




# Social deprivation, the Area Deprivation Index, and emergency department utilization within a community-based primary and preventive care program at a Florida medical school

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## Abstract

**Introduction** Higher Area Deprivation Index (ADI) scores, indicating higher social deprivation, have been associated with more frequent emergency department (ED) utilization. Access to clinical and social services can help prevent inappropriate ED use. A community-based medical school administering a primary and preventive care program focused on the social determinants of health (SDOH) tracks annual ED utilization by its households. This retrospective study determined household ADI scores and evaluated for associations with ED use.

**Methods** The ADI uses 17 publicly available variables to assign composite scores of social deprivation at the block group level. The Green Family Foundation Neighborhood Health Education Learning Program at Florida International University provides outreach, clinical, and educational services to > 850 disadvantaged households. We conducted Poisson regression to evaluate the association between households' ADI scores and self-reported ED utilization over 2 calendar years.

**Results** For both the 2018 and 2019 cohorts, independent Poisson regression results indicate that ED visit count is significantly and inversely associated with ADI raw scores and deciles ( $p < 0.001$ ).

**Discussion** Based on findings from earlier studies, we had hypothesized a positive, yet reduced association between annual ED utilization and ADI level but surprisingly, we found an inverse association. The combination of providing primary care and connecting with social and behavioral health services as needed appeared to reverse the expected higher ED use at higher ADI scores.

**Conclusion** Tracking of ED utilization in association with composite, area-based indices such as the ADI may prove useful for other clinical and community health endeavors focused on SDOH.

**Keywords** Emergency department utilization · Primary care · Retrospective studies · Social deprivation · Area deprivation index

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## Introduction

Inappropriate emergency department (ED) utilization has contributed to overcrowded emergency rooms and rising healthcare costs, leading this issue to become a growing topic of concern (Krieg et al. 2016; Sun et al. 2003; Wesson et al. 2018). A small portion of the overall population, namely those from vulnerable populations, accounts for a disproportionate number of ED visits (Krieg et al. 2016; Sun et al. 2003). The association between ED utilization and social determinants of health (SDOH) including income level, housing status, and educational achievement has been well-established (Kangovi et al. 2013; Soto Mas et al. 2019; Sun et al. 2003; Wesson et al. 2018). However, given the multifactorial nature of frequent and potentially preventable ED utilization, the impacts that socioeconomic disadvantage and social risk have as contributors may be better captured with a composite, area-based index such as the Area Deprivation Index (ADI) (About the Area Deprivation Index 2022).

Originally extrapolated from long-form census data by the US Department of Health and Human Services, the ADI is a composite, weighted score of 17 factors including educational achievement, employment status, housing stability, and poverty. A team at the University of Wisconsin–Madison School of Medicine and Public Health has subsequently modified the ADI score to develop the Neighborhood Atlas, a website capable of generating an ADI score, from a household address, narrowed down to the block group level (2022). The ADI has been used as a tool to inform other area-based efforts to improve population health (Durfey et al. 2019; Knighton et al. 2016). Researchers in Texas and New Mexico have shown that strategies targeting SDOH and providing upstream interventions reduce ED utilization in vulnerable populations (Soto Mas et al. 2019; Wesson et al. 2018).

Within the context of service-learning educational curricula for health-profession students, our institution has developed a novel community-based primary, behavioral health, and preventive care program, aimed at addressing the SDOH faced by households in target neighborhoods. Since 2009, the Green Family Foundation Neighborhood Health Education and Learning Program (Neighborhood-HELP) of the Florida International University Herbert Wertheim College of Medicine (FIU HWCOC) has served households in disadvantaged communities within Miami-Dade County (Greer et al. 2018; Stumbar et al. 2020). Prior to this retrospective study, however, the program has not systematically analyzed the patterns of self-reported annual ED utilization among participants in relation to a composite, area-based index of social deprivation like the ADI score.

