Mapping Milwaukee's *Blueprint for Peace*: Evaluating the Geospatial Reach of a Cure Violence Implementation, 414LIFE

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ABSTRACT

Background: Cure Violence interruption programs are evidence-based interventions aimed at reducing the transmission of gun violence and its related injuries. Assessing the implementation of these programs can include the metric of "reach." This study evaluated one such program – 414LIFE – in Milwaukee, Wisconsin. The evaluation reconceptualized "reach" as a metric for reaching the individuals and neighborhoods at greatest risk for gun violence.

Methods: 414LIFE's reach was analyzed descriptively and geospatially through its program evaluation dataset from May 2019 through September 2020 using a cross-sectional design. Program referral criteria includes patients who sustained a gunshot wound, are less than 36 years old, and a resident of, or injured in, the city of Milwaukee. A choropleth map visualized location of participants' residence, which justified a global Moran's *I*, and then a local Moran's *I* calculation to identify statistically significant clustering of referrals.

Results: In the first 1.5 years of the program's partnership with the local level I trauma center and affiliated academic medical institution, 398 patients were referred. Three hundred referrals (75.4%) met program criteria; 53.8% were Black men. Statistically significant clusters were identified and mapped. Half of the top 10 neighborhoods with referrals were the city's identified priority neighborhoods.

Conclusions: 414LIFE successfully reaches its intended population and geographic locations. Geospatial reach should be considered routinely in program evaluations of Cure Violence programs to track growth and reach over time.

BACKGROUND

In the United States, there are nearly 70 000 annual nonfatal firearm injuries, with 72% attributable to assault.[1] Assault accounts for 60% of gun violence-related hospitalizations at a rate of 10.1 per 100 000.[2] Survivors of nonfatal shootings may have a lifetime of physical and psychological recovery ahead of them, including a wide range of issues, from permanent physical disability to posttraumatic stress disorder.[3-4] In addition to the physical and psychological toll these injuries take, the annual cost to the economy is estimated at $622 million.[2] Gun violence is a public health crisis whose morbidity and mortality predominantly affect young Black men.[5] Firearm injury is the leading cause of death for men in this group aged 15 to 34 years.[5]

Seminal work by Slutkin[6] and others characterizes gun violence as an infectious disease due to its wave-like transmission through social networks and geospatial clustering.[7] Approaching gun violence as a disease has led to an increased emphasis on identifying evidence-based interventions aimed at reducing its spread. Many of these interventions are local adaptations of a public health model developed from Slutkin's epidemiological work, known as Cure Violence.[8-10] Cure Violence has been replicated in numerous cities nationally and internationally.[8] Examples of these community-based adaptations include Baltimore's Safe Streets, New York City's S.O.S. South Bronx, Chicago and Philadelphia's Ceasefire programs, and, more recently, Milwaukee's 414LIFE.[11,12]

414LIFE resulted from the City of Milwaukee Health

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Department Office of Violence Prevention's community needs assessment in 2016-2017. The result of this extensive assessment was a document entitled *Blueprint for Peace*, a community-established agenda for violence prevention in the city.[13] It directed violence prevention efforts to 10 priority neighborhoods that bear the city's largest burden of the disease. One of the goals of the *Blueprint*, "stop the shooting, stop the violence," led to the local implementation of the Cure Violence model. First, a community-based outreach and street interruption component was established. Then, the Office of Violence Prevention reached out to the region's only adult level I trauma center and its affiliated academic medical institution to establish a partnership for hospital response programming. This community-hospital partnership resulted in the development and implementation of 414LIFE to target the population and neighborhoods most at risk for firearm injury.

