Project Summary
A randomized trial of abandoned housing remediation, substance abuse and violence

Housing abandonment poses a major health burden that has grown significantly over the past several decades in the US. As a typical US city, Philadelphia has some 40,000 vacant properties, a significant number with abandoned residential buildings or structures.

Research, including our own, has shown that vacant and abandoned properties are associated with drug-dependence, firearm violence, stress, sexually transmitted diseases, and premature mortality. Our prior research also shows that urban residents see abandoned buildings every day on their way to work or school and describe these undesirable structures as foremost, hypervisible detractors to community health, reducing community cohesion and creating trash, rodents, crime, fear, stress, and havens for transients, drug use, and sex work. Multiple theories posit that visible, environmental disorders, such as abandoned buildings, lead to community decline by signaling that a community is uncared-for, incivilities are tolerated, and the ability of residents to engage in shared expectations of social control over neighborhood problems is eroded. As a result, residents are prevented from engaging in positive health behaviors while unhealthy behaviors, such as substance abuse and violence, become sheltered and more prevalent. Direct remediation of abandoned housing could thus be a potent intervention to interrupt longstanding substance abuse and violence.

The proposed research team has produced several preliminary/pilot studies that demonstrate its capacity to complete the proposed study: (1) a published, citywide quasi-experimental study of the health and safety effects of a novel abandoned building remediation protocol stemming from the 2011 Philadelphia Doors and Windows Ordinance; (2) multiple published pilot randomized controlled trials (RCTs) of the effects of abandoned and vacant property remediation on health and safety; and (3) a large, citywide RCT of vacant lot greening involving over 600,000 ft^2 of land and a 5-wave, random sample survey of over 600 Philadelphians.

There have been no RCTs that test the health and safety effects of abandoned housing remediation. The broad objective of this proposal addressed this gap in knowledge by conducting a citywide RCT of the effects of abandoned housing remediation on substance abuse outcomes, both alcohol and drug related, and violence outcomes, particularly firearm violence. A total of 320 randomly selected abandoned houses, stratified into four geographic sections of Philadelphia, will be randomly assigned to four trial arms: full abandoned housing remediation (n=80, full treatment), graffiti and trash clean-up only (n=80, graffiti treatment), trash clean-up only (n=80, contact control), and no housing remediation or clean-up (n=80, no treatment). Longitudinal outcomes on and near the abandoned houses will be measured in the 18 months before and after treatment. Mixed, quantitative and qualitative methods, will be used to achieve the proposed specific aims in determining if abandoned housing remediation is a cost-effective approach to substance abuse and firearm violence.

Project Narrative
A randomized trial of abandoned housing remediation, substance abuse and violence

To the best of our knowledge, there have been no prior randomized controlled trials of abandoned housing remediation and substance abuse and violence outcomes. By randomly assigning a standard, reproducible remediation protocol to abandoned houses across Philadelphia and then studying the effects of these remediations, the proposed project's findings will contribute to the local and national effort to reduce morbidity, mortality, and disability caused by substance abuse and violence. The proposed study will therefore remediate hundreds of abandoned houses in the City of Philadelphia at no cost to the city or its residents and produce scientific findings that will have a positive effect on Philadelphia and other US cities.

a. SPECIFIC AIMS

Housing abandonment poses a major health burden that has grown significantly over the past several decades in the US.[1] Abandoned housing is especially problematic in so-called, "legacy" cities where deindustrialization, economic downturns, residential flight, and disinvestment have resulted in rapidly increasing numbers of vacant and abandoned properties.[2] As a typical legacy city, Philadelphia has some 40,000 vacant properties, a significant number with abandoned residential buildings or structures.[3]

Vacant and abandoned properties have significant negative economic, health, and safety effects on cities and their residents. Abandoned properties reduce property values and cost cities hundreds of millions of dollars each year in maintenance and uncollected taxes, monies that could have been directed to local health and welfare programs.[4] Research, including our own, has also shown that vacant and abandoned properties are associated with gun violence[5], drug-dependence[6], stress[7], STDs[8], and premature mortality[9].

Our prior research also shows that *urban residents see abandoned buildings every day on their way to work or school and describe these undesirable structures as foremost, hypervisible detractors to community health*, reducing community cohesion and creating trash, rodents, crime, fear, stress, and havens for transients, drug use, and sex work.[10 11] "Broken windows theory", "incivilities theory", and the theory of "collective efficacy" posit that visible disorders such as abandoned buildings lead to community decline by signaling that a community is uncared-for, incivilities are tolerated, and the ability of residents to engage in shared expectations of social control over neighborhood problems is eroded. As a result, unhealthy behaviors, such as substance abuse and violence, become sheltered and more prevalent.[12 13 14 15 16] The health risk environment paradigm goes even further, arguing that residents are prevented from engaging in positive health behaviors because of blighted, ambient structural conditions such as abandoned housing.[17 18] **Direct remediation of abandoned housing could thus be a potent intervention to interrupt longstanding substance abuse and violence.**

Our research teams at the Penn Urban Health Lab (www.urbanhealthlab.org) and the Penn Cartographic Modeling Lab (www.cml.upenn.edu) have studied several urban development programs in collaboration with multiple cities and their local universities. Our strongest, decades-long municipal relationship has been with the City of Philadelphia. This relationship has produced several preliminary/pilot studies that demonstrate the research team's capacity to complete the proposed trial: (1) a published, citywide quasi-experimental study of the health and safety effects of a novel abandoned building remediation protocol stemming from the 2011 Philadelphia Doors and Windows Ordinance[19]; (2) multiple published pilot randomized trials of the effects of abandoned and vacant property remediation on health and safety[20 21]; and (3) an ongoing citywide, NIH/CDC-funded randomized controlled trial of vacant lot remediation involving over 600,000 ft^2 of land and a 5-wave, random sample survey of over 600 Philadelphians living near the lots.

Given this prior research and our strong collaborations with government, community-based, and university stakeholders in Philadelphia (see letters, including from the Mayor of Philadelphia), we are now poised to conduct a larger randomized trial of abandoned housing remediation. **There have been no randomized trials that test the health and safety effects of abandoned housing remediation.** The exact, reproducible protocol for the remediation will be based on the 2011 Philadelphia Doors and Windows Ordinance that requires abandoned-building owners to clean building facades and install working doors and windows in all structural openings. Our pilot research has shown that securing buildings in this way alters physical opportunities for substance abuse and crime – replacing uncovered openings or broken plywood boards with functional doors and windows prohibits easy entry, is see-through, and may reduce squatting, illegal drug dens, public alcohol abuse, and violence that proliferate when concealed from sight in abandoned buildings.

The broad objective of this proposal is to address this gap in knowledge by conducting a randomized controlled trial (RCT) of the effects of abandoned housing remediation on substance abuse outcomes, both alcohol and drug related, and violence outcomes, particularly firearm violence. A total of 320 randomly selected abandoned houses, stratified into four geographic sections of Philadelphia, will be randomly assigned to four trial arms: full abandoned housing remediation (n=80, full treatment), graffiti and trash clean-up only (n=80, graffiti treatment), trash clean-up only (n=80, contact control), and no housing remediation or clean-up (n=80, no treatment). Longitudinal outcomes measured from regularly collected municipal data and 400 randomly selected survey respondents living near the abandoned houses will be measured in the 18 months before and the 18 months after treatment. Mixed, quantitative and qualitative analyses, overseen by a highly experienced scientific team, will be used to achieve the **proposed specific aims in determining if abandoned housing remediation changes:**

(1) The occurrence of illegal drug trafficking and consumption compared with abandoned houses that have been randomly chosen to receive only trash clean-up or no treatment;
(2) The occurrence of illegal drunkenness and drinking compared with abandoned houses that have been randomly chosen to receive only trash clean-up or no treatment;
(3) The occurrence of shootings and firearm violence compared with abandoned houses that have been randomly chosen to receive only trash clean-up or no treatment;
(4) And to determine incremental cost-effectiveness estimates of abandoned housing remediation in terms of its cost per instances of illegal drug problems, alcohol problems, and firearm violence averted.

