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Full Research Paper

A geographic information assessment of exposure to a toxic waste site and development of systemic lupus erythematosus (SLE): Findings from the buffalo lupus project

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The Buffalo Lupus Project was a community-based participatory research partnership formed to address the relationship between an identified hazardous waste site and high rates of lupus and other autoimmune diseases in the surrounding community. Most cases identified began experiencing symptoms and were diagnosed in the periods when the site was inactive. Trends suggest that the impact of the site was more likely due to chronic exposure to waste rather than it being an acute trigger.

Key words: Lupus, environmental exposure, buffalo lupus project, GIS.

INTRODUCTION

Although we are all affected by environmental health threats, there are groups that bear a larger burden of impacts from higher exposure due to environmental degradation. Minorities and those who live in poverty often reside in areas characterized by differential exposure to health risks in the physical environment, poor quality housing, and deprivation of resources and facilities to adequately address the health related problems associated with such exposures (Cattell, 2001; Williams and Collins, 2001; Gee and Payne-Sturges, 2004). There is documented evidence of the over-abundance of contaminated sites located in minority and impoverished communities and the serious health risks such sites pose to residents (Harding and Greer, 1993; Dahlgren et al., 2007; Sapien, 2001). A number of studies have suggested that environmental exposure such as inhalation or ingestion of contaminants is related to the development of lupus (Balluz et al., 2001; Kardestuncer and Frumkin, 1997; Mongey and Hess, 2002). In lupus and other autoimmune diseases, the immune system loses its ability to differentiate between foreign substances and its own cells and tissues, causing the body to attack itself (Grossman and Kalunian, 2002). Literature suggests an overall mortality rate in lupus patients that is greater than two times the rate in the general population (Centers for Disease Control and Prevention, 2002; Bernatsky et al., 2006; Krishnan and Hubert, 2006).

There are approximately two million people in the United States who suffer from lupus, though it is likely that these estimates are low (Rus and Hochberg, 2002; Office of Minority Health, 2004; Calvo- Alen et al., 2005). Young women are most frequently affected by the disease, outnumbering male patient's ten to one (Cooper et al., 2002). The disease usually strikes between the ages of 15 and 40 years and African Americans are at particularly high risk for the disease. In the United States, blacks have three-fold higher incidence and prevalence rates of SLE, as well as cause-specific mortality rates, compared with whites (Rus and Hochberg, 2002; Office

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Figure 1. Study area in Erie county New York.

of Minority of Health, 2004; Alarcon et al., 2005; Oates et al., 2003). Environmental exposure is hypothesized to play an important role as either a trigger or modifying influence in the development of autoimmune diseases. Ultraviolet light and certain drugs have been identified as the only known environmental triggers. There are several toxic substances which have been implied in the development of lupus in ethnically and geographically vulnerable populations including mercury, presence of particulates, radiation, infectious agents, and other chemical factors and metals (Balluz et al., 2001; Kardestuncer and Frumkin, 1997; Mongey and Hess, 2002). In 1993, a cluster of women with SLE was identified in one eight-block area of the predominantly African American east side community of Buffalo, New York. There were also three toxic waste sites in the same neighborhood. Two had already been remediated. The focal point of contamination and largest of the three identified sites, 858 East Ferry Street, had been designated as a level 2 Superfund site that continued to sit uncontained (lack of fencing and signage indicating hazardous waste around the site) for several years. Community members were concerned that the high incidence of disease could be linked to the contaminants identified at the site caused by historical spill or dumping by the lead smelting plant that had once operated there.

The Buffalo Lupus Project was part of the five-year National Institute of Environmental Health Sciences (NIEHS) funded community-based participatory research grant which was awarded in the fall of 2001. The purpose of the research partnership that became known as the Buffalo Lupus Project was to identify people in the community with lupus and other autoimmune disease and to see if exposure to the area toxic waste Superfund site was a trigger for high disease incidence in the area (Terrell et al., 2008). Buffalo Lupus Project research activities consisted of a registry to assess the city-wide prevalence of lupus and other autoimmune diseases, and a survey to investigate common environmental factors that could elucidate the complex causes of lupus and other autoimmune diseases. All eligible adults 18 years of age or older were invited to participate in research activities, and all participants provided their written informed consent on forms previously approved by the Health Sciences Institutional Review Board at the State University of New York at Buffalo. The Buffalo Lupus Project identified 185 cases of SLE in a population of 74,074 persons. This corresponds to an event or prevalence rate of 160 per 100,000 in the target population. These findings suggest that the observed number of events in the target population were greater than expected; it appears that there is approximately seven times greater risk of having SLE in the geographic study area relative to the general population estimates. The present study was designed to assess the geographical areas of highest risk in relation to the Superfund site, evaluate differences in disease clustering according to when the site was operational and after demolition, and gain insight into the potential impact of the site on affected community members.

MATERIALS AND METHODS

Study area

The study was conducted in the largely African American east side community of Buffalo, New York. The toxic waste sites of concern and identified lupus cluster were located in zip code tracking areas (ZCTAs) 14211 and 14215 of the 34th and 35th census tracts within this area (Figure 1). The City of Buffalo first identified the vacant property at 858 East Ferry Street as a hazardous site in 1997. Past operations of a zinc storage complex and lead smelter and refining facility, which operated from the 1920s through the early 1970s, was believed to be the source of contamination. Although state officials and interested groups usually refer to the Superfund site as 858 East Ferry Street, the original location of the lead smelting facility was the 2.3 acre lot at 856 East Ferry Street. The adjacent 3.32 acre empty lot (858 East Ferry Street) was used by the smelter to dump waste ash. The New York State Department of Environmental Contamination (NYSDEC) investigation in 1997-98 identified high concentrations of lead, mercury, arsenic, polychlorinated biphenyls (PCBs), volatile organic chemicals (VOCs), incinerator ash, and other metals in the soil on the site. Additionally, the water there was found to be contaminated with benzene and similar soil contaminants, at levels warranting remediation of the site (New York State Department of Environmental Conservation, 2005). Significant lead contamination was identified at surface levels between 149 - 11500 ppm and subsurface levels between 110 - 46700 ppm (New York State Department of Environmental Conservation, 2005).

