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ORIGINAL PAPER

Are We Serving the Most At-Risk Communities? Examining the Reach of a South Carolina Home Visiting Program

Elizabeth Radcliff[1] · Charity B. Breneman[1] · Elizabeth Crouch[1] · Icelynn Baldwin[2]

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Abstract
In addition to individual-level characteristics, characteristics of the social and physical environments in which individuals reside may adversely impact health outcomes. Careful attention to the role of "place" can result in programs that successfully deliver services to those most at risk. This retrospective, cross-sectional study used geocoded residential addresses from 3090 households enrolled in a South Carolina (SC) home visiting program, 2013–2016, and corresponding years of data for maternal and child health outcomes obtained from vital records data. ZIP Code Tabulation Areas (ZCTAs) served as the primary geographic unit of analysis. ZCTAS with high volumes of birth or adverse maternal and child health outcomes for any of 10 indicators were flagged. Distribution of enrolled households across highest-risk ZCTAs was calculated. Of 379 ZCTAS with reported data, 152 had 8 or more risk flags. Of the 152 highest-risk ZCTAs, 33 also had high birth volumes. Fifty-seven of the 152 highest-risk ZCTAs had no enrollees; seven of the 33 highest-risk/highest-volume ZCTAS had no enrollees. Service delivery gaps existed despite a statewide, county-level needs assessment conducted prior to program implementation. This study suggests methods to identify service areas of need, as an ongoing effort toward program improvement.

Keywords Program reach · Geographic information systems · GIS · Home visiting

Introduction

The federally-funded Maternal, Infant, and Early Childhood Home Visiting (MIECHV) program provides evidence-based home visiting programs for at-risk mothers and families across the United States [1]. The aims of the MIECHV program include improving maternal and child health, improving child development and early learning, reducing child maltreatment, and increasing family self-sufficiency [1]. These evidence-based programs have been shown to be effective in improving the lives of children, mothers, and families [1]. Home visiting also provides a societal return on investment in terms of reduced spending in areas related to healthcare, child protective services, and special education [2–4]. To identify families most likely to benefit from these services, MIECHV named eight legislatively-specified populations for enrollment including young mothers; families with low incomes; a history of child maltreatment or substance abuse; families with low student achievement; developmental delays or disabilities; and families that include a member of the Armed Forces [5].

However, health behaviors and health outcomes may be contingent not just on individual characteristics or risk factors, but also on characteristics of the social and physical environments in which an individual resides [6, 7]. Thus, in order to identify the most at-risk populations and communities and to inform placement of the original implementing sites, the federal MIECHV program required state awardees to conduct a state-wide, county-level needs assessment at program initiation to determine geographic areas of need. Assessing social determinants and the role of "place" has thus become an important component in understanding and addressing health outcomes [8–13]. Differences in childhood outcomes, for example stillbirths, preterm births, infants born at a low birth weight, childhood lead poisoning, and oral health status, have all been associated with differences in characteristics of their geographic location [14–18]. Identifying not only individuals or families with certain risk

✉ Elizabeth Radcliff
radclife@mailbox.sc.edu

[1] Rural and Minority Health Research Center, Department of Health Services Policy and Management, Arnold School of Public Health, University of South Carolina, Columbia, SC, USA

[2] Children's Trust of South Carolina, Columbia, SC, USA

factors for poor maternal and child health outcomes, but also identifying specific communities at risk is thus important to the successful delivery of the MIECHV program.

Identifying at-risk communities is particularly important in a largely minority and rural state such as South Carolina (SC) [19]. In 2010, a needs assessment for the SC MIECHV program was conducted by the SC Department of Health and Environmental Control (DHEC) to determine counties most vulnerable and appropriate for these new home visiting programs [20]. The needs assessment evaluated counties based on volume of live births per year and on historic county-level characteristics including selected maternal and child health outcomes, rates of poverty, and educational attainment [20].

