“Only Time Will Tell”: The Underexplored Impacts of Lead Poisoning and COVID-19 on Pre-Existing ACEs in New York

Lorenz S. Neuwirth and Kerry Whigham

Abstract: The peak of the coronavirus-19 (COVID-19) in New York City significantly impacted communities that lived in the New York City Housing Authority (NYCHA). However, these same communities have been historically reported to test positive for lead poisoning due to neglect of proper lead abatement and the removal of lead sources within these buildings. The consequences of these failed actions by NYCHA resulted in multiple generations of lead-poisoned children, which can be argued as a form of mass atrocity and genocide. The long-term neurodevelopmental and socio-economic outcomes of children exposed to lead and COVID-19 remain to be elucidated. This short communication attempts to bring attention to this overlooked matter and draws upon the scarce, but emerging, reports in the literature to start a conversation on the synergistic potential of these looming public health issues. Further, suggestions for providing consistent blood lead screening and COVID-19 testing could serve to clarify whether a “two-hit” hypothesis of a neurotoxicant (lead) and a neuroimmune (COVID-19) virus that produces an Adverse Childhood Experience (ACE-19). More work is needed in this area to (dis)confirm the potential for this “two-hit” hypothesis, and only time will tell.

Keywords: lead poisoning; coronavirus-19 (COVID-19); adverse childhood experiences (ACEs); two-hit hypothesis; childhood lead poisoning; adverse COVID-19 experiences (ACE-19)

1. Introduction

Lead poisoning has plagued the human condition since antiquity, but over the last century, it has become increasingly recognized that even at environmentally lowered exposure levels (i.e., between 5 and 20 µg/dL), lead continues to cause significant and often irreparable damage to the developing brain in children [1–5]. Thus, there is no safe level of lead poisoning for children to be exposed. These reports have been well documented, spanning from 1923 to 1996 [6], and unfortunately, later studies reported that more than half of the US’s population of children were exposed to adverse levels of lead poisoning (i.e., >5 µg/dL) from 1976 to 2016 [7]. However, despite the advancements of modern technology and medicine, a particular conundrum is observed in that as more materials are mined to produce technology and are either recycled or deemed obsolete within a few years, there is an increased risk of mining lead and extracting leaded products from e-waste (i.e., modern metallurgy), which subsequently re-enters the environment as a neurotoxicant and pollutant through global superfund sites [8–22]. Thus, it can be argued that technological advancements, to some extent, have provided a parallel opportunity for lead poisoning to remain highly relevant yet dually concerning, even in a modern world in which lead-free resources are available. What remains clear is that these lead sources continue to place children at elevated risk for neurodevelopmental disorders. Notably, families with lower income that reside in public housing or are economically...
disadvantaged often find their residences to be within close proximity to industrialized businesses, (in)active or remediating smelters, mining operations that produce dust and soil contamination, lead-acid battery sites, e-waste factories, or superfund sites [23–33]. These modern sources of lead exposure(s) have raised public awareness, and pressured the New York State government to assess the environmental lead-poisoning risks that children residing in the New York City Housing Authority (NYCHA) have faced over the last five decades and how these risks may have been compounded by the lockdown imposed by the coronavirus-19 (COVID-19) pandemic beginning in March of 2020.

As such, the long-term neurodevelopmental and socio-economic outcomes of children living in public housing who were exposed to lead and the coronavirus-19 (COVID-19) remain to be elucidated. The aim of this short communication served to bring attention to this overlooked matter and to draw upon the scarce, but emerging, reports in the literature in order to start a conversation on the synergistic potential of these public health issues (i.e., legacy lead exposure and COVID-19). Furthermore, suggestions for providing consistent blood lead screening and COVID-19 testing could serve to clarify whether a “two-hit” hypothesis of a neurotoxicant (lead) and a neuroimmune virus (COVID-19) produces an Adverse Childhood Experience (ACE-19) will be explored.