Table 1. Comparison of buffalo lupus project survey participants to study area statistics (zip codes 14215 and 14211).

	Survey participants (n=66)	Zip code 14215 (n=43,569)	Zip code 14211 (n=29,039)
Race (%) - African American	82.8	72.3	71.5
Sex (%) - Female	96.2	54.8	53.8
Median age	49 years	31.6 years	32.1 years
Education (%)			
High school	30.8	79.8	68.5
College	47.7	16.2	7.4

Source: US Census Bureau, 2000.

Materials

Of the 309 Buffalo Lupus Project registrants who identified themselves as having SLE, 87 were eligible to participate in the survey due to having ever lived or currently living in the targeted zip codes and having a previous diagnosis of SLE. Trained interviewers completed surveys with 66 SLE cases, corresponding to a 76% response rate. Survey topics included demographics, diagnosis, health care utilization, residential history and exposures, occupational history and exposures, disease specific medical history, smoking history, family health history, and social support. As part of detailed residential histories, participants were asked to recall every address where they had ever lived and the specific years they resided there. All address information was de-identified and linked with other survey components by unique identifier. For each participant, residential data were categorized into ten-year increments, beginning when the smelting plant was active (1920 - 1929) and ending with the period of data collection (2000-2009). Each participant was assigned one address per ten-year period according to where they resided for the longest duration during that period. Addresses outside of Buffalo, New York were excluded.

Methods

Information from completed surveys was entered into an electronic database, using the Microsoft Access program. A cross tabulation of participant ID and addresses was performed using the SPSS statistical package (SPSS Inc, Chicago, IL) to determine who lived where in which period. A geographic information system was constructed for the study using ArcMap software (Environmental Systems Research Institute, Redlands, CA) on a Windows-based work station. Locations of survey participants' residences within the study area were digitized into a GIS point file using the file containing participants' addresses that was matched, using ArcMap, against the U.S. Bureau of the Census TIGER (Topographically Integrated Geographic Encoding and Referencing system) line files. Incomplete records missing house numbers were assigned a random street number inside the range of highest and lowest valid street addresses in the zip code. The final GIS products for this study were databases from which locations of survey participants' residences and their respective disease status could be visually displayed. A total of nine maps were generated according to the nine ten-year periods, and each included participant residences in relation to the Superfund site of concern and whether the participant was pre-symptomatic, symptomatic without a diagnosis, or diagnosed during that period.

RESULTS

Table 1 shows that 96.92% (n=63) of survey participants were women. The median age of survey participants was 49 years. Table 1 also shows that 81.82% (n=54) of participants reported their race/ethnicity as African American. With regard to educational attainment, 30.77% of participants obtained a high school diploma or GED, while 47.69% (n=31) reported college to be their highest level of school completed. A cumulative percentage of 21.54% of participants reported participation in vocational/technical training and/or graduate or professional school. Buffalo Lupus Project survey participants were generally older and more highly educated than the general study area population residing in zip codes 14215 and 14211. Additionally, survey participants were comprised of more females and African Americans. Table 1 shows that African Americans make up approximately 72% of the population in zip codes 14215 and 14211, and approximately 54% of the population in both zip codes are female. The median age of residents of zip codes 14215 and 14211 is 32 years, and less than 20% in both zip codes reported graduating from college (CensusUSBot, 2006).

During the time period that the Superfund site of concern began operations as an active lead smelting plant (1920-1929), no survey participants reported residing in the area (Figure 2). In subsequent time periods (1930-1949), a small number (n=7) of participants reported residences that were clustered to the southwest of the site, but none reported experiencing disease symptoms during this time (Figures 3 and 4). In the following time periods that the site of concern was still an active industrial site (1950-1969), residential patterns of participants were more scattered, but still concentrated most densely to the west of the site (Figures 5 and 6). Few participants reported experiencing symptoms (n=5) or being formally diagnosed (n=3) during this time. During the time period that the smelting plant became inactive (1970-1979), residential patterns of survey participants were more dispersed, but most densely concentrated to the northeast of the site. An increased number of participants reported being formally diagnosed with SLE (n=9) during this period (Figure 7). During the time periods following (1980-1999), when the site of concern was inactive, but still being used as a waste dump, the majority of survey participants reporting residences in the area were formally diagnosed, and most densely

