2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
Paper ID #50802

Impact of Lead Based Paint on Well Being of Adults - A Case Study for Capstone Project

Craig Gullo
Dr. Amitabha (Amit) Bandyopadhyay, State University of New York, College of Technology at Farmingdale

Dr Bandyopadhyay is a SUNY Distinguished Service Professor and Chaired Architecture and Construction Management Department at Farmingdale State College for twenty four years. He is also the Director of Green Building Institute and Graduate Program coordinator at the college. He was ETAC chair in 2012-13

1. Introduction

On January 1, 1978 lead-based paint was officially banned by the United States Government for human health and environmental hazards; although it was being phased out in residential use years earlier. Prior to that, lead was used in paint for a variety of reasons: pigmentation, durability, moisture resistance, and as a drying accelerant but time revealed toxicity critical to bodily functions. Lead exposure in adults can lead to fertility problems, high blood pressure, digestive problems, nerve disorders, memory and concentration issues, and muscle and joint pain. Even at low levels, lead exposure can harm children with a host of additional ailments, many irreversible. The research conducted for this case study will center on adults (mostly young adults) as detrimental effects to children are already well documented.

Lead-based paint (LBP) is *usually* not a hazard *if* it is in good condition, meaning it is not peeling, chipping, cracking, chalking, wet, or damaged otherwise. Lead dust can form when LBP is scraped, sanded, heated, or rubbed together (this happens in high friction areas involving operational windows and doors). Paint chips and dust contaminate other surfaces via air currents (natural wind, vacuuming, sweeping, walking, etc.). The Environmental Protection Agency (EPA) and the U.S. Department of Housing and Urban Development (HUD) defines lead dust hazards at specified areas over the levels indicated by Table 1.1 provided below. Hazardous levels were decreased recently as lead awareness and its impact has become more precarious. HUD danger levels are equal to or more stringent than the EPA thresholds in certain areas and measured in micrograms per square foot (µg/ft²).

Table 1.1—*EPA and HUD hazardous lead-based paint thresholds juxtaposed.*

Description	EPA	HUD
Hazard Standard, Floors	≥ 10 µg/ft²	≥ 10 µg/ft²
Hazard Standard, Sills	≥ 100 µg/ft²	≥ 100 µg/ft²
Clearance, Floors	< 10 µg/ft²*	< 10 µg/ft²
Clearance, Sills	< 100 µg/ft²*	< 100 µg/ft²
Clearance, Troughs	< 400 µg/ft²*	< 100 µg/ft²
Clearance, Porch Floors	not regulated	< 40 µg/ft²

**New proposed level.*

2. Problem Statement

Is there a relationship between lead-based paint and adult health and mental well-being? This paper will use the term "well-being" here-on-out as shorthand for human physical, mental, and emotional status as lead consumption can adversely affect all three. This correlation is not new to science or the medical field; a quick online search and one may discover lead consumption and health problems are synonymous. More times than not, the main emphasis of lead poisoning awareness circles around children under six-years-old and pregnant women—as it should—due to higher risk factors. Children under six are particularly susceptible because their brains and nervous systems are still developing and absorb more of the damaging effects of lead. Pregnant women with high lead levels in their systems before or during pregnancy may expose the fetus to lead through the placenta.

However, narrow focusing the attention on two vulnerable groups of people may be indirectly diminishing the detrimental effects lead poisoning can have on adults. Realizing the term "adult" can be ambiguous—it may be, to most, subjected to those 18-years-old and older, or in the case of lead wariness, it may be relegated to those six years and older—some of this pertains to the likelihood of babies or younger children putting their hands in their mouth, which would lead to direct ingestion of lead dust. It's crucial to recognize lead poisoning can cause possible irreparable damage to children of any age (6-17 years) as physical and mental development continues into the young twenties for most; however, this indifferent approach that adults (even fully developed) would not be at risk is irresponsibly unjustified. That is the design of this research; to bring awareness to those that have been perpetually unaware. Buried within this problem statement are subsections inherently linked to the main issue, including:

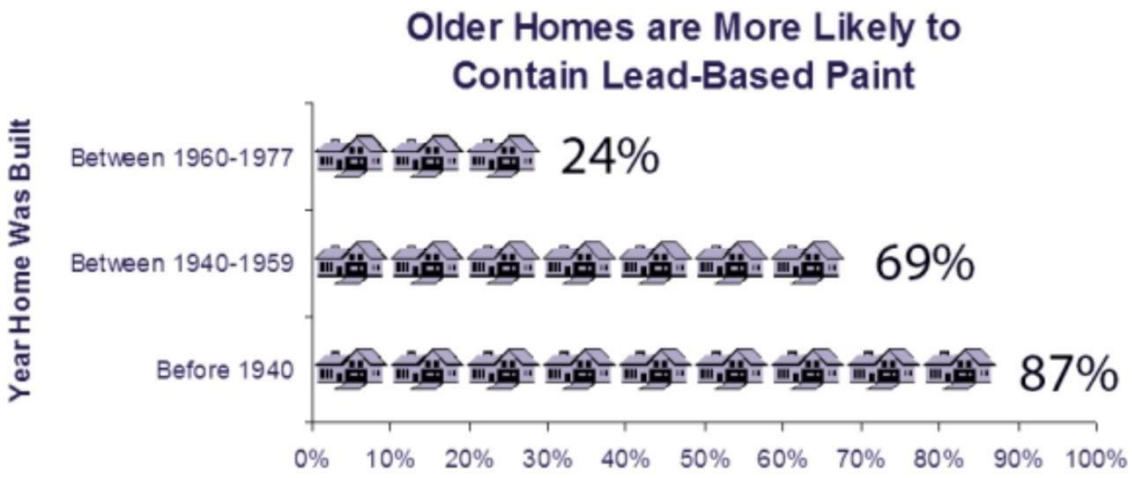
- What are the possible long term ramifications of living in a dwelling that contains lead-paint contamination?
- How long does it take to recognize potential symptoms?
- Are prospective homebuyers and renters made aware if the dwelling poses a hazard for LBP contamination before occupation/contract signing?

As subtopics, the incorporation of these inquiries tie into the overall treatment organically and not as independent problem statements, avoiding any disjointed veering from the main thesis. New homebuyers/renters are looking at potential new spaces enthusiastically (and innocently) picturing their belongings setup and their children playing, not if the original layers of substrate are contaminated with toxic substances. It's important to understand that even if a home's painted surface contains lead, it only becomes a hazard if it is disturbed—a similar trait of asbestos. Unfortunately, painted surfaces can become disturbed in multiple ways: high friction areas where painted surfaces get hit, touch or rub together; sun/heat and moisture damage; water damage; chalking; making cuts or holes in the substrate; and even spackling/sanding can potentially bring older layers of lead paint to the surface and create a dust. It's not the aim of this paper to scare readers into never buying or renting space that was constructed before 1978; conversely, it's simply to enlighten those that do into taking precautions and being alert.

3. Goals and Objectives

The goal of this research was to collect enough data for purposeful examination and to discuss if a correlation exists, or not, between lead-based paint detection in older homes and adult peoples' well-being. This paper uses the term "older homes" here in lieu of the pre-1978 for how seldom it was used in paint coatings in the late 1960's and 70's. Generally, dwellings that test positive for lead-based paint were constructed in the 50's or earlier. Nonetheless, assuming a home built (or more precisely, painted) on December 31, 1977 doesn't have LBP on initial substrates and skipping precaution would be reckless. See the line graph below (Figure 3.1) from EPA's website that illustrates how percentages significantly reduce as year-built parameters become more recent.