Based on implementation science literature, a program's reach is an important first step in evaluating whether a program is impacting the target population.[9,14,15] Reach has been measured previously as "the proportion of the target population that was reached by the program."[15] It is important to determine if those most at risk for future violence recidivism are being reached by the program. While there is evidence for the use of "reach" as a metric to assess program implementation within youth violence prevention programs, there is a dearth of literature about the reach of Cure Violence programs.[15] Understanding a program's reach is vital to continue to refine and implement programs across the United States, particularly with the significant rise in gun violence during the COVID-19 pandemic.[16]

At this writing, 414LIFE is in its second year of its hospital partnership and is seeking citywide expansion. It is necessary to ascertain the extent to which the hospital component of 414LIFE is reaching the population determined by the city of Milwaukee *Blueprint* to be most at risk for the disease of gun violence. And although reach is infrequently reported in Cure Violence's evaluation literature, it is an important metric for evaluating program implementation.[17-19] Therefore, we sought to determine if this community-hospital partnered program was reaching both the individuals (young Black men) and geographic areas (*Blueprint* priority neighborhoods) most at risk for future violence after surviving a nonfatal shooting. Though geospatial analyses have been used previously to map injury, to our knowledge, this is the first work that has used a geospatial approach to assess reach (as a metric of Cure Violence implementation) of a targeted, at-risk geographical location and population.[20]

METHODS

This was a cross-sectional descriptive and geospatial analysis of the 414LIFE program evaluation dataset, which includes the hospital side of the partnership and is a collection of program-related data abstracted from referred patients' medical records. General demographic and injury characteristic information and geographic location of injury were collected from patients referred to the program since its start in May 2019 through September 2020.

Research Ethics Approval and Reporting Guideline

This project was approved as a quality improvement project and was, therefore, exempted from review by the Institutional Review Board of the primary author's institution. Inherent to this approval was a waiver of consent to access data from the program evaluation dataset. The project did not have direct contact with participants. The SQUIRE 2.0 guideline was used to ensure proper reporting of methods, results, and discussion (Appendix).

Patient and Public Involvement

The project aim, design, and dissemination plan for results was informed by the City of Milwaukee Health Department Office of Violence Prevention's 2016-2017 community needs assessment, *Blueprint for Peace*. The methodology of this community needs assessment is described elsewhere.[13] The *Blueprint* identified priority neighborhoods for violence prevention efforts. These geographic units are the primary focus of the geospatial analysis that aims to determine the hospital partnership's reach to patients from these neighborhoods.

