Heavy Metal Poisoning and Psychiatric Illness

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INTRODUCTION

Every day we are exposed to toxins from our environment. We may ingest lead and copper from drinking water, phosphate from processed food and soda, various synthetic chemicals from plastic food containers, and pesticides from fruits and vegetables. Both natural heavy metals and man-made chemicals disrupt hormones and brain development.

The brain, especially the developing brain, is very vulnerable to contaminants because of its large size (relative to total body weight) and its high concentration of fats which serve as a reservoir for toxicants to build up.
Learning Objectives

At the end of the presentation, the participant should be able to:

1. Recognize the effect of heavy metal poisoning on the developing brain

2. Identify the neuropsychiatric manifestation of heavy metal poisoning particularly plumbism

3. Appreciate the importance of history, collateral information in establishing the differential diagnoses and treatment plan
Outline

1. Case study
2. Literature review
3. Discussion
4. Conclusion/Recommendation
Patient is a 27 year old Caucasian male, designated to the Buffalo Psychiatric Center on CPL 730.40 from Niagara County Jail after being arrested with charges of **criminal mischief 3\textsuperscript{rd} degree**, **Harassment in the 2\textsuperscript{nd} Degree**, **Obstructing Governmental Administration in the 2\textsuperscript{nd} degree**, and **menacing with a weapon**.
He reportedly became **aggressive** and **angry** after his mother refused to give him money to buy **Marijuana**.

Mother had to lock herself in her bedroom; however, patient managed to break the door down and use a piece of the door in a “threatening manner”. Mom hid in the bathroom and had to call the police.

Patient continued to act in an **“aggressive and hostile”** manner when the police arrived.

*He was ultimately* designated to BPC on CPL **730.40** from Niagara County Jail after 3 forensic Psychiatrists evaluated him and found him incompetent to stand trial.
Reason for referral to BPC

He was evaluated by three forensic examiners who noted that patient was **difficult to engage and refused to answer most questions**. His behavior **was odd, quite irrational and out of touch with objective reality.**

It was unclear if patient was responding to symptoms of mental illness or his refusal to cooperate was volitional.

His behavior was **unpredictable and at times threatening**. He was observed to **avoid eye contact** and would often **smile inappropriately**. He continued to deny Suicidal ideations/Homicidal ideations. Denied Auditory/Visual Hallucinations, delusions.

Incompetent to stand trial. (Unable to understand charges)
Admission to Buffalo Psychiatric Center:

Uncooperative, irritable, avoided any eye contact and unable to fully engage in an interview.

He was unable to link the chain of events (from the jail to the hospital) and was unable to understand why he was admitted to the hospital.

Unable to focus or respond appropriately to the questions posed by the examiner.

He would frequently get irritable and would often get into arguments with some of the loud peers.

Denied any psychiatric symptoms, auditory /visual hallucinations, delusions. Denied having any history of mental illness.
MENTAL STATUS EXAMINATION

Appearance: Poorly kempt, disheveled, malodorous ill fitting clothes,

Behavior: Suspicious, guarded, poor eye contact, uncooperative irritable

Motor: Right hand tremor.

Speech: Disjointed, at times incoherent speech, Normal volume

Mood and affect: irritable, anxious

Thought process: concrete

(Repeats the same sentence “I have to leave. Call me a cab” with increasing frequency and intensity.

Thought content: consisted of the desire to leave; At times guarded, suspicious of staff and peers.

Perception: Denied auditory and visual hallucinations, delusions. He did not appear to be responding to internal stimuli

Insight and Judgement: extremely poor

Cognitive exam: did not formally participate but attention/memory deficit evident.
Substance use history:

Adamantly denied any substance use. However, would walk to the nursing station every day to ask for “A line of cocaine, a beer and a few lortabs”.

He declined to sign any paper work. Denied to give consent for collateral. Unable to obtain health records as he declined to sign consent to obtain records of previous treatment.
Admitting Diagnosis:

Psychotic disorder  R/O Schizophrenia
Substance use disorder
R/O intellectual disability
R/O Autism spectrum disorder
First two weeks of inpatient stay

He was prescribed Zyprexa 10 mg PO daily and he remained selectively compliant.

He refused to comply with any blood work, labs or imaging.

