Disclosures

none
Agenda

- Flint Water Timeline
- Lead Facts
- Hurley/MSU Research Findings
- Introduction to ACEs
- Next steps – Secondary / Tertiary Prevention
- Q & A
Flint Drinking Water Crisis

- State appointed financial emergency managers (Nov 2011)
- Water switch to Flint River (April 2014)
Flint Drinking Water Crisis

- Fecal coliform and boil advisories *3 (Sept 2014)
- GM stopped using Flint water – corroding parts (Oct 2014)
- Disinfectant byproducts TTHM (Jan 2015-Sept 2015)
Perfect storm for lead leaching
- Flint River water more corrosive
- Lack of corrosion control
- Aging infrastructure (up to 80% lead plumbing)
- Decreased water use - population loss, high water rates
Flint Drinking Water Crisis

- High lead levels detected, EPA contacted (February 2015)
- Leaked EPA memo (June 2015)
  - LeeAnn Walters WLL 13,200 ppb (toxic waste)
- Dr Marc Edwards, Virginia Tech Research (Aug 2015)
  - Flintwaterstudy.org
  - Corrosion & water lead
- Hurley Research (Sept 2015)

Why do we care about lead?

- Lead is a potent neurotoxin with lifelong, multigenerational impacts.

- Blood lead levels (BLL) 5 ug/dL or more considered elevated blood lead levels (EBLL).

- Just a few years ago (2012), 10 ug/dL was cutoff.

- NO safe blood lead level.

- Disproportionately impacts low income and minority children.

- Primary prevention.
Primary Prevention

• “Because no measurable level of blood lead is known to be without deleterious effects, and because once engendered, the effects appear to be irreversible in the absence of any other interventions, public health, environmental and housing policies should encourage PREVENTION of all exposure to lead.”

“Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention.” 2012 CDC Advisory Committee on Childhood Lead Poisoning Prevention.
Impact on cognition

- Vast evidence supports increased likelihood of:
  - Decrease in IQ
    - An increase in BLL from 1 to 4 ug/dL, drops mean IQ -3.7 points
  - Small change in mean IQ, shifts entire population IQ distribution
    - Reduces high achievers IQs (>130) and increases kids with low IQs (<70)
    - Implications for early intervention, special education services, employment, incarceration, life achievement, etc


Impact on behavior

- Increased likelihood of:
  - ADHD behaviors
  - Delinquent behaviors and arrests
  - Total arrests and increased rates of arrests involving violent offenses
  - Other health effects: hematologic, cardiovascular, immunologic, endocrine, etc

• “For childhood lead poisoning, $5.9 billion in medical care costs, as well as an additional $50.9 billion (sensitivity analysis: $44.8–$60.6 billion) per year in lost economic productivity resulting from reduced cognitive potential from preventable childhood lead exposure.”

• “The present value of Michigan’s economic losses attributable to lead exposure in the 2009 cohort of 5 year-olds ranges from $3.19 (using U.S. blood lead levels) to $4.85 billion (using Michigan blood lead levels) per year in loss of future lifetime earnings.”


Lead in Water

Soluble metal – ingestion via particulate or dissolved in water

Drinking and cooking risks

“drinking through a lead painted straw”

Not what medicine/public health used to

- Lead paint obsessed (CDC vs EPA)
- But “plumbing”...
Disproportionally impacts developmentally-vulnerable formula-fed infants

For about 25% of infants drinking formula made from tap water at 10 ppb, blood lead would rise \( \geq 5 \text{ ug/dL} \)

Significant risk to unborn babies

- Increase in fetal deaths and reduced birth weights

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Edwards, M. Fetal Death and Reduced Birth Rates Associated with Exposure to Lead-Contaminated Drinking Water. Env. Sci. and Tech. 2013 DOI: 10.1021/es4034952
Historical Perspective

“long-running environmental and public health catastrophe: 150 years of lead pipes in local water systems and the associated sickness, premature death, political inaction, and social denial”
THE INCREASING USE OF LEAD AS AN ABORTIFACIENT;
A SERIES OF THIRTY CASES OF PLUMBISM.*

By ARTHUR HALL, M.A., M.D.CANTAB., F.R.C.P.,
Professor of Pathology, University College, Sheffield; Physician,
Sheffield Royal Hospital.

*Read before the Yorkshire Branch of the British Medical Association
at Bradford, January, 1905.

LEAD AS AN ABORTIFACIENT.