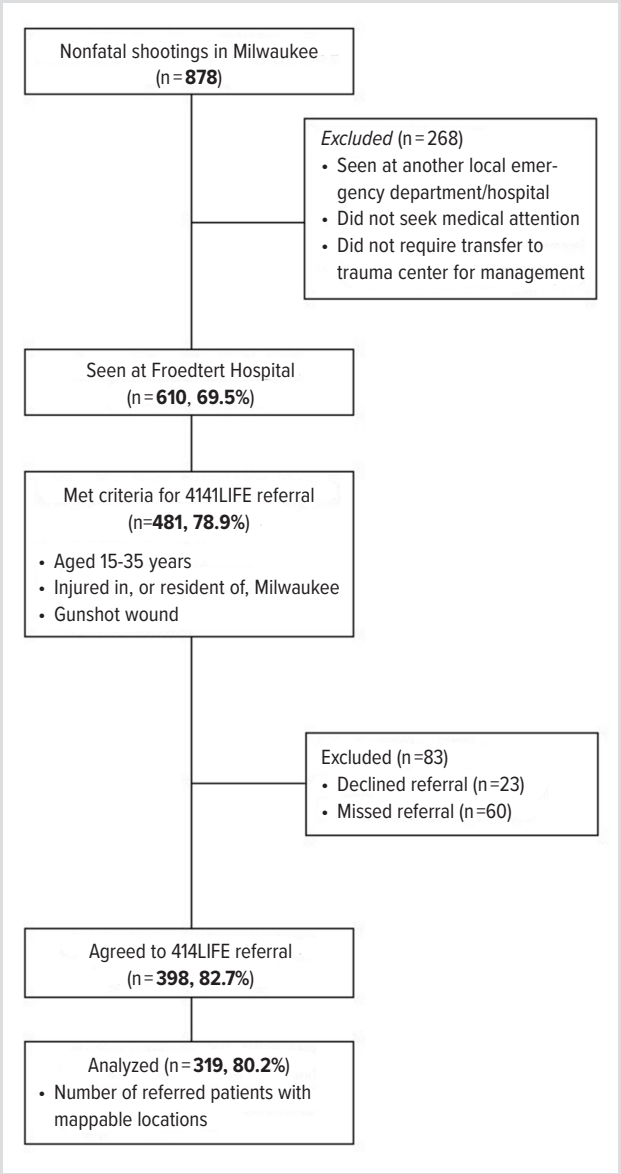
Patient Referral Process

There are 3 hospitals more proximal to the priority neighborhoods than our level I trauma center. Thus, it is not infrequent that gunshot wound patients are transported initially to those hospitals. When the injury is less severe (eg, a "through-and-through" bullet wound, no inpatient procedures required), patients can be treated and discharged directly from these local hospital emergency departments. However, when the injury is severe, these hospitals know to immediately transfer the patient to the level I trauma center.

Patients eligible for referral to 414LIFE from the level I trauma center are those who: (1) experienced a gunshot wound, (2) are 15 to 35 years old at the time of injury, and (3) were injured in, or a resident of, the city of Milwaukee. Given the circumstantial psychosocial context of traumatic injury, patients not meeting all 3 of these program criteria could be referred to 414LIFE at the discretion of the clinician or social worker and in agreement with the 414LIFE violence interrupter (known locally as the hospital responder). The main reason for exceptions is a concern for risk of violence recidivism by the patient and/or loved ones.

When a patient arrives at the trauma center and is determined to meet inclusion criteria, the emergency department social work team approaches the patient and/or family to receive consent for the 414LIFE referral. If consent is received, a 414LIFE referral page is placed and the hospital responder makes real-time contact with the patient and/or family. If the patient requires urgent surgery, inpatient clinicians will make the referral as soon as there is contact information for family or when there is the opportunity to talk with the patient for the referral. Family referral includes those patients who arrive deceased or who die soon after arrival. The

Figure 1. Flow Diagram for Evaluated 414LIFE Referrals



interaction with family can include violence interruption, conflict mediation, resource allocation, and continued case management following discharge.

Statistical Analysis

Demographic and injury information was characterized as frequencies and counts and as mean with standard deviation. These descriptive analyses were conducted using SPSS (IBM version 24). This analysis aims to assess if priority individuals are being reached by 414LIFE.

To assess geospatial reach, the geospatial analyses utilized a shapefile of the city of Milwaukee's neighborhood boundaries downloaded from the city's public geographic information system (GIS) portal website. The number of program referrals was extracted from the 414LIFE program evaluation dataset and joined to the neighborhood shapefile. For injuries occurring at the intersection of 2 or more neighborhoods, the individual's neighborhood of residence was used, because patient residence addresses were reliably available and the psychosocial origins of the interpersonal violence may be related to where people spend most of their day.[21]

Once geocoded, a choropleth density map was created to understand the distribution and number of program cases by neighborhood. Natural breaks were used in the choropleth map as the Jenks method identifies natural breakpoints inherent in the data by using a statistical formula that minimizes variation in values within classes and maximizes variation values between classes.[22] This distribution was then analyzed to assess the statistical significance of the apparent clustering of high case neighborhoods. Statistical significance was determined by an alpha of $P < 0.05$. A global Moran's I test was conducted using edges and corners contiguity, followed by a local Moran's I. The geospatial analyses and related maps were completed using ArcMap (ESRI version 10.7). To obtain a map of P values by neighborhood for the local Moran's I, this test was reproduced in GeoDa (version 1.14.0). Neither the descriptive nor geospatial analysis necessitated controlling for confounders.

RESULTS

From May 2019 through September 2020, the city of Milwaukee had 878 nonfatal shootings (Figure 1).[23] The city's level I trauma center had 610 gunshot wound patients during the same timeframe. Of those, 481 met the criteria for program referral; 398 patients agreed to a referral and 23 declined. The majority of program referrals were young (aged ≤35, 77.6%), Black (83.9%), men (82.7%), injured by a firearm (96.7%), and were injured or resided in the city of Milwaukee (98.5%) (Table). Of the 398 referrals, 300 (75.4%) met program criteria. Of note, sex and race are not program criteria, but Black men who also met all program criteria accounted for 214 referrals (53.8%).

