# THE 2015-2016 COMMUNITY SURVEY ON LYME DISEASE AND OTHER DISEASES CARRIED BY TICKS

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Dutchess County, NY

October, 2018

## Acknowledgements

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## Suggested citation:

Wheeler-Martin K, Kaufman A, Salvas V, Evans, A & Smith A. 2018. *Lyme disease and other tick-borne diseases: Dutchess County community survey 2015-2016.* Poughkeepsie, NY: Dutchess County Department of Behavioral & Community Health.

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# EXECUTIVE SUMMARY

## Purpose

Lyme disease and other tick-borne diseases have been an important health issue in Dutchess County since the 1980s, and County residents continue to experience rates of tick-borne disease between two and five times higher than the upstate average (DBCH 2016). The Dutchess County Department of Behavioral & Community Health (DBCH) works to assess and prevent Lyme disease and other diseases carried by ticks through surveillance and education. In addition to mandated case-based human disease surveillance, DBCH conducts periodic community surveys to measure residents' knowledge, opinions, experience, and practices regarding tick-borne diseases and the prevention of tick bites. The results of the surveys are used to benchmark progress, identify needs, and inform ongoing prevention activities with community partners.

## Overview of Methods

Building on previous community tick surveys conducted in 2001, 2002, 2003, and 2009, an updated survey was conducted in late fall 2015 – early spring 2016. As in the past, the county was divided into two regions based on environmental characteristics and population density (Appendix A). Region 1 comprises the southwestern corner of the county, from Beacon and Fishkill extending north through Wappinger, Poughkeepsie (town and city), and Hyde Park. Region 2 encompasses the eastern and northern areas of the county, including the municipalities of Beekman, Pawling, La Grange, Union Vale, Dover, Pleasant Valley, Amenia, Clinton, Stanford, Rhinebeck, Red Hook, Milan, Pine Plains, and Northeast. DBCH developed the survey content and a professional survey company (Alphapointe/NYSPSP) was contracted to administer the survey via telephone using random digit dialing with a target sample size of 600. In total, 598 surveys were completed (357 in Region 1 and 241 in Region 2). Mobile phones were included for the first time in the 2015-2016 survey. The survey took approximately 25 minutes to conduct. Results were weighted to the 2010 census population for Dutchess County by region, age, sex, race, and ethnicity. For comparison, 2009 survey results were updated by weighting to the 2010 census population. Statistical analysis was performed using Stata version 14.0.

## Key Findings

*Awareness, Concern, Knowledge and Information Sources*

- There was a discrepancy between the proportion of residents reporting a high level of concern about tick-borne disease and those reporting a high level of knowledge. Ninety percent of residents stated that Lyme disease was a somewhat or very serious problem, but only 70% stated that they knew a lot or something about Lyme disease. About half of respondents also expressed high levels of concern about other tick-borne diseases, but only a quarter of residents felt they knew some or a lot about them. Less than half of residents were aware of the diseases anaplasmosis and babesiosis, which, while less common than Lyme disease, are nonetheless endemic in the County.

- We found that self-reported knowledge was highly correlated with objective true/false knowledge assessment scores, which lends validity to this measure. The following subject matter strengths and weaknesses were revealed in the objective knowledge assessment portion:
    - Respondents were best able to identify high risk environments for tick exposure (91% correct) and nearly 90% correctly answered that early symptoms associated Lyme disease often resemble the flu. Nearly three quarters knew that prompt removal of attached ticks decreases the risk of disease transmission.
    - Only about half of residents were aware that the rash associated with Lyme diseases does not *always* have a bull's eye appearance. Although over 80% correctly identified tweezers as a safe and effective way to remove a tick, 10-20% of residents believed that ineffective and potentially dangerous methods should be utilized for tick removal, including matches, razors, or chemicals.
- TV/radio/print media remain the most common information sources, along with word of mouth from family, friends and peers. In 2015-2016, the percent of residents who have obtained information about tick-borne diseases from signs posted in parks, trails and recreation spaces nearly doubled (37% versus 17% in 2009).
- Sixty five percent of residents stated that information is very accessible, and another quarter stated that it is somewhat accessible, with fewer than 10% stating that is not very accessible or totally inaccessible.

*Outdoor Activity and Tick Exposure*

- Among Dutchess County adults, residents of Region 2, males, adults 65 and older, and those with wooded properties tended to spend the most amount of time in wooded, brushy, and high grass areas.
- About 30% of adults found ticks on themselves in the past year, and almost 75% of pet owners found ticks attached to their pets that go outdoors in the past year.
- Controlling for all demographic and exposure characteristics at the same time, time spent outdoors, region, and pet ownership were significantly correlated with the odds of finding an attached tick in the past year.

*Personal and Property Protection and Interest in Community Tick-Reduction Strategies*

- Fewer than half of Dutchess County residents consistently used insect repellent or acaricide-treated clothing when venturing outdoors in high risk areas. Meanwhile, the clear majority (about 80%) of residents reported frequently checking themselves for ticks upon returning from such activities.
- Mowing the lawn short and removing leaf litter were very common property-care activities among most residents, which may help reduce the risk of tick-borne disease transmission in the yard. Adding deer fencing was more common in Region 1 than the more rural Region 2. With respect to the deer population, about 1 in 2 residents would support efforts to reduce/cull local herds, however the survey did not assess support or opposition to specific culling strategies.
- Almost 30% of residents have used insecticide sprays on their property and 40% of residents would support the use of insecticide sprays on public lands for tick control. After briefly learning about small-mammal tick bait boxes in the 2015-2016 survey, 80% of residents voiced support for this

strategy to reduce the tick population on public lands; only about 5% of residents have tried this relatively new strategy on their own properties.
- The clear majority (80%) of Dutchess County residents would like to see more research into methods of tick control.

*Prevalence of Tick-borne Diseases and Medical Experience*

- About 20% of Dutchess County adults reported having ever received a diagnosis of Lyme disease, and about 2 to 4% reported ever being diagnosed with babesiosis and anaplasmosis (recognizing the latter may be potentially misclassified as ehrlichiosis). The lifetime prevalence provides useful information on what percentage of the population has ever experienced these conditions, and it is uniquely estimated by this population survey for Dutchess County adults.
- Recent estimates of *incidence rates*, better measures of year to year trends, are found in the Dutchess County Community Health Status Report (DBCH 2016); in 2014, there were approximately 250 new cases of Lyme disease per 100,000 residents, 5 times higher than the statewide average. There were around 20 cases of anaplasmosis and 16 cases of babesiosis diagnosed per 100,000 residents on average each year from 2012-2014, also 5 times higher than the statewide averages for these conditions.
- Among residents ever diagnosed with Lyme disease, 67% reported finding an *erythema migrans* rash (a circular red rash which may or may not have a bull's eye appearance), consistent with other North American estimates ranging from 60-90% (Mead 2015).
- Among those who ever received a positive Lyme diagnosis, 19% (95% CI: 13%-27%) stated they were told by a healthcare provider that they had post-treatment Lyme disease syndrome (PTLDS) or chronic Lyme disease.
- Among those who consulted a healthcare provider about Lyme disease, rankings of healthcare providers' knowledge (58% said "often knowledgeable") and responsiveness (67% said "often responsive") were similar to general levels of overall satisfaction among patients surveyed in New York State hospitals (about 65%) (McFarland, Ornstein, & Holcombe 2015).
- Nine out of 10 residents would like to see increased funding for medical research on tick-borne diseases.

## Recommendations

Results of the 2015-2016 Community Tick-borne Disease Survey should be shared with community partners and used to inform the choice of modalities, content, and target audiences for tick-borne disease prevention education campaigns. Results provide justification for continued efforts on the part of DBCH and community partners to increase the overall level of resident knowledge to match the level of concern. Efforts should be made to increase awareness and knowledge of endemic tick-borne diseases other than Lyme disease.

Risk exposure data indicate that frequency of exposure to wooded, brushy, and high grass areas was among the strongest correlates of having found a tick attached in the previous year, accounting for population characteristics and exposure characteristics. Those with daily occupational exposure may be an important target for prevention messaging. This most recent survey also provides further evidence that pet owners are an important target population for prevention messaging.

Tick removal kits are often utilized by residents who have them and provide a vehicle for just-in-time messaging to aid in the proper removal of attached ticks. While distribution efforts have reached a diverse and growing cross-section of the Dutchess County population, there is room to achieve more coverage countywide.

Likewise, tick warning signage at parks and trails provide timely reminders to employ tick bite prevention measures and have been viewed by a significantly growing proportion of residents. Again, there is room to increase this form of messaging, and to periodically assess its effectiveness (such as short- and long-term retention, behavior change, message fatigue, etc.).

There was a high level of interest in the use of insecticide bait boxes on public land to treat mice and other small mammals in the ecosystem; as ongoing research determines the effectiveness of this relatively new strategy and as well as other strategies and techniques, these findings should be shared with the community and policy makers.

Disease and healthcare experiences of respondents mirror national data and provide evidence that most residents have a favorable opinion of healthcare provider responsiveness and knowledge regarding tick-borne disease.

Most residents continue to get information about ticks from mass media (TV/radio/newspapers/magazines) and word of mouth. The role of social media should be closely explored in the future, both as a tool for promoting evidence-based prevention strategies as well its potential role in the spread of misinformation. DBCH and partners should continue to strive to provide the public and policy makers with accurate and timely information based on sound science. The larger need for more medical research on tick-borne diseases and increased scientific research on tick prevention was strongly echoed by the Dutchess County community in the 2015-2016 survey.

# INTRODUCTION

Lyme disease and other tick-borne diseases have been an important health issue in Dutchess County since the 1980s. The Dutchess County Department of Behavioral & Community Health (DBCH) works to assess and prevent Lyme and other tick-borne diseases through human disease surveillance and prevention education.

DBCH has sought to raise awareness and knowledge about tick-borne diseases in a variety of ways including sharing current data and facts and evidence-based guidelines on tick-borne disease prevention on the Dutchess County website and social media outlets; providing information and tick removal kits at health fairs and other community events throughout Dutchess County; hosting educational presentations for the medical community and other community groups; providing consultation with healthcare providers in the detection of disease; and collaborating with partners such as the County's Legislative Tick Task Force. Throughout the years, these programs have been evaluated by conducting community surveys to measure residents' knowledge, perceptions, and practices regarding tick-borne disease. Similar surveys are conducted separately with healthcare providers and the findings are likewise disseminated to the medical community. DBCH has been able to develop, modify and promote interventions based on the survey results.

Building on the format of previous Dutchess County community surveys conducted in 2001, 2002, 2003, and 2009, a community survey about ticks and tick-borne diseases was conducted in the fall of 2015 through early 2016.

# METHODOLOGY

## *Sampling*

In order to adequately sample urban, suburban and rural populations, the county was divided into two regions based on population density and environmental characteristics, following zip code boundaries (Appendix A). Region 1 (population 150,789 in 2010) covered the more densely populated southwestern portion of the county and consisted of the zip codes covering the municipalities of Hyde Park, Poughkeepsie (town and city), Wappinger, East Fishkill, Fishkill, and the City of Beacon. Region 2 (population 77,813) comprised the larger, but less densely populated northern and eastern portions of Dutchess County, which is predominantly rural. This included the municipalities of Beekman, Pawling, Union Vale, Dover, Pleasant Valley, Washington, Rhinebeck, Clinton, Amenia, Red Hook, Milan, Pine Plains, and Northeast.

A target sample size was set at 600, or approximately 300 surveys per region. This strategy was designed to ensure an adequate sample size, especially from rural areas, in order to generalize and compare results for Regions 1 and 2. A purely random sample of Dutchess County likely would have otherwise resulted in the majority of observations coming from Region 1.

## *Survey Data Collection*

A professional survey company, Alphapointe/NYSPSP, was contracted to randomly administer surveys to county residents living within the two designated regions. Telephone calls to land line phone numbers and mobile phones were made in the fall of 2015 through early 2016. The survey took approximately 20-30 minutes to complete.

Only English speaking, non-institutionalized, county residents, 18 years of age and older, were surveyed. Due to the length of the survey, an incentive of one $100 gift card drawn by random lottery was offered to participants who completed the entire survey. This was the first year an incentive was offered, in effort to boost participation across a truly random sample of respondents.

Responses were entered into a database by the survey contractor. A total of 7611 calls were made, resulting in 5174 non-responses, 1063 refusals, 768 indirect refusals (hang ups), 8 partially completed surveys that did not meet the minimum requirements for inclusion, and 598 completed surveys. This reflected a minimum response rate of 7.9% of all calls and a maximum response rate of 24.9% of all residents who answered the phone. A total of 357 surveys were completed in Region 1 and 241 surveys in Region 2. Although the total surveys completed in Region 2 fell short of the target goal of 300, it was determined to be an adequate sample size for statistical analyses by region.

### *Survey Weighting and Data Imputation*

A survey weight was assigned to each observation using proportional iterative fitting, or raking, a standard technique used in state and national surveys such as the US Behavioral Risk Factor Surveillance System, BRFSS (CDC 2018). Raking adjusts the results by matching the sample demographics (e.g., age, gender, race and ethnicity) to the actual population for Dutchess County in Regions 1 and 2. This allows groups that are underrepresented in the sample to be fully represented in the analysis, to reduce non-response bias and improve the generalizability of the results. We weighted the survey sample to the 2010 census populations of Dutchess County adults by region, age, gender, race, and ethnicity, excluding incarcerated populations in Beekman, Fishkill and Beacon.

We also updated the results of the 2009 community survey on tick-borne diseases using the same weighting methods, to allow for better comparison between the 2015-2016 and 2009 surveys where applicable (note limitations below).

Missing/unknown responses for gender (n=3), age (n=9), race (n=17) and ethnicity (n=16) were imputed and included in the final weighted sample. Missing gender responses were inferred from audio recordings in 2015-2016, otherwise missing values were re-assigned to the most common category for these four variables.

### *Survey Data Analysis*

Statistical analysis was conducted with Stata 14.0 using svy procedures. We computed survey-weighted proportions and 95% confidence intervals using the logit method. Results were analyzed for the county as a whole and for each region separately. We also explored differences across demographic characteristics. The survey-adjusted Pearson chi-square test was used to identify significant differences ($p$ value < 0.05).

### *Survey Content*

The survey covered the following topics:

a. General awareness and concerns about Lyme and other tick-borne diseases;

b. Knowledge of risks of exposure, symptoms, and treatment of Lyme disease;

c. Personal and property protection against ticks;

d. Presence of environmental risk factors;

e. Sources of information about Lyme disease;

f. Willingness to adopt and support prevention strategies;

g. Personal Lyme and other tick-borne diseases status and healthcare experience; and

h. Respondent sociodemographics: zip code, region, age, gender, income, education, race/ethnicity.

### *Data Limitations*

The survey was administered only to English-speaking adults ages 18 and older. Residents who are institutionalized or otherwise do not have an individual land line or mobile phone were not included. The 2009 survey did not include mobile phones. Despite using the same weighting methods on the 2009 and 2015-2016 surveys across age, gender, race, and ethnicity, there may be some remaining non-response bias in 2009 due to the non-inclusion of residents whose only phone is a mobile phone.

In general, surveys intrinsically rely on self-reported responses. Respondents may under-report undesirable behaviors and may over-report desirable behaviors. Ability to recall information may also affect the accuracy of responses.

The sample size and sampling strategy was designed to allow for generalizability to the county and regional level. Demographic characteristics such as gender, age, race/ethnicity, educational attainment, and income level were collected, and survey results were adjusted as described in the weighting section; however, the sample size and sampling strategy were not specifically designed to compare findings across demographic characteristics, which would have required a significantly larger and costly sample size, and challenging strategies to target specific sub-populations. We provide exploratory results, but confidence intervals should be clearly noted and caution exercised in the interpretation of these findings, particularly for race/ethnicity, with small numbers of respondents among non-Hispanic Black or African American residents (n=26) and other non-Hispanic residents (e.g. Asian-Americans, or those who identify with multiple race categories, n=27).

# RESULTS

## Demographic Characteristics of Survey Respondents

In general, the 2015-2016 sample reflected the population of Dutchess County fairly well across most population characteristics (Table 1). Sample size was small, however, for non-Hispanic black respondents (n=26) and non-Hispanic respondents of other races or multi-racial backgrounds (n=27). Weighted proportions were almost identical to the 2010 census proportions of non-incarcerated adults for the weighted variables: gender, age, race, and ethnicity. As mentioned under ***Data Limitations***, neither the 2009 nor 2015-2016 survey were sampled so as to generalize across demographic characteristics other than region. *Results cross-tables by population demographics should be interpreted with caution and are included for exploratory analysis and hypothesis generation.*

Previously published *unweighted* results for 2009 may be biased, as males had low response rates and there were no respondents with less than a college education nor household incomes below $35,000 in the 2009 sample. Education and income were not included in the raked weighting procedures and differences between the two weighted surveys may be impacted by this bias.

Proportions for gender, age, and race/ethnicity include a small number of imputed values as described in the methods; otherwise missing values are noted at the bottom of each category and excluded in the calculation of proportions.