Following the 2010 needs assessment, the SC MIECHV program selected nine original sites for program implementation and expanded to 16 sites in 2013. By the end of 2016, the 16 SC MIECHV program sites were contracted to serve in 39 of South Carolina's 46 counties. Those counties without formal MIECHV services were primarily in the north central part of the state with the remaining scattered throughout the eastern and southern part of the state.

Although the 2010 SC needs assessment identified vulnerable counties appropriate for MIECHV services, county-level assessments may mask within-county communities of particular risk. The lack of awareness of particularly at-risk communities, in otherwise lower risk counties, or the lack of outreach into particularly high-risk areas, may result in the underservice of certain populations intended for service delivery. A knowledge of the actual reach of the program, in terms of clients enrolled, as compared to the intended reach, is an important part of program implementation assessment.

Therefore, the purpose of this study was to identify SC ZIP Code Tabulation Areas (ZCTAs) at a high risk for poor maternal and child health outcomes and to identify the distribution of households enrolled in the SC MIECHV program across those high-risk ZCTAs. We anticipate that our findings can describe the reach of the SC MIECHV program into areas of high need and ultimately be used to inform more precise delivery of services. This identification of areas of greater need statewide or within otherwise low-need counties can also serve as a model for other state programs that want to ensure they are meeting those most in need of program services.

Methods

Theoretical Model

To identify vulnerable communities in SC, we referenced a socio-ecological model of prevention. Socio-ecological models are public health frameworks that suggest health behaviors and health outcomes may be contingent not just on individual characteristics, but also on characteristics of the social and physical environments in which an individual resides [6]. With this model as a guide, we identified communities in SC with characteristics that could indicate risk for poor outcomes among individual mothers and children, and thus, be in greatest need of intervention by home visiting personnel, who are skilled at mitigating those risks [21, 22].

Study Sample

This retrospective, cross-sectional study used residential address data from households enrolled in the SC MIECHV program between January 1, 2013 and December 31, 2016. As the state evaluator for the SC MIECHV program, the Rural and Minority Health Research Center (RMHRC) collects and manages all MIECHV data reported by local implementing agencies via a web-based data collection system.

There were 3229 households enrolled in MIECHV between 2013 and 2016. Of the 3229 MIECHV-enrolled households, we excluded those with missing addresses (n = 81), out-of-state addresses (n = 10), or post office boxes (n = 18), resulting in 3120 addresses for geocoding using ArcGIS Online World Geocoding Service [6] in ArcMap, Version 10.2.2 for Windows (Environmental Systems Research Institute, Redlands, CA). Any address with a match score below 80% (n = 2) were reviewed and re-matched at 100% after correcting grammatical errors. There were 30 (1.0%) households that were geocoded to locations outside of their county of residence, and therefore, they were excluded from this analysis due to possible inaccuracies in their addresses. Our final analytic sample included 3090 household addresses.

Identifying High Risk ZCTAs

To describe vulnerable communities for this study, we used ZCTAs as the primary geographic unit of analysis. ZIP Code Tabulation Areas are geographic representations of ZIP code service areas that define that area for the purpose of tabulating population-based data [23, 24]. The geographical boundaries for each ZCTA were downloaded as a shapefile from the 2010 U.S. Census Bureau TIGER/Line boundary files [23]. In each ZCTA, the total number of MIECHV-enrolled households within the boundaries of that ZCTA were summed and divided by the total number of Medicaid deliveries between 2013 and 2016. This provided the distribution of households enrolled in the SC MIECHV program across ZCTAs in SC.

We downloaded data on all births in SC that occurred between 2013 and 2016 at the ZIP code level from the SC Community Assessment Network (SCAN), which is a data retrieval system that allows users to obtain data from

various sources [25]. These data included the total number of live births and the percent of births to unmarried mothers, African-American mothers, teen mothers (10–19 years old) [20], mothers with less than a high school education, mothers who used tobacco during pregnancy, mothers who received inadequate prenatal care (based on the Kotelchuck index) [7], and mothers who were enrolled in the Special Supplemental Nutrition Program for Women, Infants, and Children during pregnancy, as well as percent of Medicaid deliveries, and percent of infants born at less than 37 weeks gestation or with a birth weight of less than 2500 g. We selected these variables because they are typically associated with at-risk health outcomes and were similar to those assessed in a previous SC MIECHV Needs Assessment and similar work done for the state MIECHV program in Ohio [20, 26]. We then linked the ZIP code-level data to ZCTAs using the 2016 ZIP code to ZCTA crosswalk table provided by the Uniform Data System Mapper [27].