b. SIGNIFICANCE

b.1. Abandoned housing is a significant, yet readily modifiable environmental factor affecting health

With over 18 million vacant homes in the US, housing abandonment and vacancy are at record levels and steadily increasing.[22] Over the past half century, cities like Chicago, Cleveland, Detroit, Pittsburgh, Philadelphia and Baltimore have experienced residential flight, disinvestment, and rapidly increasing numbers of vacant properties.[23] Philadelphia alone has some 40,000 vacant properties, a significant number with abandoned residential buildings or structures.[24] In Philadelphia, vacant properties represent $3.6 billion in lost revenue from costs associated with maintenance, remediation, policing, and uncollected taxes.[25 26 27 28]

Property abandonment in US cities has also eroded community connectedness and potentially contributed to negative health and safety consequences.[29] Research in Philadelphia has found an association between the presence of neighborhood vacant properties and increased neighborhood violence.[30] In other cities, associations have been found between boarded-up buildings and drug-dependence mortality[31], sexually-transmitted diseases[32], and premature mortality[33]. Residents in neighborhoods with abandoned homes describe the many negative impacts on community well-being, physical, and mental health. According to these residents, vacant properties reduce community cohesion, invite trash, graffiti, rodents, and crime, and increase fear, stress and anxiety.[34]

Neighborhood environment is an important correlate to a wide range of physical and mental health outcomes.[35,36] A few studies have only recently begun to touch upon the mechanism through which neighborhood environments shape substance abuse and violence.[37 38 39,40,41] If abandoned properties were remediated, neighborhoods could see a drop in the public occurrence of illegal drug trafficking and consumption, underage drinking and public intoxication, firearm violence, and ultimately an increase in quality of life and health. Other issues related to public substance abuse and violence, such as resident fear and psychological distress, may also be reduced in the wake of a strategy to remediate abandoned properties.[42]

The landmark Moving to Opportunity (MTO) study showed that changing the places people live can significantly impact their health. The MTO was a large, 5-city natural experiment that allowed a subset of families to relocate from distressed public housing to higher-income housing via a voucher lottery.[43] The results of this "housing mobility experiment" were largely mixed. Adults reported improved measures of happiness, physical health, and perceptions of safety,[44] but adolescent boys showed increased rates of depression, PTSD, conduct disorder, and criminal behavior. In addition, over half of the residents who were offered vouchers to move, did *not* actually move.[45 46 47]

While the MTO study provides some insight into what happens when people who are offered an opportunity to leave blighted public housing take advantage of it, they leave unaddressed the question of what would happen to people if their blighted home environments were remediated and they stayed in place. Moreover, the MTO's findings are largely academic now that large-scale public housing complexes are no longer a preferable policy for providing affordable housing. There are also ethical problems with mass relocation as a place-based solution for people who've experienced historical discrimination in the form of relocation.[48 49 50] Thus, a natural experiment on moving people to a new neighborhood is different from an RCT that examines what would happen if the neighborhood environment in which people live was changed for them to stay.

It is for these reasons that we are pursuing "in situ" (i.e., in-place or stationary) place-based health interventions, i.e. interventions that quickly, inexpensively, and significantly change the places within which people live, with no relocation. Some of these programs have already shown promising results. For example, vacant-lot greening showed significantly less gun violence, vandalism, sedentary behavior, and stress.[51]

Remediation of abandoned housing is an outstanding next target for such in-situ place-based interventions that may produce significant health improvements.[52 53] Abandoned houses are key, highly modifiable, and very noticeable signs of blight that may result in drug, alcohol, and violence problems.[54] Once abandoned, these buildings quickly fall further into disrepair, accumulating broken windows, graffiti, and trash. Abandoned buildings offer physical refuge to illicit, unhealthy activity and visibly symbolize that a neighborhood has deteriorated, and that the public sector does not care about the local population enough or is too impotent to take remedial action. No one is in control; illicit, unhealthy behaviors proceed with little if any objection.[55 56] In race and class polarized and decaying inner cities, the symbolic valence of abandonment takes on particularly powerful political significance because the effects of private sector disinvestment and public-sector neglect become a hyper-visible sign of disparities in access to resources with negative health outcomes.[57]

Fortunately, broad groups of stakeholders – environmental, housing, public health, and safety advocates – see property reclamation as vital to their communities and are taking action.[58] However, cities are facing historic budgetary challenges and are unlikely to engage in new investments without scientific evidence showing that abandoned property interventions can be cost-effective in improving health and safety issues, such as substance abuse and violence. Building and housing interventions that focus on actually changing the physical structure of places and scientifically testing the impacts of those changes will be key. By remediating abandoned houses in a major US city and studying the effects with robust scientific methods, this project will contribute to the local and national knowledge-base to reduce substance abuse and violence and advance a potentially high impact, yet practical policy to change the health of large populations of people.

b.2. Alcohol/drug abuse are significant problems that can be impacted via environmental interventions

In the US, alcohol use disorders affect over 17 million people 18 years of age or older and nearly 25 million people 12 years of age or older. Unfortunately, only 8% of people who could benefit from clinical treatment receive help. This is a staggering failure of the substance abuse treatment system and alternative, prevention strategies must be implemented and trialed. Both the NIDA and the NIAAA prominently recognize the need for "prevention research and programs at the community level" that "target modifiable risk factors", are "aimed at general populations", and that have a research base demonstrating "cost effective outcomes". Despite an absence of scientific testing, abandoned buildings, are highly modifiable, community level factors that can be changed to potentially prevent drug and alcohol abuse in a cost-effective way.[59 60 61]

An extensive, but largely descriptive literature exists on the environmental context of substance abuse. Environmental characteristics have been found to intersect with poverty and other community-based problems and thus potentially contribute to specific transitions in drug abuse, such as cessation of injecting.[62 63] A range of substance use behaviors – access, initiation, escalation, and relapse – have been correlated with environmental factors, perhaps based on the environment's impact on neurochemistry, cognitive rewards and stress systems.[64 65,6667,68] Residents of blighted neighborhoods may be at higher risk for substance abuse, including earlier initiation, heavier use, and public intoxication.[69 70] However, this literature is based almost exclusively on correlational studies, so it remains unclear if neighborhood characteristics actually cause substance abuse to increase.

The presence of public alcohol or drug consumption or substance trafficking may create a contagion effect of further illicit substance use, by increasing opportunities for initiation, temptation, cues that trigger substance seeking behaviors, and easier access.[71,72,73 74] This also leads to heavier use and greater difficulties in reducing use or maintaining abstinence. Public substance abuse within abandoned buildings may also affect neighboring residents who increasingly become desensitized to its existence promoting normalization of substance abuse in public or in abandoned buildings.[75] Significant knowledge could be generated via experimental testing of place-based, cost-effective interventions that actually change basic structures that generate contextual risks, i.e. abandoned buildings, as opposed to relying only on treatments for individual abusers who persistently fail to modify their behaviors because the "health risk environment" surrounding them does not permit it.[76 77 78 79 80]

b.3. Firearm violence is a significant health problem can be impacted via environmental interventions

Each year in the US, over 100,000 people are shot with firearms at a total estimated cost of $100 billion dollars. Police data for Philadelphia show some 1,500 shooting victims per year and 17,000 violent crimes. Firearm injury is a biomedical disease pathology and victims of firearm violence represent a significant public health burden, heavily using medical resources in hospitals, clinics, and medical examiners offices, and creating significant negative health repercussions to themselves, their families, their communities, and the US as a whole. This violence also has a disproportionate impact on urban, low-resource communities.[81, 82 83 84 85]

Firearm violence is a significant public health burden and a NIH priority area for intervention research.[86] Despite this, the NIH have only funded 1 major research award per 1,000,000 cases of firearm injury per decade in the US. Compare this to diseases like cholera, polio, and rabies research for which the NIH have funded roughly 1-3 major awards per 1 case of disease. In 2013, this immensely disproportionate attention to firearm injury as a major US public health problem was one thing that led the NIH to issue PA-13-363, "Research on the Health Determinants and Consequences of Violence and its Prevention, Particularly Firearm Violence (R01)", a first for the agency and a clear indicator that the NIH sees firearm violence a major public health problem worthy of biomedical research investment. This PA is co-sponsored by numerous ICs, including NIAAA and NIDA, and focuses on "evidenced-based interventions in real world settings … at the individual, family and community level" to reduce "firearm violence".[87 88 89 90]

The abandoned housing remediation intervention proposed here fits squarely within the recent NIH priority for firearm violence prevention research and prior research suggests a correlation between environmental blight, like abandoned housing, and violence.[91] For instance, cleaner and greener urban spaces have been linked to less gun violence and fewer violent crimes.[92 93] Prior research also indicates that a small share of street segments are responsible for most of a city's serious crime and violence[94, 95] suggesting that targeted, place-based interventions that change crime opportunity environments may have significant impact.

