Aedes aegypti, the mosquito that carries dengue, chikungunya, and Zika viruses, is present throughout the U.S. Virgin Islands (USVI). To reduce mosquito-borne disease transmission, the USVI Department of Health (VIDOH) is responsible for integrated mosquito management. During January 2016–January 2018, USVI experienced its first Zika outbreak, with most cases reported during January–December 2016, as well as two Category 5 hurricanes (Irma on St. Thomas/St. John on September 6, 2017, and Maria on St. Croix on September 19, 2017). The hurricanes severely damaged mosquito protection–related building structures (e.g., screens, roofs) and infrastructure (e.g., electricity, air conditioning) and might have created an environment more conducive to mosquito breeding. VIDOH, with requested technical assistance from CDC, conducted three Community Assessments for Public Health Emergency Response (CASPERs) to provide rapid community information at the household level. The three CASPERs were conducted to inform 1) the Zika outbreak response, 2) the hurricane response, and 3) the hurricane recovery. The CASPERs assessed mosquito prevention and control–related experiences, attitudes, and practices; household and environmental conditions associated with mosquito breeding, prevention, and control; and other nonmosquito–related information to inform outbreak and disaster response planning. Approximately 40% of households were very concerned about contracting Zika virus during the Zika outbreak and hurricane responses. Environmental conditions were reported to become more favorable for mosquito breeding between the Zika outbreak and hurricane response. Between 75%–80% of the community supported mosquito-spraying in all assessments. VIDOH used these data to support real-time outbreak and hurricane response planning. Mosquito prevention and control community assessments can provide rapid, actionable information to advise both mosquito education and control and emergency response and recovery efforts. The CASPER design can be used by vector control programs to enhance routine and response operations.

The Zika outbreak response CASPER was conducted during June 26–29, 2017, on the three main islands, St. Croix, St. Thomas, and St. John. The hurricane response CASPER was conducted in two geographically distinct districts (St. Croix on November 7–8, 2017, and St. Thomas/St. John on November 13–14, 2017) to account for the two hurricanes. The same questionnaire was used for both CASPERs, and the results from both locations were similar; therefore, they were considered and analyzed together as one CASPER. The hurricane recovery CASPER was conducted during February 26–March 1, 2018, on the three main islands.

The standard CASPER two-stage cluster sampling methodology was used to select a representative sample of interviewed households (1). The sampling frame was defined as all 43,214 occupied households within USVI, according to the 2010 U.S. Census. Using the Geographic Information Systems CASPER toolkit (1), 30 clusters were selected with probability of selection proportional to the number of households within each cluster. Interview teams were trained to select seven households from each of the selected clusters by systematic random sampling, with a goal of 210 interviews for each assessment. Teams made three attempts to contact one adult resident for an interview in each household before substituting another household.

The three 2-page CASPER questionnaires included the same or similar questions regarding mosquito prevention and control experiences, attitudes, and practices, including mosquito biting activity, repellent use, and household environmental characteristics. Response frequencies and percentages, including completion rates, with 95% confidence intervals (CIs) were calculated using Epi Info (version 7.2.2.2; CDC). Weighted frequencies and percentages based on probability of selection are reported, with weighted analysis only calculated for cells with ≥5 households (1). A preliminary report was presented to VIDOH within 5 days of completion of each assessment.

Teams conducted 201 of the target 210 interviews for the Zika outbreak response CASPER (95.7% completion rate; 62.2% of contacted households); 387 of the target 420 interviews for the hurricane response CASPER, including 195 on St. Croix (92.9% completion rate; 84.1% of contacted households) and 192 on St. Thomas/St. John (91.4% completion rate; 84.2% of contacted households); and 200 of the target 210 interviews for the hurricane recovery CASPER (95.2% completion rate; 81.3% of contacted households). The most represented household member age group in all three CASPERs was persons aged 18–64 years (80.8%, 75.0%, and 76.6% for the Zika outbreak response, the hurricane response, and the hurricane recovery CASPERs, respectively) followed by those...
aged ≥65 years (41.5% [Zika outbreak], 42.5% [hurricane response], and 42.2% [hurricane recovery]).