His hygiene and grooming remained poor. He refused to shower or change his clothes.

He would play the piano and often find a quiet area on the unit. He doesn’t do well with noise on the unit and sound of keys was bothersome.
Collateral from Mother

Pt. was diagnosed with **high blood lead levels** at 2 years of age during a routine screening. [40 mcg/dl] (Per CDC > 5 = increased lead levels)

He was then followed up with routine lead level monitoring.

He was treated with Iron supplementation. No Chelation. No hospitalization.
Records Obtained from Department of Health (Niagara falls)

![Graph showing lead levels over time.](image-url)
Social and Developmental History:

Born and raised in Buffalo

One of 8 children. 4 full sisters, one half sister, one full brother, one died (unknown cause)

Patient has a twin sister who is normal functioning. No history of exposure to lead levels, normal cognitive functioning.

Full brother has Down’s syndrome.

No other siblings have history of elevated blood levels.
He displayed troublesome behaviors since the age of 2 (reportedly banging head on the floor since 1.5 yrs to 4 yrs).

- Attention difficulties with difficulty comprehending instructions, sitting still.
- Delayed speech with first words at 4 yrs of age.
- **Sensory issues** (too loud, too busy, too much talking would bother him).
- Difficulty/suspiciousness in new **unfamiliar social situations**, Obsessional behavior since young age.

- He reportedly had some BOCES programming through High School.
- Dropped out of school in 11th grade.
### General
- Benton Temporal Orientation Test (BTOT) 8 impaired
- Mini Mental State Exam (MMSE) 24/30 1 impaired

### Sensory & Motor Functioning
- Visual Acuity (uncorrected) 20/40 adequate
- Grip Strength, dominant (right) 39 13 borderline
- Grip Strength, nondominant 35.8 6 borderline
- Grooved Pegboard (GPT), dominant (right) 97.5" 1 impaired
- Grooved Pegboard (GPT), nondominant 111" <1 impaired

### Estimated Premorbid Intelligence
- North Am. Adult Reading Test (NAART) 81 10 low average
- Barona Equation (BE) 97 42 average

### Intelligence
- WAIS-IV Verbal Comprehension Index 74 4 borderline
- WAIS-IV Perceptual Reasoning Index 77 6 borderline
- WAIS-IV Working Memory Index 84 9 low average
- WAIS-IV Processing Speed Index 71 3 borderline
- WAIS-IV Full Scale IQ 71 3 borderline
- WAIS-IV Block Design 7 16 low average
- WAIS-IV Similarities 5 5 borderline
- WAIS-IV Digit Span 7 16 low average
- WAIS-IV Matrix Reasoning 6 9 low average
- WAIS-IV Vocabulary 5 5 borderline
- WAIS-IV Arithmetic 6 9 low average
- WAIS-IV Symbol Search 5 5 borderline
- WAIS-IV Visual Puzzles 5 5 borderline
- WAIS-IV Information 6 9 low average
- WAIS-IV Coding 4 2 borderline
- WAIS-IV Letter-Number Sequencing 7 16 low average
- WAIS-IV Figure Weights 6 9 low average
- WAIS-IV Picture Completion 5 5 borderline

### Academic Abilities
- WJ-3 NU Broad Reading 48 <1 deficient, 2.2 grade level
- WJ-3 NU Broad Math 68 2 deficient, 4.3 grade level
- WJ-3 NU Broad Written Language 60 <1 deficient, 3.6 grade level
- WJ-3 NU Letter-Word Identification 55 <1 deficient, 2.4 grade level
- WJ-3 NU Reading Fluency 47 <1 deficient, <K.0 grade level
- WJ-3 NU Story Recall (stories 1-8) 51 <1 deficient, <K.0 grade level
- WJ-3 NU Understanding Dir. (items 2-5) 63 1 deficient, 1.7 grade level
- WJ-3 NU Calculation 72 3 borderline, 4.7 grade level
- WJ-3 NU Math Fluency 71 3 borderline, 6.1 grade level
- WJ-3 NU Spelling 88 21 low average, 7.3 grade level
- WJ-3 NU Writing Fluency 75 5 borderline, 4.9 grade level
- WJ-3 NU Passage Comprehension 71 3 borderline, 2.5 grade level
- WJ-3 NU Applied Problems 72 3 borderline, 3.6 grade level
- WJ-3 NU Writing Samples (items 1-12) 36 <1 deficient, 1.5 grade level