Of the 398 program referrals, a mappable location of injury was abstracted for 319 patients from the ambulance report of their medical records. Program participants without mappable or documented locations of injury were excluded from analyses. For the geospatial analyses, a choropleth density map was generated from the number of referrals by neighborhood (Figure 2). This map revealed clustering in the northern center of the city, prompting the use of the global Moran's I statistic. The test revealed significant clustering ($I = 0.507$, $z = 12.17$, $P < 0.001$). To locate the areas of significant clustering, an Anselin Local Moran's I yielded a map showing neighborhoods with high or low numbers of referrals surrounded by neighborhoods with low or high numbers of referrals, as well as the P value associated with each neighborhood involved in the cluster (Figures 3 and 4).

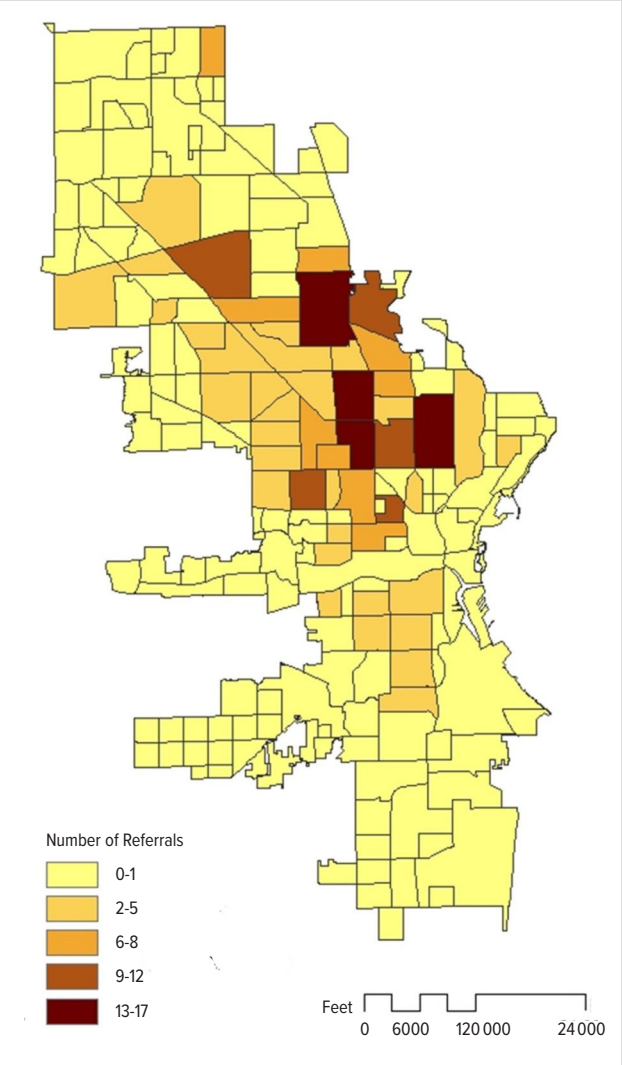
Of the top 10 neighborhoods with the highest number of 414LIFE program referrals, 5 were *Blueprint* priority neighborhoods. These neighborhoods are shown on the density map

Table. Demographic and Injury Characteristic Information for All 414LIFE Referrals Placed From Program Start Through September 2020

Demographic and Injury Characteristics	n	%
Sex		
Male	329	82.7
Female	69	17.3
Race or Ethnicity		
Black or African American	334	83.9
White	11	2.8
Hispanic or Latino	6	1.5
Asian	1	0.3
Other	23	5.8
Unknown	23	5.8
Mechanism of injury		
Gunshot wound	385	96.7
Stab	6	1.5
Blunt assault	3	0.8
Self-inflicted	2	0.5
Pedestrian struck	1	0.3
Suicidal ideation	1	0.3
Met age criterion		
Yes	309	77.6
No	89	22.4
Met city criterion		
Yes	392	98.5
No	6	1.5
Characteristic	**Mean**	**SD**
Age (in years)		
Did meet age criterion	25.37	4.84
Did not meet age criterion	43.19	7.81

Note: Self-Inflicted injuries were 1 blunt assault against self and 1 gunshot wound against self unrelated to suicidal ideation. Suicidal ideation was due to deceased family member who died from gunshot wound.