Table 1. Demographic characteristics of the 2009 and 2015-2015 survey populations, unweighted and weighted, compared with 2010 US Census and American Community Survey estimates.

| | Unweighted Proportions | | Weighted Proportions | | 2010 |
|---|---|---|---|---|---|
| | 2009 | 2015-2016 | 2009 | 2015-2016 | Census[1] |
| *Gender* | | | | | |
| Females | 73.0% | 57.7% | 52.1% | 51.9% | 51.7% |
| *Age* | | | | | |
| 18-29 year olds | 5.3% | 9.2% | 20.9% | 20.9% | 20.9% |
| 30-39 year olds | 13.7% | 10.5% | 14.0% | 14.0% | 14.0% |
| 40-49 year olds | 24.2% | 15.7% | 20.4% | 20.4% | 20.4% |
| 50-59 year olds | 25.8% | 26.4% | 19.7% | 19.5% | 19.5% |
| 60-64 year olds | 11.6% | 10.4% | 7.6% | 7.7% | 7.7% |
| 65+ year olds | 19.4% | 27.8% | 17.4% | 17.5% | 17.4% |
| *Race* | | | | | |
| White | 86.8% | 90.0% | 83.1% | 83.2% | 83.1% |
| Black | 8.7% | 4.7% | 9.1% | 8.4% | 8.4% |
| Other or multiple races | 4.5% | 5.4% | 7.8% | 8.5% | 8.4% |
| *Ethnicity* | | | | | |
| Hispanic or Latino | 6.6% | 8.0% | 8.7% | 8.8% | 8.8% |
| *Education* | | | | | |
| HS/GED or less | 0.0% | 23.4% | 0.0% | 22.9% | 40.4% |
| Some college | 45.6% | 24.7% | 48.5% | 27.2% | 27.5% |
| Bachelors degree | 46.5% | 25.6% | 46.5% | 26.2% | 18.2% |
| Graduate degree | 4.6% | 21.2% | 5.0% | 19.1% | 13.9% |
| Other | 0.0% | 5.1% | 0.0% | 4.6% | NA |
| Missing[2] | n=8 | n=40 | n=8 | n=40 | |
| *Income* | | | | | |
| <$15,000 | 0.0% | 5.6% | 0.0% | 5.3% | 8.5% |
| $15,000-34,999 | 0.0% | 11.8% | 0.0% | 11.5% | 15.3% |
| $35,000-49,999 | 8.4% | 13.9% | 6.6% | 12.3% | 11.4% |
| $50,000-99,000 | 23.4% | 30.5% | 19.7% | 28.2% | 34.0% |
| $100,000+ | 47.8% | 33.4% | 53.6% | 34.3% | 30.8% |
| Don't Know | 15.8% | 5.3% | 20.2% | 8.4% | NA |
| Missing | n=120 | n=224 | n=120 | n=224 | |
| *Home Ownership* | | | | | |
| Own home | NA | 80.7% | NA | 75.9% | 70.5% |
| Missing | | n=17 | | n=17 | |

[1] Gender, age, race, and ethnicity from 2010 US Census for Dutchess county, excluding incarcerated individuals in Beekman, Beacon, and Fishkill. Education from American Community Survey (ACS) 5-year estimate for 2010, population 25 years and older; Income from the ACS 5-year estimate for 2010, households; Ownership of home from ACS 5 year estimate for 2010, tenure among occupied housing units.

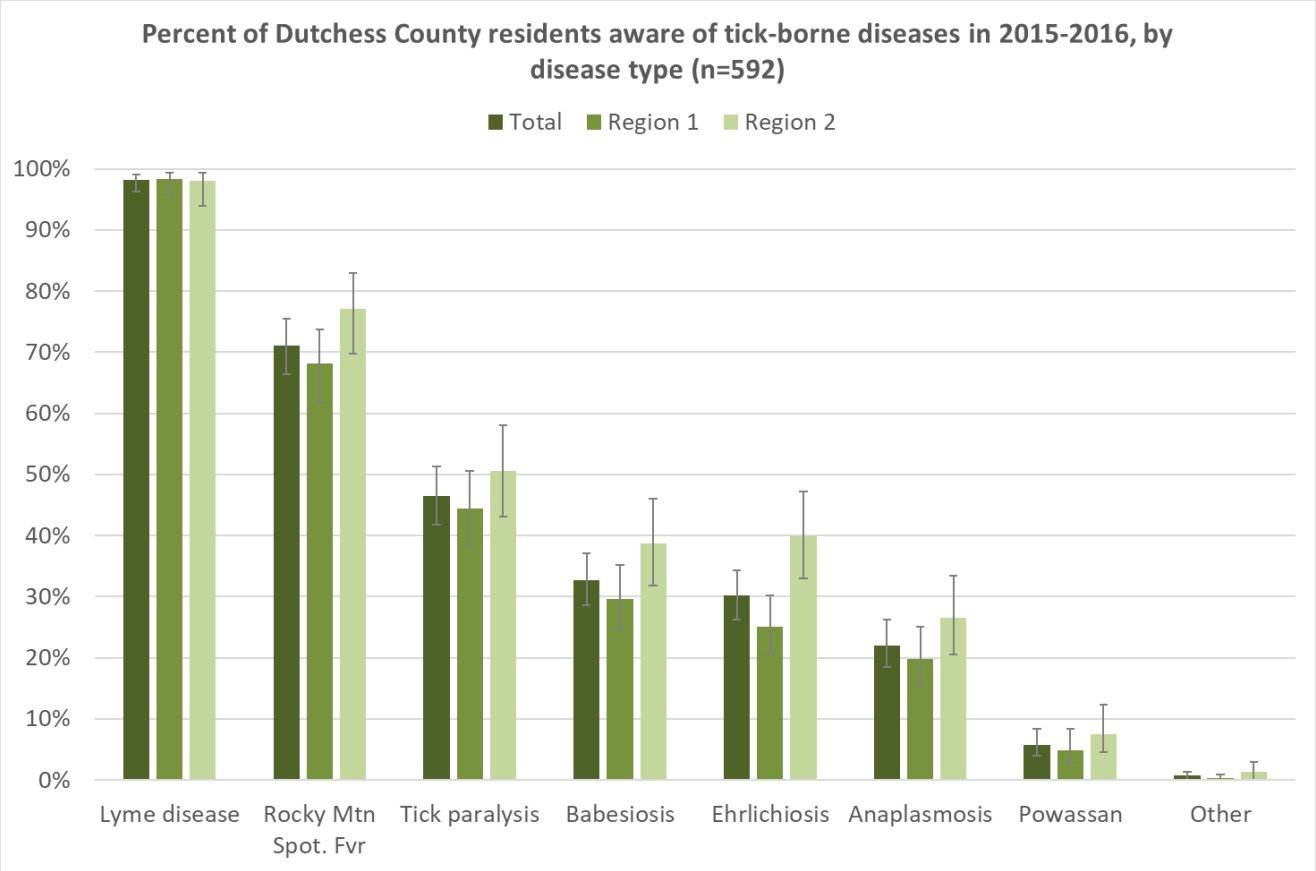
[2] Missing values were excluded from denominators in calculation of proportions

## Awareness, Concern, and Knowledge

### *Awareness of Tick-borne Diseases*

Almost all (98%) of Dutchess County residents (95% CI: 96%-99%) were aware of Lyme disease in 2015-2016, regardless of region. Region 2 residents were significantly more aware of other tick-borne diseases compared to Region 1. Recognition of other tick-borne diseases, however, was not necessarily on par with risk of exposure in the region. For instance, Rocky Mountain Spotted Fever (RMSF) was the next most commonly recognized disease (71%, 66%-75%), although it is primarily found in the southeastern and southcentral US. Tick paralysis is likewise extremely rare, and its fairly wide recognition (47%, 42%-51%) likely reflects media attention around individual cases and examples in popular culture. As compared to RMSF and tick paralysis, residents had lower recognition of anaplasmosis and babesiosis (around 30%). These diseases, while less common than Lyme disease, are nonetheless endemic in the County. Although clinically similar to anaplasmosis, ehrlichiosis is a distinct disease carried by Lone Star ticks whose range, while expanding northward, are not typically found in Dutchess County. Some confusion between anaplasmosis and ehrlichiosis may be due to their having been classified together until the early 2000s. Finally, Powassan virus is very rare but can be fatal. Awareness of Powassan virus was extremely low in 2015-2016.

Figure 1.



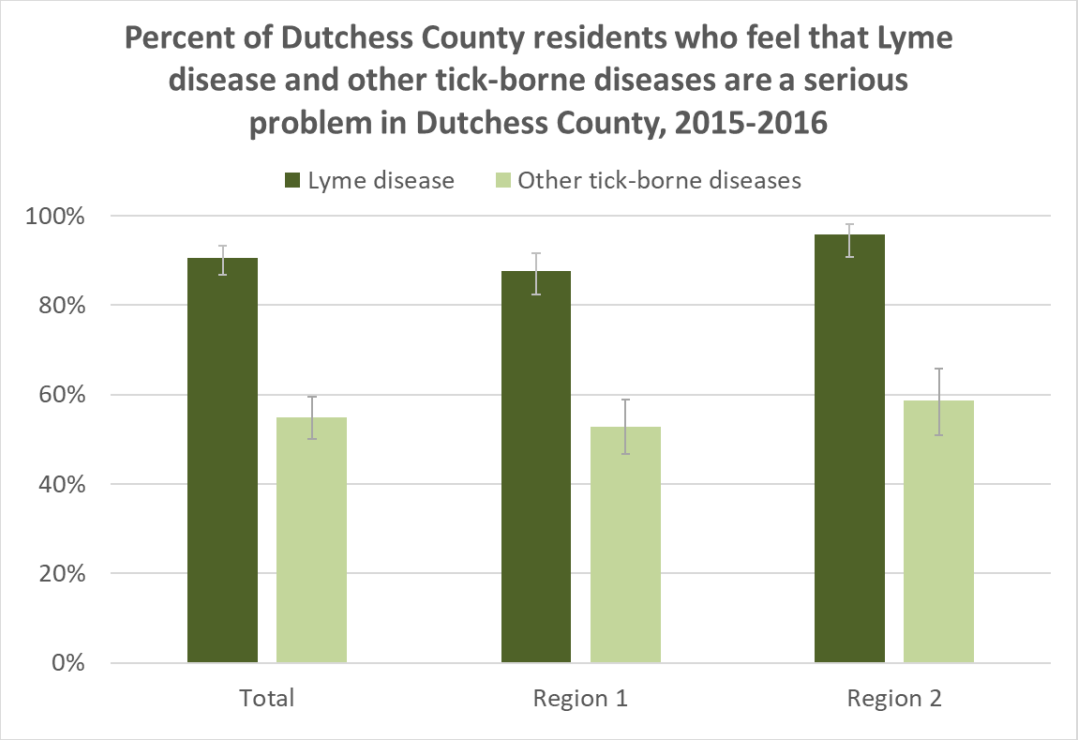

To further explore resident awareness of tick-borne diseases other than Lyme disease, awareness of babesiosis, anaplasmosis or ehrlichiosis was combined, and responses were stratified by demographic characteristics. Respondents with a college degree or higher were more likely (p=0.039) to be aware of babesiosis, anaplasmosis, or ehrlichiosis (53%, 95% CI: 46%-59%) than those with less than a college

degree (43%, 95% CI: 36%-50%). While results should be interpreted with caution due to small numbers, significant differences (p=<0.001) were also seen in the awareness of babesiosis, anaplasmosis or ehrlichiosis based on race and ethnicity, with the highest level of awareness found in residents identifying as White Non-Hispanic (54%, 95% CI: 49%-59%), followed by Other (41%, 95% CI: 26%-57%), Hispanic (37%, 95% CI: 19%-60%), and Black Non-Hispanic (8%, 95% CI: 2%-29%).

### *Concern about Tick-borne Diseases*

In 2015-2016, 91% of residents (95% CI: 87%-93%) felt that Lyme disease was a somewhat or very serious problem in Dutchess County. Meanwhile, just around half of residents felt that other tick-borne diseases were a somewhat or serious problem in Dutchess County (55%, 95% CI: 50%-60%). Concern about Lyme disease was significantly higher[3] in Region 2 (96%, 95% CI: 91%-98%) than in Region 1 (81%: 95% CI 73%-87%); the apparent difference between regions for other tick-borne diseases was not statistically significant.

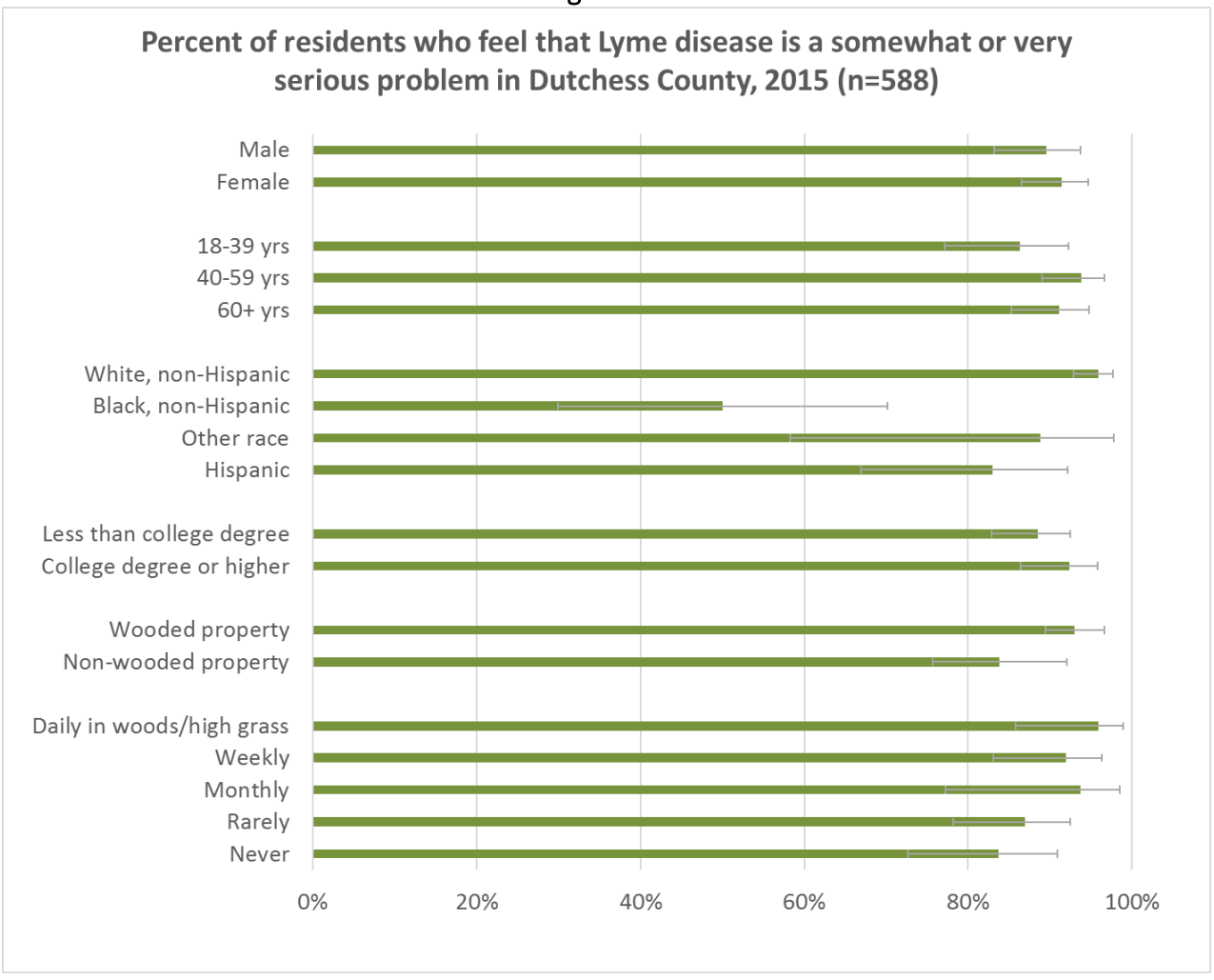
Figure 2a.




[3] p = 0.01, Survey adjusted Pearson chi-square test

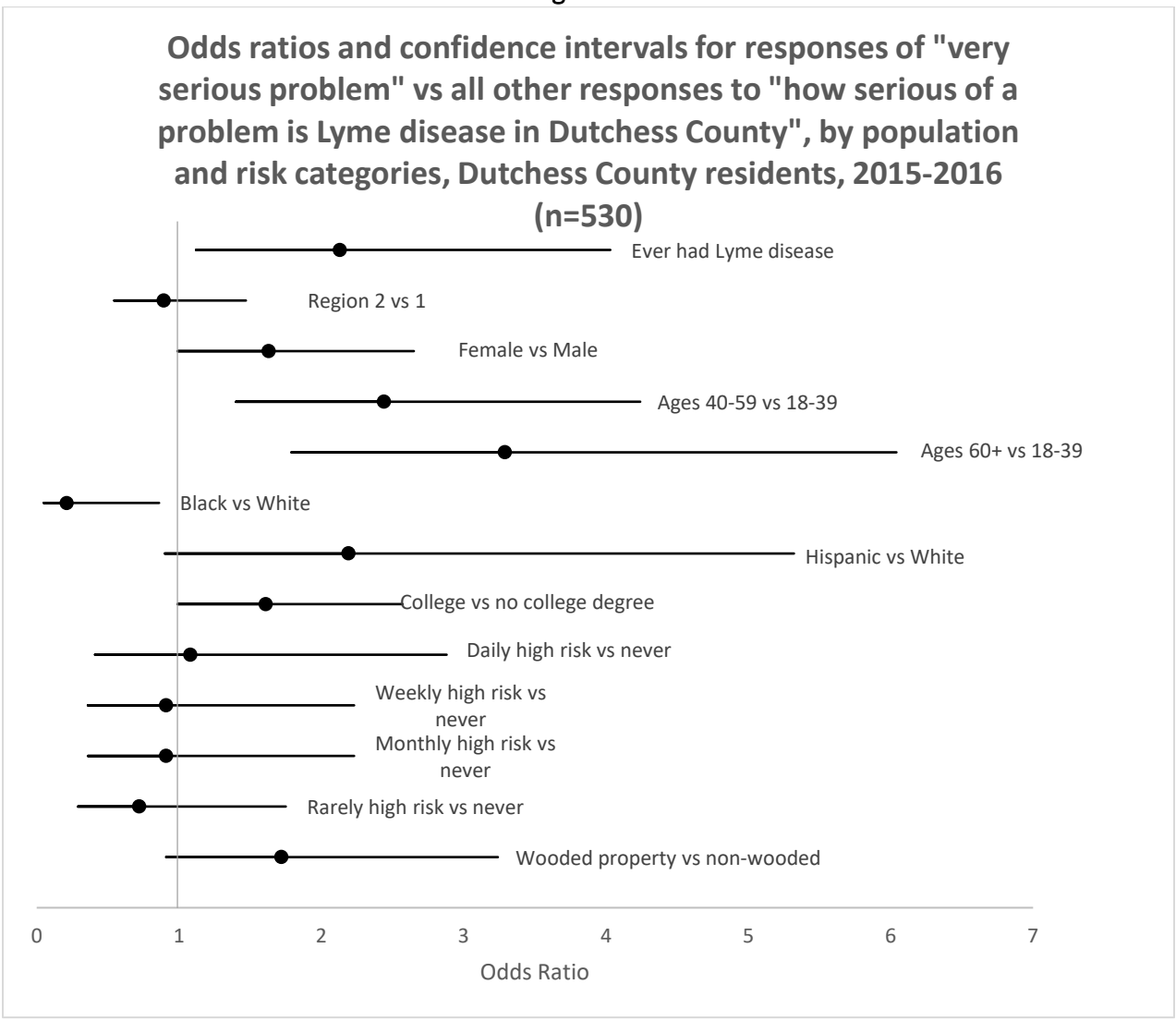
To further explore resident concern about Lyme disease, responses were stratified by demographic and exposure risk characteristics (Figure 2b). While results should be interpreted with caution due to small numbers, significant differences were observed based on race and ethnicity, with the highest degree of concern about Lyme disease expressed by residents identifying as White Non-Hispanic (96%, 95% CI: 93%-98%), followed by Other Non-Hispanic (89%, 95% CI: 58%-98%), followed by Hispanic (83%, 95% CI: 67%-92%),and Black Non-Hispanic (50%, 95% CI: 30%-70%)[4]. In a multivariable model looking at the odds of selecting "very serious," that is, the highest level of concern, and controlling for all other demographic and risk characteristics at the same time, a significant difference was no longer apparent between regions. Non-Hispanic black race remained a significant predictor of lower concern, while older age categories (as compared to age 18-39), female gender and having ever had Lyme disease also significantly increased one's odds of reporting the highest level of concern (Figure 2c).