2. Method

In order to explore whether COVID-19 increased the risk of lead exposure during the lockdown for children in NYCHA, a systematic review was conducted using three article databases: (1) Pub Med, (2) Science Direct, and (3) Google Scholar. The following combination of search terms and Boolean functions were used to find relevant articles: (1) NYCHA “AND” Lead Exposure; (2) NYCHA “AND” Lead Poisoning; (3) NYCHA “AND” Superfund Site; (4) NYCHA “AND” Environmental Justice; (5) NYCHA “AND” Environmental Justice “AND” Lead Poisoning; (6) NYCHA “AND” Environmental Justice “AND” Lead Exposure; (7) NYCHA “AND” COVID-19 “AND” Lead Poisoning; and (8) NYCHA “AND” COVID-19 “AND” Lead Exposure.

From the three databases, PubMed returned zero articles for all search terms and was therefore excluded from the study. In contrast, Science Direct returned a good number of articles for the terms NYCHA “AND” Lead Poisoning (n = 123) and NYCHA “AND” Lead Exposure (n = 366). Notably, Google Scholar returned the most articles for the terms NYCHA “AND” Lead Poisoning (n = 196), NYCHA “AND” Environmental Justice (n = 855), NYCHA “AND” Environmental Justice “AND” Lead Poisoning (n = 1010), NYCHA “AND” Environmental Justice “AND” Lead Exposure (n = 618), and NYCHA “AND” Lead Exposure (n = 733). For the search terms NYCHA “AND” COVID-19 “AND” Lead Poisoning and NYCHA “AND” COVID-19 “AND” Lead Exposure, Science Direct returned 6 and 0 articles, whereas Google Scholar returned 239 and 152 articles, respectively. Table 1 presents a summary of the articles returned from the aforementioned databases.

Notably, Science Direct and Google Scholar had the same articles that returned with overlap between the two databases, but Google Scholar had more relevant articles that were available and was therefore chosen as the sole database used for the present systematic review. From the Google Scholar articles that were returned, a systematic review of the articles that focused on the intersectionality between NYCHA, lead poisoning/exposure, superfund sites, environmental justice, and COVID-19 was conducted and all other articles on green spaces, gentrification, public housing rent-related matters or other matters not pertaining to lead poisoning, and COVID-19 aspects that digressed away from or failed to include lead poisoning were excluded. After these exclusion criteria were employed, only 20 relevant articles met the inclusion criteria.
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3. Results

After systematically reviewing the 20 relevant articles, only 1 article [34] attempted to draw comparisons of lead exposure risks between children that live in NYCHA and children living elsewhere (i.e., non-NYCHA residence), but it did not consider COVID-19 as this study commenced prior to the onset of the pandemic. Interestingly, in an effort to address the public’s concern surrounding lead poisoning risks for children living in NYCHA, Chiofalo et al. [34] evaluated the pediatric blood lead levels (BLLs) in children in public and private housing in New York City from 2003 to 2017 and found that children in public housing were associated with a 92% lower odds ratio in possessing elevated BLLs (i.e., >5 µg/dL) than children living in private housing. It should be noted that this was a retrospective observational study that statistically used logistic regression analyses for these two categories of populations of children, and the analyses were carried out on unequal sample sizes. The private (non-NYCHA) children’s overall mean BLL was 2.10 µg/dL (n = 3881) when compared to the public (NYCHA) children’s mean BLL, which was 1.92 µg/dL (n = 812) [34]. Although the BLLs were shown to be statistically different based largely on the sample sizes compared and not physiologically relevant (i.e., as both groups of children would have endured an approximate equivalent of ~0.096 µM concentration of lead circulating within the bloodstream that could cause similar brain insults to both groups).