Figure 2. Density of Locations of Injury by Milwaukee Neighborhood for 414LIFE Referrals



(Figure 2) and are part of the significant clustering identified in analysis (Figures 3 and 4). There were 6 priority neighborhoods with statistically significant clustering ($P < 0.05$).

DISCUSSION

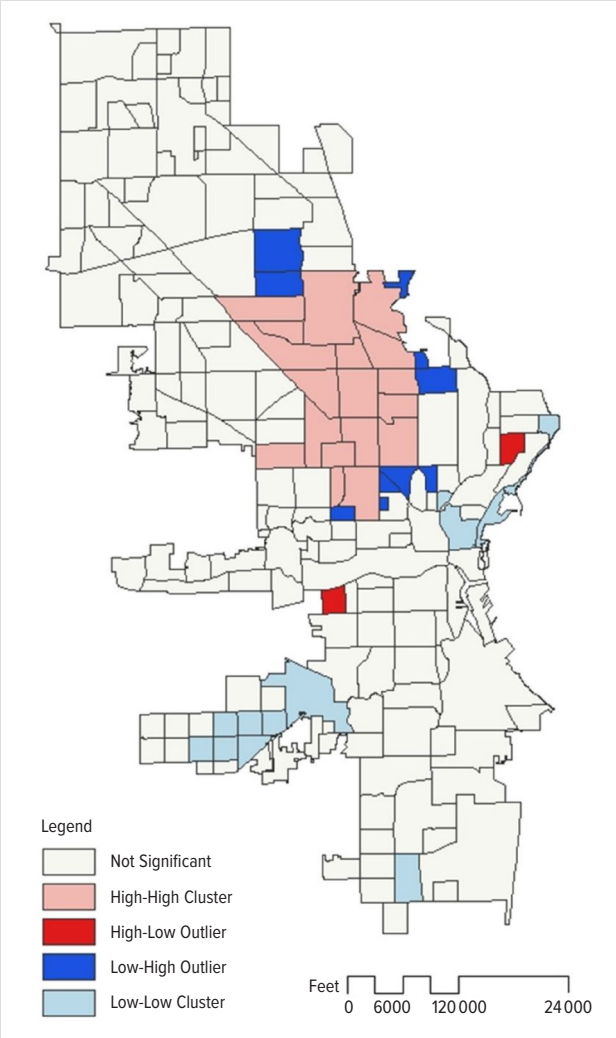
The goal of this preliminary analysis of the 414LIFE's early programmatic data was to evaluate the individual and neighborhood level reach of this local Cure Violence adaptation. Individual reach was described by the proportion of patients agreeable to program referral who belonged to the patient population most at risk for gun violence and the proportion meeting program referral criteria. Neighborhood reach of the program's referred patients was geospatially evaluated for clustering in priority neighborhoods.

At the individual level, 414LIFE is reaching its target population: young Black men who are at greatest risk for firearm violence, re-injury, and future mortality following a nonfatal gunshot wound.[5,17,24] This population was most represented in the program's referrals (Table). Young Black men who met all program criteria represented 53% of all referrals, inferring fidelity in the program's implementation.

Previous Cure Violence implementation evaluations do not specify if programs are intentionally targeting their geographic reach to those most at risk for gun violence.[17-19] It is not a requirement per Cure Violence Global, nor of models that also implement a hospital response component. Evaluations often focus on number of homicides, nonfatal shootings, and/or acts of recidivism that occur in predetermined neighborhoods. This approach is outcome-oriented, while the current study is people and community-oriented in its analysis of program reach. While several programs report the demographic characteristics of their participants, it is unclear how many participants uniquely meet all of the age, gender, and racial characteristics of those at high risk within in a given geographic target area.[17] To our knowledge, our work is the first to document geospatial reach as a metric for a Cure Violence adaptation and even more so when specifically considering the hospital response component of a Cure Violence adaptation.