Figure 2b.




[4] p=<0.001, Survey adjusted Pearson chi-square test

Figure 2c.

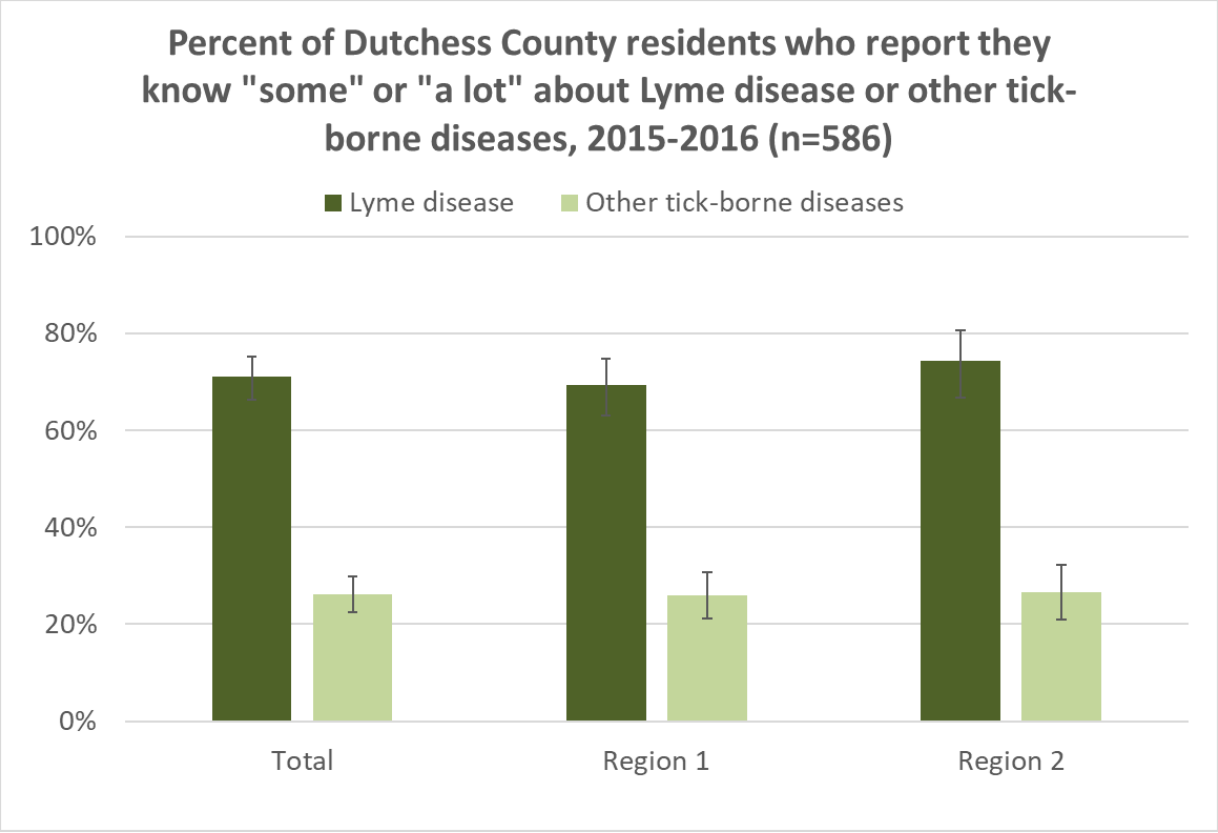

Odds ratios and confidence intervals for responses of "very serious problem" vs all other responses to "how serious of a problem is Lyme disease in Dutchess County", by population and risk categories, Dutchess County residents, 2015-2016 (n=530)
Ever had Lyme disease
Region 2 vs 1
Female vs Male
Ages 40-59 vs 18-39
Ages 60+ vs 18-39
Black vs White
Hispanic vs White
College vs no college degree
Daily high risk vs never
Weekly high risk vs never
Monthly high risk vs never
Rarely high risk vs never
Wooded property vs non-wooded
0
1
2
3
4
5
6
7
Odds Ratio

*Self-Reported Knowledge of Tick-borne Diseases*

In 2015-2016, 70% (95% CI: 66%-75%) of residents reported they knew "some" or "a lot" about Lyme disease. Meanwhile, just about one-quarter (26%, 95% CI 22%-30%) reported knowing "some" or "a lot" about other tick-borne diseases. There were no regional differences in those who reported at least some knowledge, despite the differences in awareness of specific tick-borne diseases other than Lyme (Figure 1).

Self-reported knowledge about Lyme disease was relatively unchanged from the 2009 survey, where 68% (95% CI: 62%-64%) reported "some" or "a lot" of knowledge, using the updated analytic weighting approach. However, the 2009 survey may have overestimated knowledge given the homogenous educational background of participants in 2009.

Figure 3.



*Tick-borne Disease True & False Assessment*

Residents responded to a series of true or false statements about ticks and tick-borne diseases (Table 2). They were also asked about safe and effective ways to remove a tick (Figure 4). Sixty-three percent of residents (95% CI: 54%-72%) answered 5 or more of the true/false questions correctly, 33% (95% CI: 29%-38%) answered 3 or 4 correctly, and 4% (95% CI: 3%-7%) answered less than 3 correctly. Those who self-reported higher levels of knowledge were more likely to score higher in the objective assessment (p= 0.01).

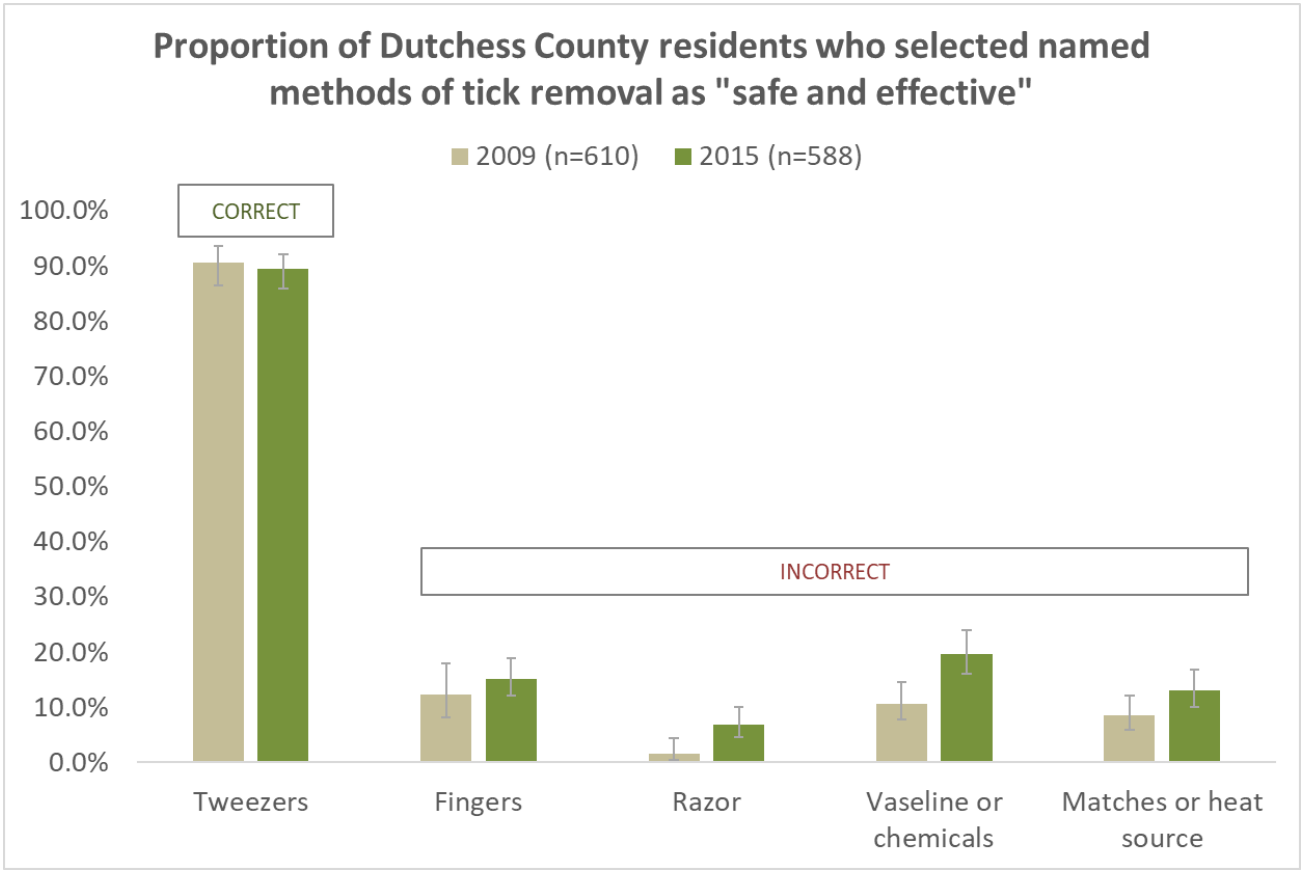
Knowledge of risky locations and early symptoms of illness were frequently answered correctly (about 90% of residents). Almost three-quarters of residents were aware that the likelihood of disease transmission declines the sooner a tick is removed, and that mice and rodents are important in the tick life cycle. About half of residents knew that a Lyme rash does NOT always have a bull's eye appearance, and that May-July are the riskiest months to contract a tick-borne disease.

Table 2.

| True or False Question | Percent Correct (95% CI) |
|---|---|
| I'm at greatest risk for a tick bite in wooded, brushy, and tall grass areas (TRUE) | 91% (88%-93%) |
| Some early symptoms of Lyme disease and other tick-borne diseases can resemble those of the flu, such as fever, muscle aches, and fatigue (TRUE) | 90% (87%-93%) |
| The sooner a tick is removed, the less likely it is to transmit disease (TRUE) | 74% (69%-78%) |
| Mice and rodents are important in transmission of Lyme disease (TRUE) | 72% (67%-96%) |
| The rash associated with Lyme always has a bull's eye appearance (FALSE) | 53% (48%-58%) |
| May-July are the riskiest months to contract tick-borne diseases (TRUE) | 52% (47%-57%) |

In 2015-2016, 89% of residents (95% CI: 86%-92%) correctly stated that tweezers are a safe and effective method of removing a tick attached to one's skin. However, there were increases compared to 2009 in the proportion of residents who *incorrectly* stated that other methods of tick removal were safe and effective, including matches, Vaseline and chemicals, or razors (Figure 4).

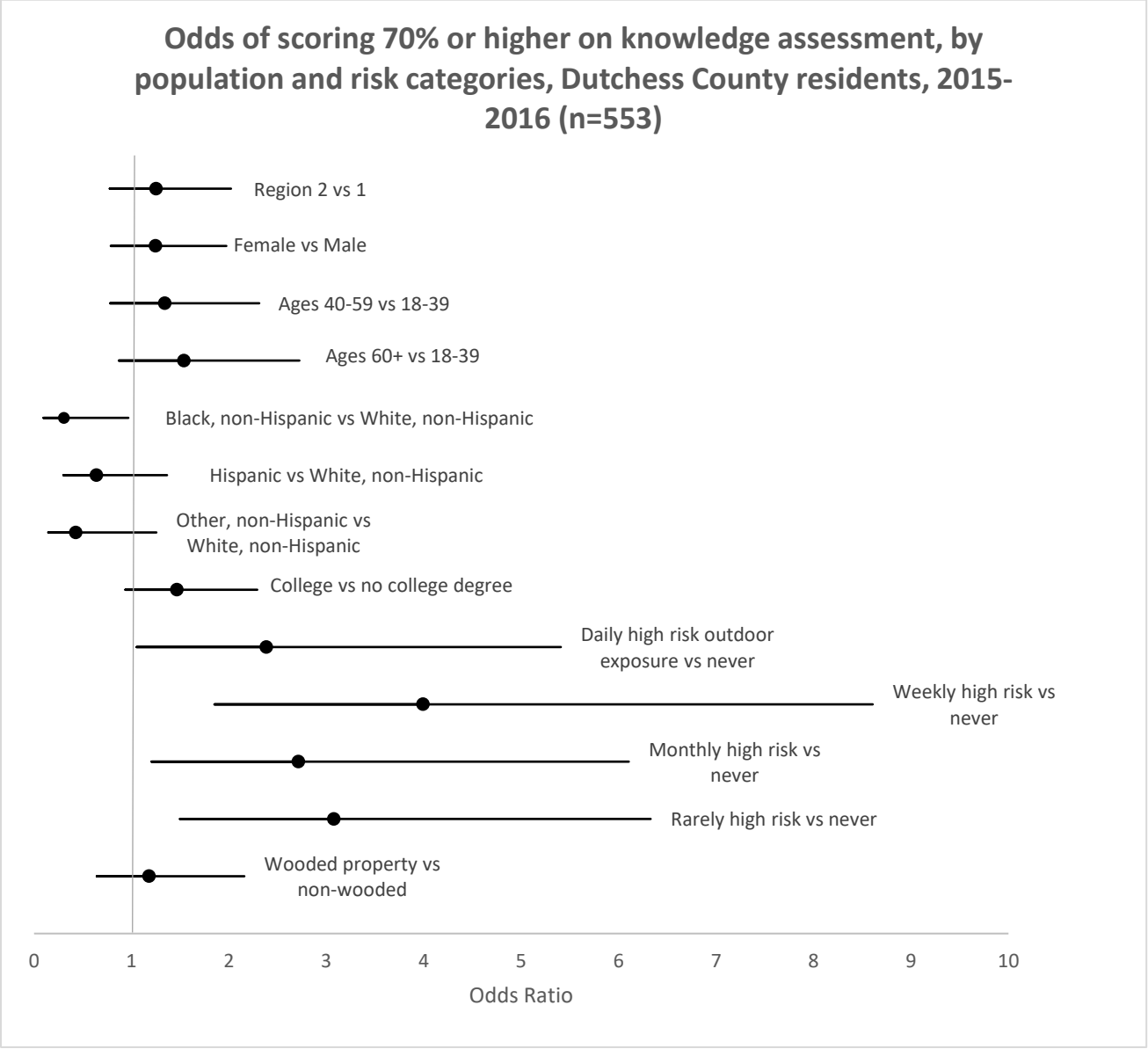
Figure 4.



## Factors Associated with Knowledge of Tick-borne Diseases

We used a multivariable logistic regression model to explore characteristics associated with higher scores on the objective true and false knowledge assessment. Daily, weekly, monthly and even rare exposure to grassy, wooded, and tall grass areas (explored in detail in the next section) were significantly correlated with scoring 70% or higher on the assessment. Region, sex, age, ethnicity, education, and wooded property status were not significantly associated with knowledge scores, after controlling for time spent outdoors in high risk areas. There was evidence that non-Hispanic Black, Hispanic, and other Non-Hispanic residents tended to score lower than White, non-Hispanic residents. Due to small numbers, as a sensitivity analysis, non-Hispanic Black residents' and Hispanic residents' results were combined, resulting in significantly lower scores compared to non-Hispanic White residents (OR 0.47, 95% CI: 0.24-0.91).

Figure 5.