Figure 3.1—*Line graph depicting likelihood of LBP based off age of home.*



With that goal established, the objectives are as follows:

- Interview Town of Brookhaven (TOB) occupants in pre-1978 dwellings with a series of questions pertaining to their well-being since occupation.
- Research case studies where lead-based paint or dust consumption were attributed to physical, mental, and emotional disorders in adulthood to provide the thesis backbone.
- Evaluate results and correlate whether the occupation of hazardous LBP contaminated dwellings had a negative impact on the well-being of adults.

4. Scope

Data collection in the form of interviews was limited to Town of Brookhaven residents and restricted to pre-1978 dwellings where visual assessments and subsequent risk assessments failed during rental arrears or residential rehabilitation program requirements. Both of these programs are federally funded allotments given to townships to assist residents and therefore require professional lead evaluation. [Note: in the rental arrears program, applicants meeting certain criteria must be approved through Long Island Housing Partnership (LIHP), which relies

on local jurisdictions for code enforcement and various inspections.] Conversely, all data samples were retained to correlate answers from occupants in both lead contaminated and non-lead contaminated dwellings as an ersatz double blind study. Neither the researcher nor the participant knew if the dwelling contained hazardous levels of lead-based paint when the interview took place, which is why collection was optimal (but not mandatory) before the visual assessment commenced. During visual assessments, if HUD-established deteriorated paint thresholds are exceeded, a risk assessment must be performed by a certified contractor (see Appendix C for examples of memos sent from the TOB Housing Department to LIHP indicating passing or failing visual assessments). As a reminder, if HUD-established lead paint thresholds are exceeded, by default, EPA-established thresholds are also as the prior is the more stringent of the two agencies (exemplified by Table 1.1).

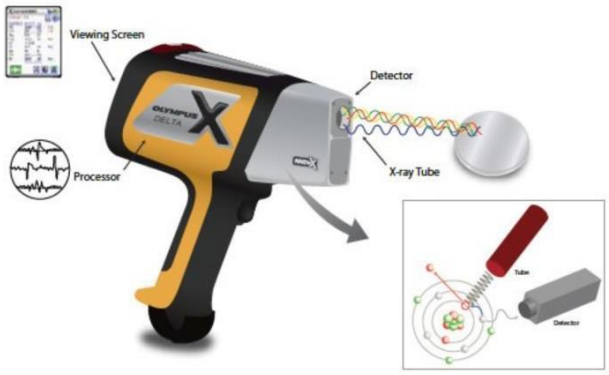
Visual assessments typically fail in one or more of three areas. One, deteriorated painted surfaces exceed 2 square feet for any one interior room. Two, deteriorated paint exceeds 10 percent of the surface area for small component types (door/window components, moldings, trim, heating covers, etc.). Three, paint deterioration exceeds 20 square feet on all exterior surfaces (collectively). This includes decks, sheds, and outdoor structures if erected before 1978. It's the homeowners' or landlords' obligation to prove construction timelines or the structures are assumed to be pre-1978 (at building inspector's discretion). These HUD established thresholds are referred to as *de minimis* levels. One can either assume the painted surface contains LBP and use safe work abatement practices (see the EPA guides listed in Appendix B) or have a certified risk assessor perform a LBP test to ensure all layers of paint are lead-free. In the case of rental arrears, the Housing Department contacts a certified risk assessor for the appropriate testing. The risk assessor will characteristically walk the entire premises and test all painted surfaces, not only the deteriorated areas called out on the visual assessment memo (see Appendix C)—this is a great double check as inspectors are not infallible. Figure 4.1 provided below courtesy of the HUD visual assessment training website shows a common example of an exceeded de minimis threshold due to paint deterioration on a small component type.

Visual assessors typically prefer risk assessments be performed using a portable X-Ray Fluorescence (XRF) instrument for speed, accuracy, and the tool's ability to not mark or damage

walls but HUD permits other testing techniques as well, including paint-chip analysis and chemical testing (XRF tool illustrated in Figure 4.2 provided below by www.olympus-ims.com). However, the agency strongly recommends the XRF test in Chapter 7 of their "Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing" for aforementioned reasons. If the risk assessment returned positive for LBP, the data collected (interviews posed at the initial visual inspection) were included in the essential analysis. All sample data collected on negative risks assessments (those that come back clearing painted surfaces for lead) are invalid as we know the ailments weren't LBP related—at least not from the current domicile. Therefore, including sample data from all interviews would skew stats. As briefly mentioned, most of the actual interviews were done prior to risk assessments to prevent dubious answers (as interviewees *may* potentially get a case of hypochondria or paranoia once results confirm lead).

Figure 4.1—*HUD threshold exceeded at window.*

Figure 4.2—*XRF analyzer diagram.*



The total number of interviews were catalogued for record-keeping and cross examining but as stated, only interviews of those inhabiting LBP contaminated dwellings were included to support the hypothesis of this research. Nonetheless, this study does not overlook the invalid samples and made notes of "outliers," or data that contradicted the hypothesis by offering symptoms affecting adult well-being without the presence of the catalyst. Relegating this data to a separate minefield was crucial in avoiding non-sampling errors especially within a small sample size. It's not the purpose of this research to angle for a particular narrative; rather the goal is merely an objective analysis of data to provide a better understanding of LBP ramifications.

The memos mentioned earlier in this section articulate exactly that witnessed in the field, documented by pictures at the time of inspection (see Figures 4.3 and 4.4 below). This is important so building owners and/or management aren't tempted to enter units after receiving the memo request for risk assessments and simply repair or cover up the area(s) without certified testing first. One landlord hired a certified mold expert (not a certified risk assessor) to do the LBP test, which returned negative via a chemical test one can purchase at almost any hardware store. The findings were not accepted, not because an XRF test wasn't performed but because the expert had no credentials as a certified risk assessor (registered in EPA's website).

Figures 4.3 and 4.4 (left to right)—*Pictures of hazardous levels of paint damage on a wall and heating cover.*

Note: Both the pictures above were called out in the memo displayed in Appendix C.

The preceding figures were included within this section to show elements of inspection field work in an effort to give readers a cogent visual. The following two paragraphs are not related to the scope of research work intrinsically but are noteworthy here as contextual aspects of the data collection process. Many additional samples were required for collection beyond those incorporated for data analysis; hence the ensuing information is not superfluous but rather one can argue it's essential to the topic.

Data collection didn't always produce viable samples as many visual assessments clear; meaning, there wasn't enough disturbed paint at any location observed to warrant calling for a risk assessment *at the time of the visual assessment*. This could change over time as painted surfaces can deteriorate in inhospitable conditions. High moisture areas within improperly vented

bathrooms are often a culprit or a wall could be purposely (or inadvertently) damaged after the inspector leaves, which would have unceremoniously changed the outcome of the assessment had those conditions pre-existed at the inspection time and date. The word "purposely" isn't used with malicious intent as someone may simply be aiming to mount a television or do minor repair work; however, the damage to enough painted surface would establish the dwelling as a contender for a risk assessment. Collectively, over 2 square feet in any one interior room qualifies a risk assessment requirement as per HUD standards. If the existing room already contained, for instance, 1.75 square feet of surface damage and the television installation caused a mere .25-sf of additional damage, the outcome of the visual assessment segues into a risk assessment, which could potentially return positive for lead-based paint and necessitate proper abatement.

Poignantly, seemingly innocuous sequences could dictate totally different outcomes. The abetment process itself would bestow the contractor and/or landlord with the unwelcome job of kicking the tenants out until remediation was complete and a clearance test passed. Not to mention the possibility of additional damage or issues discovered once building components are removed and wall cavities exposed such as mold, rot, bugs, etc. Things can spiral down quickly, which is why some erudite owners and landlords attempt to circumnavigate issues by repainting or covering damage. This usually won't prevent the disturbed paint (and latent lead dust) from resurfacing as adherence will only last so long, but it can conceal problems long enough to sidestep a failed visual assessment. It's a sinister practice that revolves around time and money more than people and health concerns. Residents have the right to know if their well-being has been unfavorably affected by lead dust, allowing each the decision to have a doctor test and treat conceivable causes if need be.

