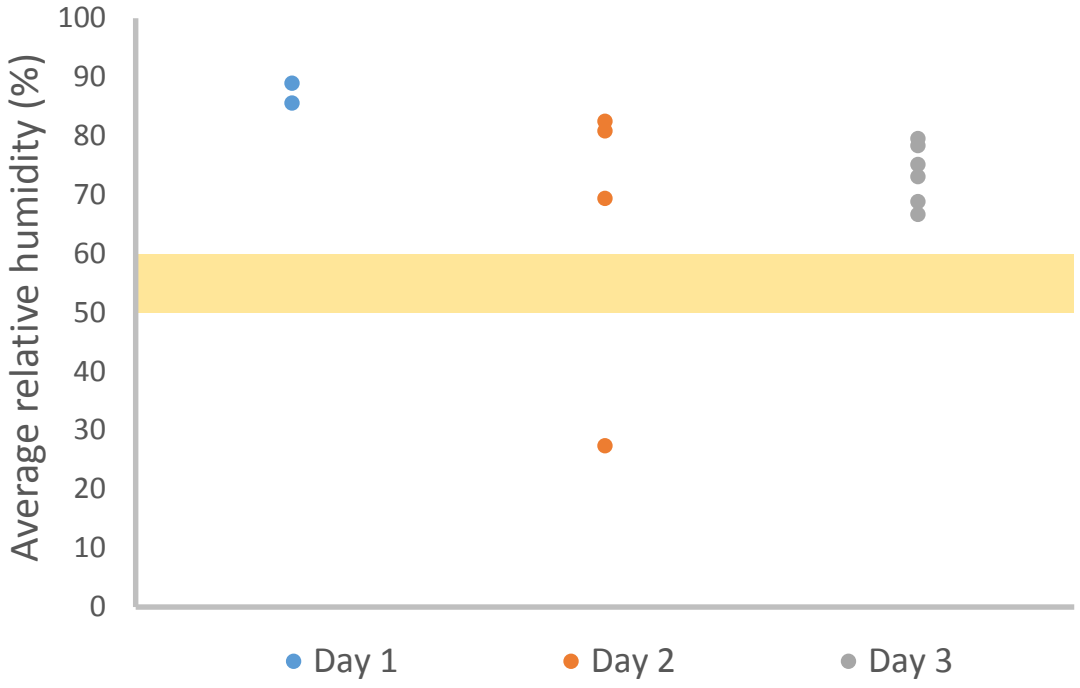
Air temperature was BELOW the recommended range

Recommended range for hotel pools 82°F – 85°F

52°F – 77°F

over the 3 days

Relative humidity was ABOVE the recommended range



Recommended range for buildings with swimming pools 50%–60%

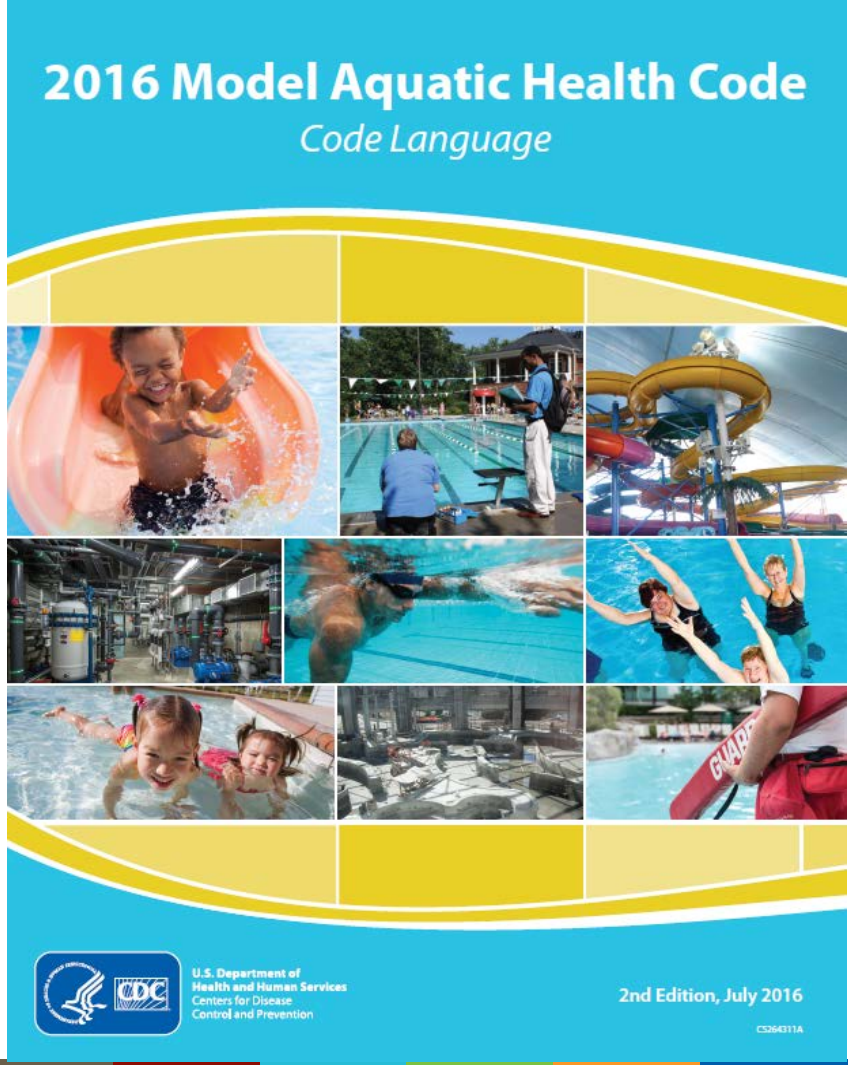
Ventilation equipment was NOT well maintained