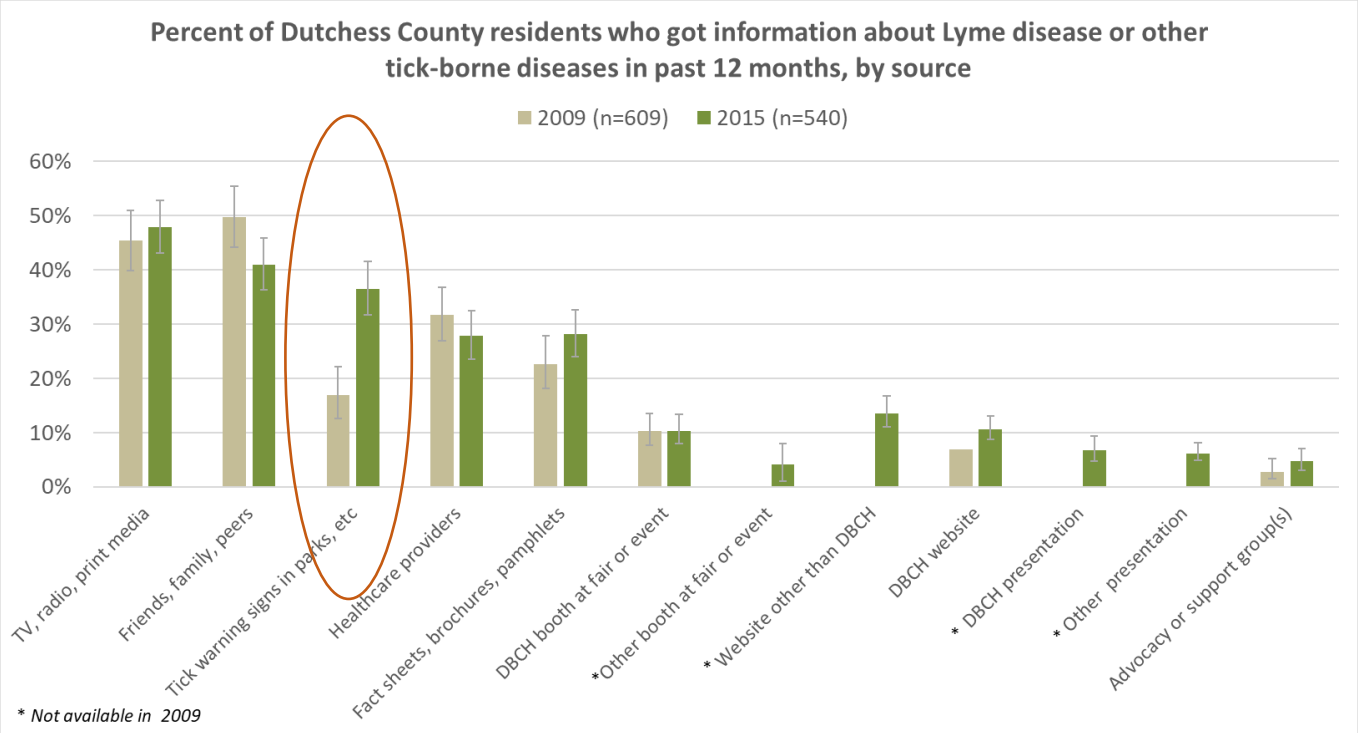


## Information Sources and Accessibility

TV/radio/print media (48%, 95% CI: 42%-53%) and word-of-mouth from family and peers (41%, 95% CI: 36%-46%) were the two most frequent sources of information about Lyme disease reported by Dutchess County residents in 2015-2016, similar to 2009 (Figure 6a). The proportion of residents who got information from warning signs in parks more than doubled in 2015-2016 to 37% (95% CI: 32%-42%) compared to 17% (95% CI: 13%-22%) in 2009, as highlighted in red below.

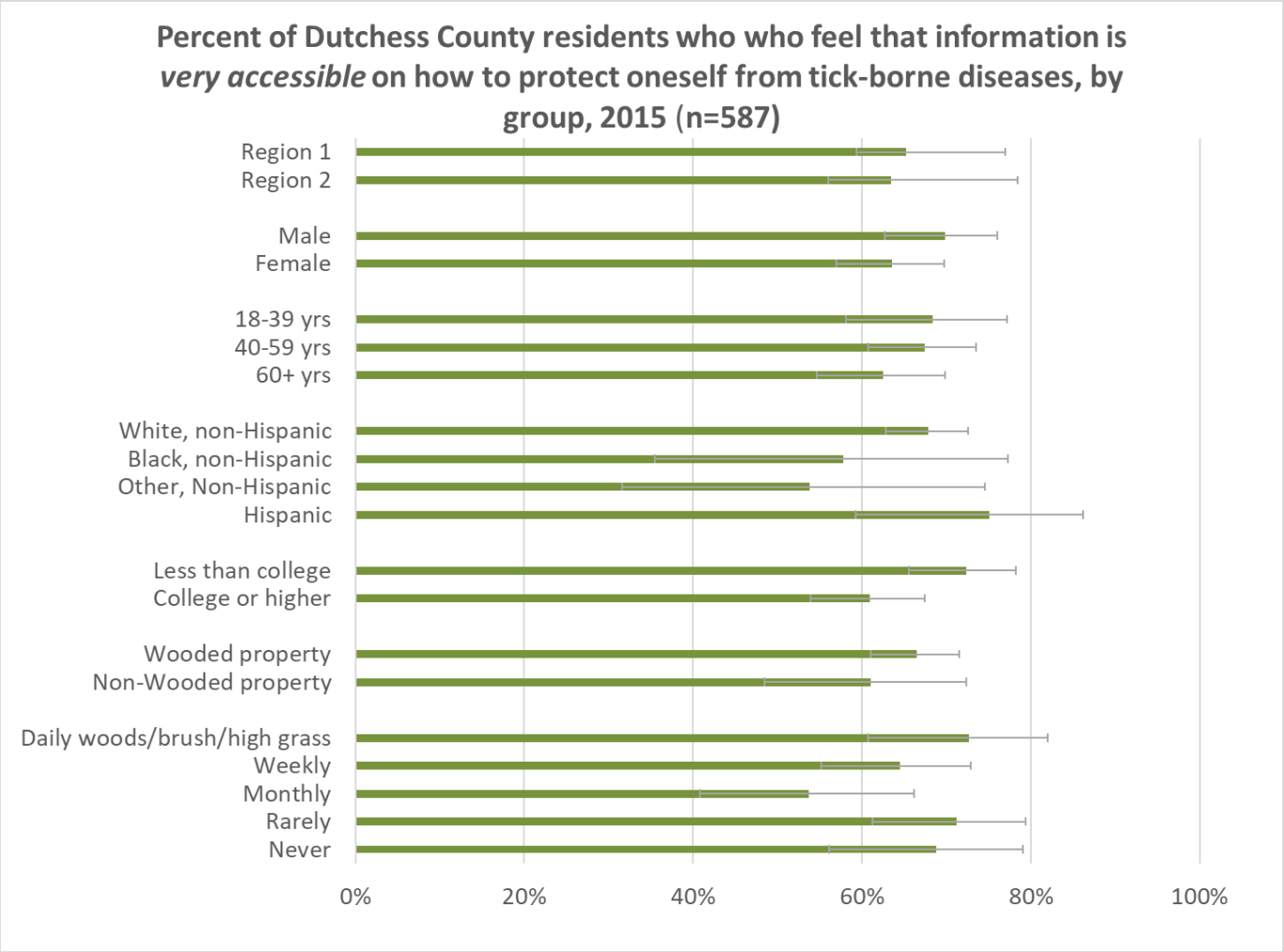
Healthcare providers were the next most common source of information in 2015-2016 (28%, 95% CI: 24%-32%), ranking 4$^{th}$ as in 2009. Somewhat surprisingly, residents more frequently got information about Lyme disease from fact sheets and brochures (28%, 95% CI: 24%-32%) than websites (DBCH or others, about 11% and 14% respectively). Fair/event booths, presentations, and support groups reached between 5% and 10% of residents both in 2009 and 2015-2016.

Figure 6a.



More than half of Dutchess County residents felt that information on how to protect oneself from tick-borne diseases was very accessible in 2015-2016 (65%, 95% CI: 60%-69%). College education was the only significant difference across any demographic or outdoor risk categories (Figure 6b); paradoxically, college educated residents were less likely to rate information as being highly accessible.

Figure 6b.

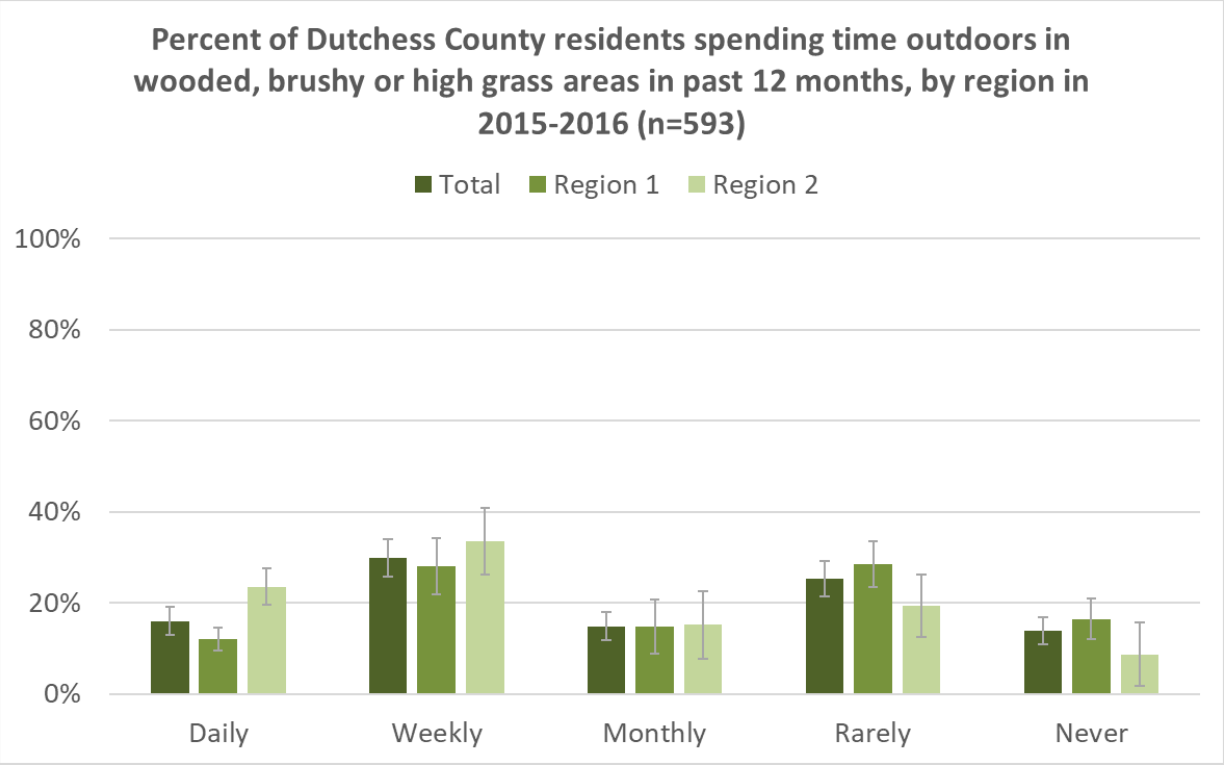


## Exposure, and Personal and Property Protection

### Time Spent Outdoors in Wooded, Brushy, or High Grass Areas

Among Dutchess County residents surveyed in 2015-2016, 16% (95% CI: 13%-20%) spent time outdoors *daily* in wooded, brushy, and high grass areas over the previous late spring through early fall (Figure 7). Thirty percent (95% CI: 26%-34%) spend time *weekly*, 15% (95% CI: 12%-19%) spend time *monthly*, and the remaining 40% rarely or never spend time outdoors in wooded, high grass or brushy areas. Residents of Region 2 spent more time outdoors than residents of Region 1 ($p < 0.01$).

Figure 7.




Residents having wooded properties more frequently reported daily exposure to wooded, brushy, and high grass areas than residents having non-wooded properties (Figure 7a, $p < 0.01$). Also, males were more likely to report more frequent daily exposure to high risk areas than females (Figure 7b, $p < 0.01$). There was a complex relationship between exposure and age, with older adults having the most daily exposure as well as the most non-exposure, likely reflecting differences between active seniors and less active older seniors (Figure 7c).

Figure 7a.

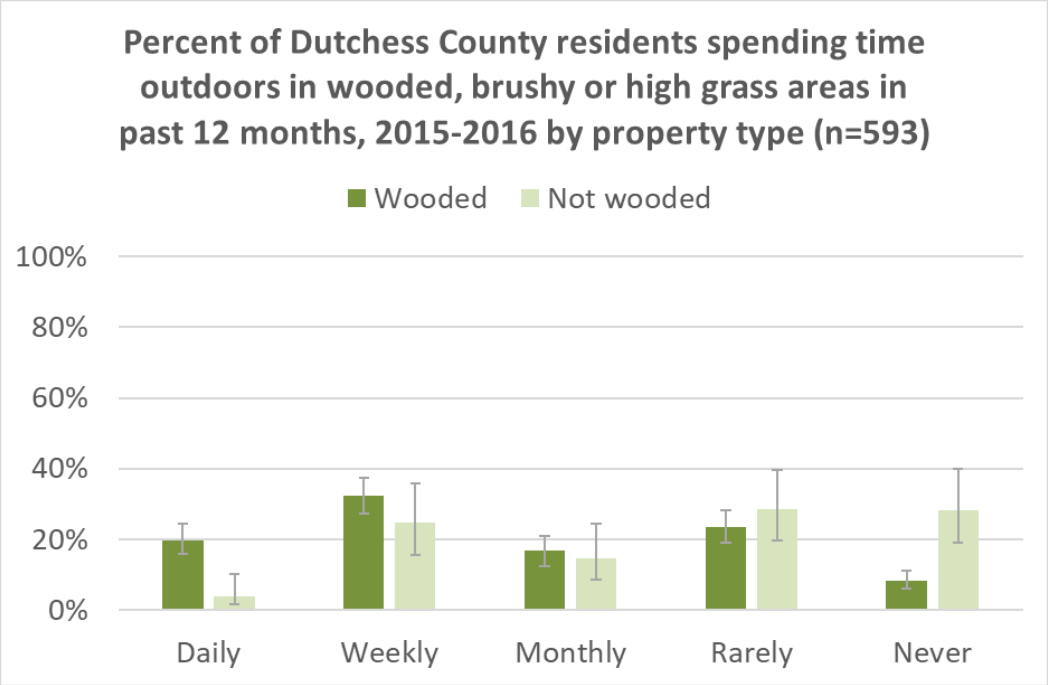



Figure 7b.

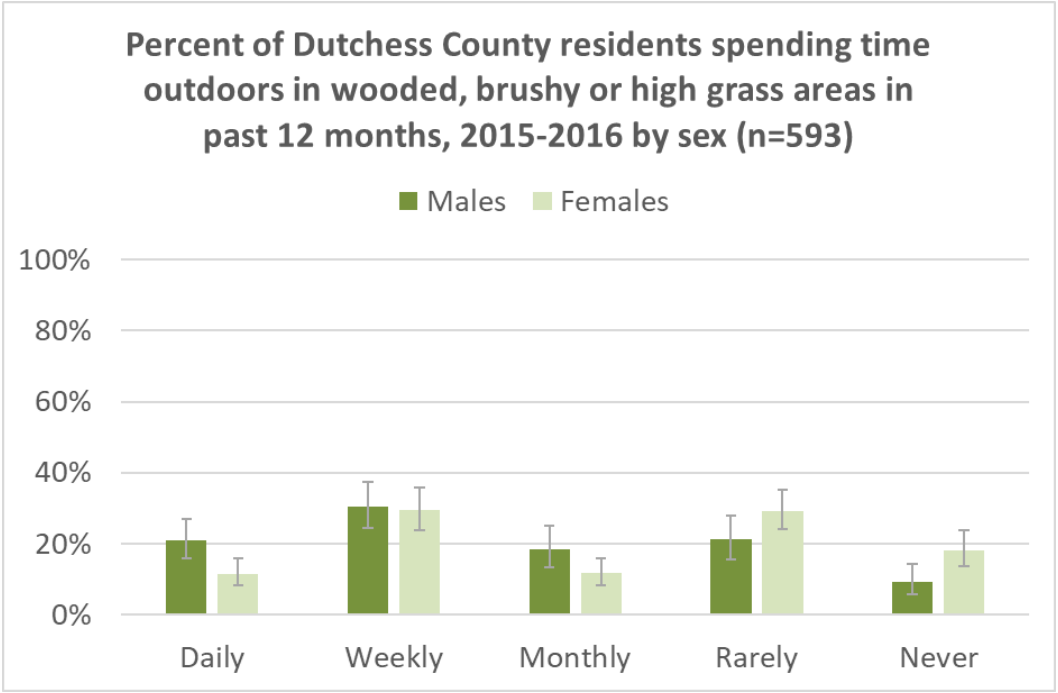
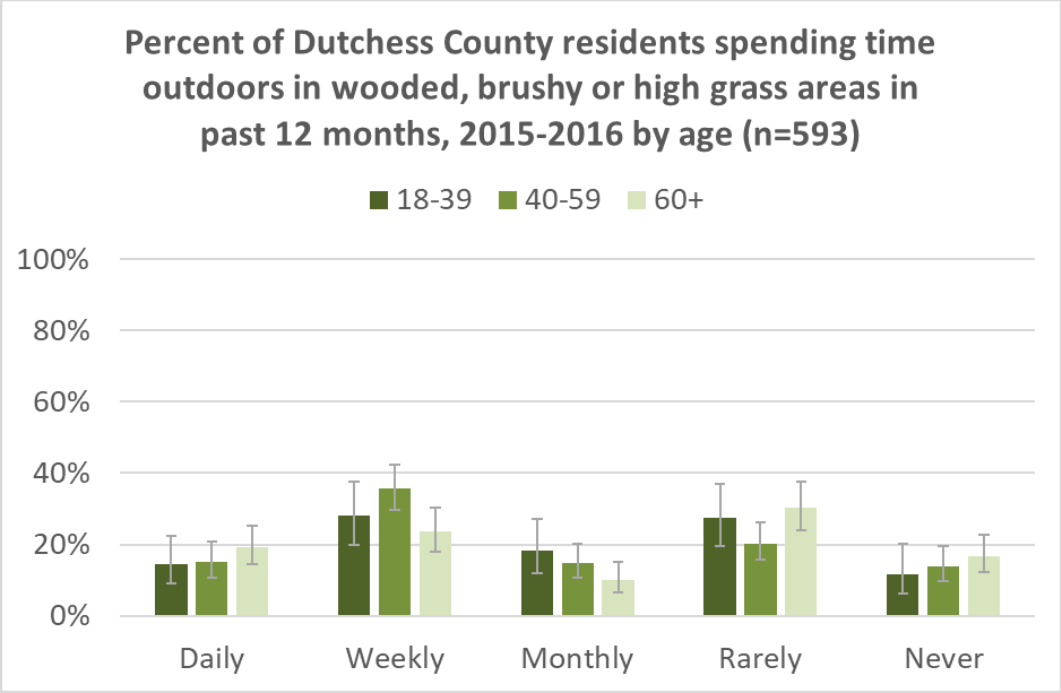


Figure 7c.