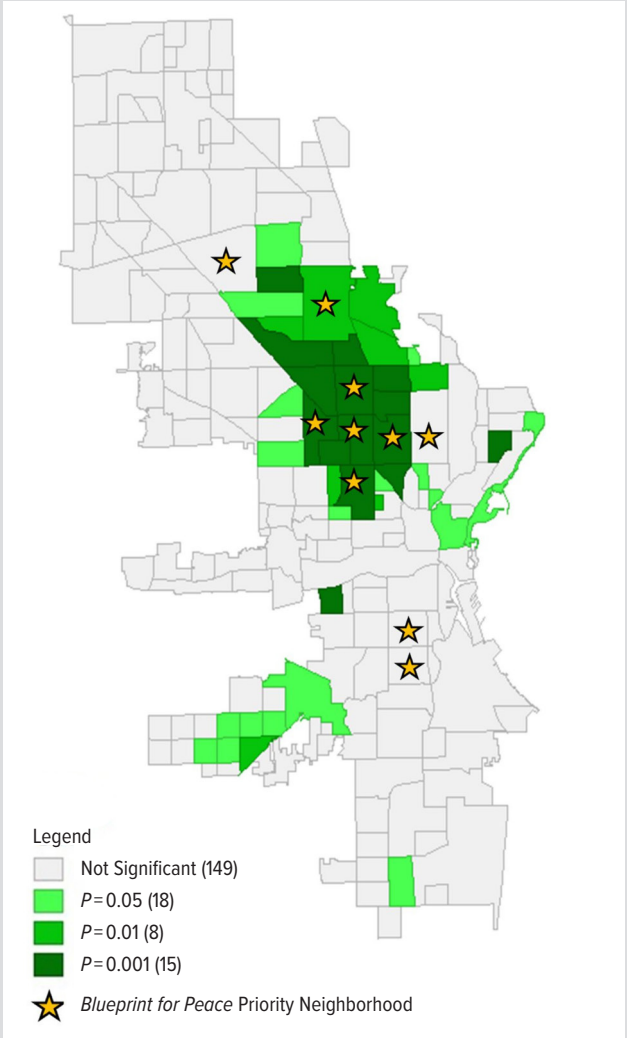
At the neighborhood level, after just its first year, 414LIFE is significantly reaching over half of the priority neighborhoods.

Figure 3. Statistically Significant Clustering of Number of 414LIFE Referrals by Neighborhood From the Local Moran's *I* Test.



Note: A "high" area indicates a neighborhood with a high number of referrals due to a violent injury occurring in this neighborhood. That area is located next to a neighborhood with high or low volume of referrals. A "low" area indicates a neighborhood with a low number of referrals located next to either a neighborhood of high or low referrals.

Figure 4. The Level of Statistical Significance for the Clusters Revealed From the Local Moran's *I* Test



One meta-analysis on program implementation found that positive outcomes resulted in programs with 60% implementation and that very few achieved greater than 80%.[14] Though the meta-analysis focused on reach in a nongeospatial sense and the work evaluated prevention and health programming for children and adolescents, the results can be extrapolated to similar adult programming. It also offers an opportunity to reconsider the operational definition of reach to extend beyond quantified numbers of participants and to begin to consider the geospatial location of violence. With respect to this benchmark, 414LIFE's reach is considered meaningful as substantiated by the presence of statistically significant clustering in 60% of priority neighborhoods and 50% carrying the highest neighborhood referral case load. This provides a benchmark for future expansion in subsequent years.

The current study provides both a benchmark and novel analytical approach for other Cure Violence programs looking to geographically evaluate program implementation. This expands upon the utilization of GIS technology from previous work by supporting the novel use of geography as a type of implementation metric for reach that can visualize and analyze willingness to engage at the individual level (number of referrals) and buy-in at the community level (neighborhoods with most referrals). Past literature has documented referral counts by a geographical unit, like neighborhood or ZIP code, without testing for statistical significance and sometimes without visualization.[9,25] By assessing statistical significance, we were able to determine which of our priority neighborhoods were well reached and which need increased access to the program.