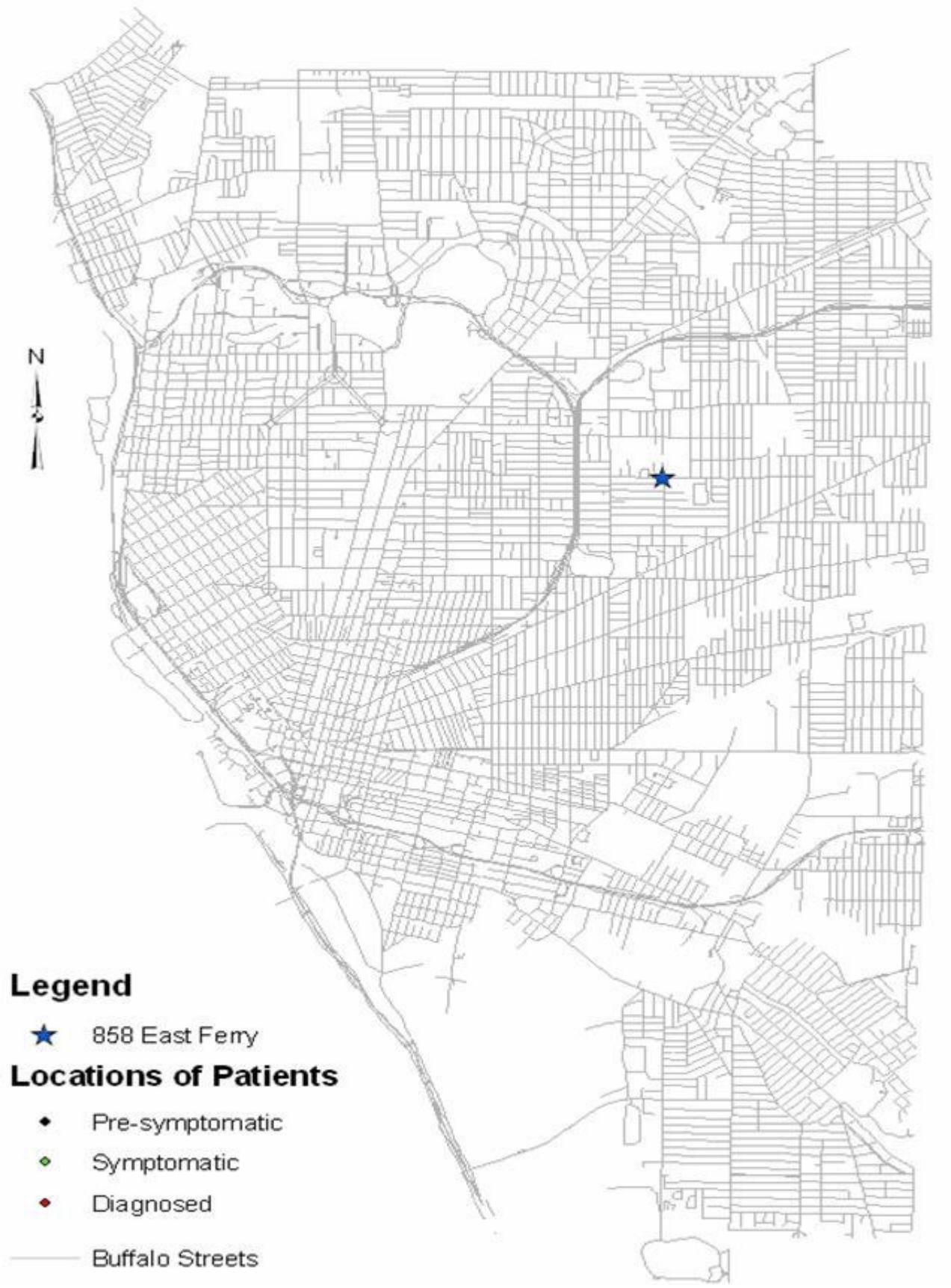

Figure 2. Residential patterns of Buffalo lupus project survey participants, 1920-1929 (n=0). Source: Author.

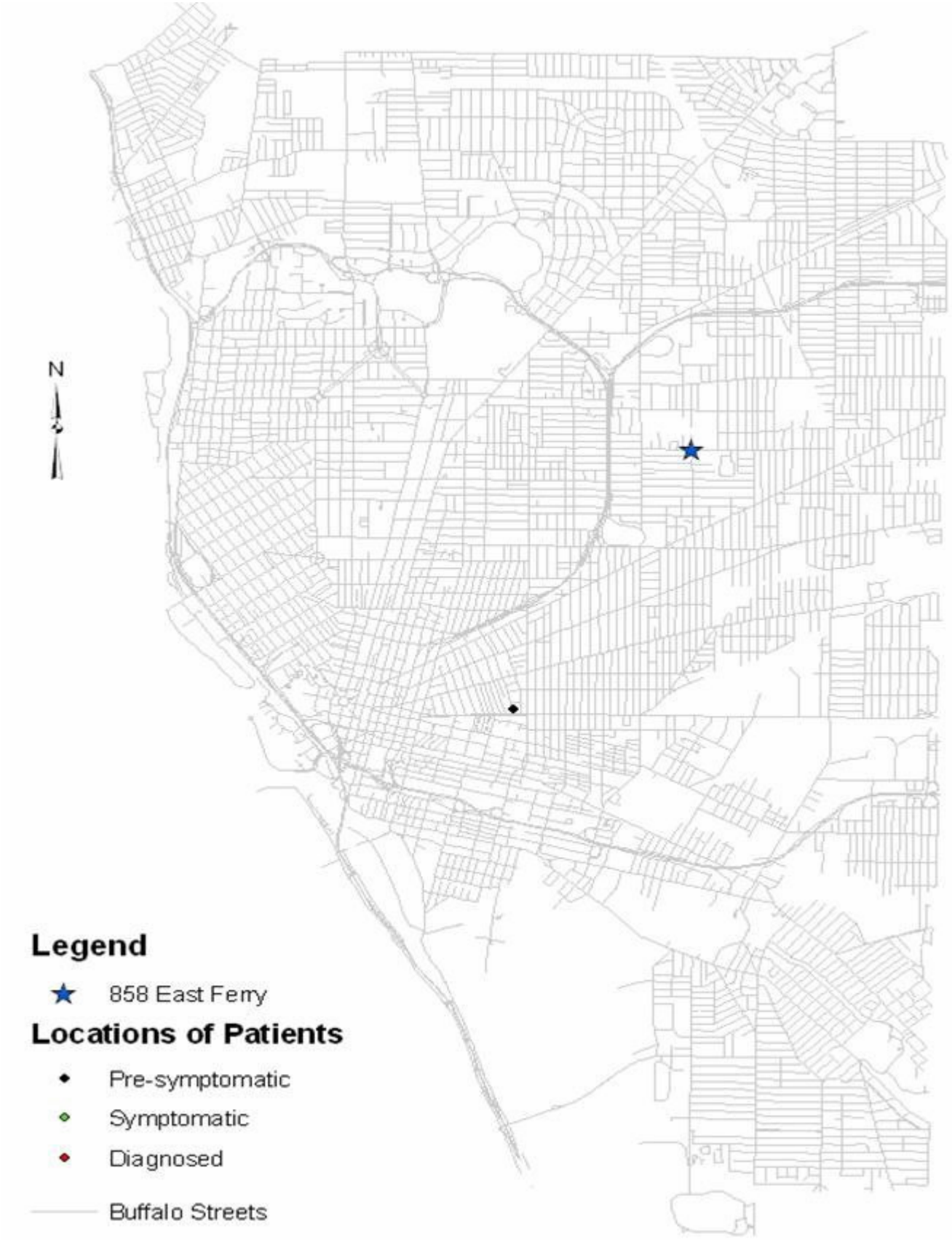

Figure 3. Residential patterns of Buffalo lupus project survey participants, 1930-1939, n=2. Source: Author.