The research within this paper had additional limitations, not only from a dwindling number of qualifying applicants LIHP submitted to the town (as the world gets further away from the stark fallout of the pandemic) but from remaining funds supplied by the federal government to assist those who have claimed hardship causal of COVID-19. Furthermore, there was a sequence of processes that curtailed qualifying sample collection thereafter: visual inspection and risk assessment must *both* fail. The target goal was 30 samples, which was

obtained; however, usable samples are those collected from dwellings that exposed occupants to hazardous levels of lead dust. That is what this paper refers to as "valid" samples. It's another reason rental arrears applicants were preferred over residential rehabilitation applicants as renters are often in large complexes owned by companies such as Fairfeld, Heatherwood, and Main Street Properties. This circumstance advocates the unlikelihood of past unpermitted level two alterations as legitimate management companies *usually* apply for the proper permits/certificates. If such unpermitted construction happened in private homes (which it often does), inspectors hypothetically wouldn't know and/or couldn't test the areas as walls and surfaces may have been removed or altered before the inspections took place. The result would be a passed visual assessment where lead-dust had ominously affected inhabitants over time unbeknownst to all.

5. State of the Art Review

Preliminary examinations of peer reviewed journals and scholarly articles facilitated a credible foundation in several aspects relating to underlying risks of lead-based paint contamination in housing. A multitude of scholarly articles were mined in conjunction with data sampling so that technical research had a reliable "jumping off" point. Thus far, information noted in preceding sections was predominately based on the researcher's field and professional experience with the subject matter. This study strategically centers on the impact of lead-based paint on the well-being of adults but does not refute that children are the most susceptible to lead poisoning through various ingestion methods. The Centers for Disease Control and Prevention (CDC) states roughly 4.4% of children between the ages of one to five have high levels of lead in their bodies as a direct result of LBP in their homes (Leaders in Lead, 1999). A major concern is children may often go undiagnosed for lead poisoning then become adults and exhibit behavior incorrectly assigned to other ailments (which may actually derive from elevated blood lead levels). Lead poisoning doesn't crave attention like Lyme disease and draw bulls-eye patterns on skin after bacterially infected tick bites. Lead infection is a coward that hides in the human composition in duplicitous forms accusing other ailments for its malice. It never tells on itself and thus its menacing presence continues to wreak havoc within the body, mind, and soul until someone calls it out.

This article was referenced because it confirms testing to check for elevated lead levels in blood exists. Whether such testing can pinpoint direct origins of certain conditions or not is a question

for a medical doctor, but the presence of both the high blood lead levels and one or more symptoms lead is known to cause may not be a coincidence.

The American Family Physician published an article imploring those at an increased risk get screened and tested for elevated blood lead levels. The journal describes people of an increased risk as pregnant women and children living in homes built prior to 1960 with deteriorated paint or living with an adult exposed to lead though work or hobbies. The hope was the proactive approach may prevent future lead exposure from environmental sources. The study analyzed potential benefits of early detection and intervention or treatment within the context of understanding the detrimental neurological effects related to behavioral and learning issues associated with lead exposure to children, as well as impaired organs and nervous systems and risk of adverse perinatal outcomes with lead exposure to pregnant women. Conclusively, current evidence was insufficient to assess the balance of benefits and harms of screening for elevated blood lead levels in asymptomatic children and pregnant women (2019). However, for the sake of this research, the notion of taking a tactical approach only has favorable outcomes as comprehending lead effects on people of any age can only arm prevention.

One would assume licensed field professionals understand the perils of lead ingestion and would take all precautions required to safeguard against ingesting the toxic metal. The previous article mentioned people of an elevated risk to LBP, noting those exposed to lead through work in particular. Occupations such as general contractors, lead abatement contractors, and painters would qualify as specifically risky because laborers can inadvertently transport lead from the jobsite back to their homes, thus endangering themselves and their families. Researcher Carol Boraiko published an article in the *Journal of Environmental Health* and found that proper remediation practices and safety protocols are not always strictly followed, enabling lead dust to contaminate workers' personal vehicles. In one case, lab testing proved high levels of contamination in more than half of the vehicles dust wiped as part of the study. This work concluded households containing lead remediation workers are at greater risk for lead poisoning from household members not following required protective equipment use procedures. It was noted, the ultimate unfavorable outcome would be the transfer of lead particles to family members causing potential harmful results to both children and adults (2013). An aim of this research project was the hope homeowners stay vigilant against lead hazards; it is essential professionals don't contaminate additional homes by not following safety precautions on

jobsites.

Those reviewing this paper may adopt a false belief that a little lead ingestion probably means nothing; similar to if someone innocuously walked by a nearby smoker and inhaled a small plume of secondary cigarette smoke. A recent study links low-level lead exposure with increased risk of adult deaths from cardiovascular disease with additional findings suggesting as many as 400,000 deaths per year are attributed to lead exposure (Hegstad, 2018). Equally as startling, the same article noted a 2005 study that showed IQ losses in children exposed to lower levels than those thought to cause harm—which, coincidentally, assisted to drive an earlier EPA rule setting safety standards for LBP in residential homes. The National Institute of Environmental Health Sciences reported that there is no safe amount of lead in blood. They added lead exposure affects one out of every three children worldwide (NIEHS, n.d.).

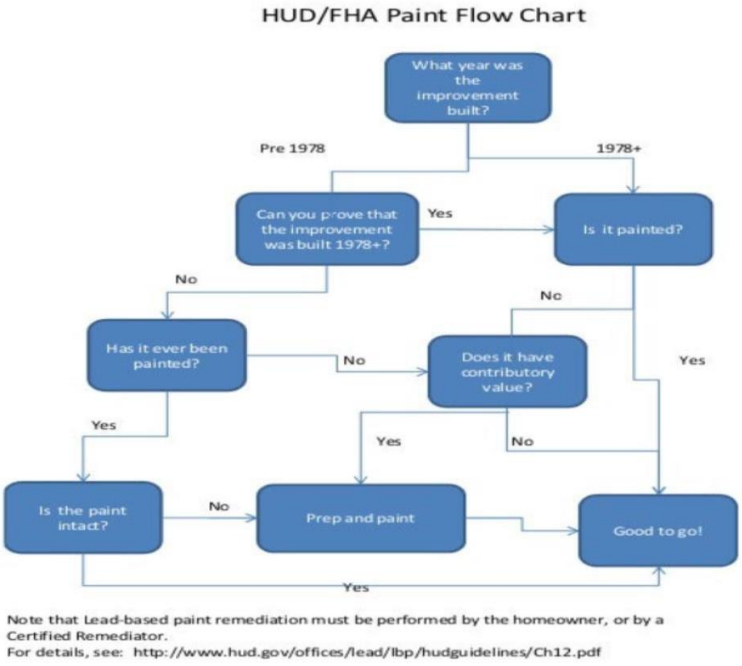
Exactly how many homes in the United States are at risk for containing lead-based paint hazards? A two-year survey was conducted which determined the outcome of a national random sample of housing units with varying levels of potential lead hazards was in line with nationwide figures. Those results yielded lead-based paint positive units in the U.S. had decreased significantly since 1990; however, an estimate of 24 million units still maintained substantial lead-based paint hazards (Jacobs, 2002). This article attempted to quantify (approximately) the number of lead-based paint contaminated units remaining in the United States. These facts are relevant to research within this write-up as inferential statistics were proposed. The aim was to project a wider view comparative to sampling within one township. Special attention was required as only the units that were tested and yielded results one way or the other were to be included; as stated, assessed units not exhibiting paint deterioration over HUD established de minimis levels do not require risk assessments. That doesn't mean the home or unit is not LBP positive.