Based on the risk definition used in the initial SC MIECHV Needs Assessment, we defined vulnerable ZCTAs in two ways: (1) *volume* of live births per year and (2) *number* of poor maternal and child health indicators [20]. The 2010 SC Home Visiting Needs Assessment used specifically high volume of live births as one indicator of need [20]. We first obtained total number of live births per year, 2013–2016, by ZCTA and then calculated the average number of live births yearly between 2013 and 2016. We then grouped each ZCTA into quartiles based on average number of live births annually between 2013 and 2016. Any ZCTA falling within the first and last quartiles were characterized as low and high-volume areas, respectively. The middle two quartiles were collapsed to describe ZCTAs with a moderate volume of live births.

Our second step in identifying vulnerable counties involved flagging ZCTAs if they had maternal and child health outcomes worse than the state average for any of the 10 indicators. The number of flags across all 10 indicators were summed together in order to identify those ZCTAs with multiple indicators that were worse than the state average. Low risk was defined as 0 to 3 flags of poor maternal and child health outcomes and high risk was defined as 8 or more flags. Three types of ZCTAs were identified based on volume of live births and the number of flags for poor maternal and child health outcomes: low risk/high volume of live births; high risk/low volume of live births; and high risk/high volume of live births.

Analysis

Descriptive statistics were calculated for MIECHV household characteristics of our sample, total births in SC between 2013 and 2016, and characteristics of three types of ZCTAs (low-risk/high-volume, high-risk/low-volume, and high-risk/high-volume). Because our aim was to identify the most high-risk geographic areas, we did not include ZCTAs with low and moderate risk/volume combinations in the analyses. ArcMap, Version 10.2.2, was used to create choropleth maps to display the volume of births (low, moderate, high-volume) and level of risk (low, moderate, high-risk) as well as the location of the three types of ZCTAs (low-risk/high-volume of live births, high-risk/low-volume of live births, high- risk/high-volume of live births) throughout SC.

The Institutional Review Board at the University of South Carolina reviewed and approved the study protocol.

Results

Study Sample Characteristics

Of the 3090 MIECHV households included in our analysis, 75.8% were on Medicaid or SCCHIP (South Carolina Children's Health Insurance Program) and another 10.7% had no insurance (Table 1). Approximately 42.4% of the households had an annual income of less than $9000. Furthermore, the caregivers who headed these households were predominately unemployed (61.6%) and black (53.0%). Over one in ten (10.9%) households were teen mothers.

Distribution of MIECHV Households in Vulnerable ZCTAs

We evaluated a total of 424 SC ZCTAs (Table 2). Of the 424 SC ZCTAs, 45 had no data from South Carolina Community Assessment Network (SCAN); these 45 ZCTAs were excluded from the analysis. Of the remaining 379 ZCTAS, a total of 99 were categorized as low risk (0 to 3 flags), 128 were categorized as moderate risk (4–7 flags), and 152 were classified as high risk (8 or more flags). Of those 152 ZCTAs with eight or more risk flags, 95 (62.5%) had at least one MIECHV-enrolled family during the reporting period.

Of those 99 low-risk ZCTAs, 48 (48.5%) had a high-volume of births between 2013 and 2016. Of those 152 ZCTAs classified as high-risk, 33 (21.7%) had a high-volume of births between 2013 and 2016 (Table 2). The MIECHV program enrolled at least one client in 26 of the 33 (78.8%) high-risk/high-volume ZCTAs between 2013 and 2016, 55 of 84 (65.5%) high-risk/moderate-volume ZCTAs, and 14 out of 35 (40.0%) high-risk/low-volume ZCTAs.