Nevertheless, prior studies often represent only cross-sections in time, making it difficult to determine if actual changes to abandoned and blighted environments lead to reductions in firearm violence (or, conversely, if the occurrence of firearm violence itself leads to abandonment and blight). Select before-after, quasi-experimental studies of vacant land and abandoned buildings have addressed this reverse causation to some degree, although no RCTs exist that isolate the causal effects of abandoned buildings on firearm violence.

The Institute of Medicine has called for the study of environmental approaches to the prevention of firearm violence.[96 97] Prior studies[98] suggest that if abandoned buildings in surrounding environments could be remediated, neighborhoods might see an ensuing drop in violence. The study proposed here represents a unique opportunity to study a new environmental intervention around abandoned building remediation and potentially develop an innovative, cost-effective, evidence-based strategy to prevent firearm violence.

c. INNOVATION

c.1. Innovations and gaps in scientific knowledge that the proposed study will fill

Runaway blight, substance abuse, and violence have forced cities into action, initiating highly innovative but untested programs that abate physical signs of disorder in the hopes of revitalizing their neighborhoods, reducing costs, and improving public health and safety.[99 100 101 102] Blight to the physical environment in cities affects two very distinct structures: land and buildings. When abandoned and in disrepair, buildings and land can negatively affect health and safety for surrounding populations in very different ways, and therefore deserve separate study. Although prior blight-reduction trials on vacant land have been conducted[103 104], to date, only one quasi-experimental study has tested the impact of abandoned building changes, and this one study only considered crime outcomes.[105] Other, smaller studies have been cross-sectional and have bundled together blighted land and blighted buildings into larger indices of physical disorder without specifically studying them as independent factors.[106,107,108,109,110] The body of evidence has thus been scant and limited in its ability to causally connect abandoned housing and health outcomes. To the best of our knowledge, the currently proposed study is then innovative in that it would be:

(1) The first RCT of a unique, yet practical and inexpensive treatment of abandoned buildings that, if found effective in reducing substance abuse and firearm violence, could be adopted in many cities and towns
(2) The first to investigate health outcomes, such as substance abuse, related to the actual remediation of blighted and abandoned housing
(3) The first to disentangle the separate effects of different abandoned building remediation sub-activities, such as replacement of doors and windows vs. graffiti removal vs. trash pick-up and maintenance.
(4) The first cost-effectiveness study of abandoned housing remediation, and its various sub-activities, to be conducted in the context of a RCT

c.2. No prior randomized controlled trials (RCTs) of abandoned housing remediation

To the best of our knowledge, there have been no prior experimental trials of the effects of abandoned housing remediation on substance abuse and violence-related outcomes. Numerous cities have programs to remediate abandoned buildings but none have been studied or evaluated in a rigorous experimental sense.[111] Precedent does exist however in terms of trials to abate lead and other environmental modifications.[112,113]

The absence of a prior trial of abandoned housing remediation and substance abuse and firearm violence is a glaring gap in knowledge that, if filled by the proposed study, could offer important recommendations to urban abandoned housing remediation programs as well as substance abuse and firearm violence prevention efforts. Moreover, the proposed project is original and innovative in newly applying trial methods to study an upstream, environmental modification that could have long-term and sustained benefits in many cities, beyond only the proposed study city. As such, the proposed project will confront existing paradigms and practices by addressing an innovative and as yet unanswered hypothesis regarding the remediation of abandoned housing.

Furthermore, although there exists some evidence to support Wilson and Kelling's 35-year old Broken Windows theory, there are few, if any, experimental studies that establish internally valid causal evidence that physical incivilities, such as broken windows and abandoned buildings, truly result in violence and other illicit activities, and perhaps poor health. The proposed study can develop this causal evidence-base by considering the before-after effects of an intervention that makes changes to actual places. As a result, the proposed study could be have important implications for theory as well as empirical research – the long debated Broken Windows theory could now be tested with the highest levels of evidence under the proposed RCT. If the proposed RCT achieves its specific aims, it could thus be a highly novel scientific contribution.

d. APPROACH

d.1. Prior experience of proposed scientific team

The proposed scientific team has a long history of publications and grants (including multiple active and past R01s and Center Grants) focusing on violence, substance abuse, and urban health, including multiple experimental RCTs and quasi-experimental studies testing the health and safety effects of place-based change. The team will consist of senior and mid-career scientists with high-level expertise in a variety of disciplines: epidemiology, geography, anthropology, community health, criminology, sociology, economics, and biostatistics. The team has also established long-standing collaborative relationships with community and municipal partners who will work on the proposed RCT (see letters, including from the Mayor of Philadelphia). Each research team member has been included because they will offer unique scientific skills and, given his prior work, Dr. Branas is uniquely positioned to lead the proposed trial as PI. More detail is in their biosketches.

d.2. Research design and methods

d.2.1. Conceptual framework, theory, and rationale

Our focus on the remediation of abandoned buildings as solutions to substance abuse and firearm violence is based on a recognized conceptual framework and past theory. This framework and theory is then buoyed by the rationale that abandoned buildings are in great abundance in US cities, have been singled out by community members as detrimental[114 115], and are highly modifiable, structural factors that, if remediated, could yield sustained, lasting health benefits at relatively low costs.[116 117]

d.2.1.1. Structural, scalable, and sustainable framework of place-based health interventions[118]

Interest in health and safety programs that directly change the places that people live, work, and play has grown over the past decade.[119] In many ways, these place-based programs are a departure from business-as-usual public health and medical practice, which has focused primarily on individuals and lifestyle modifications.[120] Even when proven effective, individually-based programs can lose sight of the bigger picture. Episodically treating small numbers of people, while ignoring the obviously unhealthy surroundings within which people live, has stunted our treatments and moved the health of the nation forward at too slow a pace.[121]

If done right, upstream structural interventions, such as place-based remedies, have the potential to become truly transformational policies for the health and safety of large populations. Place-based programs such water systems, building codes, and roadway redesign did more to enhance the health of the public than many (maybe any) other programs, including medical care.[122,123,124,125] [126] These programs were widely successful because they focused on places or structural changes while being cost-effective and readily scalable to cover entire communities, thus impacting large numbers of people over multiple generations.[127]

We have published a conceptual framework[128] as a basis for selecting and testing high-impact public health programs, like abandoned housing remediation. These programs typically have three cardinal features:

(1) They make basic, *structural* changes, for example to places,
(2) They are *scalable* to cover large populations, and
(3) They are *sustainable* over long periods of time.

Programs that focus on basic structural changes, such as place-based interventions, can influence more people for longer periods of time than those that focus on individually-based interventions.[129] The IOM has pointed out that it is unreasonable to expect peoples' health to improve when the basic environment around them is constantly, and by its very design, working against such improvements.[130]

Public health interventions should also be scalable to large populations and whole regions, widespread in their reach and offering universal health benefits to persons with a political voice and those without. Although such programs are undoubtedly ambitious, they should not be overly complex or expensive if they are to be scaled-up and tailored to the needs of other regions in producing widespread returns on health. Scalability is thus defined by the likelihood of reproducing a program in additional places.