We expected ED utilization rates of our households to increase with higher levels of deprivation, based on established patterns of ED utilization by ADI score as reported in the literature (Carlson et al. 2021). We hypothesized that enrollment in NeighborhoodHELP would mitigate the anticipated ED utilization amongst our study population, blunting the expected association of increased self-reported ED use by households at higher ADI scores and ADI deciles.

## Methods

### The area deprivation index (ADI)

The ADI uses 17 variables available from the United States Census' American Community Survey (ACS) in the domains of education, income/employment, housing, and household characteristics (Maroko et al. 2016). The index was originally created by Singh and colleagues at the US Health Resources and Services Administration using data from the 1990 Census to examine area deprivation and widening inequalities in US mortality (Singh 2003). The ADI shares the same limitations as the Census and the ACS, including limited accounting for undocumented immigrant populations. It has, nevertheless, been refined and continuously updated by researchers at the University of Wisconsin Applied Population Laboratory (Kind and Buckingham 2018), and the updated index has been validated for a range of disease domains and health outcomes at the neighborhood level (Kind et al. 2014; Lantos et al. 2018). Since its conception, the ADI has been validated as an indicator to show neighborhood-level disadvantage in the United States and as a research tool with correlations between poor health outcomes, mortality, and hospital readmission (Durfey et al. 2019; Kind et al. 2014). Kind and colleagues at the University of Wisconsin, who currently maintain and update the index, report: "Multiple academic, health system, and state and federal collaborators are already using the Neighborhood Atlas and the granular data it contains to inform research, outreach, and policy" (Kind and Buckingham 2018).

More recently, ADI scores have been associated with increased ED utilization and preventable acute care utilization (Carlson et al. 2021). Other deprivation indices, used internationally, have shown similar correlations of social deprivation with non-urgent ED utilization and with use of the ED by populations with chronic illnesses such as diabetes (Barbadoro et al. 2015; Fleury et al. 2019). Deprivation indices have also been correlated with the burden of multiple chronic illnesses and with ED use for acute illnesses such as influenza or flu-like syndromes (Hull et al. 2018; Martin et al. 2020). Overall, these studies show a pattern of higher ED utilization by households in

geographic areas of higher levels of deprivation. Our team generated and analyzed the 2018 and 2019 ADI scores for enrolled NeighborhoodHELP households and tested the association between these values with the households' self-reported ED utilization in calendar years 2018 and 2019.

### Green Family Foundation Neighborhood Health Education and Learning Program

Through the collaboration of interprofessional teams, NeighborhoodHELP offers services including health education and coaching, free medical care through mobile health centers, social work, legal assistance, and behavioral health services. The program includes three major components: outreach, clinical, and curricular (Garba et al. 2021). The outreach team recruits and enrolls households, manages partnerships with community organizations, and regularly maintains contact with all households. During recruitment, outreach workers describe the program and its various components, and emphasize that households will be expected to receive interprofessional teams during home visits. Outreach team members are assigned to each household enrolled in the program and regularly communicate with their respective household members (Greer et al. 2018). Through these regular communications, outreach staff track various indicators of SDOH and healthcare utilization, including ED visits. These are entered into an online portal for other members of the interdisciplinary team to monitor. The clinical team provides full-service primary care on mobile health centers to uninsured program enrollees, about 1/3 of the total program participants. The curricular component, which reaches approximately 40% of all households, involves interprofessional teams of students, supervised by faculty, conducting home visits. These visits occur, on average, 3 times a year per household and include health education, health coaching, and care navigation.

NeighborhoodHELP currently serves over 850 households and works with a network of 150 community partners including faith-based organizations, daycare centers, public schools, assisted living facilities, recreational facilities, municipalities, and other social service providers (Garba et al. 2021). Through its interprofessional framework, the program addresses the complex medical, legal, social, and behavioral issues and inequities in care that exist in the neighborhoods served. NeighborhoodHELP household members are eligible to receive free primary and preventive healthcare through grant-supported mobile health centers. If further care is necessary, members are assisted and guided in connecting with community partners to receive the appropriate care.