The Department of Housing and Urban Development did a study from 1994-1999 on homes in 11 states where various types of abatement techniques took place in order of intensity—how aggressive the effort was to remedy, from spot painting to full lead-based paint abatements—with hopes to discover which methods were most effective in eradicating lead dust. The conclusion was window lead-hazard abatement was the most effective way to resolve lead

dust on windows (and window components) as long as other measures were taken in addition. Less intense treatments such as encapsulation have lower costs but may not eradicate lead dust from the environment. The study confirms that when proper precautions are used with work safe practices, there were significant reductions associated with declines in blood lead levels of resident children (Dixon, 2005). As the construction industry discovers contaminated units, rather than mask, the movement should be geared toward full abatement to protect homeowners, contractors, and people in general from ingesting lead dust. Remember, even if the painted surface is intact, construction to contaminated areas will release lead dust. It's best to eliminate the hazard once it's identified to prevent future homeowners or renters from inadvertently causing themselves harm.

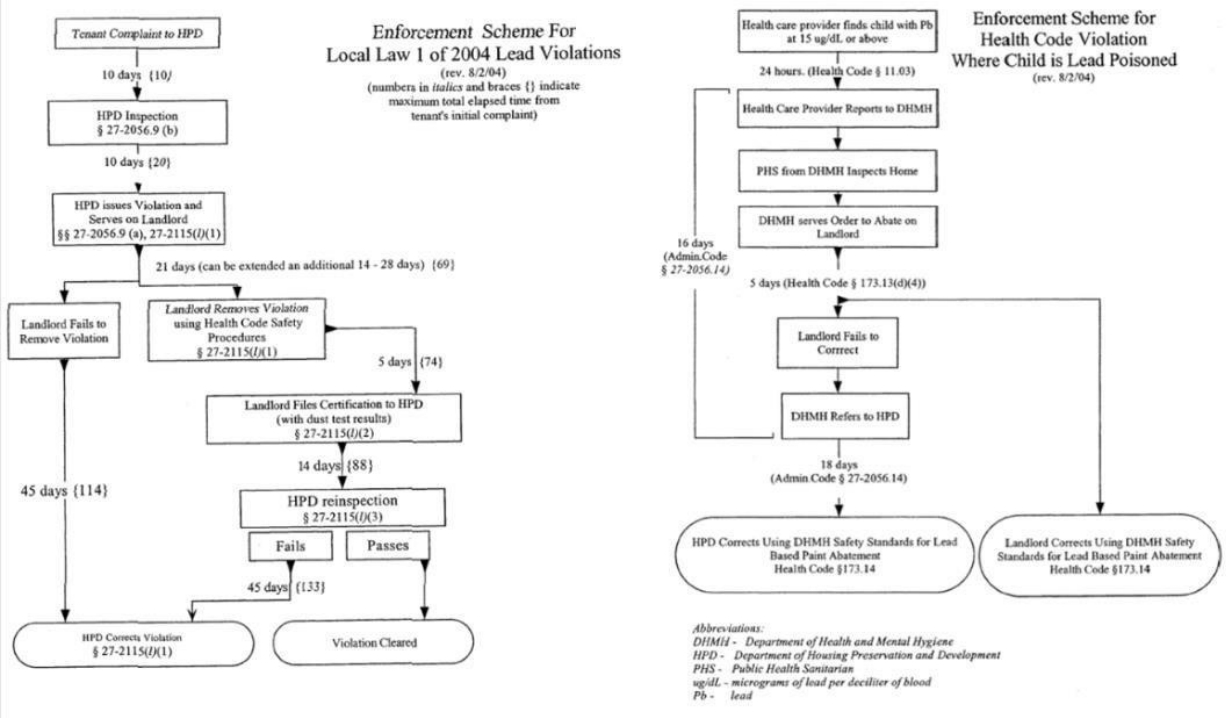
A series of questions should be considered before just assuming a surface is contaminated and requires abatement. Some information found online may be confusing or even misleading. Figure 5.1 below is a flow chart illustrating the typical Housing Department preamble courtesy of the Federal Housing Administration (FHA). This was relevant as a comparable process is deliberated during work write-ups for the residential rehabilitation projects; however, it is missing one crucial action. After confirming the paint is not intact, do not simply prep and paint! Either have the deteriorated paint tested by a professional or assume it's lead and call a qualified contractor to abate it properly. Homeowners can do the work at their own risk and they can also remove asbestos-laden tiles or cement shingles as well, but should they? No, unless they are okay with endangering household members' health (or anyone that comes to visit afterward).

Figure 5.1—*LBP flowchart.*



According to *Environmental Science and Technology*, house lead dust and soil contamination are major sources of lead exposure and adverse health conditions for children in the United States. Advanced technology was incorporated to measure lead contaminate in these sources, both of which were contributed to paint. The American Healthy Homes Survey, HUD, and the EPA teamed up to provide representative data by collecting samples from 1146 homes in the U.S. between 2005-06 where children most likely lived (Sowers, 2021). This study was done to improve the understanding of the relationship between the lead species found in household dust and the human health risk assessments used to evaluate lead exposure with children. The notion is continual refinement of such studies will improve the bioavailability analysis of dust and soil samples from other investigations so to increase the understanding of how indoor sources and surrounding soils may impact lead contamination in the home. Again, the article revolves around exposure to children because of the sensitivity to their development process; however, the baseline theme, for the intention of this study, is based purely on the route of ingestion. It's easy to transport lead dust into a home, whether adults and/or children live in the home is secondary to the purpose of this research. Nonetheless, to show the concern the federal government has regarding LBP and child exposure, see the enforcement scheme for lead violators in juxtaposed scenarios below (Figure 5.2 courtesy of Microsoft images).

Figure 5.2—*Enforcement scheme for lead violations (2004).*



6. Methodology

The research method used for data collection was of the primary quantitative type as numbers were assigned to symptom levels; however the interview process was technically mixed between quantitative and qualitative methods. The samples were collected directly from the main source, the occupants, through original one-on-one semi-structured interviews; mainly in person but some through the telephone using closed-ended questions (with a small caveat). The questions were designed as "yes" and "no" but left room for interpretation. The severity level of all conditions noted was scaled from one to five. Originally, research gathering proposals toyed with the idea of providing surveys or possibly using both surveys and interviews for data collection depending on the occupant's preference. Ultimately, the decision to use only interviews was made as they felt more personal and like a natural precursor to the inspection. Filling out a survey may feel like homework to some and leeway the spoken word enables for further explanation and clarity was invaluable. This would also support maximum reliability and accuracy within answers. Hence the reason this paper is labeling the interviews "semi-structured," as there was a pre-determined format for each question yet the ability for expansion (for any and all to explain further) existed naturally within the process. The hardest part was attempting to write everything down and organize it all after data collection concluded—eventually, with permission, a cell phone was used to record interviews, which were promptly erased after being transcribed.

The first step was gathering data via the interview process. It should be noted that the approval to interview occupants for this project was granted by the Commissioner of Housing and Community Development before data gathering commenced. Additionally, subjects were informed interviews were not part of the visual assessment but instead part of graduate research that could potentially assist with a better understanding on how lead dust can negatively affect people of any age. Each interviewee was promised anonymity and all interviews were conducted with whoever was present at the time of inspection—in almost every case it was the applicant; conditionally, the subject had to live in the unit. With that formality stated, procedural elements are listed in the subsequent paragraphs.