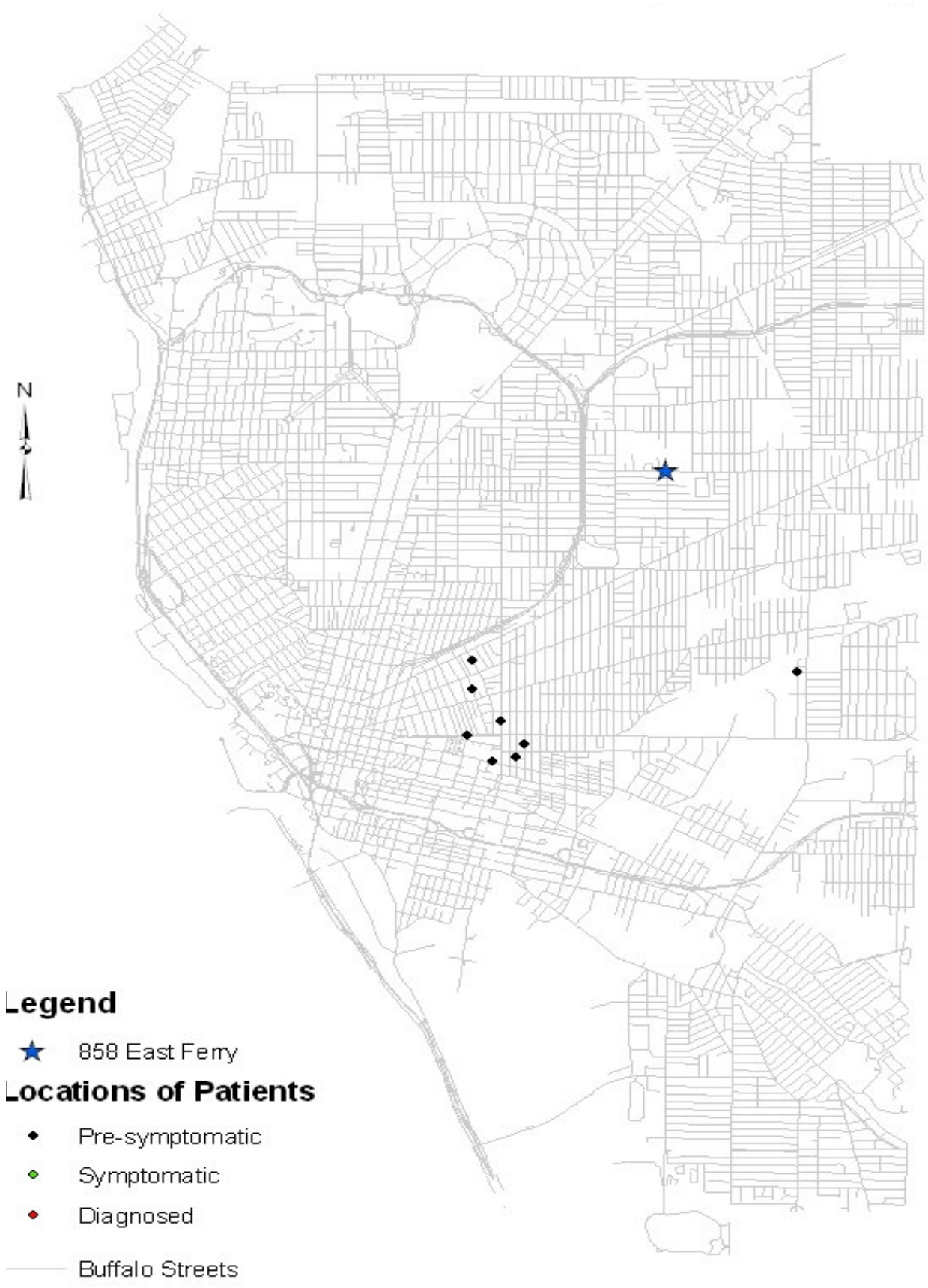

Figure 4. Residential patterns of Buffalo lupus project survey participants, 1940-1949, n=14. Source: Author.