### Study design

We performed a retrospective review of all households enrolled in NeighborhoodHELP as of the date of Institutional Review Board approval in February 2020. A total of 851 households were included in the study with, on average, 2.3 household members each. As part of the outreach component of NeighborhoodHELP, each household is asked about ED utilization. We obtained the self-reported ED utilization data for the years 2018 and 2019 as well as each household's address. Each address was entered into ArcGIS 10.1 (Environmental Systems Research Institute; Redlands, CA., USA) both to generate a geographic identifier (GeoID) and to match each household with its respective census block group.

ADI scores for each census block group in Miami-Dade County were generated from the Neighborhood Atlas (2022). The scores used were based on the 2011–2015 American Community Survey which was the most recent data available. We included decile rankings of ADI scores in our analysis (2022). We further calculated average annual self-reported ED utilization by decile and compared ED utilization averages by decile as reported in the work of Carlson et al. (Carlson et al. 2021).

### Statistical analysis

Using these data, we conducted a Poisson regression to evaluate the association between ADI scores and ED utilization. Because we sought to model count data and assumed our outcome (self-reported ED utilization) followed a Poisson distribution, Poisson regression was selected for primary analyses. Analyses for 2018 and 2019 were conducted at the census block group level using ED utilization per household and ADI scores for each census block group. Generalized linear model (GLM) statistics, including log-likelihood and deviance, were used to compute 95% confidence intervals and significance levels. Python and R software were used for all statistical analyses with a significance value set at  $p < 0.05$ .

### Results

Of the 851 households enrolled in the program at the time of this study, our outreach team was able to collect ED utilization data on 491 (57.7%) and 788 (92.6%) of households in 2018 and 2019 respectively (Table 1). The minimum raw ADI score reported in 2018 and 2019 was 0, and the maximum ADI score reported in both cohorts was 100 (Fig. 1). Higher ADI scores represent higher levels of deprivation. The mean ADI score in 2018 was 58.3, while the mean ADI score in 2019 was slightly lower at 54.9 (Fig. 1). Across all

**Table 1** Self-reported household emergency department utilization in 2018 and 2019

	2018 cohort ( <i>n</i> = 851)	2019 cohort ( <i>n</i> = 851)
Response recorded	491 (57.7%)	788 (92.6%)
Number of ED visits	63	58
Zero	459	745
One	24	34
Two	5	8
Three	2	1
Four	0	0
Five	1	0

responding households, there were 63 ED visits reported in 2018 and 58 ED visits reported in 2019 (Table 1). The greatest number of ED visits reported by any household was five in 2018 and three in 2019; however, most households reported no ED visits in 2018 and 2019 (93.5% and 94.5% respectively).