Public health interventions also need a reasonable likelihood of sustainability. Practical place-based interventions like abandoned housing remediation are relatively straightforward to reproduce and low cost. In addition, the amount of effort required of individuals to improve their health is inversely proportional to the likelihood that they will get healthier, and stay healthier.[131] [132] [133] To paraphrase one author, "filling in a brackish tidal pool is far more likely to reduce malaria years after funding has ended than expecting local community members to continue regular applications of larvicide".[134] Sustainability is thus defined by reproducibility over time and ease of compliance by would-be beneficiaries, and simple placed-based interventions can be highly sustainable.

Abandoned housing remediation is a potentially important intervention that changes basic, place-based structures and can be scaled to improve health for large populations, sustainably over long periods of time. The NIH, the CDC, and the IOM are advocating for RCTs of interventions like the one proposed here for the prevention of negative health outcomes such as substance abuse and violence.[135] [136] [137] [138]

d.2.1.2. Abandoned housing as a theoretical opportunity to reduce substance abuse and violence

Broken Windows Theory suggests that improving and maintaining blighted environments to prevent small incidents such as graffiti, public drinking and drug sales helps to create an atmosphere of order and lawfulness, thereby preventing more serious incidents, such as substance abuse and firearm violence from happening.[139] [140,141] If left unchecked, physical blight then spreads via a process of contagion.[142] [143] [144] Incivilities Theory and the Theory of Collective Efficacy, suggest that physical incivilities and blight in neighborhoods, such as abandoned buildings and litter, promote weak social ties among residents and encourage negative behaviors such as drug abuse and violence.[145] [146] [147] [148] Deleterious individuals, such as criminals and substance abusers, are emboldened in areas with greater physical incivilities while residents are less willing or able to intervene.[149] Community stress is also a possible mechanism between blighted environments and poor health[150], promoting cycles of fear, depression, and substance abuse.[151] Finally, our own Infrastructural Health Risk Environment Paradigm focuses on the political, economic, and practical logistical and infrastructural mechanisms through which the risk environment shapes conscious and unconscious logics for individual health behaviors and decision-making.[152]

d.2.2. Preliminary studies establishing need and feasibility of proposed RCT

The proposed study team has previously conducted numerous large-scale, related studies in Philadelphia and multiple other cities demonstrating their ability to logistically implement the study proposed here. Our preliminary studies of abandoned housing and vacant lots, while small-scale or non-RCTs, suggest effects on public drunkenness, drug sales and use, and firearm violence. These studies set the stage for a now unique opportunity to experimentally test the remediation of abandoned housing in a large-scale RCT.

d.2.2.1. Our preliminary quasi-experimental study of abandoned housing and safety outcomes[153]

- Kondo MC, Keene D, Hohl BC, MacDonald JM, Branas CC: A difference-in-differences study of the effects of a new abandoned building remediation strategy on safety. *PLoS One*: e1-14, 2015.

This citywide Philadelphia study used a quasi-experimental, difference-in-differences design to evaluate the same abandoned building remediation strategy proposed here for testing via RCT. In 2011, Philadelphia began enforcing a Doors and Windows Ordinance requiring owners of abandoned buildings to clean their facades and install working doors and windows in all building openings.

Poisson regression models were used to compare pre-post treatment differences in measures of crime in and around buildings that were remediated as a result of the ordinance (n=676) and randomly-matched wait-list control buildings that were not remediated (n=676), while also controlling for sociodemographic and other confounders measured around each building from January 2011 to April 2013. In the year after abandoned buildings were remediated there was an estimated 19% reduction in assaults, 39% reduction in firearm assaults, and a 16% reduction in nuisance crimes ($p<0.001$) near the buildings. No significant spatial displacement effects were found. The size and significance of some effects varied by city section and significant but small increases were found for illegal narcotics sales and possession ($p<0.001$).[154]

The City of Philadelphia is the only place in the U.S. where actual doors and windows have been replaced on abandoned buildings as part of a large-scale program and then studied. Abandoned building remediation seems to offer a low-cost method of reducing certain crimes, but additional studies, including RCTs, are now needed. This quasi-experimental study has laid the groundwork for the larger RCT proposed here by:

(1) Demonstrating that actual, physical remediation of abandoned buildings is operationally possible on a scale large enough for the proposed RCT;
(2) Establishing strong, working relationships with the community and municipal agencies that will implement the actual building remediations in the larger RCT proposed here;
(3) Generating important hypotheses about the effect of abandoned building remediation on substance abuse and firearm violence that can only be answered by implementing a larger RCT.

d.2.2.2. Our preliminary RCTs of vacant land remediation and health and safety outcomes[155] [156]

- South EC, Kondo MC, Cheney RA, Branas CC: Neighborhood blight, stress, and health: A walking trial of urban greening and ambulatory heart rate. *American Journal of Public Health* 105(5): e1-5, 2015.
- Garvin E, Cannuscio CC, Branas CC: Greening vacant lots to reduce violent crime: A randomised controlled trial. *BMJ Injury Prevention* 19(3): 198-203, 2013.

Similar to abandoned buildings, the remediation of vacant lots of land is important because these blighted spaces are abundant and highly modifiable with the potential for sustained, long-term health and safety benefits at relatively low cost. In partnership with the Pennsylvania Horticultural Society (PHS) and the City of Philadelphia, we performed multiple RCTs of a standard protocol involving the "cleaning and greening" of vacant lots by removing debris, grading the land, planting grass and trees to create a park-like setting, and installing low fences to show that lots are cared for and deter illegal dumping. Through these RCTs we tested the impact of vacant lot greening on crime, perceptions of safety, and stress. We collected real-time and dynamic data (using GPS, heart rate monitors, and smartphones) for 21 randomly selected study participants living near two vacant lots totaling 5,205 ft^2 that were randomly assigned the “cleaning and greening” treatment and two vacant lots totaling 3,333 ft^2 that were randomly assigned as controls.

Greening was associated with reductions in gun crimes and people living near treatment lots felt significantly safer after greening than those living around control vacant lots ($p<0.01$). Being in view of a greened vacant lot also significantly decreased heart rate by an average of over 10 beats-per-minute compared with being in view of a nongreened lot ($p<0.001$). This pointed to a biological link between vacant lot greening and a reduction in acute stress and, to our knowledge, is the first published walking trial in which a physiological marker was measured in real-time for individuals in their native environments.[157] [158]

With grants from NIH (R01AA020331) and the CDC (R49CE002474), our research group is also now actively completing a much larger RCT to further investigate the effect of vacant lot greening on various outcomes, including substance abuse and violence. In partnership with community-based, municipal, and scientific colleagues, 525 vacant lots were randomly sampled from tens of thousands of vacant lots in Philadelphia, stratified into four geographic sections of the city, and then randomly assigned to one of three trial arms: vacant lot greening (full treatment), trash clean-up only (trash control), and no vacant lot greening or clean-up (no treatment). Substance abuse and violence-related outcomes on or near the lots were measured via a 5-wave, longitudinal, in-person household survey of over 600 randomly sampled Philadelphians in the years before and after the greening treatment. Geocoded police data and video documentation of all vacant lots were also successfully collected. This large RCT is in its final years and, as such, no results are yet available. However, the successful completion of this large vacant lot RCT is an excellent indicator of probable success for the abandoned housing RCT proposed here and the same infrastructure (data systems, field interview teams, scientific and analytic teams, etc.) from this large vacant lot RCT is fully functioning and available for the abandoned housing RCT proposed here.

d.2.2.3. Our preliminary quasi-experimental studies of vacant land and health & safety outcomes[159] [160]

- Branas CC, Cheney RA, MacDonald JM, Tam VW, Jackson TD, Ten Have TR: A difference-in-differences analysis of health, safety, and greening vacant urban space. *American Journal of Epidemiology* 174: 1-11, 2011.
- Kondo MC, Low S, Henning J, Branas CC: The impact of green stormwater infrastructure installation on surrounding health and safety. *American Journal of Public Health* 105(3): 114-121, 2015.