### Language
- Boston Naming Test (BNT) 32/60 <1 impaired
<table>
<thead>
<tr>
<th>Test</th>
<th>Score</th>
<th>Norm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controlled Oral Word (COW-PAS)</td>
<td>16</td>
<td>impaired</td>
</tr>
<tr>
<td>Controlled Oral Word (COW-animal naming)</td>
<td>4</td>
<td>impaired</td>
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<tr>
<td><strong>Spatial Abilities</strong></td>
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<tr>
<td>Judgment of Line Orientation (JLO)</td>
<td>14/30</td>
<td>&lt;1</td>
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<tr>
<td>Rey Complex Figure Test (RCFT), copy</td>
<td>26.5/36</td>
<td>&lt;1</td>
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<tr>
<td><strong>Learning and Memory</strong></td>
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<tr>
<td>CVLT-2 Trials 1-5</td>
<td>11/80</td>
<td>&lt;1</td>
</tr>
<tr>
<td>CVLT-2 List B</td>
<td>3/16</td>
<td>3</td>
</tr>
<tr>
<td>CVLT-2 Short Delay Free Recall</td>
<td>1/16</td>
<td>&lt;1</td>
</tr>
<tr>
<td>CVLT-2 Short Delay Cued Recall</td>
<td>2/16</td>
<td>&lt;1</td>
</tr>
<tr>
<td>CVLT-2 Long Delay Free Recall</td>
<td>0/16</td>
<td>&lt;1</td>
</tr>
<tr>
<td>CVLT-2 Long Delay Cued Recall</td>
<td>2/16</td>
<td>&lt;1</td>
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<tr>
<td>CVLT-2 Total Recog. Discriminability</td>
<td>1.5</td>
<td>3</td>
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<tr>
<td>WMS-4 Logical Memory I Recall</td>
<td>1/50</td>
<td>&lt;1</td>
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<tr>
<td>WMS-4 Logical Memory II Recall</td>
<td>1/50</td>
<td>&lt;1</td>
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<tr>
<td>WMS-4 Logical Memory II Recognition</td>
<td>19/30</td>
<td>3-9</td>
</tr>
<tr>
<td>WMS-4 Designs I</td>
<td>51/120</td>
<td>5</td>
</tr>
<tr>
<td>WMS-4 Designs I Content</td>
<td>30/48</td>
<td>9</td>
</tr>
<tr>
<td>WMS-4 Designs I Spatial</td>
<td>13/24</td>
<td>5</td>
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<tr>
<td>WMS-4 Designs II</td>
<td>46/120</td>
<td>9</td>
</tr>
<tr>
<td>WMS-4 Designs II Content</td>
<td>31/48</td>
<td>16</td>
</tr>
<tr>
<td>WMS-4 Designs II Spatial</td>
<td>11/24</td>
<td>16</td>
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<tr>
<td>WMS-4 Designs II Recognition</td>
<td>12/24</td>
<td>10-16</td>
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<tr>
<td>BVMT-T-R Trials 1-3</td>
<td>4/36</td>
<td>&lt;1</td>
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<tr>
<td>BVMT-T-R 20 min Delay</td>
<td>1/12</td>
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<td>BVMT-T-R Recognition (Discr. Index)</td>
<td>4</td>
<td>1-2</td>
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<td><strong>Memory/Attention</strong></td>
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<td>Reliable Digit Span (RDS)</td>
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<tr>
<td>CVLT-2 Forced Choice Recognition (FCR)</td>
<td>14/16</td>
<td>--</td>
</tr>
<tr>
<td>TOMM Trial 1</td>
<td>39/50</td>
<td>&lt;1</td>
</tr>
<tr>
<td>TOMM Trial 2</td>
<td>37/50</td>
<td>&lt;1</td>
</tr>
<tr>
<td>TOMM 15 min delay</td>
<td>45/50</td>
<td>&lt;1</td>
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**Executive Functioning**