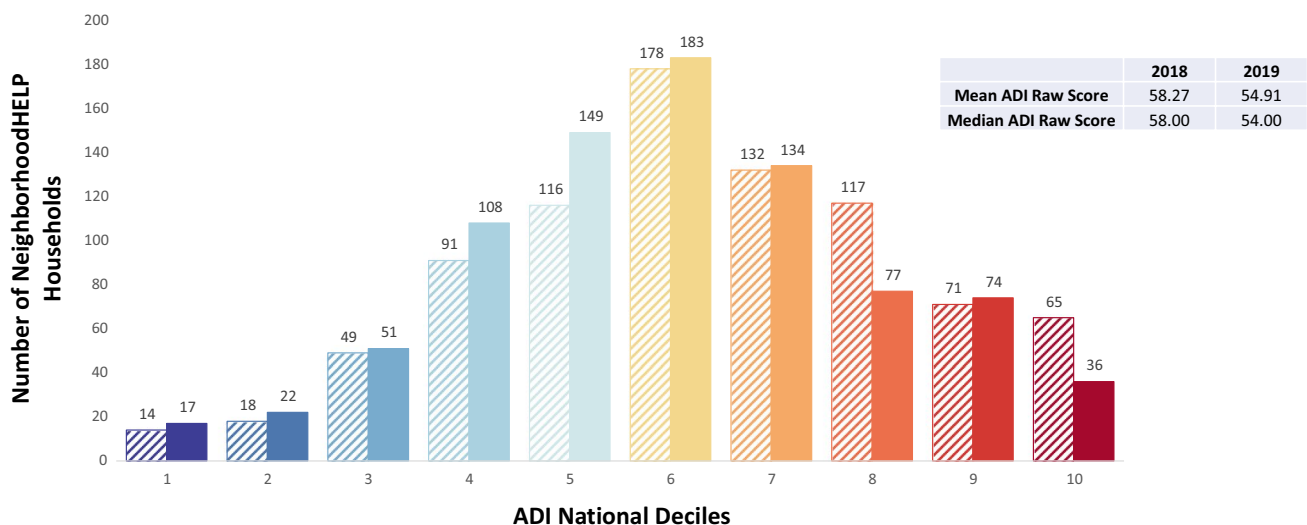
When looking at only those households for whom we had self-reported annual ED use, the pattern of ADI scores was similar although not identical. In 2018, the mean ADI score was 59.4 and the median was 59, for the 491 households included. In 2019, the mean ADI score was 55.04 and the median was 54, for the 788 households included (Fig. 2). Figure 3 illustrates the average numbers of self-reported ED utilization by ADI deciles for the 2018 and 2019 cohorts.

For the 2018 cohort, independent Poisson regression results indicate that ED visit count is significantly and inversely associated with ADI raw scores ( $z = -14.9$ ,  $p < 0.001$ ) and ADI deciles ( $z = -12.7$ ,  $p < 0.001$ ) (Table 2).

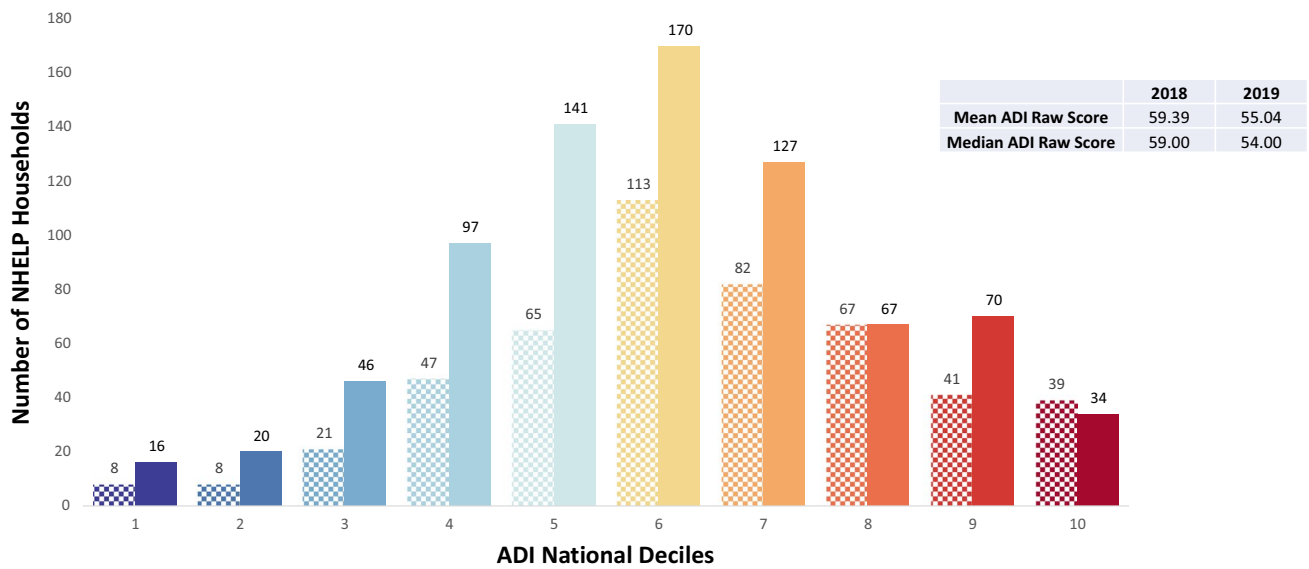
Regression coefficients for the subsequent cohort are comparatively smaller across all measures, suggesting a slightly stronger inverse association between ED visits and ADI scores for that particular year. In 2019, ED visit count is significantly associated with national ADI scores ( $z = -18.1$ ,  $p < 0.001$ ) and ADI deciles ( $z = -15.4$ ,  $p < 0.001$ ) (Table 2). In other words, NeighborhoodHELP participants from geographic areas of less deprivation, as indicated by lower ADI scores, are more likely to utilize the ED.