We conducted a decade-long, quasi-experimental, difference-in-differences study of the impact of the PHS vacant lot greening program on health and safety outcomes in Philadelphia. Control lots from 2 eligibility pools were randomly selected and matched to treated lots at a 3:1 ratio by city section. Before and after outcome differences among treated vacant lots were compared with matched groups of control vacant lots that were eligible but did not receive treatment. Illegal drug trafficking and use, public drunkenness, and other health outcomes were measured near these vacant lots. Mixed-effects regression models were completed.

Across Philadelphia, 4,436 vacant lots totaling almost 8 million square feet were greened from 1999 to 2008. Regression-adjusted estimates showed that vacant lot greening was associated with reductions in gun assaults and vandalism ($P < 0.001$) as well as self-reported stress and sedentary behavior ($P < 0.01$). Despite this, the study's quasi-experimental design made it impossible to fully determine whether vacant lot greening was causally related to the various outcomes we analyzed (e.g., the selection of lots for treatment may have been prompted by motivated residents in cohesive neighborhoods) and larger RCTs were thus pursued.

d.2.3. RCT design, locations, and inclusion criteria

The proposed RCT will be a stratified random assignment of abandoned houses into full treatment, graffiti treatment, contact control, and no treatment arms matched within 4 sections of Philadelphia: north, south, west/southwest, and northwest. These sections of Philadelphia have clearly delineated roadway and water boundaries. Northeast Philadelphia is excluded because of the very limited number of abandoned buildings. The four sections of Philadelphia that will be involved in the study represent 90% the city's population. A significant portion of the City of Philadelphia will thus be touched by the proposed trial.

Abandoned house addresses will serve as the index locations of data collection for the trial and its outcomes. Outcomes will be surveyed around each abandoned house. Study arms (treatments and controls) will be concurrently exposed to the intervention, or not, within the same 6 month period, with the study following a parallel group trial design where each abandoned house receives only one treatment. Treatment or control status will be assigned to randomly selected houses within the same four sections of Philadelphia, i.e. matched by geographic section, to promote balance between study arms. As we have successfully done in the past, an urn or repeat randomization procedure will also further ensure balance between study arms.[161]

Across these four sections of Philadelphia, a total of 320 abandoned houses will be randomly selected and screened for inclusion into the trial from a larger universe of approximately 40,000 vacant properties. A master list of abandoned houses will be compiled from the City of Philadelphia and US Postal Service records and will determine the universe of candidate abandoned houses available for random selection and enrollment. These 320 abandoned houses will each be a standard 2-3 story Philadelphia rowhome and will be clustered in groups of 3-5 houses (4 houses on average, called sites) on neighborhood blocks with at least 80% housing occupancy. Each group of houses will be either immediately contiguous or within 660 feet/1/8 mile (a standard metric of proximity in Philadelphia City ordinances) of its nearest-neighbor abandoned house. These parameters are in keeping with standard municipal practices for remediation of abandoned houses in Philadelphia. Thus, across all four Philadelphia sections there will be 320 abandoned houses in 80 sites; each arm of the RCT (full treatment, graffiti treatment, contact control, no treatment) will have 80 houses in 20 sites.

All 320 abandoned houses, across all four arms of the RCT, will also be screened for inclusion *as if they were all going to receive the full housing remediation treatment*. Of course, only 80 of these homes will be randomly assigned to the full treatment arm of the RCT, but as a necessary counterfactual, all homes will be screened for eligibility in this way. Only abandoned houses that the Philadelphia Housing Development Corporation (PHDC, www.phdchousing.org, see letter in Appendix) is authorized to remediate as per the City of Philadelphia's Office of Housing and Community Development (OHCD, www.phila.gov/ohcd, see letter in Appendix) will be eligible for inclusion in the RCT. The PHDC and OHCD already work closely together and this will be the exact same authorization procedure that PHDC uses in its day-to-day abandoned housing remediation program outside of the proposed trial. Houses authorized for remediation will: (1) be in violation of the Philadelphia Doors and Windows Ordinance and Section 306 of the Philadelphia Property Maintenance Code requiring owners of abandoned buildings to clean their facades and install working doors and windows in all building openings[162] and (2) have been abandoned, as confirmed by a call by OHCD to the owner of record who is given 10 days to reply and offers no reply in said time; or (3) have been authorized for remediation by the house owner themselves within the 10 day period (i.e., they want the free housing treatment). The vast majority of abandoned houses in Philadelphia that are randomly selected for inclusion in the trial will fall into one or more of these categories and be available for enrollment and random assignment. Houses that have already been remediated by the PHDC or other local or municipal agencies will not be eligible for enrollment. We expect based on our prior work that roughly 70% of eligible houses will be enrolled.

d.2.3.1. Full abandoned housing remediation RCT arm ("full treatment", n=80)

Over a 6-month treatment period, the full abandoned housing remediation treatment will be performed on 80 of the abandoned houses randomly assigned to this RCT arm, followed by monthly maintenance and trash clean-up for the remainder of the post-treatment period. (see Figure below) These remediations will done by the PHDC, a non-profit, community-based entity. Since 1964, the PHDC and its contractors have performed hundreds of housing remediations annually in the City of Philadelphia. The full abandoned housing remediation treatment will follow a standard protocol and include these activities:

(1)Replacement of plywood boards or missing or broken doors and windows with new, standard, exterior, front entryway, wooden doors and standard, double-hung, wooden windows;
(2)Removal or replacement of deteriorated structures on front building façade, such as eaves, downspouts, or gutters;
(3)cleaning, new paint, and graffiti removal on building façade;
(4)monthly maintenance of new doors and windows and clean building façade, including the subsequent abatement of new graffiti; and
(5)monthly trash clean-up.

Figure. Abandoned housing remediation in Philadelphia.

New doors and windows and a newly cleaned building facade signal that a property is care for, prohibit easy entry, and are see-through thereby helping to reduce squatting, drug dens, and violence that proliferate when such behaviors are concealed from sight in abandoned buildings. Thus, in addition to a clean and cared for appearance, the dual-challenge of being seen more easily through glass windows (as opposed to, for instance, plywood coverings) and entering the openings of abandoned buildings through glass windows that make noise when shattered and leave a lasting, visual sign of forced entry, may prevent illegal substance abuse and violence.

d.2.3.2. Graffiti removal and trash clean-up RCT arm ("graffiti treatment", n=80)

During the same 6-month period as the full treatment arm, a graffiti removal only housing remediation treatment will be performed on 80 of the abandoned houses randomly assigned to this RCT arm, followed by monthly maintenance and trash clean-up for the remainder of the post-treatment period. This will again be done by the PHDC. The graffiti treatment arm will follow a standard protocol and include these activities: (1) cleaning, new paint, and graffiti removal on building façade; (2) monthly maintenance of clean building façade, including the subsequent abatement of new graffiti; and (3) monthly trash clean-up.

A motivation for inclusion of this study arm is isolation of the effects of the doors and windows replacement itself from the removal of graffiti and the cleaning of building facades. This study arm will also allow us to directly test whether graffiti remediation itself has an effect on substance abuse and violence outcomes. This is significant because graffiti removal is a very common and inexpensive practice in cities around the world that is being conducted with almost no scientific evidence-base. Whether the removal of graffiti actually affects negative outcomes like substance abuse or firearm violence (as many have speculated) remains an outstanding but largely unanswered research question with sparse evidence, especially from RCTs.[163] [164] [165]

d.2.3.3. Trash clean-up only RCT arm ("contact control", n=80)

During the same 6-month period as the full treatment arm, 80 abandoned houses will be randomly assigned to receive monthly trash clean-up only as a control condition of the proposed trial. This will be timed to match the treatment arms of the RCT and will be followed by monthly trash clean-up for the remainder of the post-treatment period. This trash clean-up only control will also be performed by the PHDC, follow the same standard protocols for trash clean-up as in the treatment arms, and parallel the number of workers and the amount of time typically spent on trash clean-up at abandoned houses in the treatment arms.