Whenever federal money is used, visual assessments are protocol as a way to seek out and identify remaining LBP contaminated dwellings. The interview target number was relegated to as many LBP visual assessments as LIHP provided during the research period (May – November 2023). So there was not a hard number on interviews; however, there was a target goal of 30 lead-based paint positive units for a data benchmark. This was a bit lofty as many units either passed visual inspection or the actual lead test itself. Fortunately, years of backup files guaranteed the assemblage of 30 lead-positive samples. The intention was to use the least amount of these backups as possible as telephone interviews would have to be done after-the-fact. The result was 10 backup files were procured and used as data within this research.

The interview was conducted using a five question survey pertaining to the occupants' physical, mental, and emotional status since occupying the dwelling. The interview did not count age, gender, race as questions. Nonetheless, it was important to collect this information as subsequent studies could examine demographics associated with lead poisoning. Piggybacking off data collected within this research would require such statistics.

The second step was to conduct the actual visual assessment. This is performed by walking the entire house, property, apartment, etc. and inspecting for deteriorated or damaged painted surfaces in any fashion (listed earlier). Documenting with pictures, inspectors are careful to observe high friction areas where paint is routinely disturbed. These areas include base moldings or low points on walls where people often kick into, walls behind doors, and window and door components. Other typical areas paint is often damaged include along windowsills as they get colder or hotter seasonally, in high humidity areas like bathrooms where ventilation may be lacking, in children/teenagers' bedrooms where damage painted surfaces occur more frequently, and at exteriors where paint is exposed to the elements.

This paper mentioned both the EPA and HUD set different de minimis threshold limits for this inspection; where each agency determines minimal damage (whether it's LBP positive or not) won't result in hazardous amounts of chips or dust—that tableau is offered below for comparison. See Table 6.1 from HUD's Lead Safe Housing Rule (LSHR) and the Renovation, Repair and Painting (RRP) Rule.

Table 6.1—*HUD and EPA de minimis comparisons.*

Threshold minimum amounts of interior paint disturbance which trigger lead activities.	HUD has a lower interior "de minimis" threshold (2 sq. ft. per room, or 10% of a small component type) than EPA for lead-safe work practices. HUD also uses this lower threshold for clearance and occupant notification.	EPA's interior threshold (6 sq. ft. per room) for minor repair and maintenance activities is higher than HUD's de minimis threshold.	None.

Next, in dwellings that exceed HUD limits (charted above in red), the risk assessment process commenced. The risk assessor or LIHP (in the case of rental arrears) forwarded the reports to the Housing Department. Lead results below 1.0 mg/cm² are acceptable; results equal to or above that figure are considered positive for LBP and must be abated by a certified RRP contractor using work safe practices according to the EPA. A third party contractor must then test the area(s) using dust wipes and lab analysis for clearance before sign off so the rental arrear process can continue. Examples of the preceding statements are showcased in Appendix D. The last step was to gather all samples and catalogue results in the form of charts and/or tables as required for proper analysis. This may allow extrapolation of a wider population (see the Data Analysis section for elaboration).

7. Data Collection

As stated in the section above, the goal was 30 valid interviews as collectable data using a five question format as a basis. The actual number of interviews conducted was more than double (67), as many passed either the visual or risk assessment tests. The question process was to interview the occupants(s) face-to-face or on the telephone using the five questions noted below. Data collection was assembled by asking the following questions. It is understood question number 5 is a three-part inquiry and could have been broken up but the relation of the questions established a common thread and therefore they were grouped as one. See appendix F for interview samples.

1. Since occupying this dwelling, have you noticed or been diagnosed with any changes to physical health including high blood pressure, brain, kidney, or fertility issues, headaches, digestive problems, nerve disorders, memory and concentration issues, stomach cramps, constipation, muscle and/or joint pain, trouble sleeping, fatigue, irritability, hearing loss, or decreased sex drive that hadn't ailed you prior? Other? If yes, please specify condition(s).

Of the conditions listed above, please rate the severity from 1-5, with 1 being the least and 5 being the most severe.

2. Since occupying this dwelling have you noticed or been diagnosed with depression, anxiety, obsessive-compulsive disorder, mania and or schizophrenia that hadn't ailed you prior? Other? If yes, please specify condition(s).

Of the conditions listed above, please rate the severity from 1-5, with 1 being the least and 5 being the most severe.

3. Since occupying this dwelling have you developed a drug, tobacco, and or alcohol addiction that you hadn't had prior?

Of the addictions listed above, please rate the severity from 1-5, with 1 being the least and 5 being the most severe.

4. Since occupying this dwelling have you noticed, been diagnosed with, or had others say you are suddenly less agreeable, less conscientious, and or more neurotic than you were prior? Other? If yes, please specify condition(s).

Of the conditions listed above, please rate the severity from 1-5, with 1 being the least and 5 being the most severe.

5. How long have you lived in this house/apartment unit? When did you first start to feel symptoms, if any? Where you ever made aware by anyone (agent, landlord, property manager, seller, etc.) in any form (verbal or written documents) that the construction date of the dwelling made it a candidate for LBP?

Twenty of the 30 data samples (~67%) came from the tenement in Patchogue noted in an earlier section, six (20%) from other rental buildings, and the final two (~7%) were samples stemming from the Residential Rehabilitation Program, where similar assessments are performed; however, as previously mentioned, the chance for potential misses increases within privately owned dwellings. Of the 26 rental arrear samples, 10 (33%) came from past archived files where risk assessments failed from 2020-2023 (nine of those 10 from the aforementioned complex in Patchogue). In this case, tenants were contacted over the phone to conduct the interview after-the-fact. In some cases, the tenants either moved or were unavailable for the phone interviews—meaning, more than 10 files were accessed and called. Nevertheless, this paper considers all of these samples valid for research purposes.

8. Data Presentation

Data collected from interviews was cataloged and set aside until risk assessments returned. Those that returned positive for lead-based paint were effectively charted. There were two charting methods applied. The first denotes a pie chart to illustrate percentages of those occupying LBP dwellings and which trauma category they belong to. The total breakdown for all interviews regarding collectable data is presented in the table on the next page; as mentioned, the units confirmed positive for LBP were then separated as used as “valid” data. This is not to suggest the other data is truly “invalid” as those results are still relevant and is shown accordingly in this section for comparison. The second illustration is a column chart showcasing the time of inhabitation and the average severity of each category. Axiomatically, the allotment of time it took to notice symptoms is a flawed premise as the occupant can only guess how long the painted area(s) in question had been deteriorated at the current hazardous levels—if the disturbed paint was even recognized to begin with—in relation their health decline. Instead, this paper uses inhabitation as the measure due to the fact the occupant would know (with fair accuracy) how long they’ve lived in the unit or house. Table 8.1 below shows the breakdown of all interviews with symptom categories included.