- 5 of 6 HVAC units had non-operable fans
- Facility changed filter type, which may have affected intake of outdoor air

Comparison to the Model Aquatic Health Code

- Voluntary guidance developed by CDC

- Based on design specifications
  - The waterpark's ventilation systems **CAN** meet the standard
  - But **DID NOT** during our visit



Air distribution design

- To remove contaminants
  - Some air flow across pool surface

Air distribution design

- To remove contaminants
  - Some air flow across pool surface
  - Return at deck level

Air distribution design

- To remove contaminants
  - Some air flow across pool surface
  - Return at deck level

- **75% of air returned at ceiling height**

Conclusions

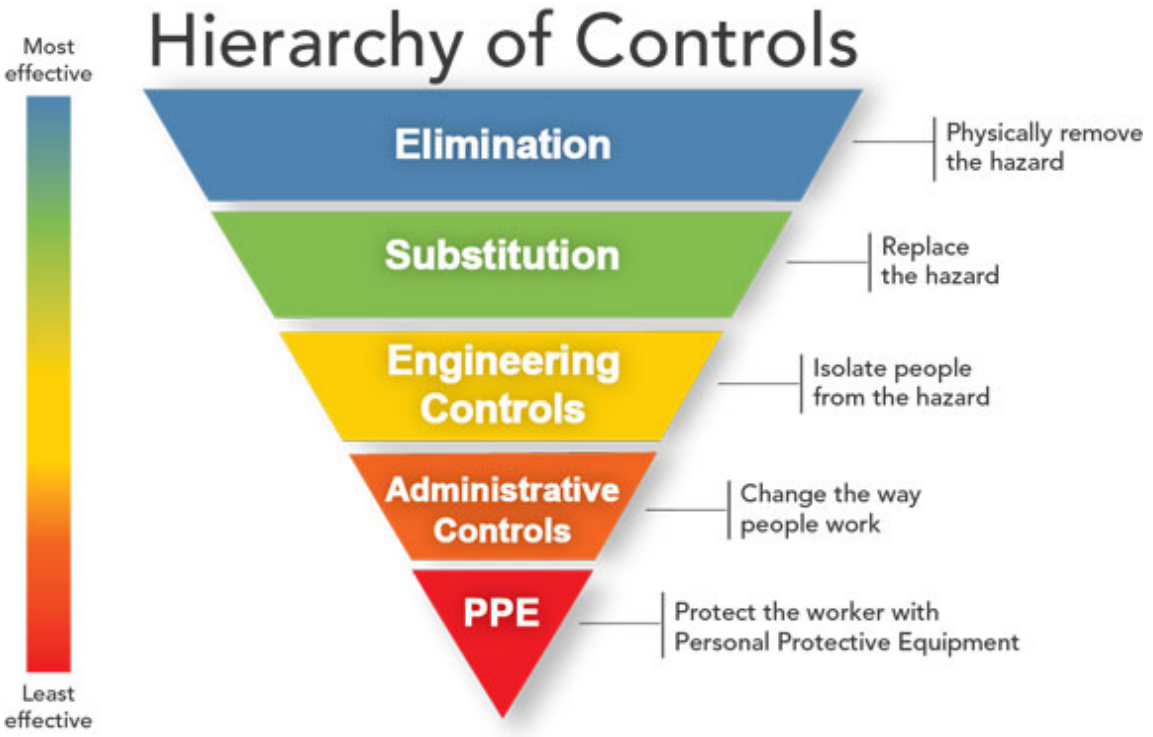
- Waterpark employees were 4 times more likely to have work-related eye and respiratory symptoms
- High water combined chlorine and detectable air chloroform levels indicate disinfection byproduct exposure
- Ventilation systems were not operating properly
- Temperatures below and relative humidity above recommended ranges