Uncontrolled trials fail to provide unbiased and reliable statistical inference regarding what would have happened to subjects if they had not received the test treatment.[166] Our proposed use of a randomly assigned trash clean-up control group of abandoned houses will be akin to a "placebo" group in a clinical trial, that is it will be intended to eliminate observer bias, mimic the psychological benefit of offering active treatment[167], and allow isolated study of the nonpsychological benefits of treatment.[168] The proposed trash clean-up control group will allow us to disentangle the psychological effects of abandoned housing remediation and the act of having workers present and in contact with surrounding residents (i.e. its function as a contact control) from the actual active ingredient of abandoned housing remediation, the physical changes to the buildings themselves.

d.2.3.4. No housing remediation, graffiti or trash clean-up RCT arm ("no treatment", n=80)

As a second control arm of the proposed trial, we will also randomly assign a separate group of 80 abandoned houses to receive nothing, i.e. no new doors and windows, graffiti removal or trash clean-up. This control group of abandoned houses will be monitored over the same periods as the other 3 arms of the trial.

Although "no treatment" controls fail to simulate the psychological effect of treatment, they are important when used in conjunction with controls that do simulate such psychological effects of treatment.[169] Our use of a randomly assigned control group of abandoned houses to receive nothing is therefore intended to eliminate observer bias and other selection effects, when compared with the other arms of the trial.[170]

d.2.4. Random assignment procedures

The random assignment of abandoned houses to 4 different trial arms will be done to balance known and unknown factors between treatment and control groups.[171] Geographic sections of Philadelphia represent covariates necessary for the internal validity of the study and, as such, random assignment of abandoned houses will be performed independently within strata by geographic section of the city. This will keep the variability of lots within strata as small as possible and the between-strata variability as large as possible and will prevent imbalance with respect to important covariates related to geographic location (e.g., class, race, ethnicity, etc.). To avoid contamination between study arms or dilution of true effects we will also set geographic selection rules to prohibit any abandoned houses in our study from being within ¼ mile from each other. We have used this ¼ mile distance restriction successfully in past community-based RCTs.[172,173,174,175]

As we've also successfully done in past community RCTs, an urn or repeat randomization will be used in advance to ensure balance in several key, baseline covariates. Urn or repeat randomization further reduces experimental bias and insures balance, over and above the balance that is obtained by standard random assignment alone.[176] These key covariates, measured only in the baseline, pre-treatment period, and within a ¼ mile radius around each abandoned house enrolled in the trial, will be: (1) number of abandoned houses that were already remediated as part of normal city operations, outside of the RCT; (2) number of people below the poverty line; (3) number of college educated people; and (4) number of people unemployed. The repeat randomization will effectively iterate the random allocation process until balance is achieved between the 4 arms of the RCT in these key baseline covariates, by city section.[177]

Once random assignments undergo acceptable quality assurance checks, the RCT's treatment and control arms will be cleared for implementation. A final, unalterable random assignment list will be locked in a database with the study's biostatistician to maintain blinding and prevent any tampering until interim or final analyses need to be performed. A Manual of Procedures will document the entire process.

d.2.5. Blinding procedures

We will employ double blinding: i.e., our investigative team (except for the biostatistician and the PI) and field surveyors, our study participants completing surveys, and those reporting information to us from the field (such as the Philadelphia Police Department) will be blinded to the assignment of treatment or control to abandoned houses. This will help avoid biases created by subjective judgment in reporting, evaluation, data processing, and statistical analysis, as well as participant or field interviewer awareness of nearby abandoned houses that will or will not be remediated as part of the RCT (as opposed to just regular municipal processes). We will also determine whether the blinding has been seriously violated by asking both participants and investigators to guess the treatment assignment at the conclusion of the trial prior to unblinding. With this information the degree of unblinding and any biases it may have introduced can be directly assessed.

d.3. Outcomes data to be collected

d.3.1. Observational metrics of substance abuse and firearm violence outcomes

Crime data will be collected from the Philadelphia Police Department every month in the year preceding the treatment, for the treatment period itself, and for 12 months following the treatment. Police data will include dates and address locations of narcotics possession, sales, and trafficking arrests, public drunkenness, firearm assaults, and other crimes. These arrest data have been validated as accurate.[178] Address locations will be geographically coded ("geocoded") to points in space using geographic information systems (GIS) software.

We will also use inverse-distance weighted (IDW) measures to calculate spatially interpolated estimates of the levels of crime at the point-in-space representing each abandoned house.[179] We will also incorporate bandwidths (maximum distances) for our IDW measures as is standard practice. IDW measures will offer several important advantages over simply assigning subjects to solitary geographic polygons, such as census tracts or block groups. Analyses in which subjects are nested within solitary administrative geographic units (i.e., a single census tract or block group) can generate challenges, including the mis-estimation of effects. Oftentimes, the boundaries of these administrative geographic units have been determined for purposes other than the specific relationships under study and as such may be awkwardly shaped, poorly correspond to lived space, have edge-effects (i.e., a subject assigned to a tract but located on its border may be more influenced by their neighboring tract), or impose a neighborhood scale that is inappropriate for the subjects being studied. Our experience in Philadelphia with IDW measures shows that they are continuous and essentially boundary-free, avoid aggregation effects, directly account for spillover effects and variability in neighboring areas, and can be quite reliably calculated.[180,181]

d.3.2. Observational metrics of abandoned houses

We will also use recurring field observations of all abandoned houses and immediately proximal spaces (at least 2 observations per house in the pre- and post-periods) at regular intervals to gauge pre-existing conditions and visual impact of the intervention, on-going maintenance, and post-treatment conditions. These field observations will be unobtrusive and coordinated *not* to coincide with scheduled treatment interventions and maintenance in avoiding contamination effects. Serial video and visual analog scale measures of houses will be analyzed using systematic protocols that we have successfully used in past research.[182] [183] [184,185] These measures will focus on the physical properties of the houses – general appearance, evidence of forced entry, amount of trash including detritus from substance abuse (cans, bottles, syringes, vials, etc.), illegal dumping, and evidence of animal refuge. As we have also done successfully in the past, we will use time-stamped (to the month and year) Google Street View images to supplement our field observations of abandoned houses.

d.3.3. Self-reported metrics of drug and alcohol consumption and other outcomes

d.3.3.1. Participant random selection and recruitment

A total of 4 interview waves (2 waves in the 18 month pre-treatment period and 2 waves in the 18 month post-treatment period) of randomly selected Philadelphians living near the study abandoned houses will be conducted. These will be face-to-face household interviews of 5 randomly selected Philadelphia residents over 18 years of age for each of the 80 abandoned house sites across all three arms of the proposed trial for a total of 400 study participants. Based on our past experience with household interviews in Philadelphia, a loss-to-follow up rate of about 20% across all 4 survey waves is expected prompting us to recruit and consent 5 participants per site to obtain at least 4 fully enrolled and interviewed respondents per site as per our sample size and power calculations.[186,187,188] Participants will often live within sight of the study abandoned houses, but no further than ¼ of a mile away. Residents will be paid a total of $100 using bank gift cards for completion of all 4 waves of the survey. Surveys will average out to be approximately 35 minutes per wave.

The locations of the 3-5 abandoned houses within each site will be used to create a bounding polygon and its accompanying centroid longitude-latitude (X-Y) point location. The location of the closest building address to this point location will be determined and a survey team will physically go to this building. Surveyors will then walk in a pre-determined random direction, sampling all occupied households on this first city block segment, followed by subsequent randomly pre-determined, contiguous city block segments, until they have enrolled 5 survey participants. In addition, the first 2 randomly selected city block segments will have had yellow post-it note announcements left ahead of time on all occupied household doors in order to maximize response rates.