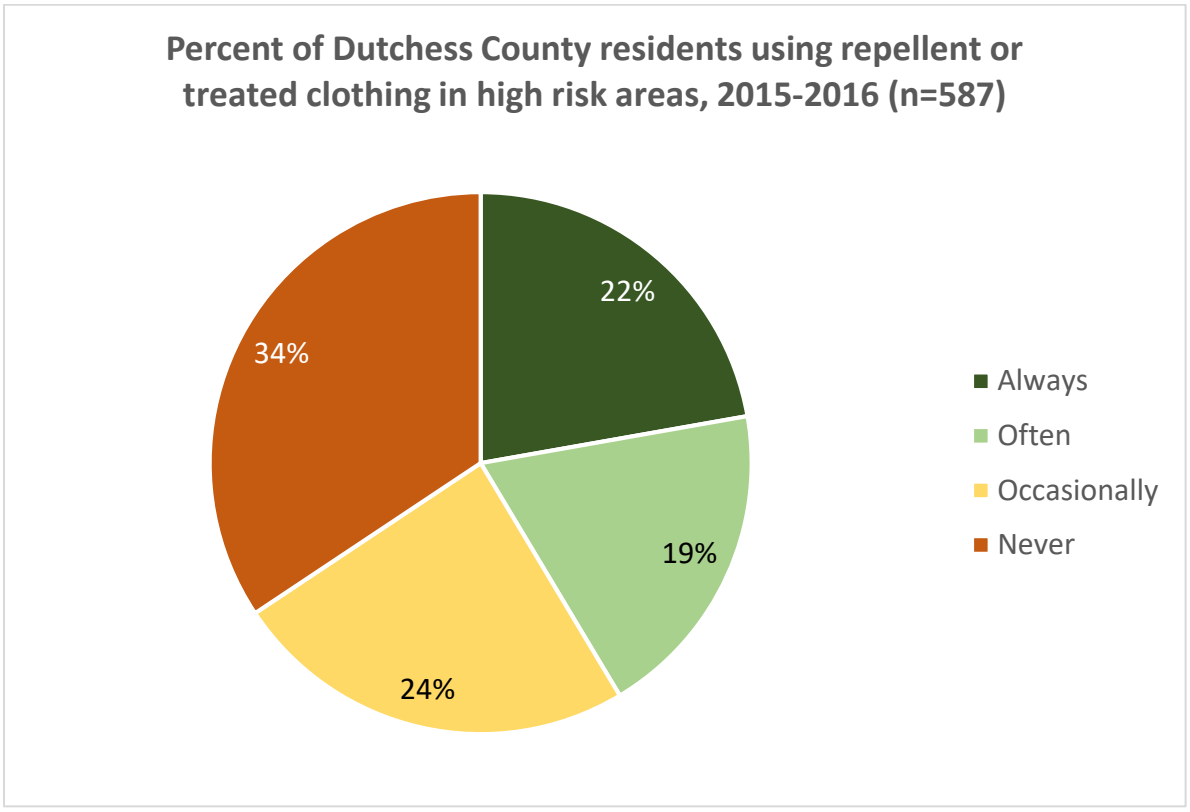

Percent of Dutchess County residents spending time outdoors in wooded, brushy or high grass areas in past 12 months, 2015-2016 by age (n=593)
18-39
40-59
60+
100%
80%
60%
40%
20%
0%
Daily
Weekly
Monthly
Rarely
Never

## Use of Repellents and Tick Checks

Fewer than half of Dutchess County residents use repellents consistently when spending time outdoors in wooded, brushy, or high grass areas. In 2015-2016, 22% (95% CI: 18%-27%) reported using repellents on their skin or clothing all of the time, 19% (95% CI: 16%-24%) applied repellents often, 24% (95% CI: 20%-29%) used repellents occasionally, and 34% (95% CI: 30%-40%) never used any repellents (Figure 8).

The 2009 survey did not include repellent-treated clothing in the wording of the question and therefore the results cannot be directly compared.

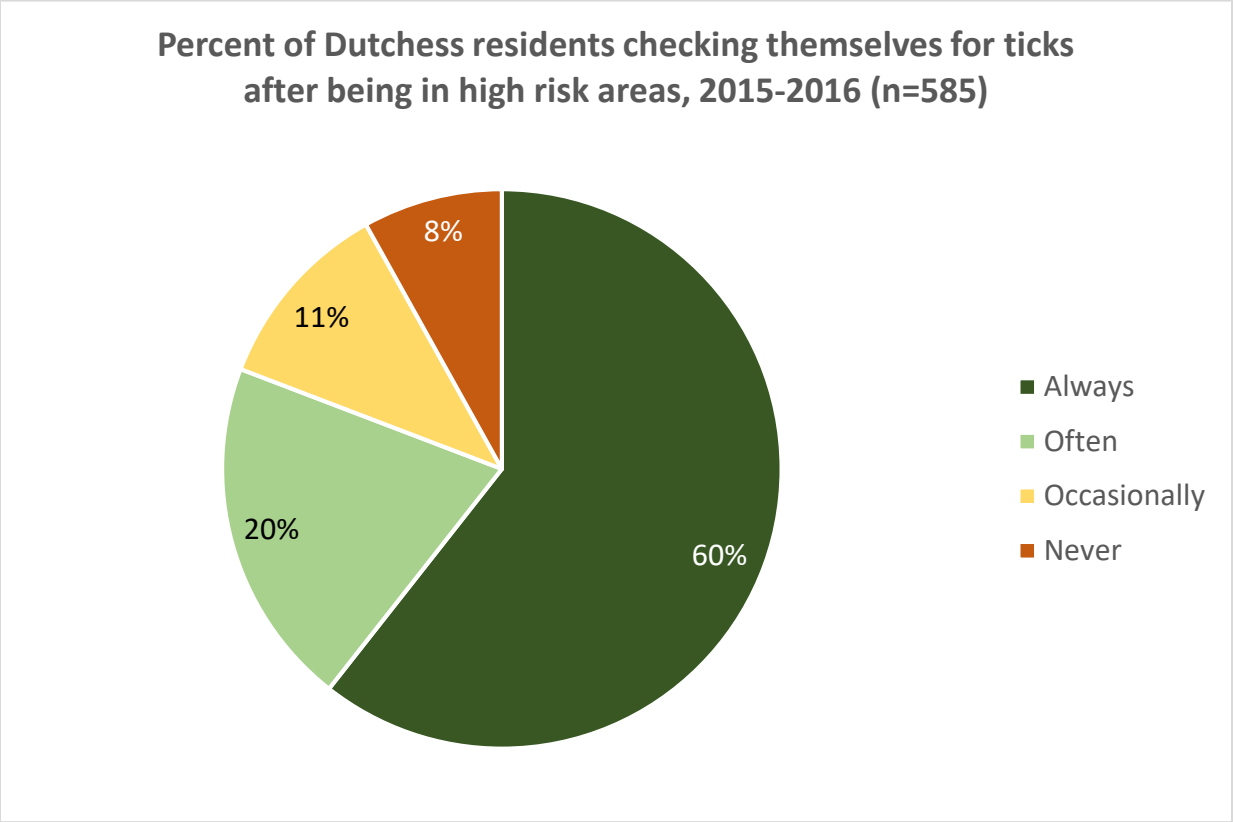
Figure 8.



Meanwhile, the majority of residents reported checking themselves for ticks after being in high risk areas (Figure 9). In 2015-2016, among those who spent any time in wooded, brushy, or high grass areas, 60% (95% CI: 55%-65%) *always* checked for ticks and another 20% (95% CI: 16%-25%) *often* checked for ticks, while 11% (95% CI: 8%-15%) occasionally checked for ticks and only 8% never checked for ticks (95% CI: 6%-12%).

The proportion always or often checking for ticks has held constant since the 2009 survey, which was 66% (95% CI: 60%-72%) and 17% (95% CI: 13%-22%) respectively, when weighted according to the current methodology.

Figure 9.



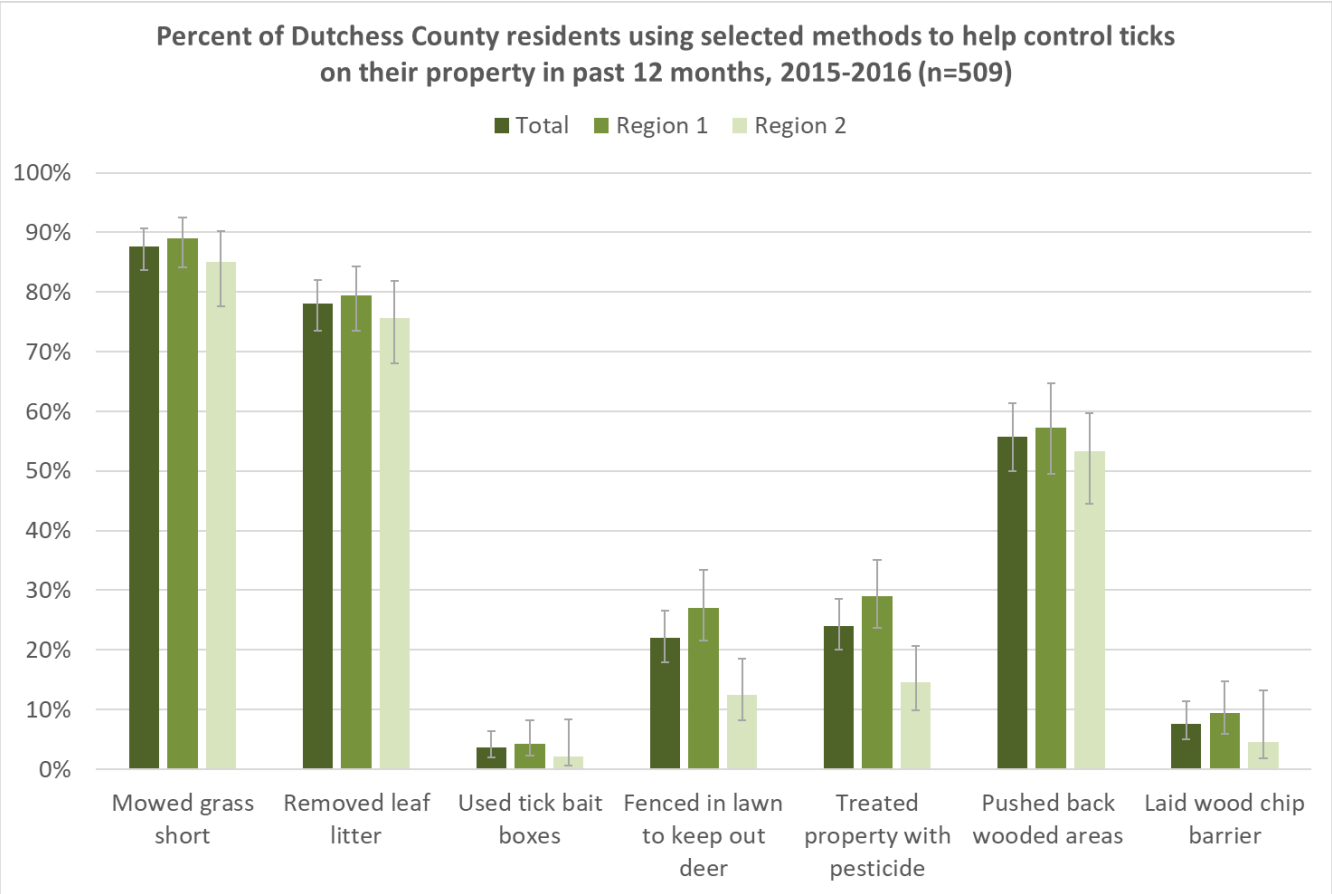
## Actions to Control Ticks on the Property

Mowing the grass short and removing leaves, common activities for general lawn maintenance, were the two most frequently reported actions taken to control ticks on personal property (Figure 10). In 2015-2016, residents in Region 1 more often reported having fencing for the purpose of, or suitable for, keeping out deer compared with residents in Region 2. Region 1 residents also more frequently treated their properties with pesticides. These two differences were statistically significant ($p < 0.01$). There also appeared to be a significant increase in the proportion of residents who treated their properties with pesticide in 2015-2016 (24%, 95% CI: 20%-29%), compared to 2009 (11%, 95% CI: 8%-15%) when weighted according to the current methodology.

Tick bait boxes are a relatively new product designed to reduce ticks by attracting and treating mice and other small mammals against ticks using the same topical insecticide approved for cats and dogs. Very few residents (<5%) in either region of Dutchess County had used these devices as of 2015-2016, although there was strong interest after hearing about them (see "Adopting Prevention Strategies in the Community" below).

Pushing back wooded boundaries and applying a wood chip barrier are sometimes recommended to help reduce and delineate higher risk areas on one's property. More than half of residents with wooded properties have pushed back their wooded boundaries, while fewer than 10% have laid a wood chip barrier. There appeared to be a significant increase in those who reporting pushing back wooded boundaries in 2015-2016, compared to an average of 35% (95% CI: 30%-41%) in 2009.

Figure 10.



## Pet Ownership, Tick Repellent Use and Ticks on Pets

In 2015-2016, we estimated that 49% of Dutchess County adults owned indoor pets that go outdoors (95% CI: 44%-53%), with more owners in Region 2 (60%, 95% CI: 53%-67%) compared with Region 1 (43%, 95% CI: 37%-49%), which was statistically significant (p <0.01). For this question, we imputed missing (15%) to mean "no" due to a skip pattern in the telephone survey.

The large majority of pet owners (87%, 95% CI: 82%-91%) applied tick repellents or used tick repellent collars on their pets in 2015-2016. This was somewhat higher than reported in 2009; differences between Regions 1 and 2 were not statistically significant (Figure 11a). Almost three quarters of pet owners (74%, 95% CI: 67%-79%) found ticks attached to their pets in the past 12 months (Figure 11b), more so in Region 2 (85%, 95%: 76%-90%) than Region 1 (65%, 95% CI: 55%-73%), which was significant (p < 0.01). This question was not available in 2009.

Figure 11a.

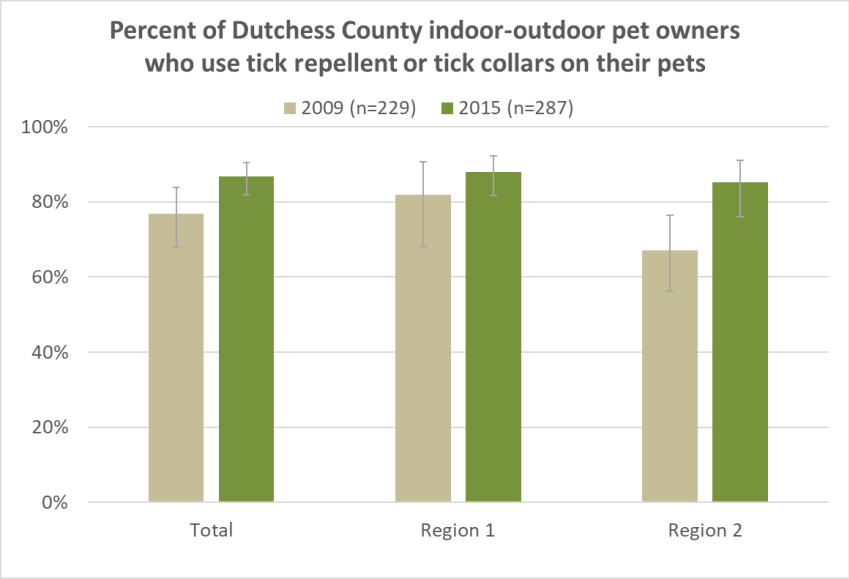
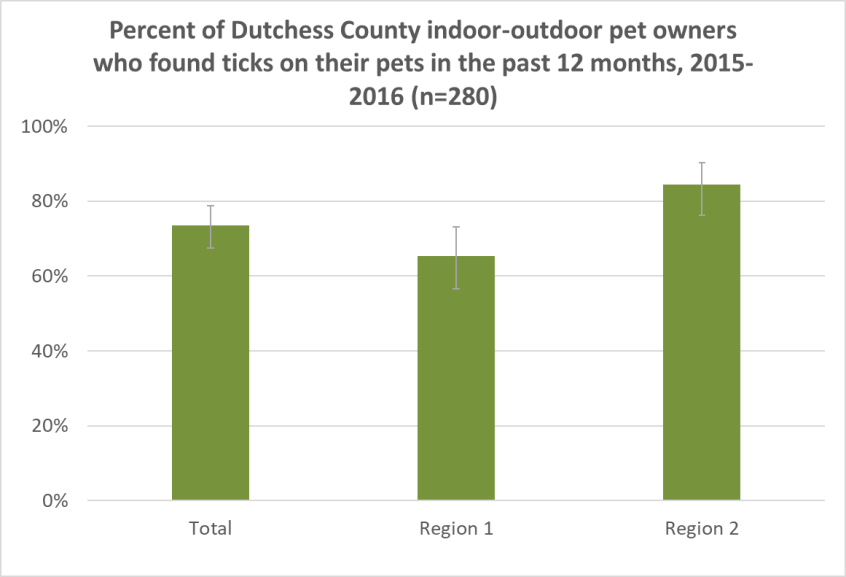