Conclusions

Disinfection byproducts and **environmental conditions** likely contributed to the higher prevalence of symptoms among waterpark employees

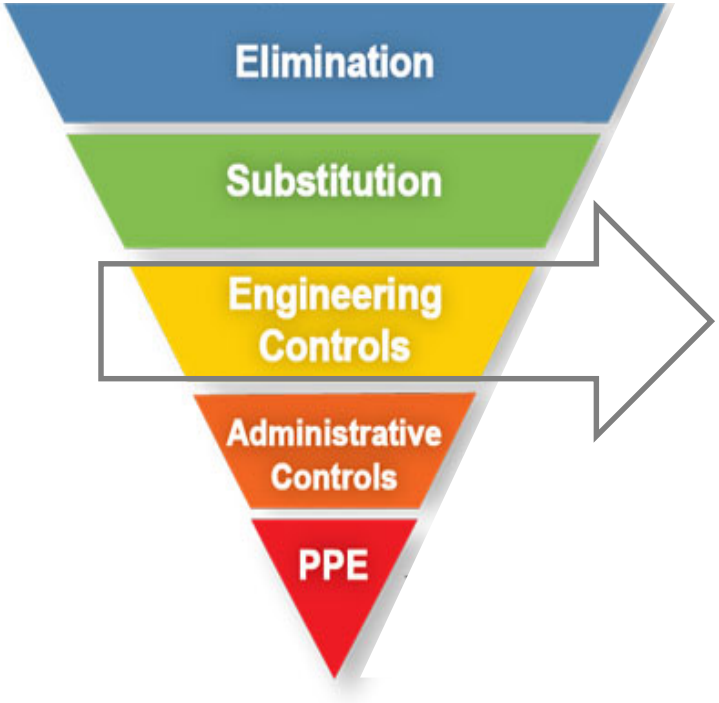
Limitations

- Waterpark open for fewer hours in the winter
  - Less exposure
  - Lead to underestimation
- Unable to measure exposure for each participant
  - Interfere with job duties
  - Wet equipment
- No reliable method to measure chloramines in air



Recommendations

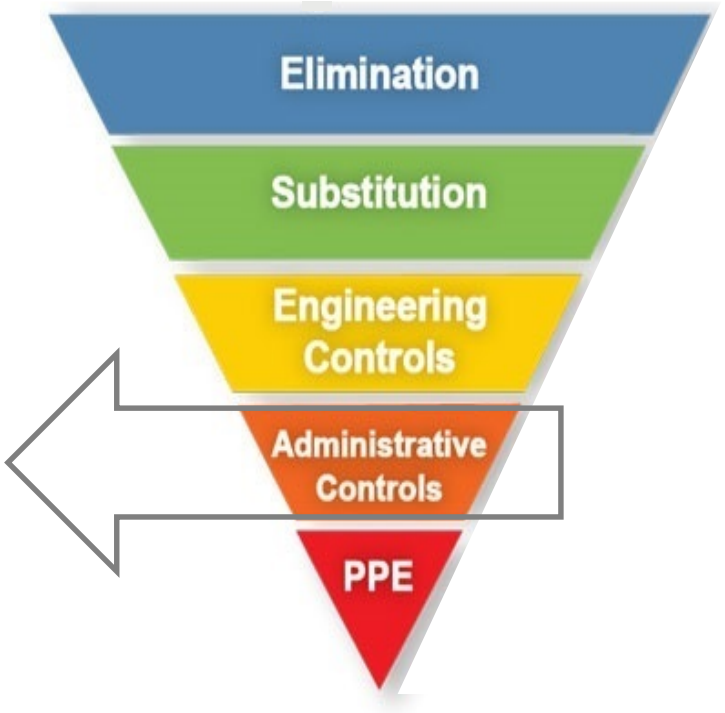
Engineering control recommendations



- Maintain or repair the ventilation equipment
- Identify an air filter that provides sufficient filtration efficiency and minimizes air flow resistance
- Add more return air intakes and air flow at pool level

Administrative control recommendations

- Develop an HVAC preventive maintenance schedule
- Encourage waterpark users to shower before entering
- Encourage employees to promptly report symptoms. Implement a system to track and follow up.