Table 8.1—*Table showing total data results.*

Results of Assessments	**Total No. of Interviews**	**Reported Physical Conditions Only**	**Reported Mental Conditions Only**	**Reported Emotional Conditions Only**	**Reported Multiple Conditions (at least two)**	**Percentage of Reported Conditions**
Passed Visual Assessment	20	3	1	0	1	25% (5/20)
Failed Visual Assessment (Passed Risk Assessment)	17	2	2	1	1	35% (6/17)
Failed Risk Assessment	30	12	5	3	5	83% (25/30)
Totals	67	17	8	4	7	54% (36/67)
Percentage of Valid Returns	44% (30/67)	70.5% (12/17)	62.5% (5/8)	75% (3/4)	71.4% (5/7)	X

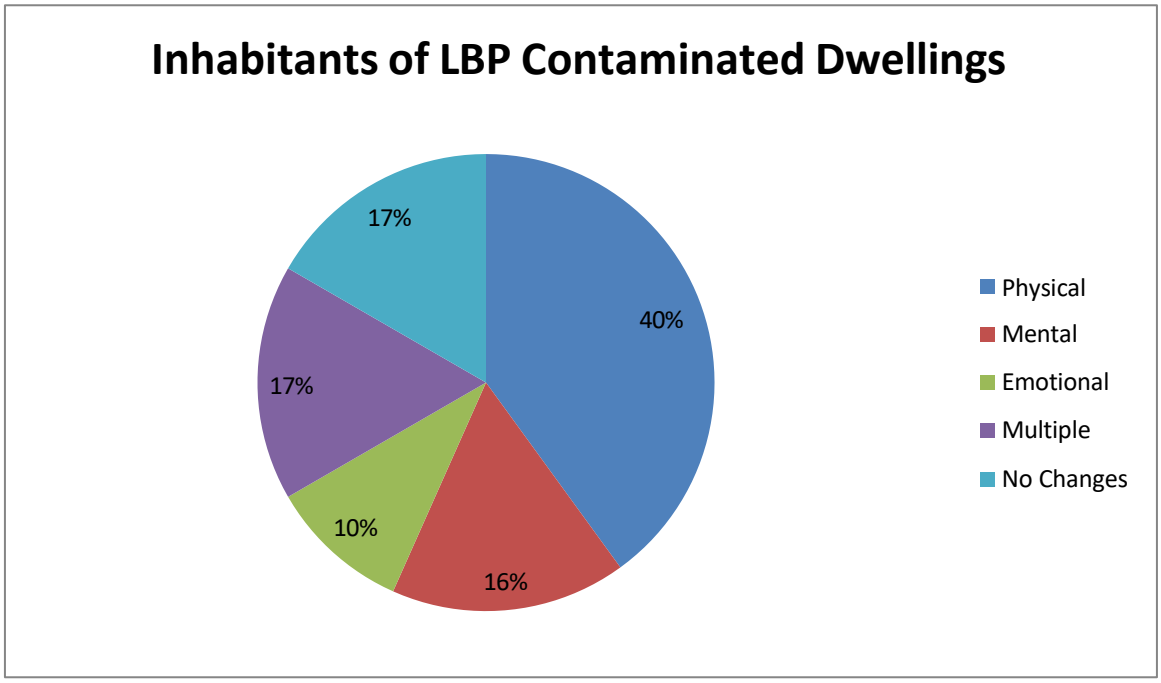
Note: Data accumulated from in-person and telephone interviews.

Data sampling shows that 44% of the results came from valid units—those where painted surfaces inside the dwelling exceeded HUD established thresholds *and* were confirmed positive for LBP. The results of those reporting conditions (a negative state of well-being) amongst the confirmed positive LBP dwellings were even higher than expected at 83%. The research will not call tallies from the top two rows "false positives" as the negative well-being may be from other reasons; however, they are labeled "invalid" only for the purpose of this research because one of

the two assessments passed. The rows are separated because those within the "Passed Visual Assessment" row may technically be living in a lead contaminated dwelling; however, not within a lead hazardous dwelling. It's important to understand the difference. The table also shows the drastic increase of reported negative well-being of those residing in LBP positive dwellings. Five subjects living in lead hazardous dwellings registered no side effects—one of those five had over five years occupation. The group "No Side Effects" did not dictate a column because, by default, this group can't register severity levels.

Figure 8.1 below displays the total of all LBP positive interviews and reciprocating percentages categorizing which state of well-being was altered: physical, mental, emotional, multiple (more than one), or none.

Figure 8.1—*Pie chart of percentage breakdown of conditions.*



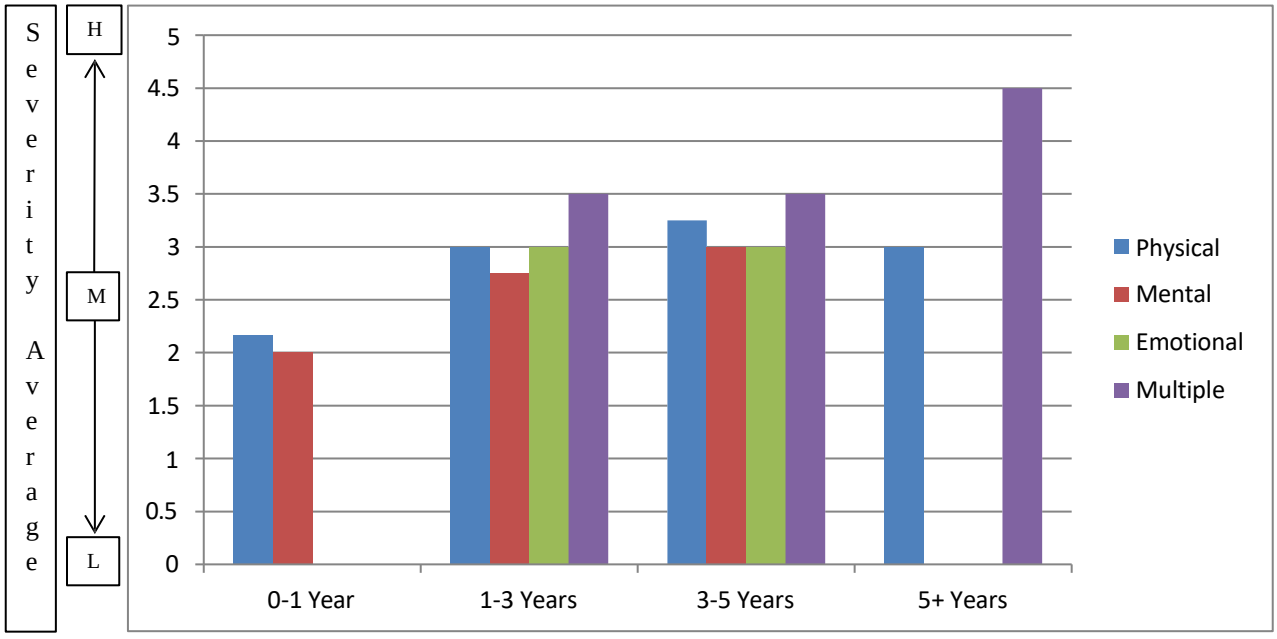
Note: Mental, multiple, and no changes each registered 5/30 (16.67%).

Forty percent of people complained of physical side-effects—by far the most common complaint. However, within the "Multiple" category, additional physical complaint tallies were collected. Concerningly, the *zeitgeist* of this country and the negative stigma associated with mental health could dissuade people from claiming a mental disorder out of embarrassment;

hence, numbers would potentially increase had interviews been conducted in an environment (i.e., the office of a medical professional) more conducive of forthrightness.

Figure 8.2 displays the inhabitation time in the confirmed LBP hazardous dwelling and the average severity levels of symptoms, utilizing a column chart. The year range posted at the bottom of the chart should be recognized as "up to that year." For example, if an occupant said he/she lived in a unit for three years, it would go in the "1-3 years" range; however if the answer was three years and one day, that occupant would be designated to the "3-5 years" range. Creating a "+" in front of the dash looked confusing and therefore a brief clarification was offered here. Additionally, it would be cumbersome to detail people in the multiple symptom category with separate severity numbers; for the sake of conciseness, if subjects claimed multiple ailments, the average was taken for each individual and catalogued in the "Multiple" (purple) column. If only two of the three well-being categories were affected in a single person, the third (unaffected) category was dismissed and not counted as a zero (0), which would devalue the other well-being states and lower averages. This is not perfect science but the research is attempting to quantify affected well-being in some capacity. A longer, more extensive work would produce less variance; however, although flawed, the numbers give substance to the hypothesis.