Within each randomly selected household, participant consent and a “household census” will initially be conducted. This will determine eligibility of occupants and their willingness to participate. If a household is identified with multiple eligible respondents who consent to participate, we will select the respondent whose birthday is closest to the date of the interview. If multiple families live in the same building, they will be regarded as one household unless they each have separate street entrances. Households with no one home after 5 attempts will not be revisited. Interviewers will proceed in teams of 2 on weekdays, weekends, and during the day and after dark.

d.3.3.2. Survey administration, domains, and measurement

The survey will be administered in English or Latin-American Spanish (translated and back-translated). Before implementing the full survey on actual respondents, we will test it for readability, timing, logic, flow, and burden on a series of pilot subjects. We will consent all participants and establish excellent rapport, assuring them that we are in no way representing law enforcement or government.

The survey itself will ask respondents about their observations of public behaviors such as drug and alcohol use in their immediate vicinity, as well as their own drug and alcohol use behaviors, and their feelings of safety especially with respect to firearm violence. Survey questions will be standardized with mostly closed-ended, yes/no, or scaled questions and some open-ended questions and opportunities for respondents to provide narrative responses. Questions will be bounded to a 30-day recall to obtain multi-wave information relevant to specific periods in time and avoid errors due to telescoping and over-estimations.

The survey questionnaire itself will be separated into the following sections – Introduction, Background, Neighborhood Observations of Public Substance Use and Sales (Alcohol and Drugs), Personal Substance Use and Sales (Alcohol and Drugs), Crime, Mental Health, Trauma History, Stress and Fear, Closing Remarks, and Interviewer Impressions. Standardized instruments and questions that we and others have validly and reliably implemented in Philadelphia and other cities will be used: from our own prior survey work of substance abuse and the urban environment [189,190,191,192], other validated substance abuse and alcohol quantity-frequency consumption questions[193,194,195,196] [197,198,199,200], validated neighborhood environment questions from Philadelphia[201,202] and other cities like the Project on Human Development in Chicago Neighborhoods Survey[203], as well as the Trauma History Questionnaire[204], the Primary Care Stress Questionnaire[205], the National Health Interview Survey[206] [207,208], the WHO (Five) Well-Being Index[209,210,211], and other validated survey metrics for health issues such as sleep quality[212,213]. Additional biometric data – sitting systolic and diastolic blood pressure, resting heart rate, height, and weight – will also be serially collected for all participants in every survey wave. Blood pressure and heart will be taken with Omron® automated arm monitors as per prior field protocols. Our past field experience has been successful in collecting such biometrics.

d.4. Analysis strategy

d.4.1. Statistical analyses

Our primary analyses will be performed under the intent-to-treat (ITT) principle, i.e., pre-post changes to factors linked to abandoned houses will be analyzed according to the trial arms to which they were randomly allocated. Tests of group differences in pre- versus post-intervention accounting for longitudinal changes in continuous, ordinal, or binary outcomes will be made using spline-based, linear, log-linear or logistic regression models, as appropriate. Such models will include random effects for temporal and spatial correlations and fixed effects for treatment/control factors, time factors characterizing changes across pre- and post-intervention periods, and interactions between the treatment/control factors and pre-post intervention temporal effects.

Secondary analyses will include as-treated analyses. Before random assignment occurs, we will define "as-treated" to be any house randomly assigned to be remediated (or not) that actually receives the intervention (or not), but "not as-treated" to be any house randomly assigned to be remediated (or not) that does not actually receive the intervention (or not). For this analysis, we will include the "as-treated" status variable as the treatment factor rather than the original random assignment. A 2-stage IV regression, where the instrument is the actual random numbers originally used to do the random assignment (as this is clearly orthogonal to the outcomes under study), will also be used to calculate an as-treated estimate of the treatment effect.[214 215 216]

We will also assess whether effects vary across the different sections of the city by testing section-treatment interaction effects. Models will be fit using Proc Glimmix in SAS V9.2 based on the modeling procedures in Brown et al. as a special case of multiple-membership classification models (accounting for spatial clusters of nearby houses). Missing data weights based on inverse probability weighting will be used as a sensitivity analysis if missing data are significantly related to baseline factors.[217] Statistical analyses will be coordinated by Co-I statisticians Drs. Ridgeway and Ross.

d.4.2. Cost-effectiveness analyses

The proposed study's final aim will be to determine, from the perspective of city government, incremental cost-effectiveness estimates of abandoned housing remediation in terms of its cost per instances of public drunkenness and problem drinking, illegal drug trafficking and consumption, and firearm violence averted. This will be coordinated by Co-I economist Dr. Polsky. The economic costs of abandoned housing remediation and maintenance, graffiti removal, and trash clean-up are easily estimated because the prices paid by the PHDC are market prices. Marginal costs will thus be estimated directly from expense reports provided by the PHDC. We will conduct a sensitivity analysis using various fixed costs, although in a scaled-up version of the program, fixed costs associated with planning and executing the remediations will be relatively small. Costs will be estimated from the perspective of municipal government.

A first cost-effectiveness ratio will be drug problems averted, a second will involve alcohol problems averted, and a third firearm violence averted. A fourth cost-effectiveness ratios analysis will estimate a measure that combines drug, alcohol, firearm violence problems.

Incremental costs, estimated as the difference in average costs between pair-wise comparison of treatment groups, divided by incremental effectiveness, estimated as the difference in average effectiveness between pair-wise comparison of treatment groups will be estimated for the comparison of the two active treatment arms and between each of the active treatment arms and the control arms. We will conduct multivariable analyses as described above for effectiveness and for costs (except costs will be estimated using a generalized linear model with a gamma distribution and a log link) and, as commonly done in the cost-effectiveness literature, we will express the uncertainly of our cost-effectiveness estimates using acceptability curves. Based on these cost effectiveness ratios, we will be able to compare how economically attractive each different strategy, full abandoned housing remediation, graffiti removal, and trash clean-up, will be in terms of averting the outcomes under study relative to the attention control group and relative to each other.

Cost-effectiveness analysis is most useful when there is a single outcome of interest and when that outcome is a frequently used outcome so that the cost-effectiveness ratios can be compared so that it can be determined whether the costs are worth it for the outcome delivered. In this case we have three common outcomes around drugs, alcohol, and firearms, but what we do not have is a good way to understand whether the costs are worth the problems averted across all three outcomes. We will implement two strategies. First, we will covert these costs outcomes into a single composite measure of total problems averted, but because the severity of these problems tend to differ, we will apply a weight to each based on estimates provided by the city as to the average difference in city resources devoted to drug vs. alcohol vs. firearm problems. Second, we will cover all costs and benefits into dollars from the perspective of the city government to better understand the net benefits of the intervention. We will use the estimates of the dollar benefits of drug, alcohol, and firearms problems averted using the dollar estimates of McCollister, French, and Fang[218] and produce an estimate total net benefits of the intervention which takes these total benefits of problems averted in dollar terms and subtracts the total costs. If the net benefits are positive it suggests that the intervention is beneficial or cost effective from the perspective of city government. We do not propose a formal cost benefit analysis because it would be beyond the scope of the study with full willingness to pay scale estimation and because we have found that the simple costs-averted estimates are sufficient proxies and more easily translated for policy decision making.

d.5. Qualitative analyses for increasing the scientific value-added of intervention

A methodologically innovative dimension of the proposed project is the qualitative analyses coordinated by Co-I anthropologist Dr. Bourgois. Dr. Bourgois has developed multiple protocols for interdisciplinary dialogue (both theoretical and methodological) between epidemiologic research and the social sciences/humanities.[219 220 221 222 223 224 225 226 227 228] Several of these protocols specific to the unique potential of RCTs measuring structural interventions were refined with the PI, Dr. Branas.[229] Qualitative components of RCTs represent scientific value-added in that they can help control for intervention contamination effects, develop detailed understanding of the processes and mechanisms by which interventions, such as abandoned housing and its remediation, affect outcomes and change the behaviors of vulnerable individuals.[230] This mechanistic detail will be vital to establishing causality should statistically significant, numerical results be found.

We will employ a “strategically targeted, intensive case study" protocol developed by Dr. Bourgois in his previous cross-methodological collaborations. The epidemiologic survey already being implemented will also be used to recruit qualitative study participants emblematic of salient study topics. Articulate study participants are readily recruited and can offer additional contextual information of value in helping understand how structural forces affect individual behavior change. These strategically selected participants will be additionally remunerated for their time and will enable us to clarify emerging quantitative findings and triangulate responses about risky or taboo behavior that could lead to systematic distortions in the quantitative findings of the RCT.