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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Extra slides

Legionella

- Bacterium thrives in warm, wet environments
  - ~60 species, ~70 serogroups
  - Most common cause of human infections is *Legionella pneumophilia*

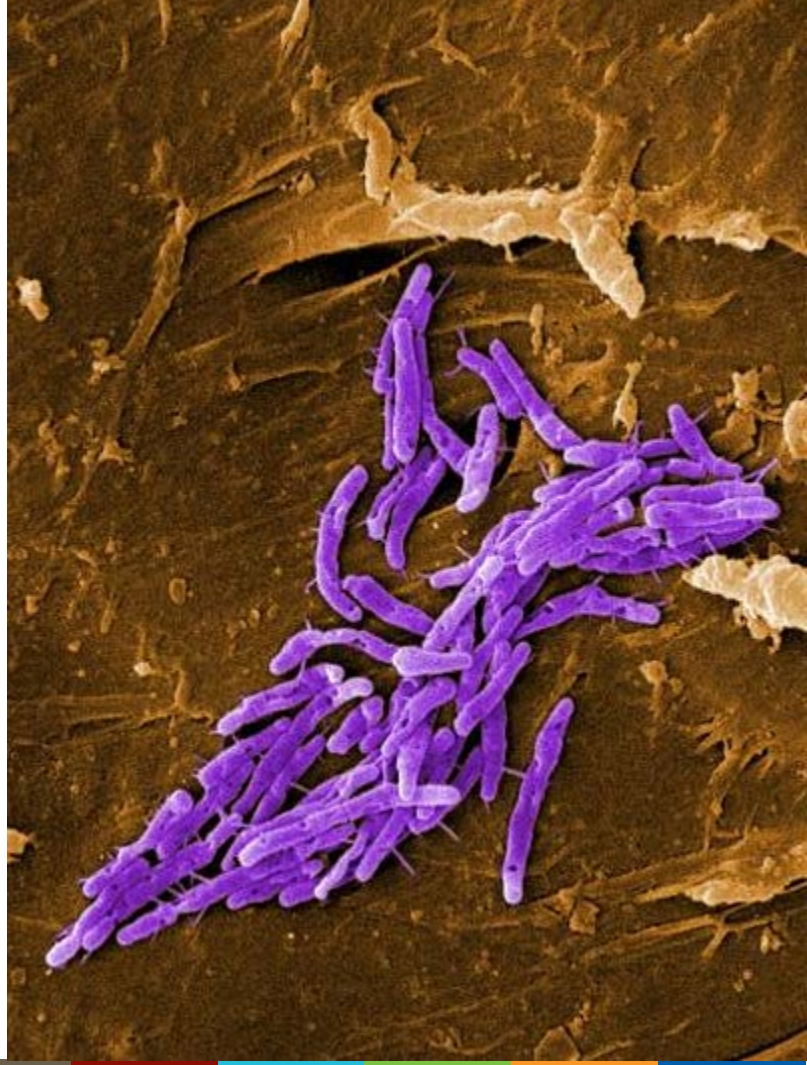
- Legionellosis
  - Legionnaire's disease: pneumonia with high fever, chills, cough, shortness of breath, muscle aches, headaches
  - Pontiac fever: self-limited flu-like illness with fever, chills, malaise

- Outbreaks associated with
  - Recreational water venues
  - Warm water systems that produce aerosols, sprays, or mists
  - Exposure to hot tubs is a recognized risk factor

Nontuberculous mycobacteria

- Rod-shaped bacteria found in aquatic environments

- *Mycobacterium avium* complex associated with hypersensitivity pneumonitis and pneumonia in spa users and workers
  - Cough
  - Dyspnea
  - Fever
  - Chills
  - Malaise