Sir,—Some time ago, in country practice, I had a message from a neighbour asking me to see with him a case of acute abdominal disease. The history was this: A robust young woman (married three months) had had pain in the stomach a few days previously, and again on the day before, when she was first seen. On inquiry her doctor was
Lead testing results for water sampled by residents

FLINT HAS A VERY SERIOUS LEAD IN WATER PROBLEM

Note: We will update results from the remaining 25 samples by 10/8/15

http://flintwaterstudy.org/
Role of MD MPH

- Prevention of everything to optimize children’s health… today and tomorrow
- Population/community health
- Inquiry and advocacy
- Lead screening as recommended by CDC and AAP at 1 and 2 years of age and Medicaid mandated
Hurley Children’s RESEARCH FINDINGS

Sept 24
Medical Community Press Conference
HMC IRB approved
Data from all blood lead levels processed at Hurley Medical Center
ZIP code based
Two periods of comparison (same seasons):
  • PRE-SWITCH: January 1, 2013 – September 15, 2013
  • WATER SWITCH APRIL 26, 2014
  • POST-SWITCH: January 1, 2015 – September 15, 2015

• Analyzed % Elevated Blood Lead (EBLL)
  • EBLL = Blood lead Levels >= 5 ug/dL
## Initial Research Results

### Zip code based (in media)

<table>
<thead>
<tr>
<th></th>
<th>ALL FLINT ZIPS (n=1746)</th>
<th>HIGH-WLL FLINT ZIPS (48503-48504) (n=742)</th>
<th>NON-FLINT ZIPS (n=1670)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRE-SWITCH</strong></td>
<td>2.1%</td>
<td>2.5%</td>
<td>0.6%</td>
</tr>
<tr>
<td><strong>POST-SWITCH</strong></td>
<td>4.0%</td>
<td>6.3%</td>
<td>1.0%</td>
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</table>
GEOcoded Analysis

- N= 1473 for Flint water children (pre n=736, post n=737)
- N= 2202 for non-Flint water children (pre n=1210, post n=992)

Flint results for children 5 years and under:
- PRE-SWITCH % EBLL: 2.4%
- POST-SWITCH % EBLL: 4.9%
- p < 0.05; STATISTICALLY SIGNIFICANT CHANGE
Focus on high WLL wards (5, 6, 7); i.e., those with high water lead levels

Results:
- PRE-SWITCH % EBLL: 4.0%
- POST-SWITCH % EBLL: 10.6%
- $p < 0.05$; STATISTICALLY SIGNIFICANT CHANGE

Note: Hot spots between wards/zips
High Water Lead

CITY OF FLINT MAJOR WATER INFRASTRUCTURE
WATER AGE & WATER SAMPLE LOCATION MAP
January 21, 2015

Predicted BLL based on Ordinary Kriging Geostatistical Analysis:

- 1.01 - 1.25
- 1.26 - 1.5
- 1.51 - 1.75
- 1.76 - 2
- 2.01 - 2.25
- 2.26 - 2.5
- 2.51 - 2.75
- 2.76 - 3.35

"Ward Y WLL = XXX%" → % of ward where any water sample exceeded 15 ppb

*Non-residential zones screened from results
Pre/Post EBLL

**Comparison of Pre/Post EBL Percentage**

- **Outside Flint**: Pre - 0.7, Post - 1.2
- **All Flint**: Pre - 2.4, Post - 4.9
- **High WLL Flint**: Pre - 4, Post - 10.6

* p < 0.05
% of children with EBLL in Flint zips increased
  • Most striking increase in areas with highest water lead levels

Results significantly underestimate exposure:
  • Infants not screened for lead
  • BLL may have peaked before being measured (blood half life 20-30 days)
  • Kids exposed in different settings throughout city

Widened disparities

Failure of primary prevention
Elevated Blood Lead Levels in Children Associated With the Flint Drinking Water Crisis: A Spatial Analysis of Risk and Public Health Response

Mona Hanna-Attisha, MD, MPH, Jenny LaChance, MS, Richard Casey Sadler, PhD, and Allison Champney Schnepp, MD

Objectives. We analyzed differences in pediatric elevated blood lead level incidence before and after Flint, Michigan, introduced a more corrosive water source into an aging water system without adequate corrosion control.

Methods. We reviewed blood lead levels for children younger than 5 years before (2013) and after (2015) water source change in Greater Flint, Michigan. We assessed the percentage of elevated blood lead levels in both time periods, and identified geographical locations through spatial analysis.

Results. Incidence of elevated blood lead levels increased from 2.4% to 4.9% (P < .05) after water source change, and neighborhoods with the highest water lead levels experienced a 6.6% increase. No significant change was seen outside the city. Geospatial analysis identified disadvantaged neighborhoods as having the greatest elevated blood lead level increases and informed response prioritization during the now-declared public health emergency.

Conclusions. The percentage of children with elevated blood lead levels increased after water source change, particularly in socioeconomically disadvantaged neighborhoods. Water is a growing source of childhood lead exposure because of aging infrastructure. (Am J Public Health. Published online ahead of print December 21, 2015: e1–e8. doi:10.2105/AJPH.2015.303003)
What happened next?