Figure 8.2—*Column chart denoting duration of occupation and severity levels if reported.*



Results here indicate the longer the occupants live in the lead hazardous dwellings, the higher the chance a combination of ailments affected them and at a moderate (M) to high (H) severity level. Interestingly, the multiple column is absent from interviewees that had only been in the lead hazardous dwellings for up-to-or-under one year and both "Mental Only" and "Emotional Only" are absent from those that had been in the lead hazardous dwellings for over five years. "Emotional Only" and "Mental Only" conditions were recorded in data ranging between 1-5 years. Although absent from the "Only" columns, the mental and emotional ailments are still present within the "Multiple" designation for those spending more than 5 years in a lead hazardous dwelling.

Overall, physical issues (in one form or another) was the most popular "yes" answer throughout—perhaps because physical conditions are easier to detect for people in general. Another observation was of the "Multiple" category subjects, most had the combination of physical and mental conditions as answers, which begs the question, do these two human strata tie into one another when blood lead levels are elevated? To clarify, this research was limited to subjects' well-being *potentially* being affected as the cross reference between positive LBP test results and answers have linkage. Commanding subjects go to physicians for blood tests then waiting for results as confirmation is impractical in this application. Table 8.1 recorded the tallies from all interviews. Table 8.2 below shows the breakdowns within the "Failed Risk Assessment" or valid row. The numbers within this table do not represent severity levels; they are only a total of "yes" answers or "hits" inside each category. It's this researcher's assumption that larger numbers would populate the "Multiple" category row more frequently as both years (living within the LBP hazardous dwelling) and the sample size increase. If given, for instance, 200 LBP positive units (with additional time and resources), one may witness a greater consistency within the hits proportional to years occupied. More applicable charts such as the Pareto Diagram could be useful in displaying the significance of this relationship if the data pool was large enough.

Table 8.2—*Table showing breakdowns within categories.*

Well-Being Category	0-1 year	1-3 years	3-5 years	5+ years
Physical Only (12)	3	2	2	5
Mental Only (5)	2	2	1	0
Emotional Only (3)	0	2	1	0
Multiple (5)	0	1	2	2
No Side Effects (5)	3	1	0	1

As indicated earlier, this paper will not discount the 37 interviews labeled dubiously as "invalid." They are, for this study, peripheral stats for comparison as no proof of lead hazardous can be connected to "yes" answers. Eleven of the 37 (~30%) complained of some type of noticeable condition since occupation; nonetheless, it's a glaring difference from numbers in the valid row (83%) shown in Table 8.1. The mean severity level amongst this group was just under 2 (slightly lower than moderate). Years occupied will not be noted for this assemblage as this research will assume LBP was not a factor.

9. Data Analysis

After all data was collected and presented, a formal analysis commenced. The initial proposal was to use inferential statistics and analytical tools to estimate the potential number of LBP hazardous dwellings within the Town of Brookhaven then extrapolate on a larger scale—Suffolk County, Long Island, New York, etc. As mentioned previously, time limitations on research coerced the expediting of interviews in one particular complex to fulfill the target goal of 30 valid samples. This process superseded any generalizations the study desired for secondary goals as the essential objective was a direct comparison of those living within hazardous lead conditions and its impact on their well-being. Therefore, the data would not properly lend itself to a fair deduction using this analysis.

The focus shifted to applying multiple regression analysis (Figure 9.1) to predict if a relationship existed between the number of years occupants lived inside confirmed LBP

hazardous dwellings and severity levels of symptoms. The analysis broke down as follows: data collected (samples) represented the years (y) occupants were living in hazardous LBP contaminated dwellings; the severity level of physical (x_1); the severity level of mental (x_2); the severity level of emotional (x_3); and the severity level of those with multiple symptoms (x_4). Data was keyed into an excel program to process an equation. A null and alternate hypothesis was set up to establish if a consequential relationship existed between the phenomena or not. The plan was to use this method to support the findings discussed previously in the summary of data analysis. Results expected were the rejection of the null hypothesis for *all* categories, establishing the relationship lead and its impact on adults are present or heightened the longer occupants were exposed to lead dust. However, after the summary output was produced, a miscalculation was realized. In an attempt to not misrepresent those suffering with compound symptoms (i.e. physical and mental) in the column chart (Figure 8.2), a "Multiple" symptom category was created. Subjects were not counted in the "Physical Only" or "Mental Only" or "Emotional Only" columns if they had more than one of these ailments. This strategy appeared to work for the column chart but the multiple regression tool exposed this methodology as unreliable (as results only accounted for a partial truth as stated below).

After inputting data for all categories, the P-values for the three individual symptoms (physical, mental, and emotional only) produced values that fell outside the rejection region; failing to reject the null hypothesis (H_0) in these areas. However, this analysis correctly determined the longer occupants live in such conditions, the higher the chance for multiple ailments at higher severity levels; albeit there's still opposition to what data determined for "Physical Only" conditions (which existed in the five-year plus category as shown in Figure 8.2). This evaluation also indicates (at a surface level) that those in the three-to-five-year category are no worse off than those in the zero-to-one-year category. Figure 8.2 disproves this assumption. Where did this analysis go astray?

A logistical error besmirched the multiple regression analysis as the rationality approaching data input was imprecise. The "Multiple" symptom value did fall within the rejection region (as predicted), denoting there is a relationship between years occupying a LBP hazardous dwelling and the association of multiple symptoms at higher severity levels (most

typically physical and mental). It is assumed the inclusion of the "Multiple" symptom independent variable caused a disruption in regression formula by "stealing" data from the other categories. Although there are inconsistencies in this analysis, this research is not failed. A strategic reconfiguring of data would likely produce a truer correlation with the descriptive summary illustrated by the charts and tables in the data presentation section.

Figure 9.1—*Multiple Regression Analysis.*

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.903964
R Square	0.817151
Adjusted R Square	0.787895
Standard Error	0.6891
Observations	30

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	4	53.05352	13.26338	27.93119	6.7E-09
Residual	25	11.87148	0.474859		
Total	29	64.925			

	Coefficients	*tandard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	1.633977	0.599168	2.727075	0.011512	0.399967	2.867988	0.399967	2.867988
Severity of Physical	0.078625	0.11911	0.660104	0.515223	-0.16669	0.323936	-0.16669	0.323936
Severity of Mental	-0.34595	0.226436	-1.52781	0.139115	-0.81231	0.120403	-0.81231	0.120403
Severity of Emotional	0.014697	0.180182	0.08157	0.935638	-0.35639	0.385789	-0.35639	0.385789
Severity of Multiple	0.682886	0.115386	5.918291	3.55E-06	0.445244	0.920527	0.445244	0.920527

The wildcard was the occupants' ages and whether "older" people were more prone to displaying symptoms. The problem with this theory (in this study) was a majority of the interviews were with "younger" people (approximately 75% were aged 20-39 years)—hence the nature of the rental arrears program. Therefore, this research will withhold the possibility of producing a model with misleading statistics as there simply wasn't enough data to defend age is or isn't a factor regarding symptoms.

10. Conclusion

This paper's inference based on reasoning and data examined, assists the presumption that adults living in lead-based paint contaminated dwellings are adversely affected in any or all of three categories: physical, mental, and emotional well-being. Based on this research, one could safety conclude people living in lead hazardous dwellings for more than one year are more prone to experiencing (at the very least) a diminished well-being at a moderate to above moderate level in one or more area. Both physical and multiple symptoms tallied the most claims; more often than not, physical and mental symptoms were tied together.

Consequently, the only way to know if there's a direct connection between ailments would be for the participants to get tested by a physician for elevated blood lead levels. For the purpose of this research, using the confirmed hazardous deteriorated paint levels in conjunction with the positive lead-based paint test and interview data, it can be objectively assumed the symptoms are prospectively related. It should be understood, lead can also be ingested through water from lead pipes; therefore, the drinking water should be subsequently tested if blood lead levels come back high.