## Discussion

With NeighborhoodHELP's major emphasis on SDOH and on assisting households with social needs, we had hypothesized a weaker association between annual ED utilization and ADI level as seen in other studies, with plateauing of the association. Surprisingly, in our analysis, we found that ADI scores had statistically significant, though inverse, associations with reported ED utilization. These results contradict existing literature that has shown significantly positive associations between ADI (and social deprivation in general) and care utilization in urgent and emergent care settings (Carlson et al. 2021; Davies et al. 2017; ASPE Reports 2021; Wesson et al. 2018). Given the well-established impacts that SDOH have on overall health and access to care, we aimed to establish a threshold ADI decile at which households were at a higher risk for ED utilization. In a large study in the Boston area, Carlson et al. have shown an inflection point at approximately the seventh ADI decile, where individuals tend to frequent the ED at notably higher rates (Carlson et al. 2021) (See Fig. 4.) We were unable to determine an inflection point in our study. This result is likely multifactorial, in part due to



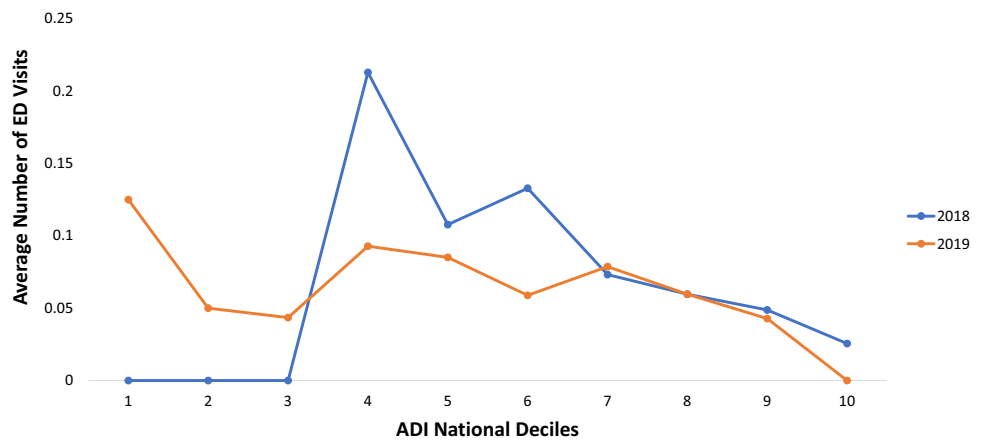
**Fig. 1** Histogram of ADI deciles for all households ( $N = 851$ ) 2018 & 2019. Key: Hashed bars indicate number of households in that decile by 2018 ADI score. Solid bars indicate number of households in that decile by 2019 ADI score



**Fig. 2** Histogram of ADI deciles for households for which self-reported ED utilization was available in 2018 ( $n = 491$ ) & 2019 ( $n = 788$ ). Key: Hashed bars indicate number of households in that

decile by 2018 ADI score. Solid bars indicate number of households in that decile by 2019 ADI score