A total of 1494 (48.2%) MIECHV households were located in ZCTAs with high-risk (8 or more flags) for poor maternal and child outcomes (Table 2). Of those 1494 households, 961 (31.1% of total sample, 961/3090) were also located in ZCTAs with a high-volume of live births. Another 876 MIECHV households were located in ZCTAs with low-risk (0 to 3 flags). Of those 876 households, 759 (24.6% of

Table 1 Demographic characteristics of SC MIECHV parents/caregivers, 2013–2016 (n = 3090)

Characteristic	n	%
Age of parent/caregiver (years)		
Less than 15	9	0.3
15–19	327	10.6
20–29	1883	60.8
30–39	698	22.5
40+	181	5.8
Race		
White	1176	38.1
Black	1631	53.0
Biracial or other race	211	6.8
Unknown	72	2.3
Ethnicity		
Hispanic or Latino	541	17.5
Non-Hispanic or Latino	2500	80.9
Unknown	49	1.6
Education		
Less that high school diploma or equivalent	939	30.4
High school diploma or equivalent	988	32.0
At least some college or additional training	997	32.2
Other or unknown	166	5.4
Employment		
Employed Full-Time	627	20.3
Employed Part-Time	446	14.4
Not Employed	1904	61.6
Unknown	113	3.7
Income		
Less than $9000	1311	42.4
$9001 to $20,000	974	31.5
$20,001 to $30,000	370	12.0
$30,000 or more	357	11.6
Unknown	78	2.5
Insurance		
Medicaid/SCCHIP	2342	75.8
No insurance	330	10.7
Private or other	302	9.8
Unknown	116	3.7

SC South Carolina, *MIECHV* Maternal, Infant, and Early Childhood Home Visiting, *SCCHIP* South Carolina Children's Health Insurance Program

total sample, 759/3090) were also located in ZCTAs with a high-volume of live births.

Distribution of Vulnerable ZCTAs with no Enrolled MIECHV Clients

A total of 57 ZCTAs categorized as high-risk had no enrolled MIECHV households reported during the study period (Table 2; Fig. 1). Also, a total of 16 ZCTAs categorized as having a high-volume of live births had no enrolled MIECHV households reported during the study period (Table 2; Fig. 2). Among the 33 high-risk/high-volume ZCTAs, seven had no enrolled MIECHV households reported during the study period (Fig. 3). Five of those ZCTAs were in the north central area of the state within counties with no formal MIECHV services between 2013 and 2016. All seven of those high-risk/high-volume ZCTAS had at least 9 out of 10 maternal and child outcomes worse than the state average.

Discussion

Reaching the hard-to-reach and most at risk families is a priority of MIECHV programs [28]. A number of state leads have implemented initiatives to reach and engage families [29]. These initiatives include examining program infrastructure, referral and intake processes, community and family factors, and characteristics of participant-home visitor relationships that may facilitate engagement. To our knowledge, none have identified gaps in the geographic reach of the program.

Our study describes a unique use of geographic information system (GIS) methods to determine whether or not the SC MIECHV program was reaching the most at-risk communities within its state for service delivery [30–32]. We used GIS methods to map the residential location of all enrollees during a 3-year period and compared that map to a layover map of high-risk and high birth volume ZCTAs. Using this method, we were able to identify specific communities smaller than county-level that had no MIECHV enrollees despite having a high volume of births and multiple ZCTA-level risk factors at levels above state averages.

From a programmatic perspective, the ability to identify the *actual* as compared to the *projected or intended* reach of a program is important for determining if those potential clients who are most at-risk are receiving needed services [33]. This does not preclude the value of an initial needs assessment done at the county level, as the county is a natural geographic unit for program delivery. However, assessing the actual reach patterns after program implementation can be important to continued program success. This knowledge can be used by local implementing sites to guide precision outreach into underserved communities and to inform possible program expansion [34, 35]. In 2018, recognizing uncovered areas in north central SC, the SC MIECHV program expanded to cover counties that included five of the seven high-risk/high-volume ZCTAs previously without services. Future research will help identify if clients are enrolled from these high-risk areas.