As such, the largely unequal sample sizes could have skewed the results of the odds ratio as being ~4.75 times more favorable for the more normally estimated larger dataset of non-NYCHA children that were sampled when compared to NYCHA children; thereby, misdirecting lead exposure risks away from the NYCHA children as a false negative risk factor (for a review on improving logistic regression with imbalanced datasets to improve weighting when drawing comparisons against smaller datasets, see [35]). Furthermore, the data of 4693 children that were available from the Federally Qualified Health Center’s (FQHC) New York City centers from 2003 to 2017, only represented three of the five boroughs (i.e., but only the Bronx—65.4% and Manhattan—26.6% were identified), with the majority of the sample (41.2%) representing African American race/ethnicity; it did not serve as a fair nor representative sample of the NYCHA children population [34]. Ultimately, this study was limited as its sample size was not evenly distributed nor representative of all the boroughs and did not control for the unequal sample sizes used from the available
datasets. At best, based upon the physiological relevance of the BLLs’ reported data from both non-NYCHA and NYCHA children groups, what can be extrapolated is that in New York City from 2003 to 2017, these children were at equal risk for low-level lead exposures (i.e., that come/emanate from different sources of lead exposures) and could negatively impact their future quality-of-life outcomes. However, one must be both intentional and careful in remaining to hold the understanding that a substantial number of children living in NYCHA, although lower than privately housed children as reported by this report’s sampling methods and analyses of the datasets, were still lead-poisoned at low levels, which should not be overlooked due to the way this group reported their statistical findings.

Consequently, this study raised significant controversy in New York, as from 2016 to 2018, an abundant display of public newspapers case-after-case covered children in NYCHA having lead poisoning, and this exposed the misconduct issues under the Mayor Bill de Blasio administration from 2014 to 2021 (see Figure 1); thus, suggesting the identified misconduct of NYCHA officials and the responsible parties involved in the scandal.

This situation presented the public with much confusion and distrust on the reports offered by Chiofalo et al. [34]. Moreover, Jacobs [36] attempted to offer an editorial in response to the Chiofalo et al. [34] report suggesting that lead poisoning is still harming both US-born and immigrant children (i.e., 4–7 times higher blood lead levels than US-born children) in NYCHA and “lead paint in public housing is required to be fully abated at the time of modernization, and hazards are required to be controlled in the interim.” However, given this “NYCHA scandal”, no hazard controls nor modernization took place in many buildings, and increasing cases of identified lead paint exposures were being covered up and not handled by the responsible NYCHA parties as a form of misconduct, which became increasingly public from 2018 up until the COVID-19 pandemic. Thus, although the editorial by Jacobs [36] was well intended, the expected responsible actions by NYCHA did not actually take place and do not represent the current and continued lived experiences of children living in NYCHA exposed to lead. Contemporaneously with these events, a timely and emerging body of literature grew, suggesting misconduct by the state that resulted in legal actions to address lead paint issues in NYCHA, amongst other unacceptable housing
conditions arguing that failure to address these issues was an environmental injustice and racism that disproportionately affected Black children [29–33,37–44]. The remaining 18 articles [24–33,37–44] from the systematic review all converge upon lead poisoning as it relates to environmental racism and injustice issues faced by children and families within NYCHA, as detailed below. Future studies are warranted to appropriately examine both the short- and long-term effects of children who were lead-poisoned and then contracted COVID-19.

In New York, these geographic risks have been identified to be further compounded by the NYCHA’s failure to provide timely and proper lead abatement: (1) all apartments that may contain residual lead paint on the walls, window sills, and doorways/frames, all of which are subject to chipping, cracking, and accumulating dust that children may come into contact with and become exposed to; and (2) pre-1940s water plumbing systems where lead soldered pipes are likely to remain until the present day—an unaddressed public health issue for over 75 years [23], which are consistent with reports of other major urban and inner cities in the US that have children with elevated lead-exposure risks [45–87]. Notably, only a few of NYCHA’s oldest buildings predate these water plumbing concerns, whereas many NYCHA buildings were constructed years later; thus, the major lead poisoning risks within NYCHA arise from the chipping, peeling, and water bubbling of old leaded paint. These risk factors have been reported for many decades (i.e., estimated occurrence since the 1950s), but these risk factors may have escalated further when COVID-19 hit in 2020 in New York City. The risk for lead poisoning may have been greater when New York City became the first area of COVID-19 contagion within the United States, soon thereafter becoming an unprecedented “hot spot” for the spread of the virus within the state, the country, and the world. At this point in time, both logically and as a precautionary mitigation strategy for the public’s health in order to contain the spread of the virus, the global population sequentially went into phases of lockdown [88]. In New York, the lockdown that affected everyone particularly placed NYCHA residents at increased risk for remaining within their apartments that may have contained unabated lead paint, and these risks may have been overlooked by the government and public health officials.