**Fig. 3** Average number of self-reported ED visits by ADI decile 2018 & 2019



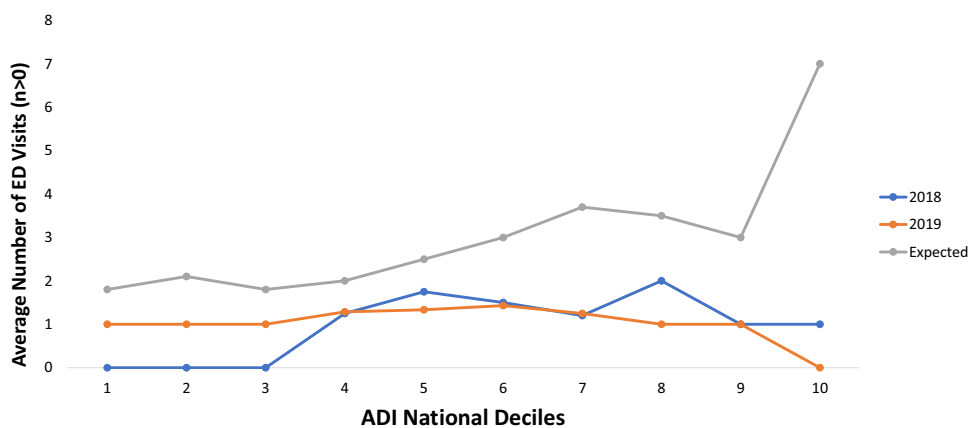
**Table 2** Poisson regression analysis of ADI scores and deciles and self-reported ED utilization 2018 & 2019

		Z-score	Coefficient	95% CI	P-value
2018 ( $n = 491$ )	ADI scores	-14.907	-0.042	-0.047, -0.036	< 0.001
	ADI deciles	-12.707	-0.527	-0.609, -0.446	< 0.001
2019 ( $n = 788$ )	ADI scores	-18.104	-0.052	-0.057, -0.046	< 0.001
	ADI deciles	-5.401	-0.618	-0.697, -0.539	< 0.001

a smaller dataset, in addition to NeighborhoodHELP itself serving to mitigate factors leading to ED utilization.

The clinical arm of NeighborhoodHELP, by providing full-service primary care to the uninsured in approximately 1/3 of our households, may be one significant mitigating factor. Coster et al. and Kangovi et al. have found that lack of access to primary care or an alternative form of care, as well as perceived quality of care, were key factors influencing the use of the ED for low-acuity or non-emergent reasons (Coster et al. 2017; Kangovi et al. 2013). Furthermore, a growing body of literature suggests that social programs, community partnerships, and increasing access to primary care within communities mitigate the SDOH, improve health, and decrease ED utilization (Daniel et al. 2018; Knighton et al. 2016; Smith-Campbell 2005; Weinick et al. 2010; Wesson et al. 2018). Wesson et al. implemented a program to address

**Fig. 4** Adjusted average number of ED visits by ADI decile including households reporting at least one annual ED visit 2018 & 2019. Deciles with an indicated average of “0” have no households with any ED visits that year. “Expected” averages derived from the averages reported by Carlson et al. 2021



SDOH that consisted of wellness services and access to a primary care clinic, regardless of ability to pay. They found a significant reduction in ED use and inpatient care visits among those utilizing the program (Wesson et al. 2018). Knighton et al. employed ADI scores in multiple settings, and found that ADI score was a significant incremental risk factor in identifying high-risk patients who would thus benefit from enhanced care management services (Knighton et al. 2016). The Innovation Center’s Accountable Health Communities Model was established in 2017 and aims to link Medicare and Medicaid beneficiaries to resources within the community that address their social needs, to improve health and reduce ED visits (ASPE Reports 2021). Preliminary data released in 2020 showed a 9-percent decrease in ED visits for Medicare beneficiaries who were provided access to community resources working to address their health-related social needs [Accountable Health Communities (AHC) 2020].

NeighborhoodHELP explicitly provides a targeted, team-oriented approach to care, focused on identifying and addressing the needs experienced by a household that may impact their health outcomes (Garba et al. 2021; Greer et al. 2018). The social needs addressed include employment, housing, access to healthcare, transportation, and education, among others — many of which are measured in the ADI. As mentioned above, the program utilizes three major branches: outreach, clinical, and curricular. Collectively, these interconnected teams remain in contact with each other and with their assigned household at least monthly, allowing for continuity of care, a means to triage household needs, and an easily accessible outlet for household members to ask questions.