- Sept 25 City of Flint Lead Health Advisory
- Sept 29 GCHD Health Advisory
- Oct 1 GCHD Public Health Emergency
- Oct 2 State filter program, increased water testing, expedited corrosion control
  - Oct 3 First filter distribution
- Oct 8 Three schools toxic WLL, announced reconnection to DWSD
- Oct 16 Water switched back to DWSD
A team of researchers at Wayne State University have discovered that mothers with high levels of lead in their blood not only affect the fetal cells of their unborn children, but also their grandchildren. “
Now

- Preventable population-wide exposure
- Community traumatized
- Loss of trust in government and agencies
  - In 2016, in the middle of the great lakes, no guarantee of safe drinking water
- Task forces, federal investigation, lawsuits, resignations, international media, celebrities...

- Federal State of Emergency
Quick Introduction to ACEs/Toxic Stress...
ACEs are potentially traumatic events that can have negative, lasting effects on health and well-being.

Also referred to as toxic stress or childhood trauma.

CDC ACE study

Kaiser Permanente from 1995 to 1997 with more than 17,000 participants.
ACE score

- Recurrent physical abuse
- Recurrent emotional abuse
- Sexual abuse
- Emotional or physical neglect
- An alcohol or drug abuser
- An incarcerated household member
- Someone who is chronically depressed, suicidal, institutionalized or mentally ill
- Mother being treated violently
- One or no parents
The majority of adults with an ACE score of 0 have few, if any, risk factors for diseases that are common causes of death in the US.

An ACE Score of 4 or more results in having multiple risk factors for chronic disease.

An ACE score of 6 or more results in a 20 year decrease in life expectancy.
Mechanisms by Which Adverse Childhood Experiences Influence Health and Well-being Throughout the Lifespan
Toxic Stresses...
Stress

**POSITIVE**
A normal and essential part of healthy development
EXAMPLES
- getting a vaccine
- first day of school

**TOLERABLE**
Response to a more severe stressor, limited in duration
EXAMPLES
- loss of a loved one
- a broken bone

**TOXIC**
Experiencing strong, frequent, and/or prolonged adversity
EXAMPLES
- physical or emotional abuse
- exposure to violence

https://kaboom.org/play_matters/toxic_stress_and_caring_adults
Impact of Toxic Stress

- Disruption of hypothalamic-pituitary-adrenal axis and cortisol release
- Environment influences genetics (epigenetics)
  - First 5 years are critical in brain development
  - Brain circuits that are used are strengthened; those not used are diminished/pruning (developmental neuroscience)

How Early Experiences Alter Gene Expression and Shape Development

1. EXTERNAL EXPERIENCES (e.g., stress, nutrition, toxins) spark signals between neurons

2. NEURAL SIGNALS launch production of gene regulatory proteins inside cells

3. GENE REGULATORY PROTEINS attract or repel enzymes that add or remove epigenetic markers

4. EPGENETIC "MARKERS" control where and how much protein is made by a gene, effectively turning a gene "on" or "off," thereby shaping how brains and bodies develop

GENE – a specific segment of a DNA strand

DNA strands encircle histones that determine whether or not the gene is "readable" by the cell

CHROMOSOME – can pass on genes to next generation

Ecobiodevelopmental Model

• “Ecology becomes biology and together they drive development across the lifespan”

  - Andrew Garner MD PhD
Take Home Points

- Adverse childhood experiences and toxic stress are bad
- Contributes to disease, disability and social problems; disparities
- Based on ecobiodevelopmental model and growing field of developmental neuroscience, toxic stress causes life-long and multigenerational impact
Flint kids...
Now what can we do???
Short-Term Secondary Prevention

- Water still not safe (public health emergency)
  - Corrosion control optimization
  - Ongoing risk from scale disruption
  - Door to door filter/replacement distribution
  - Public education re water precautions (filters, flushing, cold water, cooking, infants, etc)
  - Lead plumbing
Unique opportunity to be proactive, to build a model public health program to buffer impact of exposure
MSU/Hurley
Pediatric Public Health Initiative

- Assess
- Monitor
- Intervene

Experts and community

http://humanmedicine.msu.edu/pphi/
Assess the impact of the exposure

- Newborn blood spots – lead levels & epigenetics
- Maternal fetal complications
- Psychological trauma
- Economic impact
Monitoring

- Cohorting/database building
- Long term neurodevelopmental follow-up/surveillance
- Academic/govt partnerships
- EBLL, epigenetic trends
Evidence Based Interventions

Long-Term Secondary & Tertiary Prevention
We know what works....

And we know what hurts...