This lockdown within New York City at the peak of the pandemic (i.e., March–April 2020) was instituted by a State of Emergency order by Governor Andrew Cuomo, who instructed people to remain in their homes and to only leave for absolutely necessary circumstances (i.e., purchasing food for survival or if one held a government or health-care occupation that was of urgent need), resulting in significant increases in people experiencing psycho-social-emotional mental health and well-being issues [88–92]. When these low-income families were unable to leave their NYCHA apartments in which lead-exposure remained, the following concerns were overlooked as risk factors: (1) children remained within their leaded apartments for longer durations of time when compared to pre-pandemic levels, increasing their inhalation risks of lead dust particles [23]; (2) children drank more water from their pipes, which may have residual lead solder, increasing their risk of ingesting lead-contaminated drinking water (i.e., this risk is potentially associated with only the oldest NYCHA buildings) [23]; (3) when reliant on food sources that were affordable and easily accessible and supplies/alternative options that were limited due to the impacts of COVID-19 on the global supply chain problems, people became dependent upon commercially manufactured food sources that were also reported to have lead contamination to feed their infants, toddlers, and children (i.e., formulas, cereal, and juice products) [93], posing additional ingestion-based lead-exposure risks; (4) the COVID-19 lockdown prevented and further reduced the likelihood of children to be screened for blood lead levels (BLLs) in both the city and suburbs [94–99]; (5) byproducts from pre-pandemic neighborhood sorting and steering via housing discrimination made restrictions and access barriers to pediatric follow-up care, appointments, and interventions worse (i.e., chelation therapy) as they were unlikely to relocate due to financial hardships and rent freezes, and their needs were not fully addressed via telehealth during the pandemic; and (6) historically, low-income families exhibit high medical drop-out rates and unstable longitudinal
follow-up, whereby new cases of children with lead poisoning could have been overlooked or, even worse, missed during the pandemic [99,100].

These unintended but devastating outcomes of the COVID-19 pandemic and the lockdowns implemented in response to it demonstrate the dangers that come from making public policy and public health decisions without applying what Alex Bellamy calls an “atrocity prevention lens” [101]. “Mass atrocities” are large-scale attacks against civilian populations, often related to the identity groups (i.e., racial, ethnic, religious, etc.) to which certain populations belong. For public administrators and public health officials, preventing mass atrocities involves attending to the specific realities of salient identity categories, making sure that policy initiatives do not intentionally or unintentionally cause harm to certain identity groups, even if the same initiatives may benefit others [102]. Generally, in the United States, public health responses to COVID-19 were applied equally across populations without regard for the circumstances of individuals or groups based on considerations like race, ethnicity, socio-economic status, etc. Applying an “atrocity prevention lens,” however, requires that policymakers consider the specific risks faced by various identity groups within a given context and develop policy responses that do not elevate risks to those groups in the process of applying a given policy. A COVID-19 response that applied an “atrocity prevention lens” would not look the same for everyone. It would consider, for instance, that a universal lockdown, while solving some problems, may also create new problems for populations living in unsafe public housing conditions with the potential for lead exposure. In order to ensure that groups living in such public housing conditions do not suffer disproportionately, policymakers would need to develop specific new policies to address this potential harm. Importantly, policy responses that are sensitive to atrocity risks are usually not applied equally across entire populations. Rather, they are applied equitably, understanding that some populations are at higher risk for suffering than others, and therefore require additional attention and modified supports, as well as resources [102,103].