The comprehensive nature of NeighborhoodHELP probably serves as a mitigating factor to ED use in our study population, leading to results contrary to those previously reported on ADI and ED use (Carlson et al. 2021). Through increased access to primary and preventive services in addition to a robust network of community resources to address

social needs, our program directly intervenes on known drivers influencing ED visits (Coster et al. 2017; Kangovi et al. 2013). Additionally, ED utilization for mental health-related conditions has increased in the past decade with research showing that individuals living in areas with high social or material deprivation are more likely to use the ED for mental health conditions than for a physical health problem (Fleury et al. 2019; Theriault et al. 2020). Gentil et al. (2020) found increasing access to outreach programs for those suffering from acute mental health disorders can decrease ED visits. Behavioral health support is available to our household members and the use of these resources may be another reason ED use is lower among our study population.

Our findings add to the growing literature showing the importance of specific community-responsive primary care efforts to help mitigate excessive ED utilization in vulnerable communities. They also support using a combination of patient-specific and population level data to guide decision-making. As Hull and colleagues have shown in a similarly sized retrospective cohort study in London, the burden of multiple morbidities was most predictive of annual ED utilization among their general practice patients. High levels of multiple morbidities were associated with levels of social deprivation. They found that access to primary care alone did not mitigate ED utilization but that multidimensional approaches, attentive to levels of disease burden and social deprivation, could potentially do so (Hull et al. 2018). The data shown here for this paper probably reflect such an effect on ED utilization among all our households, over the time of enrollment in the program. While NeighborhoodHELP does not eliminate the enduring health effects of social deprivation, it seems to blunt the use of the emergency department for primary care, across all ADI levels, perhaps even more so at higher levels of deprivation.

While interpreting the data presented, it is important to recognize several limitations. Since our analysis relies on self-reported ED utilization responses, self-report bias may be present and the number of ED visits for the years in

question may not be entirely accurate. Additionally, we were unable to determine a threshold or inflection point at which households become at-risk for preventable ED use. While we speculate this is due to our limited dataset, this could also be due to the nature of our program, which has been shown to mitigate ED use, as discussed earlier. In addition, the ADI relies on Census data which provides limited data on undocumented immigrants and other marginalized communities that may not be captured in public reporting measures, and our study population has households that match this description (Kind and Buckingham 2018).

A perhaps more significant limitation involves the potential of confounders specific to NeighborhoodHELP that might limit the generalizability of our results. It is unclear how comparable our results might be should a similar analysis be conducted in other settings. We have reason to believe that our intervention has relevance to other underserved populations. Several studies, for example, have utilized ADI scores as indicators of socioeconomic disadvantage and looked for associations with hospital readmission for common medical conditions. A national study conducted by Kind and associates looked at Medicare data on patients admitted to the hospital with congestive heart failure, pneumonia, or myocardial infarction. Those patients from the most disadvantaged 15% of neighborhoods, even after adjusting for other health conditions and age, had a 9% increased risk of being readmitted to the hospital within 30 days after discharge (Kind et al. 2014). A similar study in Maryland, which has a robust statewide hospital-by-hospital tracking system in place, looked at all patients discharged from a hospital in the state in 2015. Patients living in a neighborhood at the 90th percentile of disadvantage, as indicated by ADI score, had a 12.8% higher likelihood of being readmitted to the hospital within 30 days, as compared to patients from neighborhoods at the 10th percentile (Jencks et al. 2019). Looking at a single urban area, Hu and colleagues at a Detroit teaching hospital found that patients living in the most disadvantaged neighborhoods, as indicated by ADI score, were 70% more likely to be readmitted to the hospital than their counterparts from less disadvantaged geographic areas (Hu et al. 2018). Other nationwide studies have shown strong associations with levels of deprivation and 30-day re-observation, and especially chronic re-observation, for Medicare beneficiaries (Rahman et al. 2020; Sheehy et al. 2020). These studies cumulatively suggest that neighborhood disadvantage shapes the care that patients receive and their outcomes, at least as indicated by hospital readmission and re-observation, in many settings across the United States.