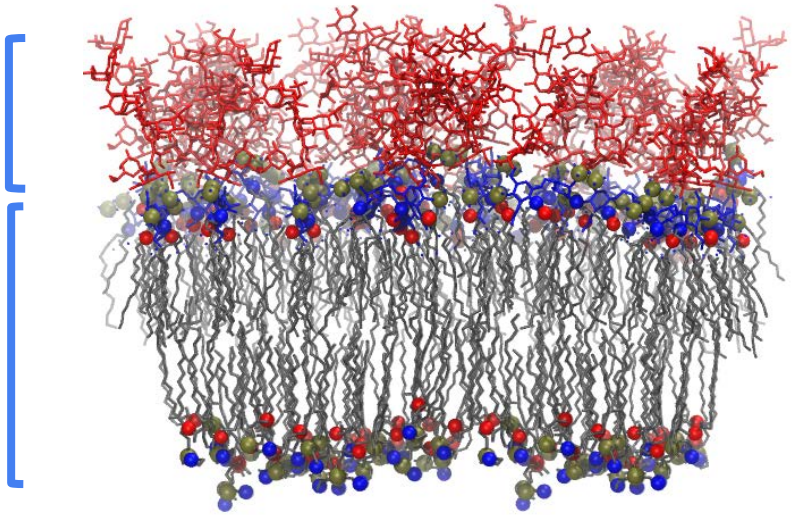


Endotoxins

- Lipopolysaccharide complexes

- Outer cell wall of Gram-negative bacteria

- Acute airborne endotoxin exposures associated with
  - Cough
  - Wheeze
  - Shortness of breath
  - Chest tightness
  - Mucous membrane irritation



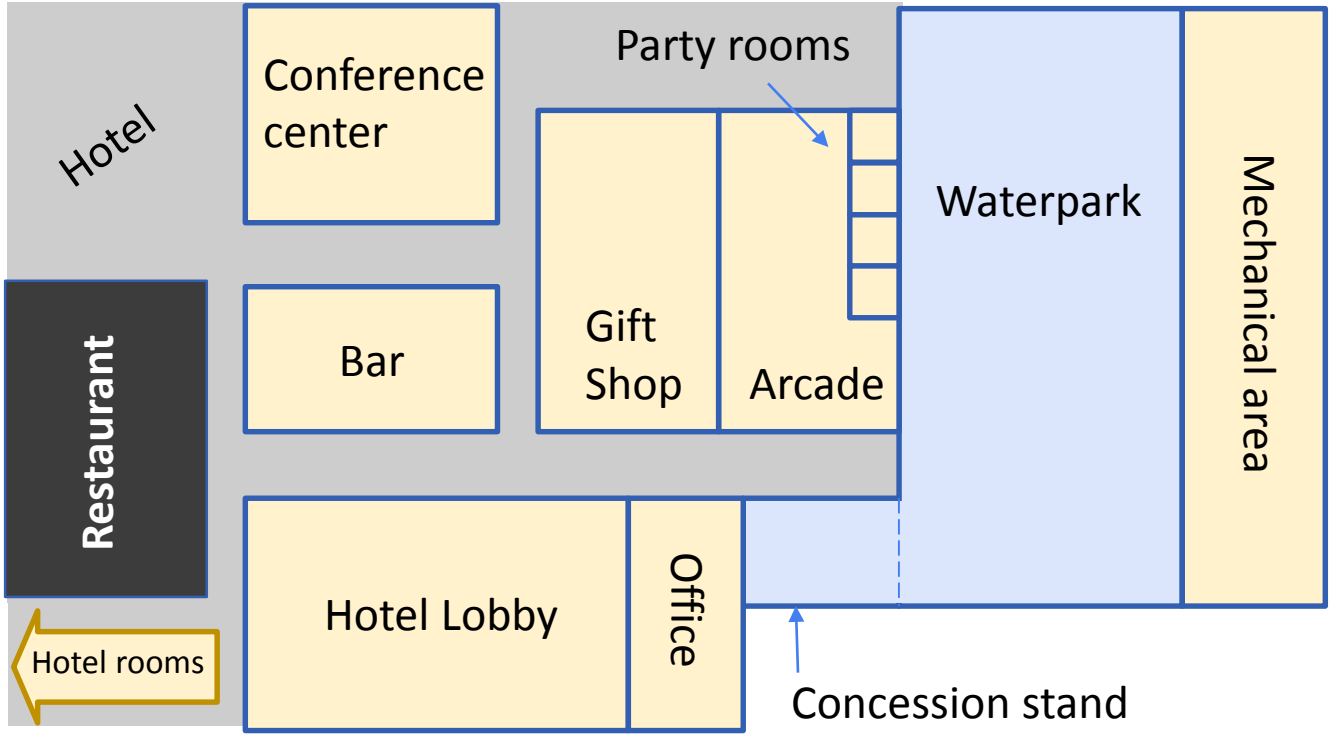
Area air sampling

- 6 waterpark locations
- Concession stand, arcade, outdoors

- Endotoxin (27 samples)
- Chlorine (26 samples)
- Chloroform (119 samples, changed every 2 hours)