A limitation to this work is that the program is in its infancy, and while priority neighborhoods were predetermined, geographic trends may change over time as more referrals are placed or as violence patterns shift in the community. For instance, trends in violence have changed due to the COVID-19 pandemic disrup-

tion to local social networks.[25,26] Future work should investigate the unintended consequence of home quarantining in placing some individuals at greater risk for domestic violence with possible accompanying gun violence.

Results of this project have been presented to the City of Milwaukee Health Department, 414LIFE team, and trauma center partners and stakeholders to guide further program implementation. Future work should examine program reach over time now that this geospatial baseline has been established. Once the time has been dedicated to the initial setup of a map for a program's target catchment area, GIS technologies and programs offer a systematic and time efficient way to reproduce maps over time. Maps are vital for tracking the landscape of violence over time within communities.

Other implementation metrics, such as dosage (ie, number of interventions, patient contacts, community outreach events, conflict mediations), fidelity (ie, to what degree 414LIFE adheres to the Cure Violence model versus necessary deviation to adapt to local context), and outputs (ie, what data points are being collected on both the hospital- and community-side and how is the process standardized and grown) could provide data on program effectiveness.[9,14,15] Likewise, longitudinal clinical data as well as city criminal charges could assess community-level, long-term programmatic impact on health outcomes and violence recidivism following program engagement.

CONCLUSIONS

Overall, this work offers an additional interpretation of the implementation metric of "reach" and presents a local adaption of Cure Violence for consideration in other cities looking to partner with trauma centers to comprehensively address the public health crisis of gun violence. 414LIFE successfully reaches its intended population and geographic locations. Geospatial reach should be considered routinely in program evaluations of Cure Violence programs to track growth and reach over time.

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Appendix: Available at www.wmjonline.org

REFERENCES

1. Fowler KA, Dahlberg LL, Haileyesus T, Annest JL. Firearm injuries in the United States. *Prev Med*. 2015;79:5-14. doi:10.1016/j.ypmed.2015.06.002

2. Peek-Asa C, Butcher B, Cavanaugh JE. Cost of hospitalization for firearm injuries by firearm type, intent, and payer in the United States. *Inj Epidemiol.* 2017;4(1):20. doi:10.1186/s40621-017-0120-0

3. Richmond TS, Wiebe DJ, Reilly PM, Rich J, Shults J, Kassam-Adams N. Contributors to postinjury mental health in urban Black men with serious injuries. *JAMA Surg.* 2019;154(9):836-843. doi:10.1001/jamasurg.2019.1622

4. deRoon-Cassini TA, Mancini AD, Rusch MD, Bonanno GA. Psychopathology and resilience following traumatic injury: a latent growth mixture model analysis. *Rehabil Psychol.* 2010;55(1):1-11. doi:10.1037/a0018601

5. McGonigal MD, Cole J, Schwab CW, Kauder DR, Rotondo MF, Angood PB. Urban firearm deaths: a five-year perspective. *J Trauma.* 1993;35(4):532-537.

6. Slutkin G. Violence is a contagious disease. In: Patel DM, Simon MA, Taylor RM; Forum on Global Violence Prevention Board on Global Health, eds. Contagion of Violence: Workshop Summary. Institute of Medicine/National Research Council; 2013:94-111. Accessed April 6, 2021. https://www.ncbi.nlm.nih.gov/books/NBK207245/

7. Tracy M, Braga AA, Papachristos AV. The transmission of gun and other weapon-involved violence within social networks. *Epidemiol Rev.* 2016;38(1):70-86. doi:10.1093/epirev/mxv009

8. Slutkin G, Ransford C. Violence is a contagious disease: theory and practice in the USA and abroad. In: Siegler M, Rogers S Jr, eds. *Violence, Trauma, and Trauma Surgery*. Springer; 2020:67-85.