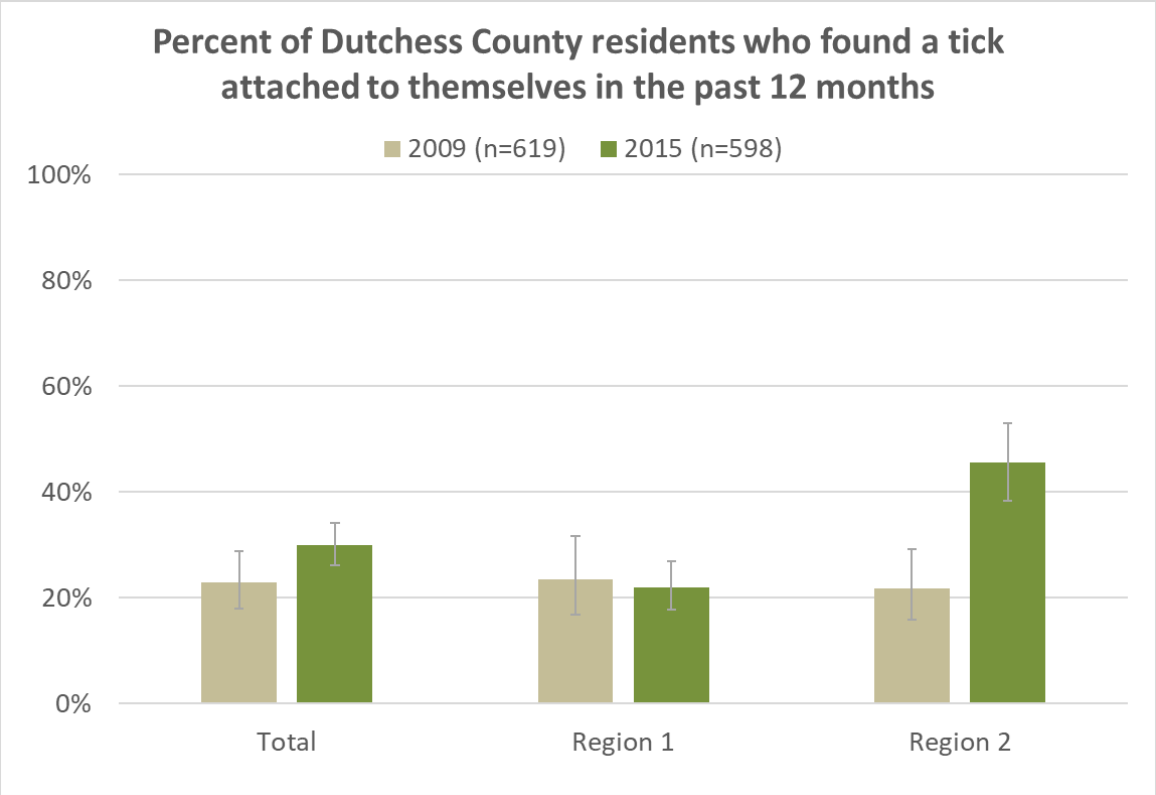

Figure 11b.



## Characteristics Associated with Finding an Attached Tick in Previous Year

In 2015-2016, 30% (95% CI: 26%-34%) of Dutchess County adults found a tick attached to themselves in the previous twelve months, compared to 23% (95% CI: 18%-29%) in 2009. Residents of Region 2 were more likely to report finding an attached tick in the 2015-2016 survey compared to Region 1 residents. We used multivariable modeling to explore characteristics associated with finding an attached tick, below.

Figure 12a.



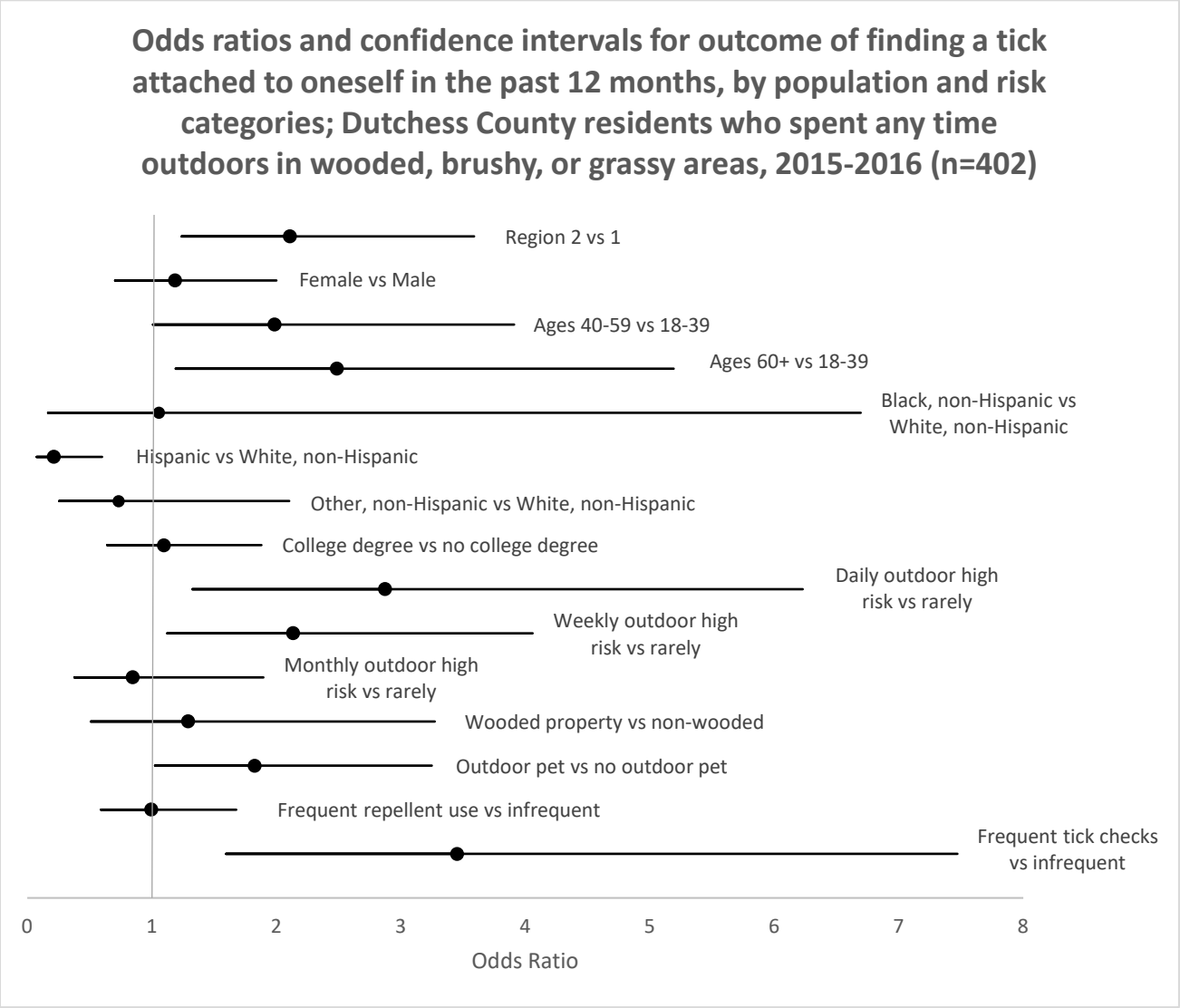

When controlling for all other demographic and exposure characteristics (Figure 12b, below), there was a significant stepwise increase in the odds of finding a tick attached to oneself in the previous year as one's time spent in wooded, brushy, and high grass areas increased from monthly exposure (OR: 0.8, 95% CI: 0.4-1.9) to weekly exposure (OR: 2.1, 95% CI: 1.1-4.1) to daily exposure (OR: 2.9, 95% CI: 1.3-6.2), compared to those who rarely spent time outdoors in such high risk areas,

There was also a stepwise increase in the odds of finding a tick associated with older age, controlling for all other variables (bearing in mind the survey only assessed adults). Adults 60 and older were more than twice as likely to note finding an attached tick in the previous year compared to 18-39 year olds (OR: 2.5, 95% CI: 1.2-5.2). Also, Region 2 residents were twice as likely as Region 1 residents to report an attached tick in the previous year (OR: 2.1, 95% CI: 1.2-3.6), and Hispanic residents were *less* likely to report finding a tick than non-Hispanic White residents, controlling for other demographic and exposure characteristics (OR: 0.2, 95% CI: 0.1-0.6). Other categories were small with more uncertainty as shown by wider confidence intervals; however, as a sensitivity check we again combined responses for Black and Hispanic residents, and the results were similar (OR: 0.4, 95% CI: 0.1-1.2).

Frequent tick checking itself was highly associated with finding an attached tick (OR: 3.5, 95% CI: 1.6-7.5), as one would expect. By including it in the model, it controls for tick-checking behavior in order to better observe how other characteristics are associated with tick exposure. For instance, those with more

frequent outdoor exposure in high risk areas were more likely to find an attached tick, even after accounting for the fact they were also more likely to check for ticks than those with infrequent exposure. Finally, having a pet that goes outdoors was significantly associated with nearly twice the odds of noting having found a tick attached to oneself (OR: 1.8, 95% CI: >1.0-3.2), controlling for all other characteristics.

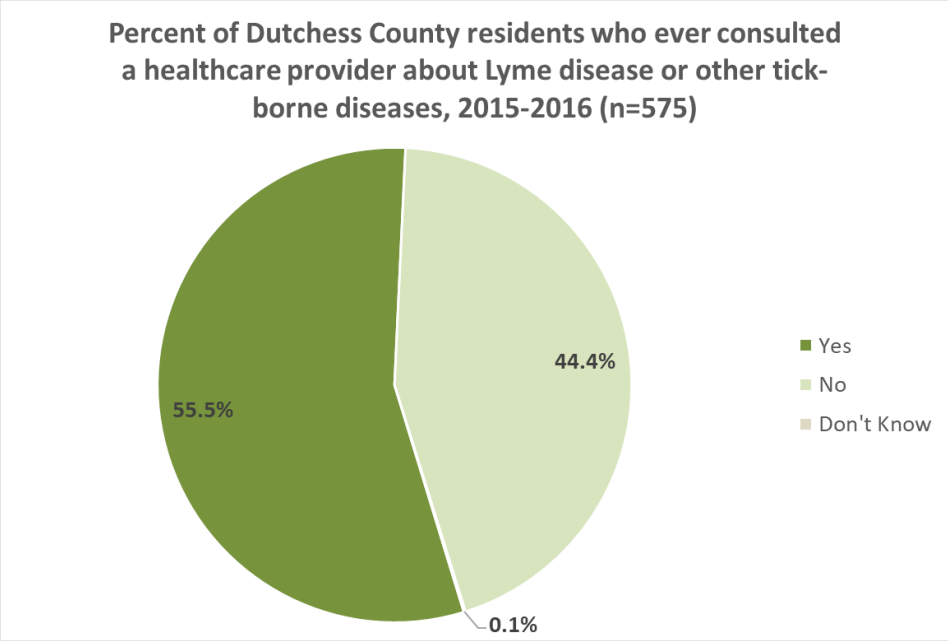
Figure 12b.



## Personal Medical History and Healthcare Experience with Tick-borne Diseases

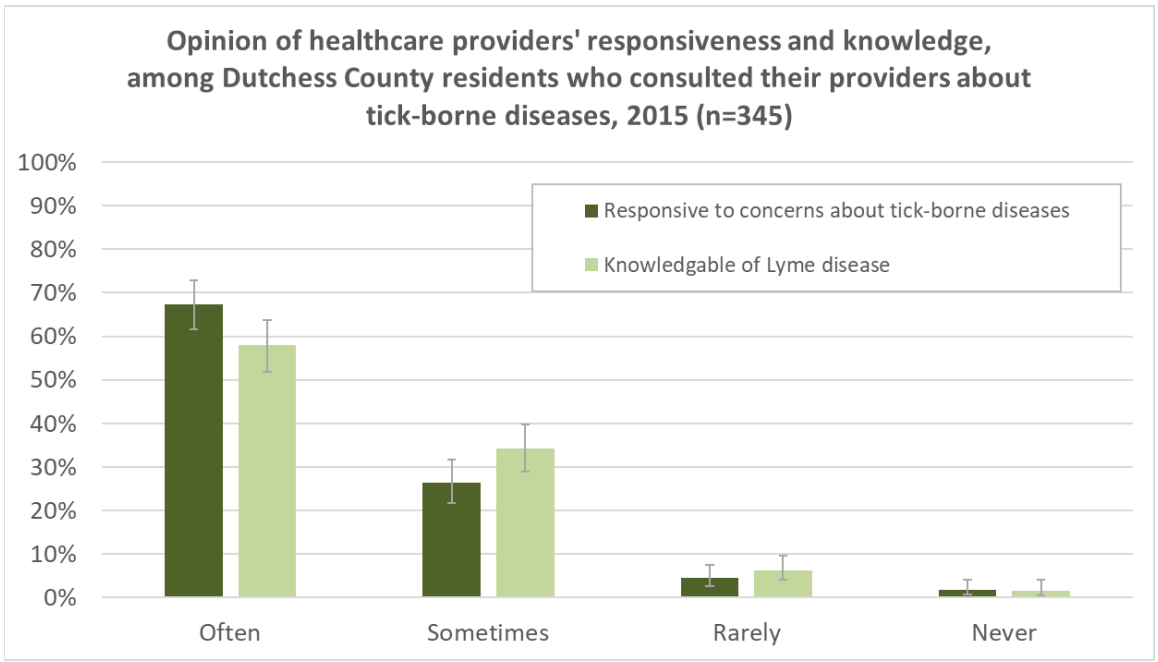
As of 2015-2016, just about half of Dutchess County residents (55%, 95% CI: 51%-60%) had ever spoken with a healthcare provider about Lyme disease or other tick-borne diseases. The question was asked of all respondents, whether or not they had ever been bitten by a tick (Figure 13a).

Figure 13a.




Among those who ever consulted a healthcare provider about tick-borne diseases, most found Dutchess County providers to be often responsive to their concerns (67%, 95% CI: 62%-73%) and often knowledgeable about Lyme disease (58%, 95% CI: 52%-64%) as shown in Figure 13b.

Figure 13b.



## Testing and Diagnosis of Tick-borne Diseases

Compared to 2009, more Dutchess County residents reported ever receiving a Lyme disease test as of 2015-2016 (59%, 95% CI: 54%-63%), more so in Region 2 vs 1 (Figure 14a). By comparison, only 12% (95% CI: 9%-15%) were ever tested for any other tick-borne diseases as of 2015-2016 (data not shown). Testing for other tick-borne diseases was not assessed in 2009. Reasons for having received the most recent test were multi-faceted in 2015-2016; routine check-up was the least common reason at 21% (95% CI: 16%-27%), and symptoms of Lyme disease was the most common reason at 54% (95% CI: 48%-60%) as show in Figure 14b.

Figure 14a.