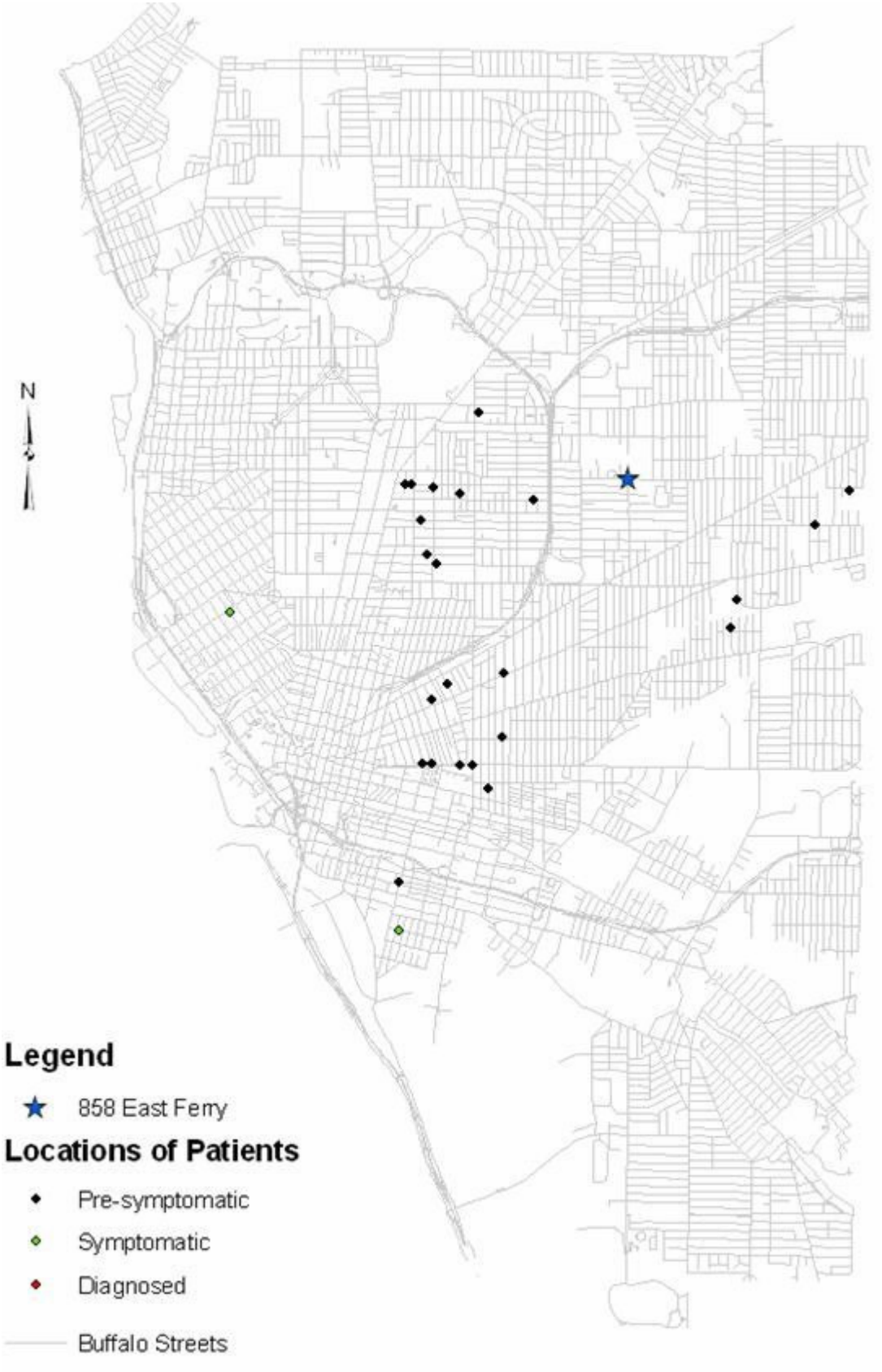

Figure 5. Residential patterns of Buffalo lupus project survey participants, 1950-1959, n=33. Source: Author.

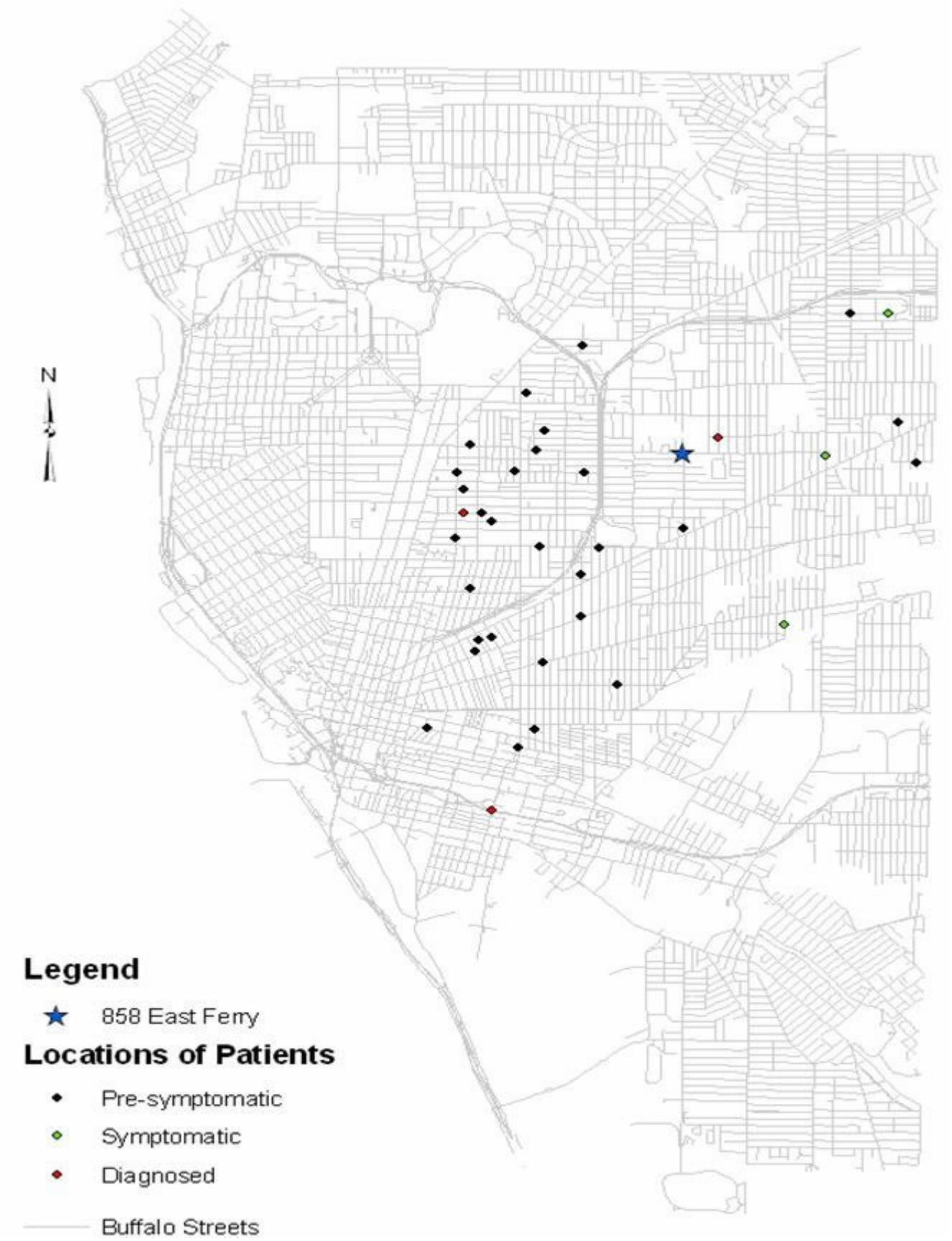

Figure 6. Residential patterns of Buffalo lupus project survey participants, 1960-1969, n=50. Source: Author.