Resilience

The human capacity to face, overcome, be strengthened by and even transformed by the adversities of life.
Tipping the scale…. building RESILIENCE

"Over time, the cumulative impact of positive life experiences and coping skills can shift the fulcrum's position, making it easier to achieve positive outcomes."
Evidence Based Interventions

An Ecobiodevelopmental Framework for Early Childhood Policies and Programs

Policy and Program Levers for Innovation
- Primary Health Care
- Public Health
- Child Care and Early Education
- Child Welfare
- Early Intervention
- Family Economic Stability
- Community Development
- Private Sector Actions

Caregiver and Community Capacities
- Time and Commitment
- Financial, Psychological, and Institutional Resources
- Skills and Knowledge

Foundations of Healthy Development
- Stable, Responsive Relationships
- Safe, Supportive Environments
- Appropriate Nutrition

Biology of Health and Development
- Gene-Environment Interaction
- Physiological Adaptations or Disruptions

Outcomes in Lifelong Well-Being
- Health-Related Behaviors
- Educational Achievement and Economic Productivity
- Physical and Mental Health

Ecology

Biology

Health and Development

http://pediatrics.aappublications.org/content/129/1/e232/F2.expansion.html
#flintwatercrisis

Interventions

- Education
- Nutrition
- Medical/Health
Interventions

**Education**

- Expand early literacy programs
- Enroll all in early head start, head start
  - Universal Preschool/Flint Pre-Promise
- Strengthen special education capacity/trained personnel
Interventions

Education

Invest in school health/wellness/behavioral health

- School nurse:student ratio – MI ranked worst in country
- 1:750 recommended
- 1:6,500 Flint
Investing in Children: Younger The Better

Rates of Return to Human Capital Investment at Different Ages: Return to an Extra Dollar at Various Ages

- Programs targeted towards the earliest years
- Preschool programs
- Schooling
- Job training

Rate of return to investment in human capital

0-3
4-5
School
Post-school

Age

Interventions

Nutrition

- Short-term mitigation/protection
  - Promotion/education of Iron, Calcium, Vit C diets
- Promote enrollment and participation in pre-existing nutrition resources (WIC, SNAP, DUFB, MTA)
- Expand WIC eligibility, access (co-locate with PMD), benefits
Interventions
Nutrition

- Long-term - Improve food access/security efforts
  - Subsidies, pilots – grocery stores, mobile groceries, urban farming, etc
- Invest in breastfeeding promotion, education, and support services
Support and education for primary care providers/medical homes regarding aggressive long-term neurodevelopmental screening & testing

- Improve access to pediatric behavioral health
- Increase recognition and education regarding trauma informed care, social determinants of health (SDOH)
- Need to support parents and programs to improve parenting skills, maternal-infant support programs
Hurley Children’s Clinic
Thinking Outside The Box

- Transportation
- Social work
- WIC RD/Nutrition
- Peds Psychology
- Training site
Genesee CHAP
A Program of the Greater Flint Health Coalition

CHAP is a collaborative, community-based, family-centered medical home improvement program intended to improve the health outcomes of children on Medicaid, while raising the quality of care, better utilizing resources, and decreasing costs.

All greater Flint area health systems and safety-net providers are partners in Genesee CHAP
(www.gfhc.org/CHAP)
National Advocacy

- **EPA LCR**
  - Prevention of future wide-scale lead in water exposures

- **Advocacy for Flint kids**

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**Sen. Debbie Stabenow** @SenStabenow @MonaHannaA testified today to strengthen drinking water standards. Proud to be her partner for #Flint families.

Dr. Hanna-Attisha tells EPA that environmental policy & the Lead & Copper Rule must PREVENT harm before it occurs.

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The Flint Water A-Team Dr. Mona Hanna-Attisha MD, and Dr. Mark Edwards PE! Fighting for childhood health and safe drinking water in Washington DC!
Flint Child Health & Development Fund

Focus is building the capacity to serve all Flint children exposed over the next 20 years.

Fund will support children and families with interventions to support optimal child health & development, early childhood education, continuous access to a pediatric medical home, nutritional education, integrated social services, etc.

www.flintkids.org
Conclusions

Primary prevention failed
Secondary/tertiary prevention must be priority

- Invest and prioritize in evidence based interventions that mitigate exposure, promote child development and build childhood resilience
It’s easier to build strong children than to repair broken men.

Frederick Douglass, 1855
Additional Resources

Harvard Center for Developing Child
http://developingchild.harvard.edu/

AAP Toxic Stress Resources

Strengthening Families: A Protective Factors Framework
http://www.cssp.org/reform/strengtheningfamilies

CDC ACE Study
http://www.cdc.gov/violenceprevention/acestudy/

Pediatrics articles
AAP Technical Report: The Lifelong Effects of Early Childhood Adversity and Toxic Stress
Thank you!