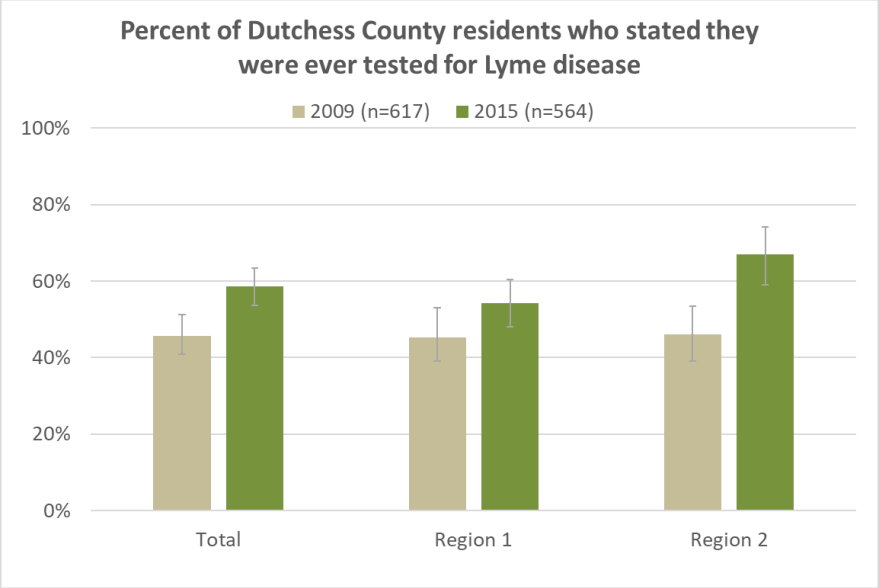
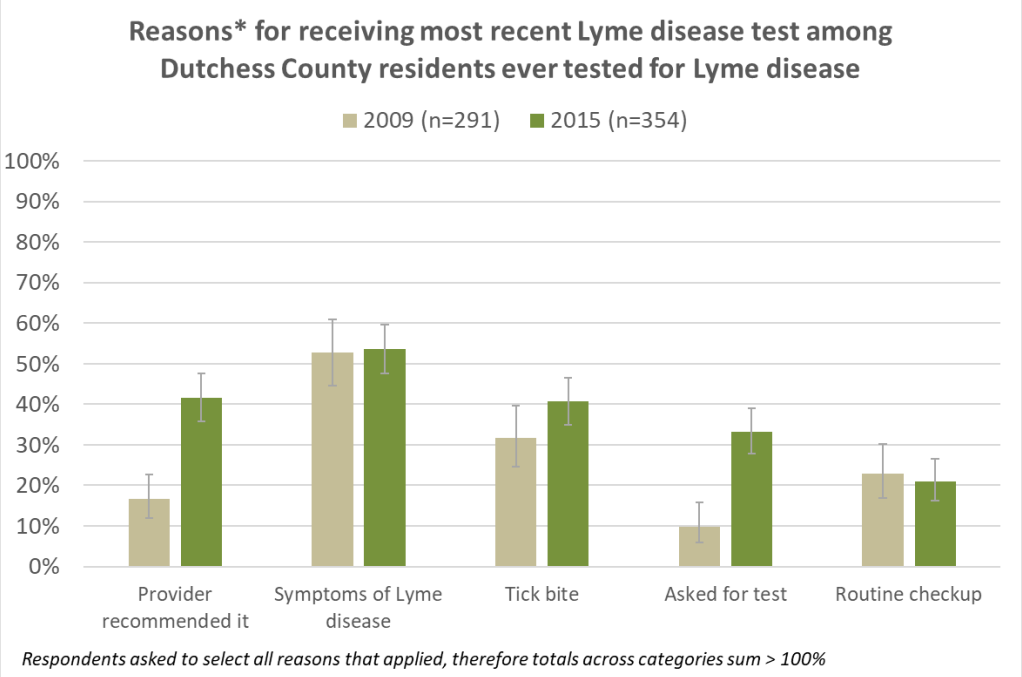
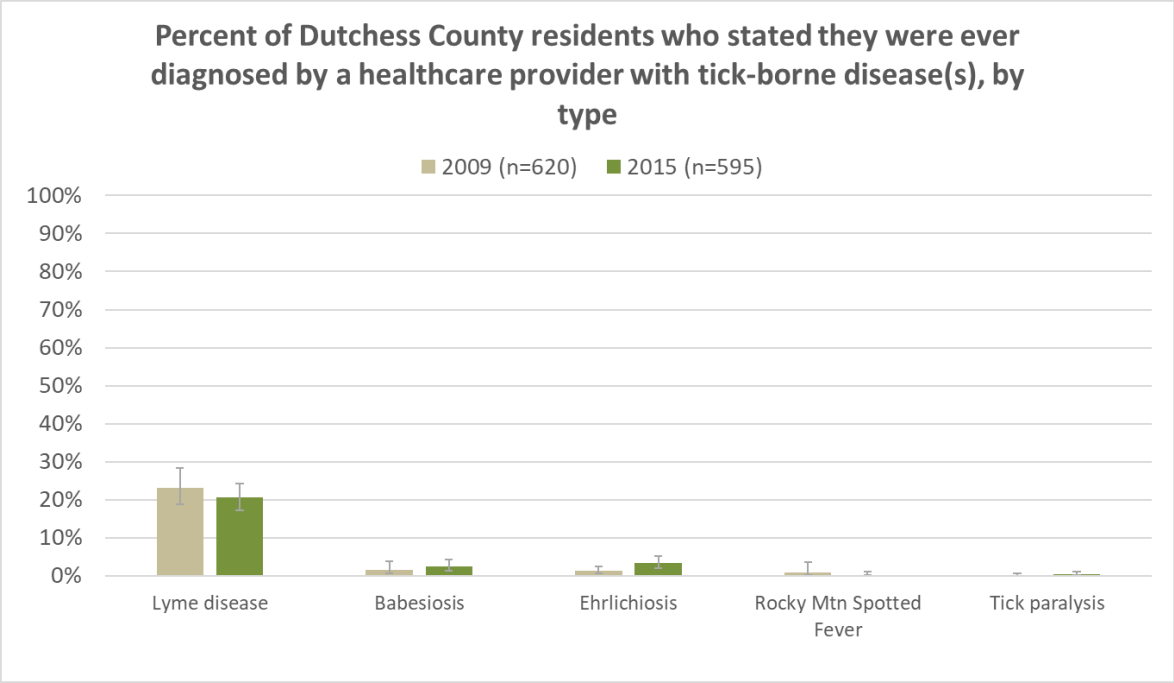



Figure 14b.



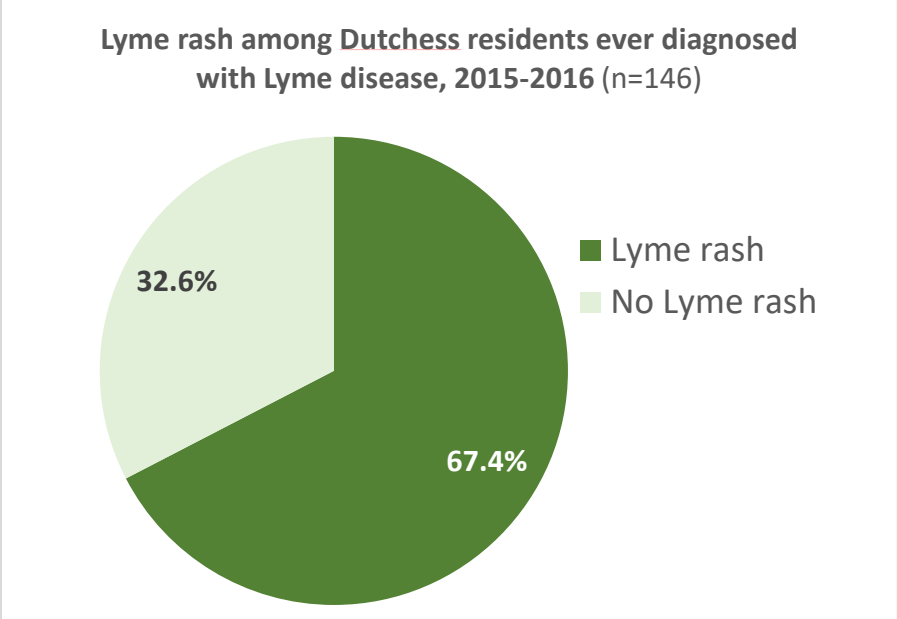
A total of 21% (95% CI: 17%-24%) of residents ever received a positive diagnosis of Lyme disease as of 2015-2016, which was about the same as in 2009 (Figure 14c). Fewer than 4% were ever diagnosed with other tick-borne diseases.

Figure 14c.



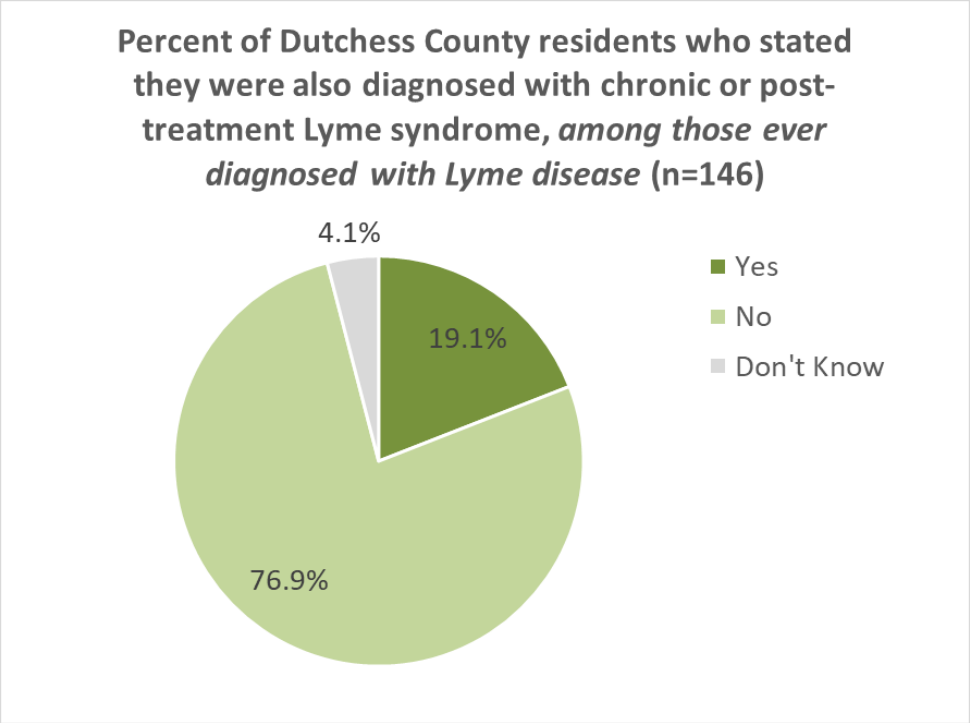

Around 2/3 of residents who were ever diagnosed with Lyme also found a Lyme rash on themselves (Figure 14d). The term "Lyme rash" was used in 2015-2016 instead of the term "bull's eye" rash (used in 2009) to be inclusive of *erythema migrans* rashes that do not conform to a bull's eye appearance.

Figure 14d.



Among those who ever received a positive Lyme diagnosis, 19% (95% CI: 13%-27%) stated they were told by a healthcare provider that they had post-treatment Lyme disease syndrome (PTLDS) or chronic Lyme disease (Figure 14e).

Figure 14e.



## Tick Removal Kits

A total of 14% of Dutchess County residents (95% CI: 11%-19%) were estimated to have received a tick removal kit as of 2015-2016, an increase from approximately 8% in 2009 (Figure 15a). Of those who received a tick removal kit, almost half (46%, 95% CI: 33%-60%) used it to remove an attached tick (Figure 15b).

Figure 15a.

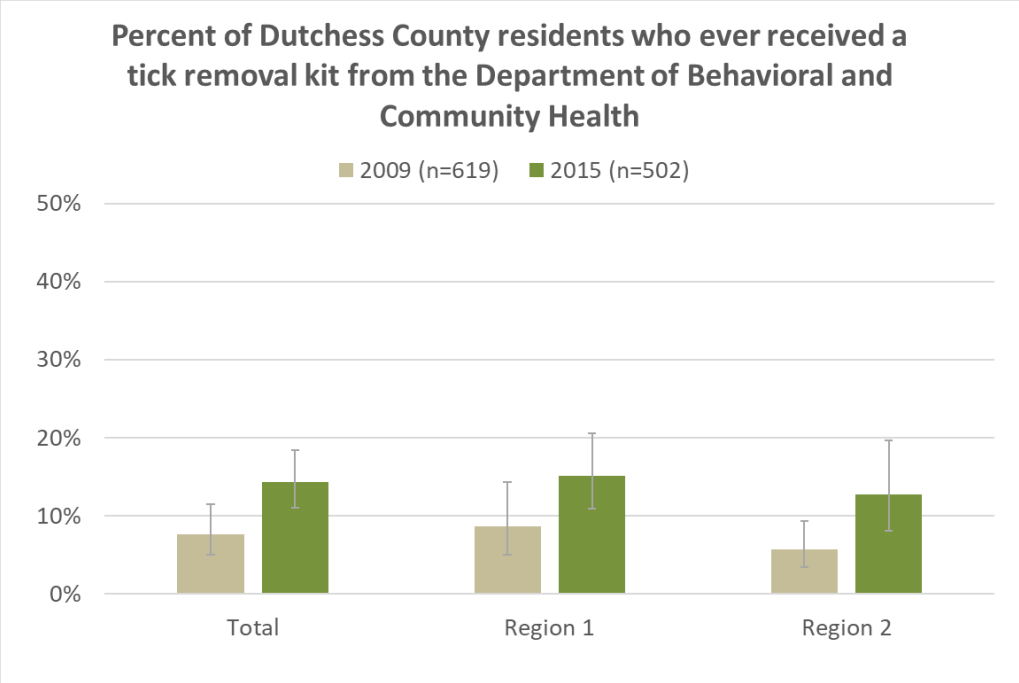
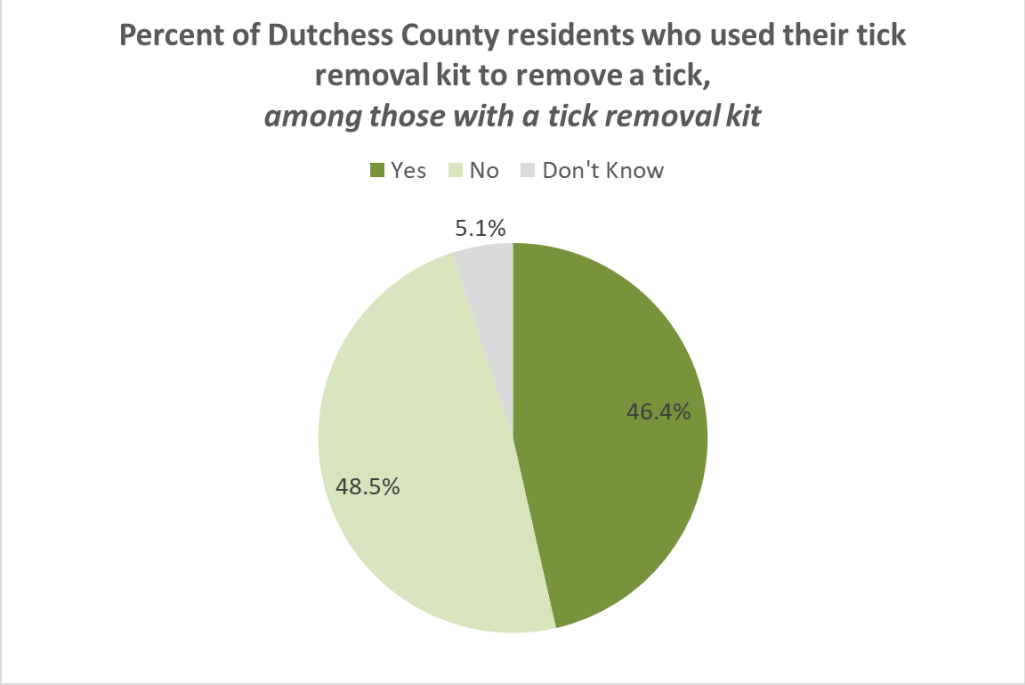



Figure 15b.



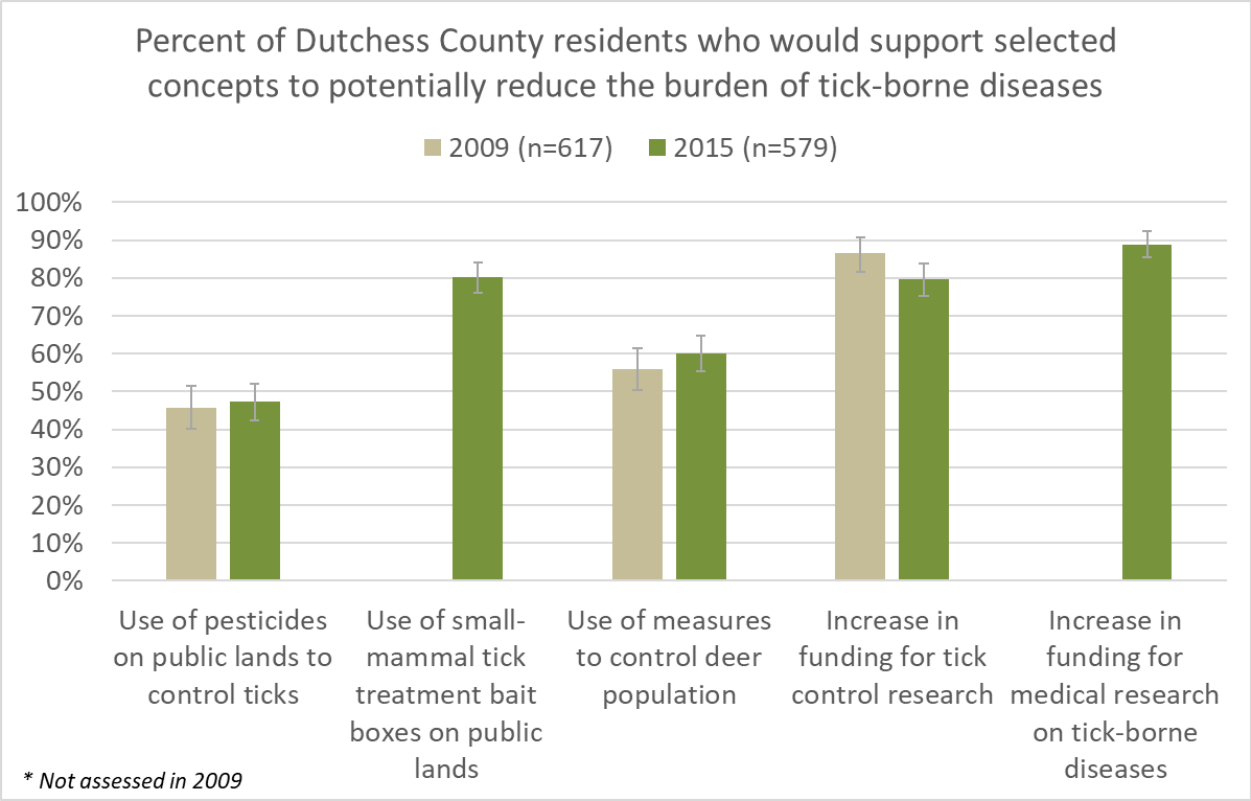
## Adopting Prevention Strategies in the Community

Dutchess County residents expressed moderate to strong support for various strategies that have been proposed to prevent the spread of tick-borne diseases (Figure 16).

Almost half (47%, 95% CI: 43%-52%) would support the use of pesticides on public lands, which has remained the same since 2009. Yet 80% (95% CI: 76%-84%) would support the use of tick-control bait boxes or bait vaccines on public lands, a new survey item added in 2015-2016 to reflect the recent availability of this strategy. Tick control bait boxes attract and treat small rodents with acaricide to disrupt tick-borne disease transmission in the ecosystem. Meanwhile 60% of residents (95% CI: 55%-65%) would support measures to control the local deer population.

Increases in funding for both tick control research and medical research on tick-borne diseases are widely popular strategies, with 80% (95% CI: 75%-84%) and 89% (95% CI: 85%-92%) of residents supporting these strategies respectively.