Tripod with sampling equipment

Waterpark resort layout



Waterpark water quality systems

- Mechanical filtration – water pumped through strainer baskets
- Sand filtration
- Ultraviolet disinfection system

- Automated chemical controller system monitored pH and free chlorine
- Maintenance staff also test and adjust

- Aquatics department staff remove fecal matter

- Water completely changed every 2 weeks with municipal water supply

Job titles or departments of resort employees

Waterpark

45 employees (49%)

42% <18 years

Aquatics	39 (87%)
Concession stand	6 (13%)

Non-waterpark

46 employees (51%)

4% < 18 years

Front desk/office	21 (46%)
Maintenance	6 (13%)
Arcade	5 (10%)
Gift shop	4 (9%)
Housekeeping	4 (9%)
Security	4 (9%)
Bar	2 (4%)

Waterpark air temperature was BELOW the recommended range

Waterpark – Lazy River	Average temperature °F (range)
Day 1	74.4 (66.4–77.2)
Day 2	73.6 (70.4–74.5)
Day 3	68.2 (51.8–71.1)

Recommended range (ASHRAE)
Hotel pools
82°F and 85°F

Waterpark – Spa	Average temperature °F (range)
Day 1	75.5 (66.1–78.6)
Day 2	69.1 (66.3–74.4)
Day 3	71.0 (59.6–72.3)

Recommended range (ASHRAE)
Whirlpool/spa
80°F and 85°F

Waterpark relative humidity was ABOVE the recommended range

Location	Day	Average relative humidity % (range)
Lazy River	1	89.0 (36.4–100)
Lazy River	2	69.4 (51.8–77.8)
Lazy River	3	66.7 (28.7–80.2)
Spa	1	85.6 (36.1–100)
Spa	2	27.4 (24–95.7)
Spa	3	79.6 (74.7–100)

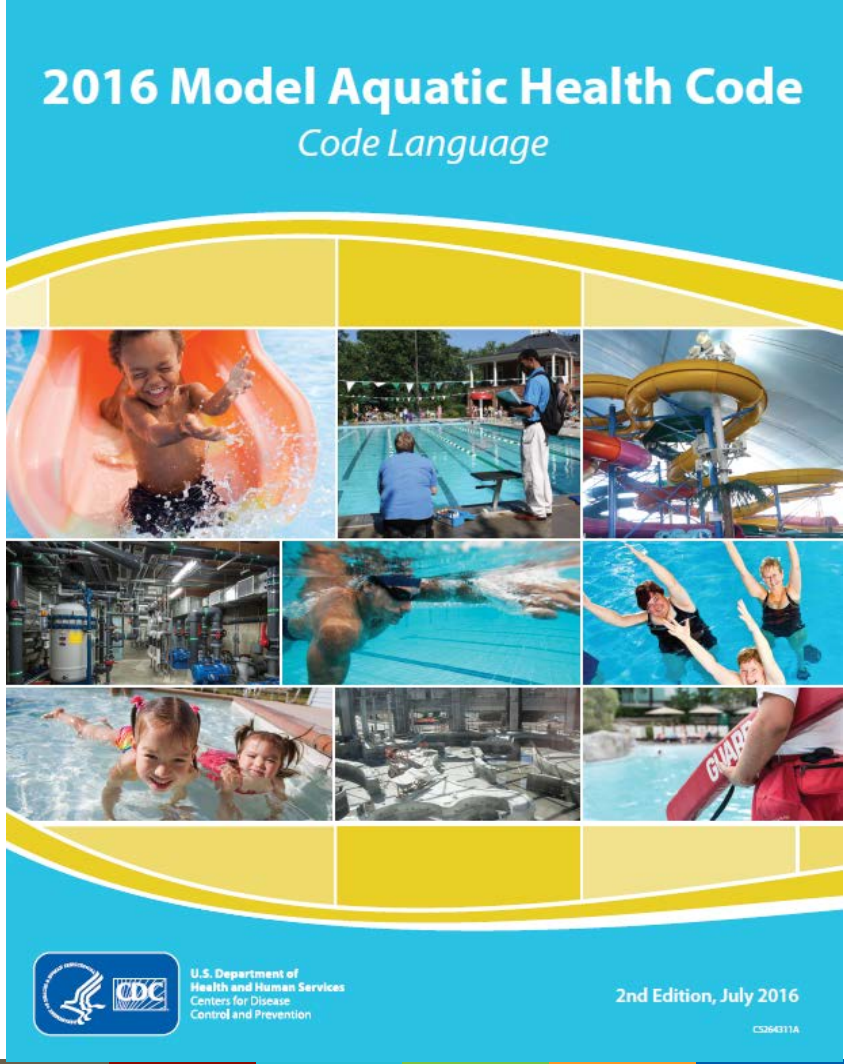
Recommended range (ASHRAE)