From a systems-level perspective, it would be important to know if these high-risk/high-volume communities

Table 2 SC ZCTAs (n = 379) with at least one MIECHV-enrolled family, by level of risk and volume of live births, 2013–2016

Risk/Volume categories	Number of ZCTAs n (%)	ZCTAs with at least one MIECHV-enrolled household n (% of total)	Number of MIECHV-enrolled households
High risk (8–10 flags)			
High volume	33 (21.7)	26 (78.8)	961
Moderate volume	84 (55.3)	55 (65.5)	503
Low volume	35 (23.0)	14 (40.0)	30
High risk totals	152	95 (62.5)	1494
Moderate risk (4–7 flags)			
High volume	14 (10.9)	12 (85.7)	295
Moderate volume	71 (55.5)	50 (70.4)	406
Low volume	43 (33.6)	8 (18.6)	19
Moderate risk totals	128	70 (54.7)	720
Low risk (0–3 flags)			
High volume	48 (48.5)	41 (85.4)	759
Moderate volume	35 (35.4)	24 (68.6)	113
Low volume	16 (16.2)	2 (12.5)	4
Low risk totals	99	67 (67.7)	876

Of the 424 SC ZCTAs, 45 had no data from South Carolina Community Assessment Network (SCAN) and were excluded from analyses (all were categorized as a PO Box or a unique/single, high volume address)

Risk flags indicate higher than state average on any of 10 risk-related measures (mothers who are unmarried, Medicaid deliveries, African-American, teens, less than high school education, used tobacco during pregnancy, had inadequate prenatal care, received WIC during pregnancy or delivered infant who was preterm or low birthweight)

Low volume of live births defined as the first quartile (< 26 births/year). High volume of live births defined as upper quartile (> 228 births/year)

SC South Carolina, *ZCTA* Zip code tabulation area, *MIECHV* Maternal, Infant, and Early Childhood Home Visiting

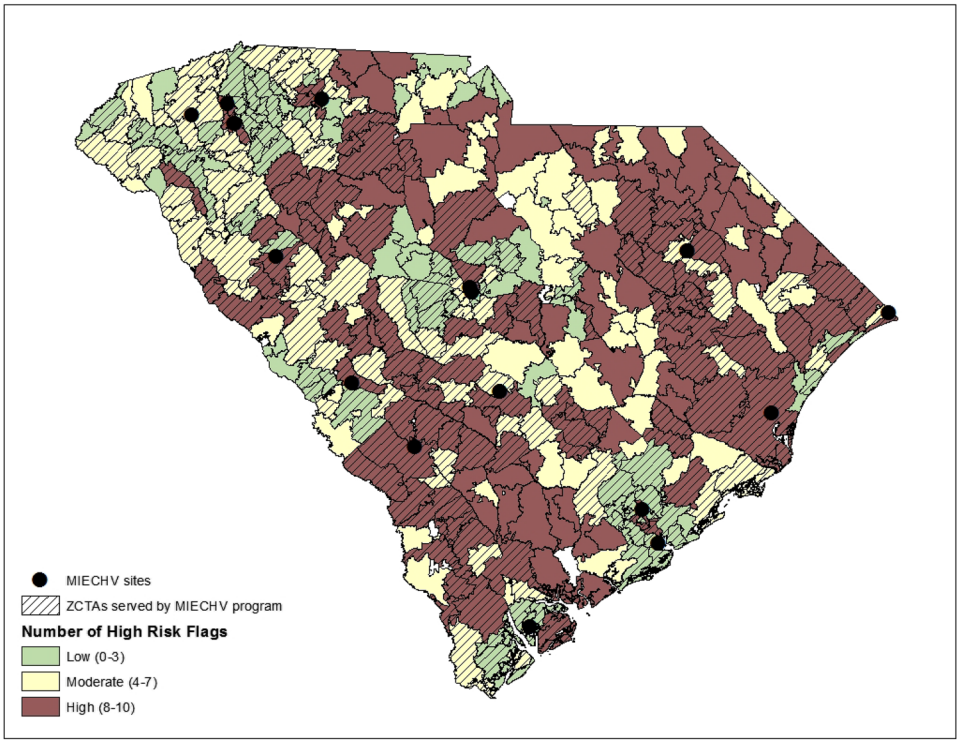

Fig. 1 Map of South Carolina showing ZCTAs by risk level and MIECHV service, 2013–2016. (Color figure online)