Emerging qualitative findings will allow for the formulation of explanatory hypotheses that are “socially-structurally plausible”. This allows for a rigorous parsing of the quantitative variables for theoretically-driven reanalysis at the end of the project. Dr. Bourgois also has an extensive fieldwork infrastructure in inner-city Philadelphia on his own primary NIH R01, which he will make fully available to this project. This is a valuable no-cost resource for the methodological dialogue aimed at understanding the socially plausible processes that lead to behavior change in response to altered health risk environments.

d.5. Sample size and statistical power

We present sample sizes for different levels of power and different numbers of time points for abandoned house-specific primary aggregate event count outcomes based on the group-pre vs. post interaction test for any pairwise comparison among the four randomized groups of houses, under the following assumptions[231]:

1) two-sided alpha = 0.0167 to control for 3 primary pairwise comparisons: full treatment vs. no treatment; graffiti treatment vs. no treatment, and full treatment vs. contact control
2) standard deviation of the drug case counts/mile = 660 and of drunkenness cases = 14.3/ mile;[232]
3) clinically significant effect size is 0.20 (= interaction parameter/std) leading to group-pre vs. post interaction = 132 for drug cases/mile and 2.86 for drunkenness cases/mile;
4) no missing data since complete drug and alcohol data are available;
5) within-house time correlation ($rho(t)_y$) for drug or alcohol data = 0.40; and
6) between-house spatial correlation ($rho(s)_y$) for event counts = 0.10; and
7) within-house correlation (rho_x) for -1,1 dummy variables of group & pre-post indicator variables = -0.01.

Using the design effect formula, $(1+(T-1)*rho_x*rho(t)_y)$, where T is the number of time points and $(1+ (K-1)*rho(s)_y)$, where K is the average number of lots within a cluster of near houses,[233] effective sample sizes accounting for the above within-lot correlations (temporal relationships) were calculated from simple random sample sizes. According to Kraemer et al.[234] (2006), we base the Cohen’s effect size on a clinically meaningful effect size of 0.20, where the effect size is the interaction parameter divided by the standard deviation of the outcome. The Table below displays sample size results for different frequencies of time period measurements and different levels of statistical power. We did not account for stratifying on the geographic sections of Philadelphia, as this would have only improved power; thus our sample size estimates are conservative. In achieving the primary aim of studying the occurrence of public drug and alcohol use we will enroll 320 houses (in 80 sites of 4 houses each) in all 4 arms of the trial to maintain 80% statistical power.

	Statistical power				
Time periods	**70%**	**75%**	**80%**	**85%**	**90%**
12 pre- and 12 post periods	352 houses (in 88 sites)	400 houses (in 100 sites)	448 houses (in 112 sites)	496 houses (in 124 sites)	560 houses (in 140 sites)
18 pre- and 18 post periods	240 houses (in 60 sites)	272 houses (in 68 sites)	320 houses (in 80 sites)	336 houses (in 84 sites)	384 houses (in 96 sites)
26 pre- and 26 post periods	144 houses (in 36 sites)	160 houses (in 40 sites)	176 houses (in 44 sites)	208 houses (in 52 sites)	224 houses (in 56 sites)
52 pre- and 52 post periods	48 houses (in 12 sites)	64 houses (in 16 sites)	64 houses (in 16 sites)	80 houses (in 20 sites)	80 houses (in 20 sites)

Table. Sample size calculations for different levels of power and frequencies of time period measurement

We calculated the minimally detectable effect size given 80% power for the participant-level outcomes and 4 time points based on the group-pre vs. post interaction test for any pairwise comparison among the three

randomized groups of lots. By minimally detectable effect size, we mean the smallest Cohen's effect size (group-pre vs. post interaction/standard deviation of outcome) that we can call significant with 80% power under the following assumptions: 1) within-participant correlation (rho_y) for participant-level outcomes = 0.70; 2) within-house correlation (rho_y) for participant-level outcomes = 0.20; 3) group-pre vs. post interaction = 11 events per mile; 4) within-house correlation (rho_x) for the -1,1 dummy variables for group & pre-post indicator variables = -0.33. Given these assumptions, we used the program RMASS[235] to compute the minimally detectable effect size of 0.50 under a nested random effects model to account for the within-lot and within-participant correlations. This is a medium effect size based on Cohen.[236] Based on this we would maintain 80% power if we randomly surveyed 4 people per abandoned housing site, twice before and twice after the treatment period (4 time points total). This calculation accounts for a 20% loss-to-follow up rate, although we target 400 survey respondents in total to insure that adequate power levels are met.

d.6. Timelines and work plan

The entire proposed project will be a 5-year commitment. A 9 month preparation period (devoted to hiring personnel, finalizing data collection and database systems, piloting and pretesting interview instruments, and launching data processing systems) will be followed by an 18 month pre-treatment period, a 6 month treatment period, and an 18 month post-treatment period. There will then be a 9 month period after the post-treatment data collection, during which quality assurance checks of all data will be completed along with all analyses and reporting, including the preparation and submission of academic manuscripts and presentations.

d.7. Potential study challenges and tactics to prevent them

d.7.1. Loss to follow-up and attrition biases

We will make every attempt to retain participants and minimize attrition bias through a range of rapport building and retention techniques, incentives, and cultural adaptation of study materials that we have successfully applied to past research in Philadelphia.[237,238,239 240] Very importantly, we already have functional field interview teams that consist of outstanding local Philadelphians with first-hand knowledge of our study population having lived much of their lives in the same neighborhoods within which the study will operate.

d.7.2. Recall and misclassification biases

Several design features will maximize recall including the use of highly structured questionnaires and limited, 30-day recall periods. Surveyors use color-coded laminated response cards to remind and reinforce response categories for respondents and minimize misclassification. We will also include some questions in our survey worded differently to determine respondent reliability and gauge misclassification bias.

d.7.3. Information biases

Missing data, due to nonresponse or incomplete records, may lead to information biases. To account for the potential effects of missingness and data missing at random or with no known pattern, we will use multiple imputation techniques. Multiple imputation datasets of any missing data will be made under a joint model for the variable in question and a missingness indicator conditional on the fully observed data.

d.7.4. Interviewer biases

We will minimize interviewer biases, including social desirability bias, through highly structured questionnaires, training in standard probes, and other techniques. In order to specifically minimize social desirability bias, we will use introductory language to reinforce the neutrality of our interviewers and the questions they are administering as well as standardized questions to measure social desirability.[241] We will also not inform the interviewers of study hypotheses and will employ double blinding.

d.7.5. Treatment spillover or diffusion of treatment onto control group sites

We recognize that treatment spillover or diffusion of treatment onto control group sites may be a threat to internal validity[242] and, as such, we will require treatment and control sites to be no closer than ¼ mile distance from each other. We will also conducting specific statistical analyses of geographic spill-over effects that we have successfully used in numerous prior studies to determine if outcomes changed in the areas under study or were simply displaced to outlying areas.[243 244 245]

d.7.6. Perceived gentrification effects of treatment

Recent qualitative fieldwork conducted by our research team showed that when residents were asked about abandoned housing in Philadelphia, the most common theme that emerged was the threat of violence and the least common theme was gentrification. Our prior work has also shown that vacant property remediation does not increase property taxes, a common mechanism by which gentrification from luxury housing development forces long-time residents to leave their neighborhoods.[246] Although simple abandoned property remedies are widely lauded and have not been shown to create forced out-migration, some residents may still object to the proposed trial's efforts based on perceptions that it may increase property taxes, create gentrification, amount to unfair seizure of neighborhood properties, or that the random selection of certain houses, but not others, is unfair. Our field personnel will be sensitive to these issues and not proceed if faced with local objections until rapport can be established and full information about the study's intentions conveyed to the neighborhood in question. The proposed trial will also only treat houses that the PHDC is legally authorized to remediate.

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