<table>
<thead>
<tr>
<th>Test</th>
<th>Score</th>
<th>Norm</th>
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</thead>
<tbody>
<tr>
<td>Trail Making Test, Part A (TMTa)</td>
<td>50&quot;</td>
<td>1</td>
</tr>
<tr>
<td>Trail Making Test, Part B (TMTb)</td>
<td>178&quot;</td>
<td>2</td>
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<tr>
<td>Brief Test of Attention (BTA)</td>
<td>7/20</td>
<td>&lt;1</td>
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<tr>
<td>CPT-2 - Confidence Index</td>
<td>99.9%</td>
<td>--</td>
</tr>
<tr>
<td>CPT-2 - # Omissions</td>
<td>39</td>
<td>99</td>
</tr>
<tr>
<td>CPT-2 - # Commissions</td>
<td>30</td>
<td>98</td>
</tr>
<tr>
<td>CPT-2 - Hit RT</td>
<td>283.2</td>
<td>4</td>
</tr>
<tr>
<td>CPT-2 - Hit RT Std. Error</td>
<td>11.7</td>
<td>99</td>
</tr>
<tr>
<td>CPT-2 - Variability</td>
<td>29.9</td>
<td>99</td>
</tr>
<tr>
<td>CPT-2 - Detectability</td>
<td>0.0</td>
<td>93</td>
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<tr>
<td>CPT-2 - Response Style</td>
<td>1.0</td>
<td>64</td>
</tr>
<tr>
<td>CPT-2 - Perseverations</td>
<td>45</td>
<td>99</td>
</tr>
<tr>
<td>CPT-2 - Hit RT Block Change</td>
<td>0.0</td>
<td>49</td>
</tr>
<tr>
<td>CPT-2 - Hit SE Block Change</td>
<td>-0.0</td>
<td>27</td>
</tr>
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</table>
Neuropsychology report from 2014

-Grip strength was borderline in bilateral upper extremities. Fine motor speed and coordination impaired.
-Premorbid intelligence was low impaired borderline to low average range. WAIS- 71 IQ. (Per calculation an IQ drop of 10.12 IQ points)
-Speeded visual and motor processing/copying was an area of weakness.
-Language abilities impaired
-Executive functioning impaired:
-Memory impairment, learning difficulty.
-Spatial construct and spatial perception was impaired.
-Screening for depressive symptoms, anxiety + (Expresses interest in social relationships but fears leaving home)
HOSPITAL COURSE AND DISCHARGE

- He was inpatient for **5 weeks with a non changing presentation**.

- He denied any intervention (blood work, MRI), referrals. Zyprexa was ordered initially but patient didn’t comply.

- Insight remained poor, however, some improvement noted in managing his emotions.

- He was discharged home with his mother who was more than willing to take him back.

- He was referred for OPWDD, SSI benefits.
DIAGNOSIS:

1. Borderline intellectual functioning due to plumbism

2. Specific learning disorder with impairment in reading (dyslexia) with substantial contribution of plumbism

3. Cannabis use disorder
GOOD MORNING DR.
YOU'VE BEEN OK YOURSELF
WILL BE LEAVING EARLY IN WEEK AND HAVE ME
THAT RIDE QUICKLY BECAUSE I CARE. THANKS TAKE CARE.
Adult Manifestation of Childhood Lead poisoning