During the Zika outbreak response, 72.3% of households were very or somewhat concerned about contracting Zika virus, whereas 25.3% were not concerned; 78.7% were very or somewhat concerned about contracting other mosquito-borne diseases, including malaria, dengue, chikungunya, or yellow fever, and 17.8% were not concerned (Table 1). During the hurricane response, 87% of households noticed an increase in mosquito biting since the storms; however, only 61.5% were very or somewhat concerned about contracting Zika virus, 61.3% were concerned about contracting other mosquito-borne diseases, and 37.4% were not concerned. During hurricane recovery, 39.8% of households noticed an increase in mosquito biting during the preceding 4 weeks; approximately two thirds were very or somewhat concerned about contracting any mosquito-borne disease, and 32.7% were not concerned.

Barriers to use of mosquito repellent differed between the Zika outbreak and hurricane responses (Table 2). During the Zika outbreak response, approximately half (49.0%) of households had no barriers to mosquito repellent use, although nearly a quarter (23.5%) did not like the feel or smell, and one in five (19.4%) was concerned about their health when using it; 3.9% said it was too expensive. During the hurricane

### TABLE 1. Weighted household mosquito-borne disease concerns from the Community Assessments for Public Health Emergency Response (CASPERs) — U.S. Virgin Islands, 2017–2018

| Observations and concerns | Zika outbreak response | Hurricane response | Hurricane recovery |
|----------------------------|------------------------|--------------------|-------------------|
|                            | June 2017 (n = 201)    | November 2017 (n = 387*) | February 2018 (n = 200) |
| Noticed increase in mosquito biting in past 4 weeks§ | Yes —§ 37,617 87.0 (83.4–90.7) | 17,203 39.8 (31.4–48.2) |
|                            | Changed daily activities —§ 23,469 63.3 (57.1–69.6) | 9,967 58.6 (47.3–70.0) |
|                            | Did not change activities —§ 13,590 36.7 (30.4–42.9) | 7,031 41.4 (30.0–52.7) |
|                            | No —§ 5,597 13.0 (9.3–16.6) | 26,011 60.2 (51.8–68.6) |

| Household current concern about contracting Zika virus§ | Very concerned 17,725 41.0 (31.4–50.6) | 16,113 37.3 (32.3–42.3) |
|                                                        | Somewhat concerned 13,540 31.3 (23.8–38.9) | 10,438 24.2 (18.4–29.9) |
|                                                        | Not concerned at all 10,961 25.3 (18.5–32.2) | 16,192 37.5 (32.3–42.7) |
|                                                        | Don't know —** 471 1.1 (0.0–2.2) |

| Household current concern about contracting other mosquito-borne diseases§ | Very concerned 21,216 49.1 (40.9–57.3) | 16,137 37.3 (32.0–42.7) |
|                                                                       | Somewhat concerned 12,786 29.6 (21.6–37.6) | 10,267 24.0 (18.2–29.8) |
|                                                                       | Dengue†† 14,528 42.7 (34.7–50.8) | 11,994 45.0 (36.2–53.8) |
|                                                                       | Chikungunya†† 10,076 29.6 (22.0–37.3) | 9,593 36.0 (28.6–43.4) |
|                                                                       | Malaria†† 3,821 11.6 (6.2–15.9) | 3,280 12.3 (8.2–16.4) |
|                                                                       | Yellow Fever†† — —** 1,775 6.7 (2.7–10.6) |
|                                                                       | Other/Don't know†† 13,767 40.5 (30.9–50.0) | 9,074 34.2 (26.1–42.3) |
|                                                                       | Not concerned at all 7,689 17.8 (10.9–24.7) | 16,145 37.4 (31.4–43.3) |
|                                                                       | Don't know 1,523 3.5 (0.8–6.2) | 565 1.3 (0.1–2.5) |

| Household current concern about contracting mosquito-borne diseases§ | Very concerned —§ —§ | —§ —§ |
|                                                                      | Somewhat concerned —§ —§ | —§ —§ |
|                                                                      | Zika†† —§ —§ | —§ —§ |
|                                                                      | Dengue†† —§ —§ | —§ —§ |
|                                                                      | Chikungunya†† —§ —§ | —§ —§ |
|                                                                      | Malaria†† —§ —§ | —§ —§ |
|                                                                      | Yellow Fever†† —§ —§ | —§ —§ |
|                                                                      | Other/Don't know†† —§ —§ | —§ —§ |
|                                                                      | Not concerned at all —§ —§ | —§ —§ |

**Abbreviations:** CI = confidence interval; HH = household.

* Two geographically distinct districts were used for the hurricane response CASPER, but the same questionnaire was used, and the presented results had no significant differences; therefore, are considered and analyzed as one CASPER, resulting in the larger "n" than in the Zika outbreak response and hurricane recovery CASPER.