To our knowledge, no other program similar to ours--focused on the social determinants of health, health education, and care navigation--has looked at impacts on care utilization or other outcomes such as hospital readmission

in conjunction with an area-level index of disadvantage. We believe NeighborhoodHELP represents the first immersive health care and social service coordination program to use the ADI as part of its efforts to reduce unnecessary ED utilization. Separate from NeighborhoodHELP, health systems throughout the country are developing programs to harness the information obtained by indices such as the ADI to target areas of high deprivation in ways that yield the largest impacts on health outcomes. There are now several examples of large academic health systems and state public insurance payers using the ADI to help create systems to identify and address patients' social needs, showing the critical future role that ADI can have in our health care system (Fahrenbach et al. 2020; Mensah and Riley 2021; Yan et al. 2021).

In future studies, we plan to partner with a major hospital system to cross-reference and verify reported ED utilization by our households with the hospital's ED records to address the self-reporting bias. We also plan to use data concerning the length of enrollment in NeighborhoodHELP for each household to investigate the effects of the length of enrollment in the program with ED utilization for this study population. Similarly, we aim to detail the level of and nature of the different interactions with NeighborhoodHELP by household, looking for especially effective interventions or patterns of intervention that might lead to fewer ED visits. To better characterize the impact NeighborhoodHELP and similar programs have on communities, we aim to compare the ADI deciles and ED utilization of those within our program with those within the ED's geographic catchment area but who are not enrolled in NeighborhoodHELP. As well, within our established program, we plan to longitudinally track ED utilization of our households by ADI decile to establish an at-risk threshold that can serve as an inflection point at which other management efforts or social programming can be implemented to further curb preventable ED utilization. These analyses can lay the groundwork for future research looking at other outcomes such as hospital admission, re-admission, observation, and re-observation.

## Conclusion

A novel community-based primary and preventive care program aimed at addressing the SDOH helps mitigate expected annual emergency department utilization among households at higher levels of social deprivation as indicated by the Area Deprivation Index. A systematic analysis of the patterns of self-reported annual ED utilization among program participants in 2018 and 2019 in association with ADI scores and ADI deciles yielded a surprising negative association with higher levels of deprivation. We conclude that enrollment in NeighborhoodHELP not only mitigated the anticipated ED utilization amongst our study population

but also reversed the increased use of the ED expected for households at higher ADI scores and ADI deciles. Our team will pursue further analysis to confirm the reported ED utilization by households, and attempt to identify crucial factors of the program that blunt the effects of social deprivation on emergency health care use. Measuring and tracking ED utilization in association with composite, area-based indices such as the ADI may prove useful for other primary and population health endeavors focused on the social determinants of health.

**Author contributions** All authors contributed to the study conception and design. Data collection and analysis were performed by Jamie Fairclough, Anuj Ojha, Prasad Bhoite, and Gregory W. Schneider. Background research and material preparation were performed by Mackenzie Mayhew, Alexa Denton, Anna Kenney, Matthew Hey, Shahab Shaffiey, Rupa Seetharamaiah, and Gregory W. Schneider. The first draft of the manuscript was written by Mackenzie Mayhew. The final draft of the manuscript was written by Gregory W. Schneider, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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**Data availability** The data that support the findings of this study are available from the corresponding author upon request.

**Code availability** Not applicable

## Declarations

**Ethics approval** The study received IRB approval through expedited review from the Florida International University Institutional Review Board, protocol number IRB-20-0351.

**Consent to participate** Not applicable

**Consent for publication** Not applicable

**Conflicts of interest/competing interests** The authors have no relevant financial or non-financial interests to disclose.

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