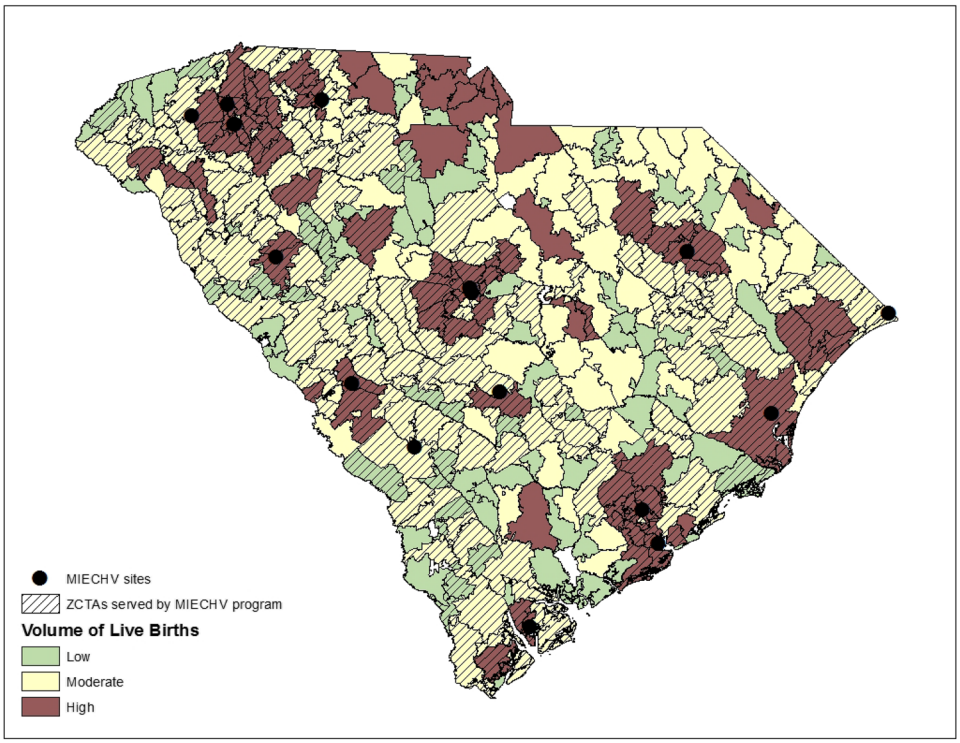

Fig. 2 Map of South Carolina showing ZCTAs by volume of births and MIECHV service, 2013–2016. (Color figure online)