9. Webster DW, Whitehill JM, Vernick JS, Curriero FC. Effects of Baltimore's Safe Streets program on gun violence: a replication of Chicago's CeaseFire program. *J Urban Health*. 2013;90(1):27-40. doi:10.1007/s11524-012-9731-5

10. Delgado SA, Alsabahi L, Wolff K, Alexander N, Cobar P, Butts JA. *The Effects of Cure Violence in the South Bronx and East New York, Brooklyn*. Research and Evaluation Center at John Jay College of Criminal Justice, City University of New York; 2017. Accessed April 30, 2021. https://academicworks.cuny.edu/jj_pubs/417/

11. Mullins CW, Wright R, Jacobs BA. Gender, streetlife and criminal retaliation. *Criminology*. 2004;42(4):911-940.

12. Smith R, Evans A, Adams C, Cocanour C, Dicker R. Passing the torch: evaluating exportability of a violence intervention program. *Am J Surg.* 2013;206(2):223-228. doi:10.1016/j.amjsurg.2012.11.025

13. 414LIFE: Milwaukee Blueprint for Peace. City of Milwaukee. Accessed July 18, 2019. https://city.milwaukee.gov/414Life/Blueprint

14. Durlak JA, DuPre EP. Implementation matters: a review of research on the influence of implementation on program outcomes and the factors affecting implementation. *Am J Community Psychol*. 2008;41(3-4):327-350. doi:10.1007/s10464-008-9165-0

15. Massetti GM, Holland KM, Gorman-Smith D. Implementation measurement for evidence-based violence prevention programs in communities. *J Community Health.* 2016;41(4):881-894. doi:10.1007/s10900-016-0156-z

16. Kim DY, Phillips SW. When COVID-19 and guns meet: a rise in shootings. *J Crim Justice*. 2021;73:101783. doi:10.1016/j.jcrimjus.2021.101783

17. The Evidence on Effectiveness. CURE Violence website. Updated 2011-2019. Accessed July 10, 2019. https://cvg.org/impact/

18. Ransford C, Decker RB, Slutkin G. *Report on the Cure Violence Model Adaptation in San Pedro Sula, Honduras*. Cure Violence, University of Illinois at Chicago School of Public Health; November 2016. Accessed June 15, 2020. https://cvg.org/wp-content/uploads/2023/08/Report-on-the-Cure-Violence-Adaptation-in-San-Pedro-Sul.pdf

19. Phalen P, Bridgeford E, Gant L, Kivisto A, Ray B, Fitzgerald S. Baltimore Ceasefire 365: estimated impact of a recurring community-led ceasefire on gun violence. *Am J Public Health*. 2020;110(4):554-559. doi:10.2105/AJPH.2019.305513

20. Newgard CD, Sanchez BJ, Bulger EM, et al. A geospatial analysis of severe firearm injuries compared to other injury mechanisms: event characteristics, location, timing, and outcomes. *Acad Emerg Med*. 2016;23(5):554-565. doi:10.1111/acem.12930

21. Haas B, Doumouras AG, Gomez D, et al. Close to home: an analysis of the relationship between location of residence and location of injury. *J Trauma Acute Care Surg*. 2015;78(4):860-865. doi:10.1097/TA.0000000000000595

22. Murray AT, Shyy TK. Integrating attribute and space characteristics in choropleth display and spatial data mining. *Int J Geogr Inf Sci*. 2000;14(7):649-667. doi:10.1080/136588100424954

23. Homicide and nonfatal shooting dashboards. Milwaukee Homicide Review Commission. Updated 2021. Accessed April 30, 2021. https://www.mcw.edu/departments/epidemiology/research/milwaukee-homicide-review-commission/reports/dashboards

24. Sims DW, Bivins BA, Obeid FN, Horst HM, Sorensen VJ, Fath JJ. Urban trauma: a chronic recurrent disease. *J Trauma.* 1989;29(7):940-947.

25. Kofman YB, Garfin DR. Home is not always a haven: the domestic violence crisis amid the COVID-19 pandemic. *Psychol Trauma*. 2020;12(S1):S199-S201. doi:10.1037/tra0000866

26. Gauthier GR, Smith JA, García C, Garcia MA, Thomas PA. Exacerbating inequalities: Social networks, racial/ethnic disparities, and the COVID-19 pandemic in the United States. *J Gerontol B Psychol Sci Soc Sci*. 2021;76(3):e88-e92. doi:10.1093/geronb/gbaa117

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