Buildings with swimming pools 50–60%

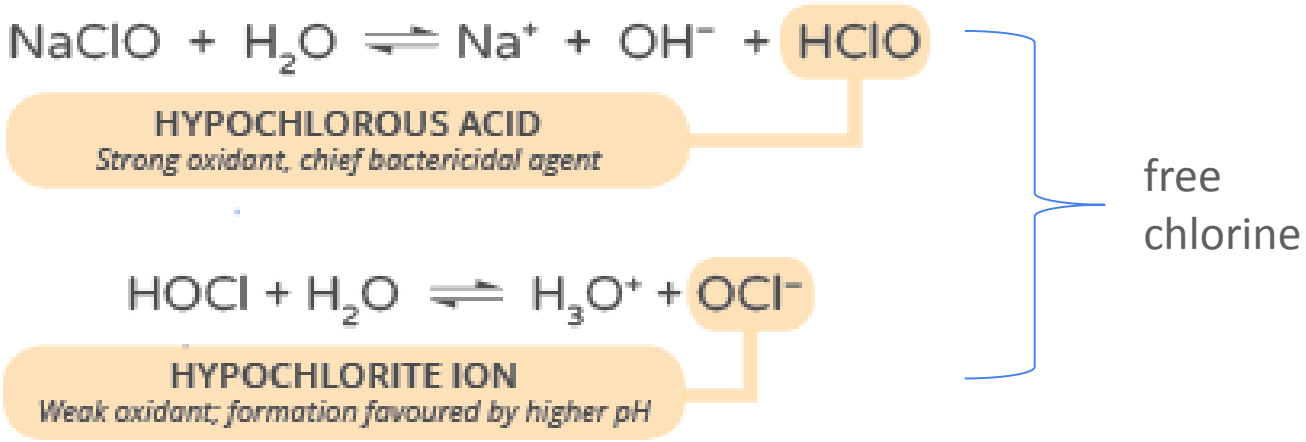
Model Aquatic Health Code

- Voluntary guidance for public aquatic facilities
- Developed by CDC
- Uniform guidelines to help state and local jurisdictions create or update their codes
- 14 topic areas
- 2nd edition in 2016

- Generally adopts ASHRAE ventilation standards, believed to dilute contaminants to acceptable limits



Chemical reactions involved in chlorination



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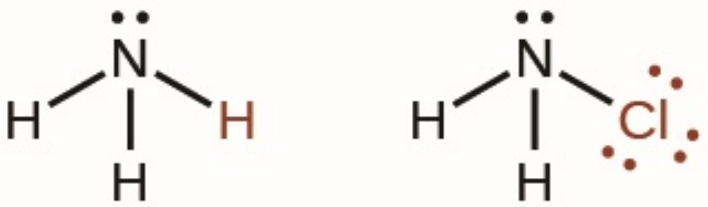
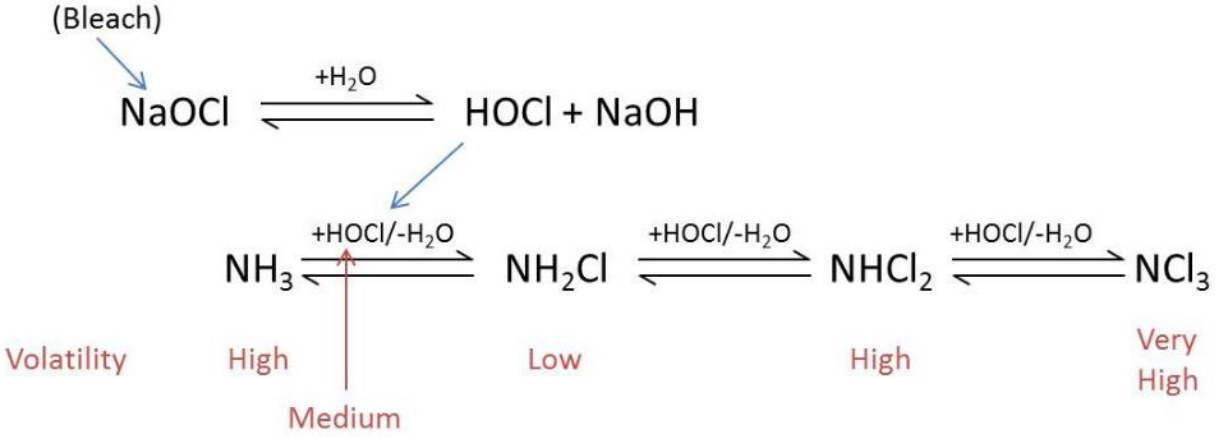
Chemical structure of ammonia and chloramine