The lack of response sensitive to the specific realities of NYCHA residents during the COVID-19 lockdown has had devasting and unintended consequences. Taken together, it is argued that lead poisoning from the aforementioned risk factors that both affected and effected children in New York from low-income families and the lockdown caused by the COVID-19 pandemic could have caused a “two-hit” hypothesis defined hereafter as the Adverse COVID-19 Experience (ACE-19). The term “two-hit” hypothesis in schizophrenia research [103] refers to an early inflammatory response to the brain as the “first-hit” in which the ensuing sequelae to the brain then becomes increasingly vulnerable to subsequent adverse events as a “second-hit.” Thus, in this example, lead poisoning (i.e., a neurotoxicant insult) is the “first-hit” as children were more likely to be lead-exposed pre-pandemic, and during the COVID-19 lockdown, they could have endured worse lead exposures if they later contracted COVID-19 (i.e., a virus-based neuro-immune insult), which would then cause the “second hit.” The proposition of this two-hit hypothesis (i.e., lead exposure and viral infections in children, which could also be bidirectional) is conceivable given the preliminary reports on peoples’ COVID-19 symptoms measured via the COVID-19 Severity Index (qCSI) score, and the elevated blood lead levels (i.e., ~11.4 µg/dL) that were observed in ~61 to 64 years old adult males [81], and the early report on COVID-19 effects on the brain [104–106]. This was the only report found through this systematic review on COVID-19 and lead poisoning, but the report examined adults and not children. Only time will tell how children might be impacted across their lifespans as the remainder of this story unfolds in the coming years within the literature. What to make of these reported medical associations with lead exposure and contracting COVID-19 in childhood and the long-term health and neurological outcomes as adults remains to be elucidated.

4. Discussion

Unfortunately, there has been a clear and systematic pattern of public health neglect and misconduct that NYCHA has not addressed regarding the longstanding issue of lead
abatement and lead pipe replacement for their residents (i.e., the latter point is only relevant for the oldest buildings). The five decades of failed lead exposure risk assessment, proper and timely abatement, and ensuring a safe and harm-/hazard-free environment in which to live, is by definition aligned with a clear form of environmental injustice [107–111]. The tenants in NYCHA are being subjected to live in apartments that contain a neurotoxicant (i.e., lead) that can cause their children to experience brain damage. The socio-economic issues of housing costs, inflation due to the COVID-19 pandemic, and the surge in prices for the housing market together have made it nearly impossible for NYCHA tenants to afford to relocate elsewhere. This form of residential learned helplessness of being unable to escape a residence that can harm their tenants has contributed to the association of NYCHA tenants being at risk for elevated lead exposures and BLLs. However, due to the limitations and constraints of the lockdown imposed by COVID-19 from the peak of the pandemic to the present day, it is unclear how many children in NYCHA have been impacted by this unprecedented situation. What is clear is that the New York State Department of Health (NYS DOH) should deploy a systematic effort for lead poisoning educational outreach and BLL screening for all NYCHA residents, with appropriate follow-up measures for individuals and families identified to test positive for lead poisoning. These assessments should also contain a record of patient self-reports or family reports of whether the person had also tested positive for COVID-19 and whether they tested positive for COVID-19 more than once. More proactive, procedural, educational outreach programs regarding BLL screenings should be created and offered relative to women’s preconception and when pregnant in an intentional effort to pin-point the time period of exposure by indirectly testing the developing fetuses in utero (i.e., by having the mother’s BLL screened in the first, second, and third trimesters), as newborns, and as postnatal children at age 1, 2, and 3 years old [100]. Future BLL screening may also seek to survey whether patients are sick, present with COVID-19 symptoms, and test positive for COVID-19 to eliminate it as a possibility (i.e., since in the incubation phase symptoms may not show/appear at the moment the individual/child is in the clinic). Thus, a BLL screening with COVID-19 elimination assessment may be a critical determinant for identifying Lead + ACE-19 (i.e., neurotoxicant + neuroimmune virus) versus Lead-only exposure (i.e., neurotoxicant). Only when such an assessment is conducted can a “two-hit” hypothesis then be (dis)confirmed. Lastly, children who reside in NYCHA buildings near an environmental contamination site or risk area and visit pre-1940 to 1960 homes or schools built during these same time periods should also be screened for both BLLs and COVID-19 as their trafficking pattern may provide insight on additional lead exposure hot spots that might serve to explain the range of variability in BLLs in children residing in and outside of NYCHA.