† Estimated number of U.S. Virgin Islands’ households.

§ Hurricane response CASPER asked “since the storms.” This question was not asked in the Zika outbreak response CASPER.

‡ Responses from the Zika outbreak and hurricane response CASPERs are not directly comparable to responses from the hurricane recovery CASPER because the questions were asked differently. Questions asked in the Zika outbreak and hurricane response CASPERs were “Currently, how concerned are you and members of your household about getting the Zika virus?” and “Currently, how concerned are you and members of your household about getting other diseases mosquitoes may carry?” The question asked in the hurricane recovery CASPER was “Currently, how concerned are you and members of your household about getting diseases mosquitoes may carry?” with a follow-up question for specific diseases.

** Number of responses was too few to be weighed.

†† Subcategories are a combination of both “very concerned” and “somewhat concerned.” Multiple responses were permitted.
TABLE 2. Weighted household barriers to mosquito repellent use and household environmental characteristics from the Community Assessments for Public Health Emergency Response (CASPERs) — U.S. Virgin Islands, 2017

| Barriers and characteristics                  | Zika outbreak response                                      | Hurricane response                                      |
|-----------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------|
|                                               | June 2017 (n = 201)                                          | November 2017 (n = 387†)                                |
| Household barriers to mosquito repellent†‡   | Estimate§ % of HH (95% CI)                                   | Estimate§ % of HH (95% CI)                              |
| Don’t like how it feels/smells                | 10,159 23.5 (18.0–29.0)                                     | 5,393 12.5 (8.9–16.1)                                   |
| Concerned about health                       | 8,396 19.4 (12.6–26.2)                                     | 4,681 10.8 (7.1–14.5)                                   |
| Prefer natural remedies                      | 4,637 10.7 (5.4–16.0)                                      | 4,760 11.0 (6.8–15.2)                                   |
| Too expensive                                | 1,681 3.9 (0.8–7.0)                                        | 3,854 8.9 (5.7–12.1)                                   |
| Concerned for environment                    | 1,399 3.2 (0.3–6.2)                                        | 1,904 4.4 (2.1–6.7)                                    |
| No availability                              | —** —**                                                     | 2,444 5.7 (2.6–8.7)                                    |
| Takes too much time                          | —** —**                                                     | 672 1.6 (0.0–3.2)                                      |
| Other ††                                     | 1,440 3.3 (0.4–6.2)                                        | 2,304 5.3 (2.0–8.6)                                    |
| No barriers                                  | 21,195 49.0 (41.4–56.7)                                     | 25,642 59.3 (53.5–65.2)                                 |
| Household has the following§§               |                                                            |                                                       |
| Undamaged window screens                     | 27,801 64.3 (54.7–74.0)                                     | 12,980 30.0 (24.1–36.0)                                 |
| Undamaged door screens                       | 17,238 39.9 (30.7–49.0)                                     | 9,813 22.7 (17.0–28.4)                                 |
| Air conditioning                             | 17,711 41.0 (31.5–50.4)                                     | 8,578 19.8 (15.0–24.7)                                 |
| Objects that may collect rain                | 11,194 25.9 (19.5–32.3)                                     | 13,096 30.3 (23.7–36.9)                                 |
| Abandoned buildings nearby                   | 10,817 25.0 (15.5–34.5)                                     | 12,960 30.0 (22.7–37.3)                                 |
| Uncovered water source                       | 6,784 15.7 (9.4–22.0)                                       | 6,320 14.6 (10.6–18.7)                                 |
| None of the above §§                         | 5,055 11.7 (4.5–18.9)                                       | 10,762 24.9 (18.6–31.2)                                 |

Abbreviations: CI = confidence interval; HH = household.
* Questions were only asked during the Zika outbreak response CASPER and the hurricane response CASPER, and not for the hurricane recovery CASPER.
† Two geographically distinct districts were used for the hurricane response CASPER, but the same questionnaire was used, and the presented results had no significant differences; therefore, they are considered and analyzed as one CASPER, resulting in the larger “n” than in the Zika outbreak response and hurricane recovery CASPERs.
‡ Estimated number of U.S. Virgin Islands’ households.
§ Multiple responses were permitted.
** Number of responses was too few to be weighed.
†† Includes too time consuming, product not available, forgot, etc.
§§ Includes households that had both no sources for mosquito breeding and households with damaged screens and no air conditioning.