A REVIEW OF LITERATURE
Recent Study Published in JAMA 2019

In a multi-decade, prospective cohort study of over 500 lead-exposed children selected from a population-representative birth cohort of individuals born between April 1, 1972, and March 31, 1973, in Dunedin, New Zealand, the Dunedin Multidisciplinary Health and Development Study. Members were followed up in December 2012 when they were 38 years of age.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Sex Adjusted</th>
<th>P Value</th>
<th>Fully Adjusted</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b (95% CI)</td>
<td></td>
<td>b (95% CI)</td>
<td></td>
</tr>
<tr>
<td>Adult psychopathology</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>General psychopathology</td>
<td>1.49 (0.22 to 2.77)</td>
<td>0.02</td>
<td>1.34 (0.11 to 2.57)</td>
<td>0.03</td>
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<tr>
<td>Externalizing symptoms</td>
<td>0.80 (0.47 to 2.06)</td>
<td>0.21</td>
<td>0.73 (0.52 to 1.97)</td>
<td>0.25</td>
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<tr>
<td>Internalizing symptoms</td>
<td>1.57 (0.30 to 2.83)</td>
<td>0.02</td>
<td>1.41 (0.19 to 2.62)</td>
<td>0.02</td>
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<tr>
<td>Thought disorder symptoms</td>
<td>1.44 (0.16 to 2.72)</td>
<td>0.03</td>
<td>1.30 (0.06 to 2.54)</td>
<td>0.04</td>
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<tr>
<td>Adult personality traits (Big Five Personality Inventory)</td>
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<td></td>
<td></td>
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<tr>
<td>Neuroticity</td>
<td>0.10 (0.02 to 0.19)</td>
<td>0.01</td>
<td>0.10 (0.02 to 0.18)</td>
<td>0.02</td>
</tr>
<tr>
<td>Extraversion</td>
<td>-0.08 (-0.17 to 0.01)</td>
<td>0.09</td>
<td>-0.09 (-0.17 to 0.004)</td>
<td>0.06</td>
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<tr>
<td>Openness to experience</td>
<td>-0.07 (-0.16 to 0.03)</td>
<td>0.17</td>
<td>-0.07 (-0.17 to 0.03)</td>
<td>0.15</td>
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<tr>
<td>Agreeableness</td>
<td>-0.09 (-0.17 to -0.003)</td>
<td>0.04</td>
<td>-0.09 (-0.18 to -0.01)</td>
<td>0.03</td>
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<tr>
<td>Conscientiousness</td>
<td>-0.14 (-0.25 to -0.03)</td>
<td>0.01</td>
<td>-0.14 (-0.25 to -0.03)</td>
<td>0.01</td>
</tr>
<tr>
<td>Childhood externalizing and internalizing problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antisocial behavior</td>
<td>0.11 (0.03 to 0.19)</td>
<td>0.01</td>
<td>0.10 (0.02 to 0.18)</td>
<td>0.02</td>
</tr>
<tr>
<td>Hyperactivity</td>
<td>0.17 (0.08 to 0.26)</td>
<td>&lt;.001</td>
<td>0.16 (0.07 to 0.25)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Internalizing problems</td>
<td>0.12 (0.03 to 0.20)</td>
<td>0.01</td>
<td>0.11 (0.02 to 0.20)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

* Covariates in the fully adjusted model were sex, childhood socioeconomic status, maternal IQ, and family history of mental illness. Of the 579 study members with childhood blood lead level measured, 551 (95.2%) had present data on all the covariates and the psychopathology outcome measures, 539 (93.1%) had present data on all the covariates and the personality outcome measures, and 552 (95.3%) had present data on all the covariates and the childhood emotion and behavior outcome measures. Regression coefficients indicate change in outcome per 5-µg/dL increase in childhood blood lead level.

b General psychopathology and the constituent psychiatric spectra are standardized to a mean (SD) of 100 (15).

c The Big Five Personality Inventory traits scores are standardized to a mean (SD) of 0 (1).

d Childhood antisocial behavior, hyperactivity, and internalizing problem scores are standardized to a mean (SD) of 0 (1).
• Across nearly 3 decades of follow-up, childhood BLLs were associated with higher levels of general psychopathology, driven primarily by greater rates of internalizing and thought disorder symptoms.

• Childhood BLLs were associated with higher neuroticism, lower agreeableness, and lower conscientiousness.

• Lead exposed children experience disrupted cognitive and behavioral development, with childhood lead exposure linked to lower child IQ, poorer academic achievement and greater rates of child behavior problems, particularly inattention.
MRI scans from participants of the Cincinnati Lead Study had striking results: childhood lead exposure was associated with brain volume loss in adulthood. Individuals with higher blood lead levels as children had less gray matter in some brain areas. The main brain region affected was the prefrontal cortex which is responsible for executive function, behavioral regulation, and fine motor control (Cecil et al., 2008).
1. Epidemiology

Lead was included as an ingredient of gasoline in the 1920s and continued to be used in paint in some developed countries until the 1970s.