Figure 16.



# DISCUSSION

### *Concern, Awareness and Knowledge*

Tick-borne diseases remain a top concern in Dutchess County. Similar to previous surveys, in 2015-2016 90% of residents felt that Lyme disease was a somewhat or very serious problem in Dutchess County. Many residents (about half) also expressed concern that other tick-borne diseases are likewise a serious or very serious problem, a new item in the 2015-2016 survey. Stratified responses examined in a multivariable model *suggest* there may be differences in degree of concern based on race and ethnicity. Older adults, females, and those with a history of Lyme disease also tended to report higher levels of concern than their counterparts.

While nearly all respondents were aware of Lyme disease (98%), fewer than half were aware of babesiosis and anaplasmosis, which, while less common than Lyme disease are likewise carried by blacklegged ticks in Dutchess County. Fewer still, less than 10%, were aware of Powassan disease, a very rare but serious disease also transmitted by blacklegged ticks. It should be noted that cases of Powassan virus diagnosed in the region in 2017 and 2018 received significant local media attention, making it likely that awareness levels of Powassan virus have increased since the time the survey was administered.

As in 2009, 70% of residents felt they knew something or a lot about Lyme disease. Nearly 90% correctly identified the highest risk areas for tick exposure (wooded, brushy, and high grass areas) and that early symptoms associated with Lyme disease often resemble the flu. Yet only half of residents were aware that the rash associated with Lyme diseases does not *always* have a bull's eye appearance and that May-July are the riskiest months to contract a tick-borne disease. It should be noted that performance on the question addressing highest risk months to contract tick-borne disease may not accurately reflect resident knowledge of the seasonality of risk. Results may have been impacted by confusion over when disease is contracted versus when disease is diagnosed, and/or the precise specification of months versus general seasonality of disease risk.

We found that self-reported knowledge was highly correlated with objective true/false assessment scores, which lends validity to this measure. Assessment scores were also positively associated with increased time spent in wooded, brushy, and high grass areas; however, it was not a linear relationship. Those with daily exposure tended to score lower than those with weekly or monthly exposure. We speculate that daily exposure may often reflect occupational exposure and an underserved target area for tick-borne disease education and prevention activities.

There was a concerning trend in misinformation on methods of tick removal; although almost all residents knew that tweezers are a safe and effective way to remove ticks, in 2015-2016 between 10-20% of residents believed that other ineffective and potentially dangerous methods should be utilized, including matches, razors, or chemicals. While this may partly reflect that the 2015-2016 survey captured a more diverse demographic cross section of the population than the 2009 survey, the spread of misinformation in the age of social media is a timely subject of concern in many venues, including public health.

On the topic of information sources, TV/radio/media remain the most common sources, along with word of mouth from family, friends and peers. Meanwhile, in 2015-2016, the percent of residents who have obtained information about tick-borne diseases from signs posted in parks, trails and recreation spaces nearly doubled (37% versus 17% in 2009). Somewhat surprisingly, only a small minority of residents obtained information online from websites. The survey did not specifically identify social media as a source of information, which likely will be of growing interest in the future.

For the first time in 2015-2016, the survey asked residents to rate the accessibility of information on tick-borne diseases and their prevention. Sixty five percent of residents stated that information is *very* accessible, and another quarter stated that it is somewhat accessible, with fewer than 10% stating that is not very accessible or totally inaccessible. Interestingly, there were no differences in perceptions of accessibility across region, age, gender, race/ethnicity, or exposure to the outdoors; however, college-educated residents tended to rate accessibility slightly lower than those without a college degree. This seemingly counterintuitive finding might suggest that college educated residents were more likely to seek out information in the first place, or be unsatisfied with the depth of information that is available.

### *Outdoor Activity and Tick Exposure*

Residents of Region 2, males, older adults, and those with wooded properties tended to spend more time in wooded, brushy, and high grass areas than their counterparts. Yet older adults also frequently reported spending the least amount of time outdoors. This contradiction likely reflects divergent patterns within the category of adults ages 60 and older, with active seniors having frequent or daily exposure, and older or infirm seniors having little to no exposure.

About 30% of adults found ticks on themselves in the past year, and almost three quarters of pet owners found ticks attached to their pets that go outdoors in the past year. Controlling for all demographic and exposure characteristics at the same time, residents in Region 2 were more likely to find ticks on themselves in the previous year. Time spent outdoors and indoor/outdoor pet ownership were also significant correlates of finding an attached tick. Our finding of indoor/outdoor pet ownership as a risk factor for tick exposure is supported by other recent studies (Jones 2018, Mead 2017).

Hispanic residents, on the other hand, were significantly *less* likely to find a tick attached on themselves in the past year, controlling for all other variables including time spent outdoors and frequency of body checks for ticks. As the survey was not designed with sufficient power to truly analyze demographic subgroups other than Region, these findings should be interpreted with caution. They provide questions for potential future research, such as whether or not tick bites and/or tick-borne diseases are more likely to go undetected among minorities.

### *Personal and Property Protection and Interest in Community Tick-Reduction Strategies*

Fewer than half of Dutchess County residents consistently used insect repellent or acaricide-treated clothing when venturing outdoors in high risk areas, although 87% of pet owners used tick repellents or tick collars on their pets in 2015-2016. Meanwhile, the vast majority (about 80%) of residents reported frequently checking themselves for ticks upon returning from such activities.

Mowing the lawn short and removing leaf litter were very common property-care activities among most residents, which may help reduce the risk of tick-borne disease transmission in the yard. While there is not extensive evidence on the matter, some agencies also suggest pushing back wooded boundaries and/or laying a woodchip boundary to help reduce and delineate areas of higher risk on wooded properties. About half of residents who lived on wooded properties in 2015-2016 reported pushing back the boundaries of their properties.

Adding deer fencing was more common in Region 1 than Region 2, which may be related to property size and the feasibility or cost, as properties are typically larger in the more rural areas of Dutchess County. With respect to the deer population, about 1 in 2 residents would support efforts to reduce/cull local

herds; it was beyond the scope of the survey, however, to assess support or opposition to various specific culling strategies, which differ in their expected effectiveness, feasibility, and likely community support.

Almost 30% of residents have used insecticide sprays on their property for the purpose of tick control, an area of ongoing research. Similarly about 40% of residents would support the use of insecticide sprays on public lands for the purpose of tick control. Fewer than 5% of residents have ever used tick control bait boxes, a relatively new environmental control strategy, on their properties to prevent the transmission of Lyme disease by mice and small rodents. After briefly learning about tick control bait boxes in the 2015-2016 survey, there was very strong interest in this method, with 80% of residents voicing support for this strategy to reduce the tick population on public lands. The vast majority (80%) of Dutchess County residents would also like to see more research into methods of tick control.

### *Prevalence of Tick-borne Diseases and Medical Experience*

Estimates of annual changes in the burden of disease are captured in *incidence rates*, that is, the number of new cases diagnosed each year divided by the population size. Incidence rates are determined through ongoing human disease surveillance rather than in population surveys. Recent estimates of incidence rates for tick-borne disease can be found in the Dutchess County Community Health Status Report (DBCH 2016); in 2014, there were approximately 250 new cases of Lyme disease per 100,000 residents, 5 times higher than the statewide average. There were around 20 cases of anaplasmosis and 16 cases of babesiosis diagnosed per 100,000 residents on average each year from 2012-2014, also 5 times higher than the statewide averages for these conditions.

This survey measured the lifetime prevalence of self-reported Lyme disease diagnosed by a healthcare provider. Lyme disease prevalence was statistically unchanged from the 2009 survey estimate for Dutchess County adults, around 20%. The lifetime prevalence of other conditions that are transmitted in the region, including babesiosis and anaplasmosis (recognizing the latter may be potentially misclassified as ehrlichiosis) was around 2 to 4%. The survey would have required a sample size of nearly 1000 or more residents to detect small differences in the estimates of these rare diseases from 2009 to 2015-2016. Lifetime prevalence provides useful information on what percentage of the population has ever experienced disease, and it is uniquely estimated by this population survey for Dutchess County adults.

The survey also provided a current estimate of the frequency of finding an *erythema migrans* rash (an expanding circular red rash which may or may not have a bull's eye appearance) among residents diagnosed with Lyme disease: 67%, consistent with other North American estimates ranging from 60-90% (Mead 2015). The survey further provided an opportunity to ask residents about the diagnosis of post-treatment Lyme disease syndrome (PTLDS), which was reported by about 20% of residents who ever had Lyme disease. This is consistent with the higher end of published estimates of PTLDS, bearing in mind the survey was inclusive of the term chronic Lyme disease, which is sometimes used interchangeably with PTLDS but differs conceptually and does not have an accepted formal clinical definition at this time (Sanchez 2015). Such results indicate that despite higher than average rates of disease, the clinical features of Lyme disease in Dutchess County are in line with those seen in the country as a whole.

Among those who consulted a healthcare provider about Lyme disease, rankings of healthcare providers' knowledge (58% said "often knowledgeable") and responsiveness (67% said "often responsive") were similar to general levels of overall satisfaction among patients surveyed in New York State hospitals (about 65%) (McFarland, Ornstein, & Holcombe 2015). These results demonstrate that most residents have a favorable opinion of healthcare provider responsiveness and knowledge regarding tick-borne disease.

Nonetheless, nine out of 10 residents would like to see increased funding for medical research on tick-borne diseases.

## RECOMMENDATIONS

Results of the 2015-2016 Community Tick-borne Disease Survey should be shared with community partners and used to inform the choice of modalities, content, and target audiences for tick-borne disease prevention education campaigns. Results provide justification for continued efforts on the part of DBCH and community partners to increase the overall level of resident knowledge to match the level of concern. Efforts should be made to increase awareness and knowledge of endemic tick-borne diseases other than Lyme disease. Performance on knowledge assessment questions should be used to prioritize content for inclusion in educational messaging.

Demographic characteristics of level of concern and knowledge responses *suggest* disparities based on race and ethnicity. The survey lacked sufficient sample size to adequately test this hypothesis. Previous studies of tick-borne disease surveillance data have also generated hypotheses regarding differences based on race and ethnicity (Fix 2000, Nelson 2016). Potential disparities are an important area for future research because they would inform prioritization of target audiences and tailoring of messaging based on risk perception.

Frequency of exposure to wooded, brushy, and high grass areas was among the strongest correlates of having found a tick attached in the previous year, accounting for population characteristics and exposure characteristics. Those with daily occupational exposure may be an underserved and important group for messaging and prevention work. This most recent survey also provides further evidence that pet owners are an important target population for tick-borne disease prevention. The trend toward increasing utilization of tick control products on pets should be encouraged in educational messaging, with recommendations that pet owners consult their veterinarians to select effective tick control products.

Frequent body checks for ticks has been more consistently adopted as a personal protection strategy than utilization of insect repellent or acaricide treating clothing. Prevention education messaging should emphasize that while early detection of tick bites decreases risk of disease transmission, greater overall protection is achieved when further upstream strategies (such as use of repellents and acaricide treated clothing) are also utilized to prevent tick bites in the first place.

Tick removal kits are often utilized by residents who have them and provide a vehicle for just-in-time messaging to aid in the proper removal of attached ticks. While distribution efforts have reached a diverse and growing cross-section of the Dutchess County population, there is room to achieve more coverage countywide.

Likewise, tick warning signage at parks and trails provide timely information and tick-check reminders, which have been viewed by a significantly growing proportion of residents. Again, there is room to increase this form of messaging, and to periodically assess its effectiveness (such as short- and long-term retention, behavior change, message fatigue, etc.).

There was a high level of interest in the use of insecticide bait boxes on public land to kill and repel ticks on mice and other small rodent in the ecosystem; as ongoing research determines the effectiveness of this relatively new strategy and as well as other strategies and techniques, these findings should be shared with the community and policy makers.

Survey results regarding testing, diagnosis, and medical experience of residents should be shared with local health care providers, practices, and health systems alongside up-to-date tick-borne disease surveillance information, and included in DBCH continuing educational offerings to clinicians. These dialogues provide opportunities to both inform clinical practice and to receive feedback from providers.

Most residents continue to get information about ticks from mass media (TV/radio/newspapers/magazines) and word of mouth. While the comparative lack of penetration of in person and web-based information sources could be seen as discouraging, survey results do not reflect the role of these modalities as source materials for the more frequently utilized modalities of mass media and word of mouth. The role of social media should be closely explored in the future, both as a tool for promoting evidence-based prevention strategies as well its potential role in the spread of misinformation. DBCH and partners should continue to strive to provide the public and policy makers with accurate and timely information based on sound science. The larger need for more medical research on tick-borne diseases and increased scientific research on tick prevention was strongly echoed by the Dutchess County community in the 2015-2016 survey.

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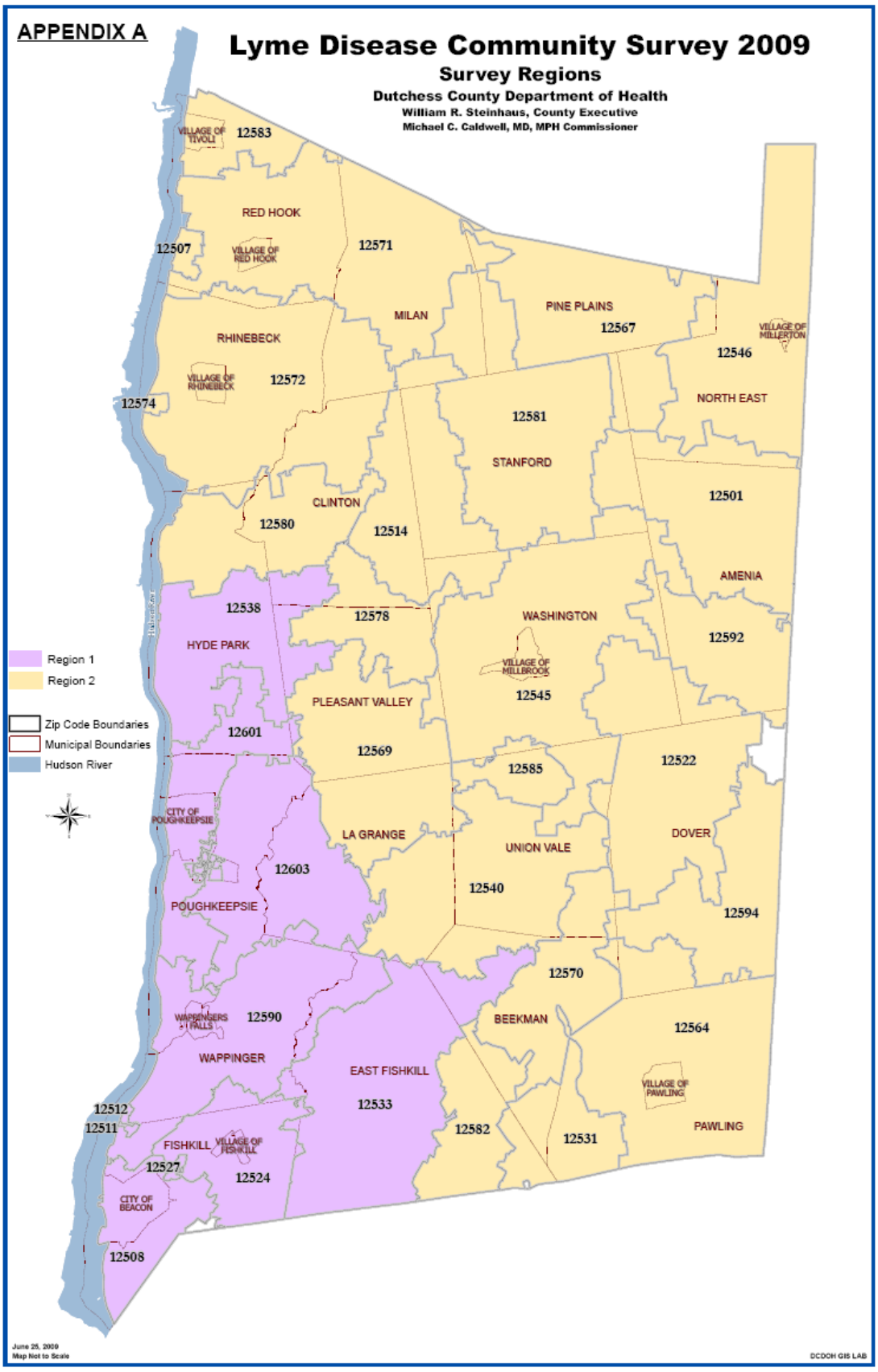
# APPENDIX


APPENDIX A
Lyme Disease Community Survey 2009
Survey Regions
Dutchess County Department of Health
William R. Steinhaus, County Executive
Michael C. Caldwell, MD, MPH Commissioner
VILLAGE OF TIVOLI
12583
RED HOOK
12507
VILLAGE OF RED HOOK
12571
MILAN
PINE PLAINS
12567
VILLAGE OF MILLERTON
12546
RHINEBECK
VILLAGE OF RHINEBECK
12572
12574
NORTH EAST
12581
STANFORD
CLINTON
12580
12514
12501
AMENIA
12538
12578
WASHINGTON
12592
HYDE PARK
VILLAGE OF MILLBROOK
12545
PLEASANT VALLEY
12601
12569
12585
12522
CITY OF POUGHKEEPSIE
LA GRANGE
UNION VALE
DOVER
12603
12540
12594
POUGHKEEPSIE
12570
WAPPINGERS FALLS
12590
BEEKMAN
12564
WAPPINGER
EAST FISHKILL
VILLAGE OF PAWLING
12512
12511
12533
12582
12531
PAWLING
FISHKILL
VILLAGE OF FISHKILL
12527
12524
CITY OF BEACON
12508
Region 1
Region 2
Zip Code Boundaries
Municipal Boundaries
Hudson River
June 25, 2009
Map Not to Scale
DCDOH GIS LAB