The attempt to uncover how long lead poisoning symptoms take to reveal themselves was not as clear. As data sampling progressed, surmising this objective proved more equivocal due to various factors—the key dynamic is veracity. Of course, a deeper study revolving around this particular aspect may be helpful but for the basis of this study, it was a secondary objective. The underlying issue with revealing accurate answers may be artificially soiled in the inability for tenants to realistically know when the painted surfaces were disturbed (specifically enough to be declared a hazard) in relation to underlying health issues arising. Symptoms can also be latent and intangible. For example, one may not feel high blood pressure or a reduced sperm count. According to various medical journals, lead poisoning could build over months or years. Instead, this study used occupation time as the scale to give some semblance of determination with the caveat there's a margin of error within this inquiry.

It was also proven that prospective renters (and in a smaller sample size within this research, homebuyers) are not consistently being made aware that the pre-1978 dwellings are potential hazards for LBP contamination at any point, before or after contract signing or occupation. Research concluded only five of the 67 interviews recalled any type of word regarding the unit as a LBP contender. The HUD disclosure rule applies to almost all housing. The fact prospective tenants are not given critical lead information is an ethics abomination. The landlords are required to provide the EPA informational pamphlet (cover shown in the Appendix B) or a clearance report (negative test or proper abatement documentation—shown in Appendix D) that the dwelling is safe from lead paint contamination. It's possible the literature is being buried within paperwork during contract signing and renters are leafing and signing without acknowledging the contents of the document. Although responsibility ultimately falls on the tenants to understand the documents, it may be wise to consult a lawyer before blindly signing any contracts; especially when the occupation of older homes is related. Those interested can Visit the Office of Lead Hazard Control and Healthy Homes (OLHCHH) at www.HUD.gov/lead for more information.

11. Next Step

What's the next step? The hope is there would be multiple. First, there's not enough emphasis on educating people on the latent irreversible effects LBP can have on adult well-being. According to a referenced peer review journal, HUD had set forth an initiative that estimated millions of these units still exist in the country. The older the home, the greater the chance the paint deteriorates—even lead coated paints have a shelf life and if the interior surface starts to break up, the outer layer can also.

With mental and emotional health awareness prevalent, new homeowners and renters should be aware if they are potentially endangering their families by moving into older dwellings. This research encourages laws passed so that *every* pre-1978 home and apartment is mandatorily tested by a certified third party contractor and the results given to the buyers/renters

prior to contract signing. That way the potential occupants can make the decision if they're willing to risk living in the home or apartment unit.

This research supports the theory lead-based paint can have a negative effect on adult well-being to any severity level. Another expectation is that self-awareness inspires readers to recognize diminished well-being may not simply be conditional. If this research doesn't enlighten readers on potential LBP ramifications, it optimistically anticipates people simply become more conscientious of the latent dangers lead and its particle dust can have on adults. This study implores those living in confirmed lead positive dwellings to get a blood test if they feel something is "off." Doctors can check for elevated blood lead levels and prescribe medications to help whichever symptoms and conditions people are suffering with.

Successive research could theoretically consider if certain gender, races, ethnicities, or age groups are more susceptible to lead hazards as each category was catalogued as part of the interview process but not factored into whether they are catalysts for adverse well-being. One could conceivably delve deeper by evaluating results on a larger scale to compare patterns of violent behavior, arrest records, graduation rates, social anxiety disorders, learning disorders, etc. with the occupation status of lead-based paint contaminated dwellings.

The discovery of detrimental lead effects on people of any age is still a somewhat esoteric topic as many know the metal is "bad" but don't realize it could be unscrupulous on the human body and psyche. This study is imperfect and only made educated determinations of what lead is capable of based on limited research, but there is much more science and advanced technology may be able to explain with regard to lead exposure and people. What is the true impact lead-based paint has on the well-being of adults? Perhaps quantum computers can answer that in time. For now, research and education are keys for unmasking the irrevocable damage this natural metal can bestow upon human functionality—in children *and* adults.

References

Boraiko, Carol, et al. “Lead Contamination of Paint Remediation Workers’ Vehicles.” Journal of Environmental Health, vol. 75, no. 7, 2013, pp. 22–27.

Dixon, Sherry L., et al. “Effectiveness of Lead-Hazard Control Interventions on Dust Lead Loadings: Findings from the Evaluation of the HUD Lead-Based Paint Hazard Control Grant Program.” Environmental Research, vol. 98, no. 3, 2005, pp. 303– 14, https://doi.org/10.1016/j.envres.2005.02.002.

Enforcement - HUD. HUD.gov / U.S. Department of Housing and Urban Development (HUD). (n.d.). https://www.hud.gov/program_offices/healthy_homes/enforcement

FHA paint lead-based Paint Flow Chart developed by Bill Streep. PDF. (n.d.). https://www.slideshare.net/BatonRougeHousingReports/fha-paint-flow-chart-developed-by-bill-streep (Flow chart for LBP)

Hegstad, Maria. “Bolstering EPA Rules, New Study Details Risks Of Lead Exposure In Adults.” *Inside EPA’s Risk Policy Report* 25, no. 12 (2018): 1–7.

Jacobs, David E., et al. “The Prevalence of Lead-Based Paint Hazards in U.S. Housing.” Environmental Health Perspectives, vol. 110, no. 10, 2002, pp. A599–A606, https://doi.org/10.1289/ehp.021100599.

Lead | US EPA - U.S. Environmental Protection Agency. (n.d.-a). https://www.epa.gov/lead

Lead and your health - National Institute of Environmental Health ... (n.d.). https://www.niehs.nih.gov/health/materials/lead_and_your_health_508.pdf

"Leaders in Lead." *Environmental health perspectives* 107, no. 6 (1999): A297-.

Scientific solutions test. measure. image. analyze. Olympus Inspection Solutions-NDT, Microscopes, XRF, RVI. (n.d.). https://www.olympus-ims.com/

"Screening for Elevated Blood Lead Levels in Children and Pregnant Women: Recommendation Statement." American Family Physician, vol. 100, no. 8, 2019, p. Online–online.

Sowers, Tyler D., et al. "High Lead Bioavailability of Indoor Dust Contaminated with Paint Lead Species." Environmental Science & Technology, vol. 55, no. 1, 2021, pp. 402–11, https://doi.org/10.1021/acs.est.0c06908.

Visual assessment training. HUD. (n.d.). https://apps.hud.gov/offices/lead/training/visualassessment/h00100.cfm

Bibliography

Articles. Cedars. (n.d.). https://www.cedars-sinai.org/health-library/diseases-and-conditions/l/lead-poisoning.html#

Blando, James D., et al. "Lead-Based Paint Awareness, Work Practices, and Compliance During Residential Construction and Renovation." Journal of Environmental Health, vol. 75, no. 9, 2013, pp. 20–27.

Derus, M. (1999, May 09). Contractors required to give lead alert federal disclosure laws on lead-based paint take effect june 1: [all edition]. *Milwaukee Journal Sentinel* https://hs1.farmingdale.edu:2443/login?url=https://www.proquest.com/newspapers/contractors-required-give-lead-alert-federal/docview/260942971/se-2

Geller, Andrew M. "Making the Needed Linkages and Economic Case for Continued Lead-Paint Abatement." Environmental Health Perspectives, vol. 117, no. 8, 2009, pp. A332–A334, https://doi.org/10.1289/ehp.13098.

Wright, N J, T D Thacher, M A Pfitzner, P R Fischer, and J M Pettifor. "Causes of Lead Toxicity in a Nigerian City." *Archives of disease in childhood* 90, no. 3 (2005): 262–266.