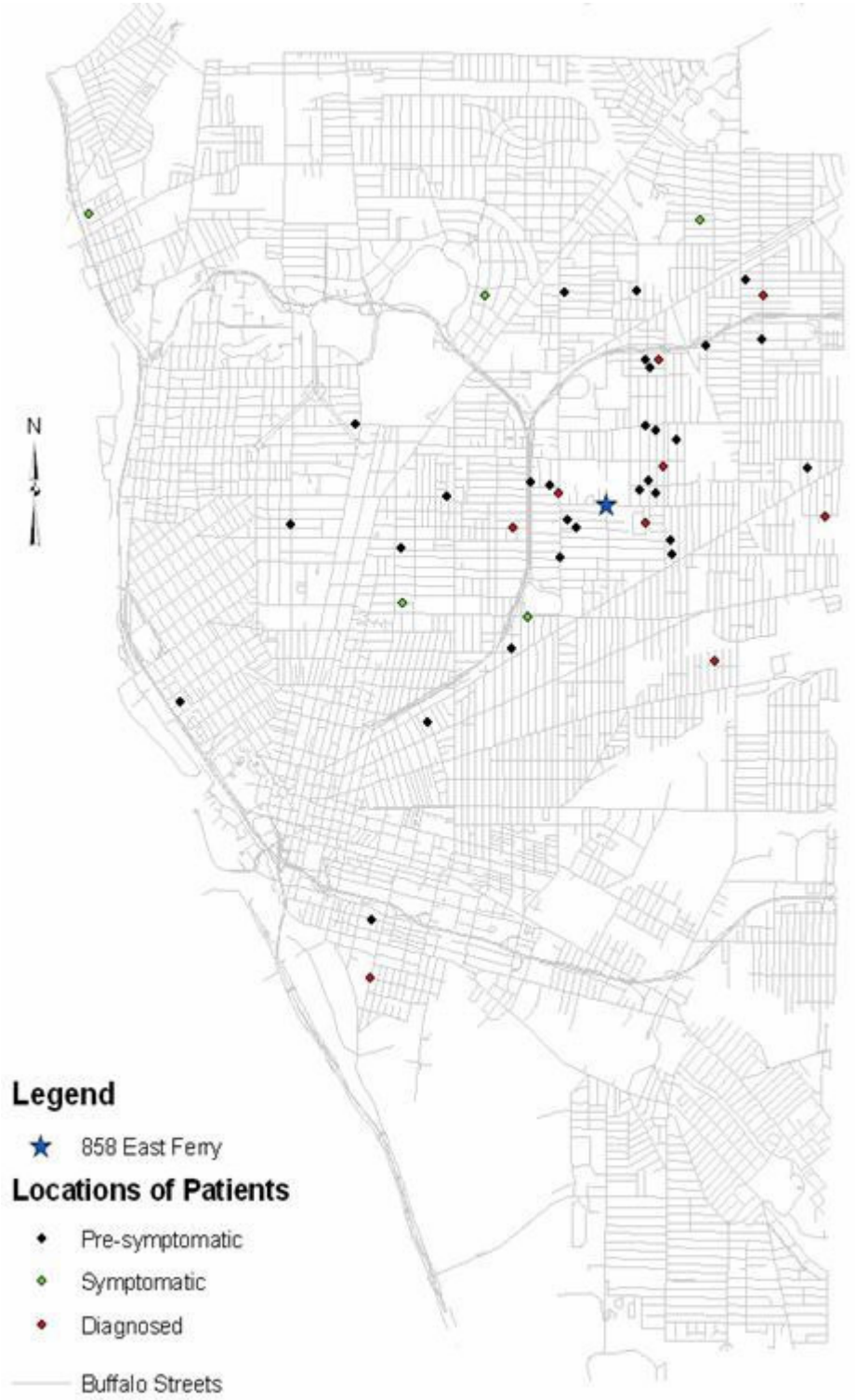

Figure 7. Residential patterns of Buffalo lupus project survey participants, 1970-1979, n=57. Source: Author.

concentrated to the northeast of the site (Figures 8 and 9).

During the last reported time period (2000-2009), the site of concern was remediated. A total of 87,200 cubic yards of contaminated soil from the site and from off-site properties was stabilized on site and moved to a