5. Conclusions

There remains a longstanding problem with respect to the New York State government and public health officials failing to properly oversee and address the lead abatement and pipe replacement issues in NYCHA apartments, which continually places multiple generations of children at risk for neurodevelopmental disorders [2]. This repeated failure to act (i.e., both proactively and reactively) results in disproportionate harm to economically disadvantaged families, many of whom are racial and/or ethnic minorities that have faced other intentional and unintentional harms at the hands of the state historically and in the present. The results of such policy inaction are not dissimilar to the harms suffered by other populations around the world that have been directly targeted by crimes of genocide and other mass atrocities [107–111]. Although not necessarily the product of a direct or intentional attack against a population, the end product of this sort of misconduct by NYCHA may be equivalent. There are disproportionate numbers of individuals suffering from the multiple intersecting harms of lead poisoning, COVID-19, and the enduring challenges of residing in housing managed by an entity that is not fulfilling its most basic obligations to provide safe shelter to its residents. Therefore, NYCHA can hardly hide behind a veil of ignorance as to the damage caused by these policy failures as public
news outlets have reminded people of the harms of lead exposure. This begets a timely opportunity for the New York state government and public officials to reimagine and re-educate the public on the dangers of lead exposure, children’s vulnerability to lead, and the importance of regular/mandatory BLL screenings amid the continuing short- and long-term effects of COVID-19.

In other recent public educational outreach efforts, the National Library of Medicine has curated and deployed an online traveling exhibition titled as follows: “This lead is killing us: A history of citizens fighting lead poisoning in their communities” [112]. Contemporaneous with this exhibit, President Joe Biden indicated in his State of the Union Address on 7 February 2023 that he will “replace poisonous lead pipes that go into 10 million homes in America...400,000 schools and childcare centers...so every child in America can drink the water instead of having damage to their brain” (minutes 22:15–22:32 of the address) [113]. This plan is further detailed in FACT SHEET: The Biden-Harris Lead Pipe and Paint Action Plan [114], the FACT SHEET: Delivering Progress on The Biden-Harris Lead Pipe and Paint Action Plan [115], and the FACT SHEET: Biden-Harris Administration Announces New Actions and Progress to Protect Communities from Lead Pipes [116]. There appears to be much promise in addressing these issues surrounding legacy lead exposures [1–7] across America. Only time will tell whether these issues are addressed or ignored and whether new forms of lead exposure (i.e., modern metallurgy through e-waste and superfund sites) will continue to threaten the neurodevelopment of children. However, without a consistently implemented Federal and State mandate to ensure that every child is screened for lead poisoning at the aforementioned time points described herein, the true public and economic impacts of lead exposure on children’s quality-of-life will remain elusive at best. Additionally, what is concerning is that longitudinal studies will be needed to evaluate the long-term neurodevelopmental impacts of lead poisoning and ACE-19 as the outcomes from this “two-hit” hypothesis are predicted to have different or even divergent neurocognitive and neurobehavioral signatures than what has been well-established regarding legacy lead exposures in children [1–7]. Consistent BLL screening in the current and future generations of children will be paramount in (dis)confirming this “two-hit” hypothesis and parsing the neurotoxicant + neuroimmune virus (Lead + ACE-19) versus the neurotoxicant (Lead) clinical presentation of children as the field moves forward. As this short communication serves to call attention to children exposed to lead and COVID-19 warranting more study, researchers should remain ever mindful of the evolving variants of the virus as this situation continues to unfold.

Author Contributions: L.S.N. and K.W. conceived, wrote, and approved the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by a SUNY Old Westbury Faculty Development Grant Award and by the Charles E. Scheidt Faculty Fellows in Atrocity Prevention at SUNY Binghamton University’s Institute for Genocide and Mass Atrocity Prevention (I-GMAP) to L.S.N.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The Charles E. Scheidt Faculty Fellows in Atrocity Prevention at The State University of New York (SUNY) Binghamton University’s Institute for Genocide and Mass Atrocity Prevention (I-GMAP) in which L.S.N. serves as a Faculty Fellow and K.W. as its Co-Director.

Conflicts of Interest: The authors declare no conflict of interest.
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