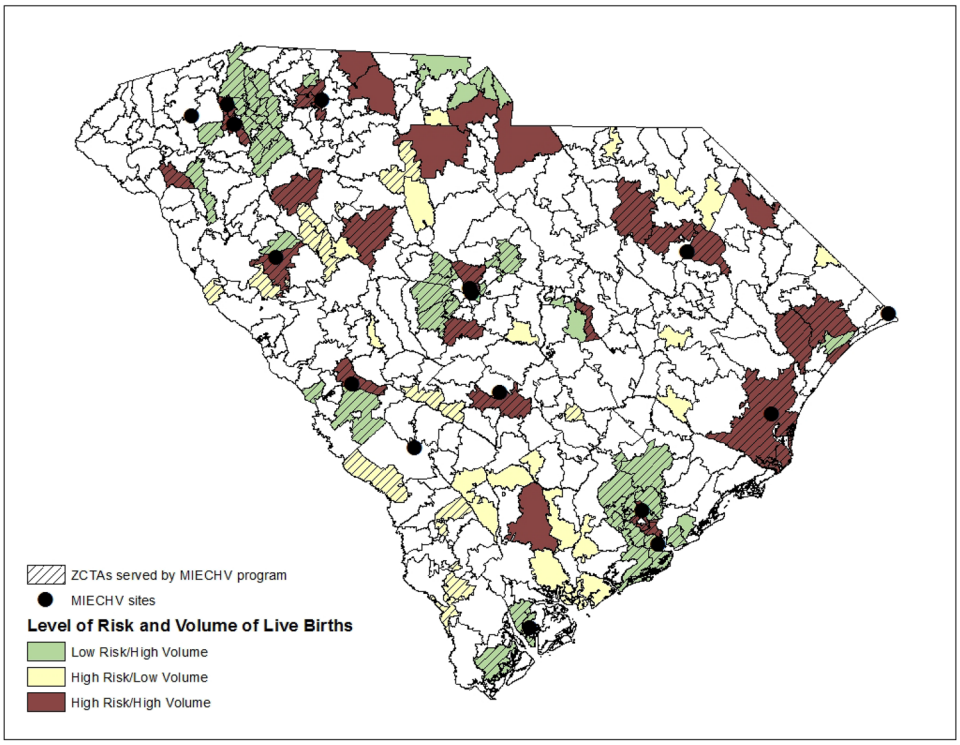

Fig. 3 Map of South Carolina showing ZCTAs with *highest* risk/volume combinations and MIECHV service, 2013–2016. (Color figure online)

had service from any other home visiting program in SC. Five other home visiting programs in the state offer similar, though not identical, services to those offered by the MIECHV program and three additional home visiting models are supported by both MIECHV funds and non-MIECHV funds [36]. However, during the study period of 2013–2016, no formal collaboration existed across home visiting programs to determine areas of coverage or to identify geographic overlap or gaps in coverage. Building a collaborative home visiting system of care, which could include a

collective effort to identify service areas, as well as long-term, the creation of a single point of entry and a system of appropriate referrals across programs, could be advantageous to home visiting in the state and improve health and well-being outcomes of residents most in need of services.

Strengths and Limitations

This study had several limitations. First, we used ZTCAs for identifying risk and live birth volumes, rather than census blocks [24, 37]. The use of census blocks may show more granularity in data and census block boundaries remain constant over time; however, the SC Community Assessment Network data used in this study were measured at the ZIP code level. Strengthening the ZIP code data was the fact that all data points were from the same census years, thus precluding any differences that could arise from comparison of ZIP codes that changed boundaries over time. This study is also limited by the fact that we do not have data from other home visiting programs in South Carolina during the study period. However, the SC MIECHV program is one of the largest home visiting programs in the state in terms of numbers of families and children served [36, 38]. Finally, this study presents data from one state; therefore, while methods may be applied elsewhere, the results are not generalizable.

One strength of this study is its unique use of GIS methods to identify local health care needs, i.e., at-risk communities without MIECHV enrollees, where available program services may exist [31, 32]. The use of GIS methods in the delivery of public health programs can promote better alignment of services and needs [31, 32]. A second strength was the use of geocoded residential addresses of the MIECHV clients, rather than relying on general zip code information, thus ensuring a more accurate identification of their geographic location. Another strength was the use of multiple data sources for the analysis, two of which are publicly available and can thus be easily accessed by other state programs. A final strength of this project is that it provides an example that may be duplicated by other researchers or program evaluators to assess intended versus actual program reach.

Conclusion

In conclusion, this project identified high-risk communities with a high volume of live births within the state of SC that did not have any enrollees in the statewide home visiting program for at-risk mothers and children during the reporting period of 2013–2016. These gaps in service delivery existed despite a statewide, county-level needs assessment conducted prior to program implementation. The methods described in this study helped identify areas of actual service delivery, as compared to identified areas of need, and can be used to further identify service areas as an ongoing measure of program improvement. Such careful attention to the role that "place" plays in health outcomes can result in programs that successfully deliver services to those most at risk and ultimately improve population outcomes of health and well-being.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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