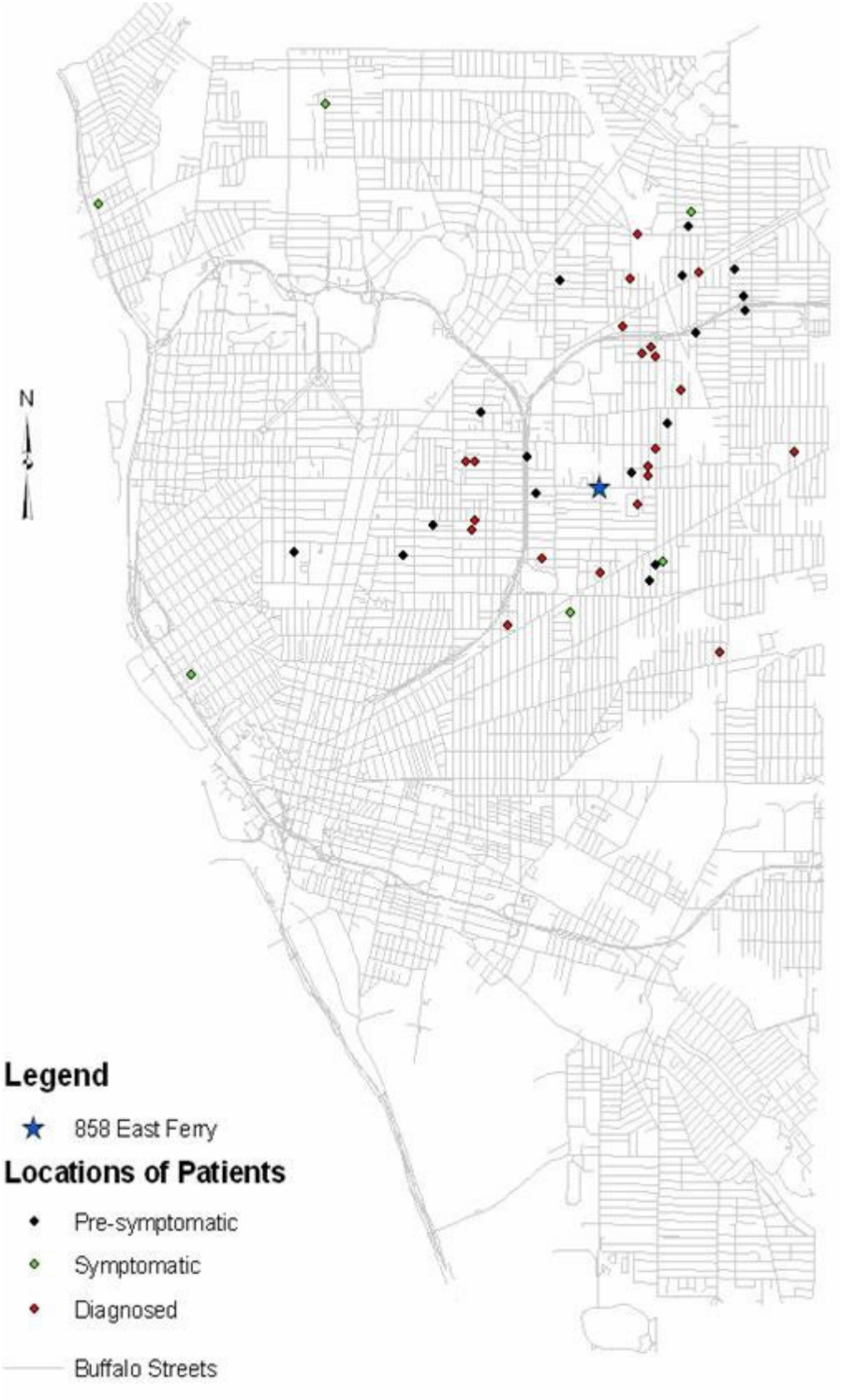

Figure 8. Residential patterns of Buffalo lupus project survey participants, 1980-1989, n= 59. Source: Author.

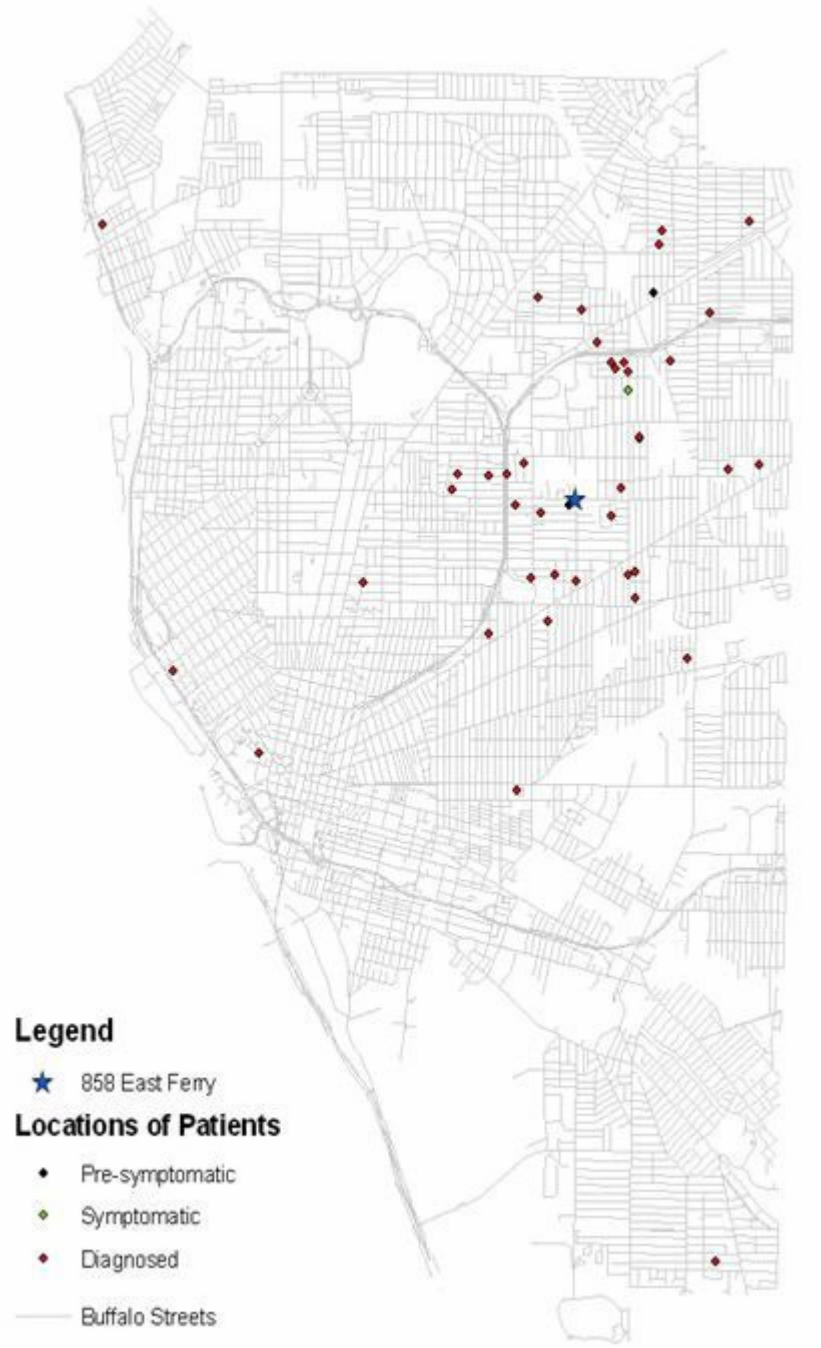

Figure 9. Residential patterns of Buffalo lupus project survey participants, 1990-1999, n=61. Source: author.

hazardous waste landfill to achieve a clean up goal used for unrestricted future use on-site and industrial/ commercial use off-site. At this time, all survey participants reporting residences in the area were formally diagnosed, and residential patterns were more dispersed, but still most densely concentrated to the northeast of the site (Figure 10).

