Dangerous Underwater Breath-holding Behavior-Related Drownings in New York State, 1988-2011

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Drowning in the United States

- Drowning is an important cause of preventable injury and mortality, ranking fifth among leading causes of unintentional injury death in the United States
  - Males are at the most risk
  - Second leading cause of injury-related deaths among children aged 1 to 19 years
  - Most prevalent among communities of color
Active Drowning Surveillance in New York

- New York State Department of Health (NYSDOH) Bureau of Community Environmental Health and Food Protection policy to investigate & report on drownings (NYS Sanitary Code 6-1).

- The Office of Public Health Engineering (OPHE) within the New York City Department of Health and Mental Hygiene (NYC DOHMH) conducts active surveillance of drowning incidents at NYC Permitted Bathing Facilities.
Fatal and Non Fatal Drowning Incidents in NYC
1988-2011*

*Data estimates are a compilation of WHO International classification of disease (ICD) 9 and 10 994.1 Drowning and nonfat al submersion incident reporting from NYC Emergency Department Syndromic Reporting, Unintentional Accidental incidents of drowning and nonfatal submersion from the Office of Vital Statistics, the Chief Medical Examiner, media reports, and incidents reported to OPHE on unintentional submersion incidents occurring at all bathing facilities and water bodies within NYC.
Drowning Investigation Process Overview
OPHE Drowning Incident Investigation

- Standard investigation:
  - Site & Supervision characteristics

- Environmental Risk Factors:
  - Location of drowning
  - Activity at the time of the incident (*Interviews*)

- Victims Personal Risk Factors:
  - Gender
  - Age
  - Swim ability
  - Medical history
  - Drug and Alcohol consumption
Precipitating Event: Hyperventilation Before Breath-Holding Underwater

- In 2011, a drowning incident was reported to OPHE of two healthy young men that died at a NYC regulated outdoor swimming pool.

- Environmental Risk Factors:
  - Prolonged duration of submersion
  - Supervision Level

- Victims Personal Risk Factors:
  - Male
  - 21 and 22 years old
  - Good Health
  - Advanced Swim Ability
  - Training for U.S Military Fitness Testing
Physiology of Breath-Holding and Prolonged Submersion

- Normal breathing: During normal breathing, the oxygen ($O_2$) level is maintained, and the carbon dioxide ($CO_2$) level remains constant, avoiding the blackout zone.

- Hyperventilation: In hyperventilation, the $O_2$ level drops significantly, and the $CO_2$ level decreases, leading to a blackout zone and an urgent need to breathe.

- Dive: During a dive, the $O_2$ level decreases due to the lack of oxygen, and the $CO_2$ level increases as the body produces carbon dioxide. The rising $CO_2$ level triggers an urgent need to breathe.

Rising $CO_2$ level triggers urgent breathing.
Epidemiology of Breath Holding Behaviors

- Differential diagnosis – phenomenon of hypoxic blackout.
- Hyperventilation prior to submersion reduces carbon dioxide sensitivity, allowing hypoxia to develop, leading to unconsciousness.
- Carbon dioxide reservoir is depleted due to hyperventilation.
Physiology of Dangerous Underwater Breath-Holding Behaviors (DUBBS)
Drowning Case Review

- DOHMH collaborated with the NYSDOH to investigate historical drowning cases with similar dangerous behavioral underpinnings.
- Database case review of all drowning incidents at NYSDOH regulated swimming facilities from 1988 to 2011
- Record review of all drowning investigation documentation
DUBBS Case Review

- Generated keywords through a review of the available literature and expert opinion from aquatic programs such as the American Red Cross and YMCA.

- Victims’ behaviors (keywords) included:
  - repeated breath-holding
  - breath-holding games/competition
  - prolonged/extended submersion
  - underwater distance swimming
  - hyperventilation
Twenty two independent drowning cases identified:

- Seizure disorders (3)
- Substance abuse (1)
- Not enough information (2)

Classification as a dangerous underwater breathing behavior (16)
| Case Summary |

<table>
<thead>
<tr>
<th>TOTAL CASES</th>
<th>N</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>Overall</td>
<td>16</td>
<td>100%</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>13</td>
<td>81%</td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
<td>19%</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 15 years</td>
<td>7</td>
<td>44%</td>
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<tr>
<td>15-24 years</td>
<td>8</td>
<td>50%</td>
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<tr>
<td>&gt; 25 years</td>
<td>1</td>
<td>6%</td>
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<tr>
<td>Drowning type</td>
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</tr>
<tr>
<td>Non-fatal Drowning</td>
<td>12</td>
<td>75%</td>
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<tr>
<td>Fatal Drowning</td>
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<td>25%</td>
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<tr>
<td>Swimming ability</td>
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<tr>
<td>Beginner</td>
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<tr>
<td>Good</td>
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<td>Advanced</td>
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<tr>
<td>Unknown</td>
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## Identification of DUBBS Behavior Types

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<th>DUBBS Behavior</th>
<th>N</th>
<th>%</th>
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<th>%</th>
<th>N</th>
<th>%</th>
<th>N</th>
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</thead>
<tbody>
<tr>
<td>Intentional Hyperventilation</td>
<td>3</td>
<td>19%</td>
<td>6</td>
<td>38%</td>
<td>5</td>
<td>31%</td>
<td>2</td>
<td>13%</td>
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<tr>
<td>Static Apnea</td>
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<td></td>
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<tr>
<td>Hypoxic Training</td>
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<tr>
<td>Intentional Hyperventilation &amp; Hypoxic Training Coactivity</td>
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DUBBS Analysis & Outcomes

- Practicing more than one DUBB increased the risk for fatality.
- A significant proportion of the cases were either advanced or good swimming ability.
- Educational and policy-level changes in order to prevent drownings attributable to dangerous behaviors.
- Pictographic Signage required by New York City Health Code.
Learn to Swim Program

- Drowning prevention strategy for children and young adults.
- New York City Department of Parks and Recreation (DPR), Youth and Community Development (DYCD) and DOHMH.
- Provides free instruction on water safety and swimming skills to children and adolescents ages 6-18 years old in low-income neighborhoods.
- 1,400 participants to date.
Learn to Swim New York City
Pictorial Risk Messaging to Reduce DUBBS

- In 2013, OPHE conducted a signage evaluation study, to assess adolescents’ understanding of three professionally designed signs.
- Evaluate existing warning signs and messaging.
- Design several draft versions of warning sign.
- Focus group test signs with more than 250 young swimmers working with YMCA.
- Validate language with supplemental survey of young swimmers during Recreational Water Illness Week at NYC public pools.
**Selected DUBBs Prevention Signage**

**NO BREATH-HOLDING CONTESTS**

Taking deep breaths, one after the other, before swimming underwater can be deadly!

“Prolonged or repetitive breath-holding can be deadly. No intentional hyperventilation or underwater competitive breath-holding.” – NYC Health Code, §165.41
Acknowledgements

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Additional Resources

- Water Safety in New York City
- Pictographic Signage required by New York City Health Code