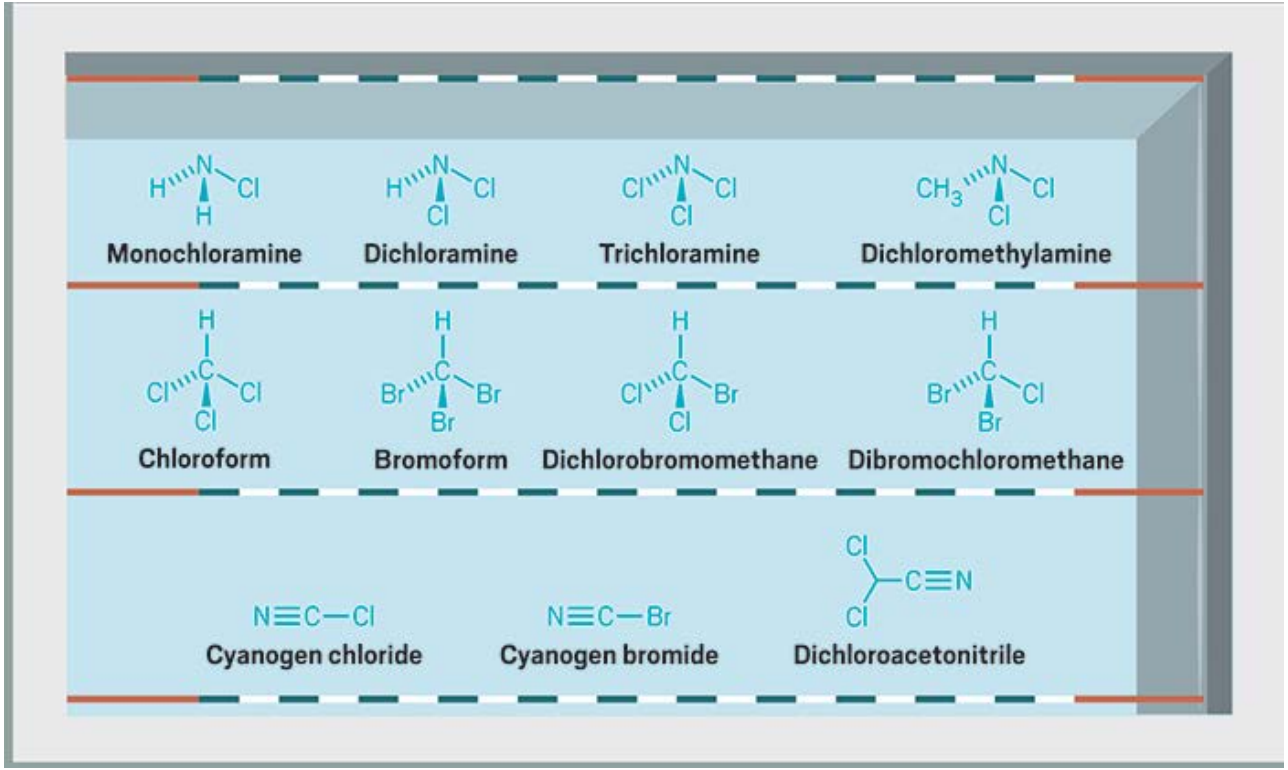
http://cnx.org/contents/VOsOd84f@2/Occurrence-Preparation-and-Com

Chemical reactions generating chloramines



http://homesteadlaboratory.blogspot.com/2013/08/aquaponics-water.html

Chlorine disinfection byproducts in swimming pools



http://cen.acs.org/articles/94/i31/chemical-reactions-taking-place-swimming.html

To view the full health hazard evaluation report, visit: https://www.cdc.gov/niosh/hhe/reports/pdfs/2015-0148-3272.pdf

For more information, contact CDC
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