DISCUSSION

The purpose of this study was to evaluate differences in SLE disease clustering according to activity of a nearby Superfund site. This study is similar to other anecdotal findings of higher rates of lupus in areas where dangerous environmental sites are located (Dahlgren et

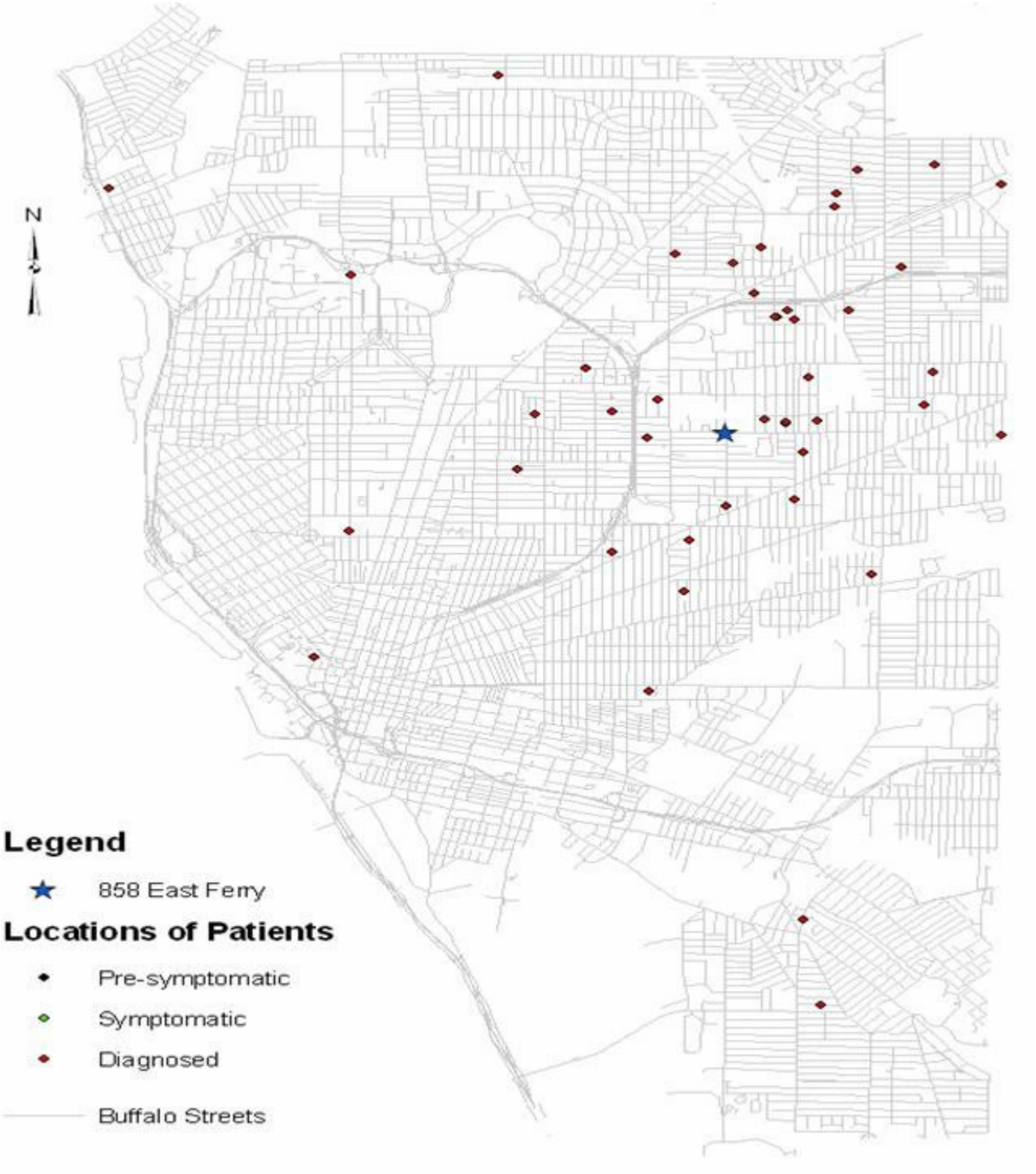

Figure 10. Residential patterns of Buffalo lupus project survey participants, 2000-2005, n=62. Source: author

al., 2007; Smith, 2007), but this study is unique in that it employed GIS technology to assess the geographical areas of highest risk in relation to the Superfund site. Our findings showed that in the early periods, when the site was active, all cases were clustered to the west of the site and few were symptomatic. Most cases began experiencing symptoms and were diagnosed in the periods when the site was inactive and resided more often to the northeast of the site. Such trends suggest that the impact of the site was more likely due to chronic exposure to waste rather than it acting as an acute trigger, although clustering does not prove a causal

relationship between exposure and disease.

The primary advantage of the present study is that disease mapping was used to show changes in disease patterns over time in an identified cluster of SLE surrounding a nearby toxic waste site. However, small-area maps of disease are difficult to interpret in a meaningful way. With regard to the use of address geocoding for exposure assessment, residential location or any one location may not be the relevant site of exposure. It is possible that occupational location, for instance, may be as important as or more important than residential location. Therefore, the amount of time spent in different locations may need to be considered. Additionally, proximity of a residence to a source of contamination may not be synonymous with exposure. It is possible that wind direction or groundwater flow influence exposure levels.

Conclusions

Even with these limitations, this project serves as an initial exploration of relationships between exposure and disease. More in-depth studies using GIS technology are recommended to more accurately estimate exposures within this geographic region.

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