In many low-income countries, lead in gasoline and industrialized uses of lead (eg, smelters, mines, or refineries) remain major sources of exposure.
The prevalence of elevated BLLs is highest among inner-city children who live in deteriorating housing that was built before the 1970s, and children exposed to lead as a result of industrialized use (eg, aerosolized lead from smelters or refineries or lead in water near mining operations).

Lead poisoning is more common among urban than rural children, low-income than middle-income children, and children who live in older housing.

In the United States, non-Hispanic black children continue to have a statistically higher BLL compared with other populations.

In addition, the prevalence of lead poisoning is increased among refugee children who have arrived recently in the United States, and among children entering foster care.
Blood lead levels in children have plummeted since the US phased out the use of leaded gas and paint in the 1970’s. Still, 24 million homes in the US contain deteriorated lead paint and elevated levels of lead-contaminated dust. Soil contains lead from air that settled during our previous industrial use.

Old toys and toys imported from other countries may contain lead-based paint as well.

Although the incidence and severity of lead poisoning in the United States are decreasing, an estimated 450,000 children in the United States were above the reference value of 5 mcg/dL (0.24 micromol/L) in 2012.
Lead poisoning in Buffalo, NY

“Old houses + poverty = Lead poisoning”

58 percent of the houses in Buffalo were built before 1940. 40% of the population live below poverty line.

Lead poisoning rates in Buffalo’s hardest hit neighborhoods were eight times higher than those in Flint, MI during city’s water crisis.

In a 2017 national report, declared Buffalo “Among the most dangerous lead hotspots in America.”
Discussion
Millions of adults now entering middle age were exposed to high levels of lead as children, a phenomenon that accompanied the peak use of lead in gasoline worldwide from the 1940s through the early 1990s.

As the generation of lead-exposed individuals age, it is also possible that bone loss during menopause and osteoporosis may result from childhood lead stored in bone being recirculated throughout the body, suggesting the testable hypothesis that the long-term consequences of childhood lead exposure may evolve or expand over time.
- Increased access to mental health services to adults with history of childhood lead poisoning
- Lead screening programs, treatment of children with high lead levels
- Banning lead in gasoline, drinking water, lead pipes, paint.
Primary prevention efforts focus on removal of lead from the environment so that exposure cannot occur. Primary prevention of childhood lead poisoning involves the removal of lead-based hazards from the environments of children (eg, lead-painted surfaces, including windows, lead-contaminated soil, or lead-soldered pipes) prior to any exposure to the child.

Policies have too often relied on secondary and tertiary prevention. Primary prevention is the only way to reduce the neurocognitive effects of lead poisoning.
LEAD PAINT MUST GO
The Global Alliance to Eliminate Lead Paint says that all countries should ban lead paint by 2020

FACT: As of August 2017, only 1/3 of countries have legally binding controls on lead paint

KEY
Countries with legally binding controls on lead paint as of 31 August 2017
- No
- Yes
- No Data
- Not Applicable

THAT’S WHY
GOVERNMENTS + INDUSTRY + CONSUMERS
Must work together to ensure all paint is free from added lead by 2020

There is no safe level of lead exposure
Other Heavy Metals associated with psychiatric diseases

Arsenic
Arsenic disrupts serotonin and dopamine metabolism, thus compromising neuronal health. Even at low-level exposure, arsenic predisposes to cognitive dysfunction and susceptibility to mood disorders.

Cadmium
Cadmium upsets the delicate balance between glycine, glutamate, and GABA to negatively impact memory and cognition by being especially destructive to white matter in the brain. Cadmium exposure has detrimental effects on neurocognitive development in children, and is associated with learning disabilities, lower IQ, attention deficits, behavioral problems, and hearing loss.

Mercury
Mercury radically skews neurotransmission – it stimulates excitatory signaling (e.g., glutamate, dopamine) and decreases inhibitory signaling (e.g., GABA). Mercury exposure can cause a variety of neurological symptoms, including irritability, mood swings, headaches, concentration and memory difficulties, and sleep disturbances.
CONCLUSION/Recommendation

- Psychiatric illnesses are multifactorial in nature. Environment may have a greater role in onset of mental illnesses than we are currently aware.
- Importance of a detailed history and collateral information.
- Rule out medical illnesses with a detailed medical & toxicological work up
Resources


Lead information| Buffalony.gov