Discussion

These community assessments conducted during the Zika outbreak, hurricane responses, and hurricane recovery in USVI found that households were more concerned about contracting mosquitoborne diseases shortly after the Zika outbreak than during the hurricane response and hurricane recovery, even though reported mosquito biting activity increased, and environmental conditions were more favorable for mosquito breeding and exposure to bites following the hurricanes.

In addition, although mosquitoborne diseases are endemic in USVI, and the population might be aware of the risk, households had concerns after the hurricanes that did not exist during the Zika outbreak, such as lack of shelter, clean water, and electricity (2). These differing levels of concern did not, however, change the community’s support for mosquito spraying, although support for specific spray methods varied.

VIDOH used the CASPER data to make real-time outbreak and hurricane response decisions to improve mosquito bite prevention, mosquito control, and community education. For example, because the percentage of households concerned...
The findings in this report are subject to at least three limitations. First, data generated from the CASPERs represent limitations. First, data generated from the CASPERs represent

about contracting mosquitoborne diseases declined after the hurricanes compared with during the Zika outbreak response, VIDOH hurricane response education campaigns prioritized household-level mosquito bite prevention. The differing levels of support for various spray methods were also recognized and considered during decision-making. For example, these data, along with unique environmental considerations, were used by the administration in place during the responses and recovery to determine backpack spraying to be the only acceptable option.

The CASPER is a useful tool for assessing mosquitoborne disease risk factors and creating immediately usable data to guide vector-related public health campaigns (3). According to CDC’s internal CASPER database (4), a limited number of CASPERs have been conducted that assess mosquito bite prevention- and control-related factors, such as knowledge of mosquitoborne diseases; ways to protect against mosquito bites; and how to identify, quantify, and manage potential mosquito breeding sites. Even fewer CASPERs have focused solely on mosquitos. A CASPER in Long Beach, California, during a Zika outbreak identified the need for increased mosquito abatement (5). In two areas of Texas, CASPERs successfully assessed the prevalence of vectorborne disease risk factors and the communities’ knowledge of mosquito bite prevention and Zika virus (6,7). A CASPER conducted in American Samoa identified increased vector problems and the need for vector control after a tsunami (8).

| Desired VIDOH prevention and control actions**†† | Zika outbreak response | Hurricane response | Hurricane recovery |
|-------------------------------------------------|-------------------------|---------------------|-------------------|
|                                                 | June 2017 (n = 201)     | November 2017 (n = 387§) | February 2018 (n = 200) |
| Spraying/Fogging (any)†                         | 32,959 (76.3 (69.2–83.3) | 34,243 (79.2 (75.4–83.1) | 32,966 (76.3 (70.7–81.9) |
| By truck                                        | 27,094 (62.6 (55.3–70.1) | 26,747 (78.1 (73.4–82.8) | 24,872 (63.4 (56.5–70.4) |
| By hand (backpack)                              | 12,779 (29.6 (20.4–38.7) | 15,358 (44.8 (38.0–51.7) | 24,286 (61.9 (51.5–72.4) |
| By plane (aerial)                               | 5,515 (12.8 (6.5–19.1)  | 9,858 (28.8 (22.3–35.2)  | 6,444 (16.4 (10.5–22.4)  |
| Other (e.g., unsure, “best way”)†              | 3,190 (7.4 (3.5–11.2)   | 2,834 (8.3 (5.4–11.2)    | —*                    |
| Education                                       | 16,435 (38.0 (27.8–48.2) | 13,179 (30.5 (23.6–37.4) | —*                    |
| Inspection of property                          | 10,563 (24.4 (15.1–33.8) | 9,759 (22.6 (16.9–28.3) | —*                    |
| Other††                                         | 5,961 (13.8 (8.0–19.6)  | 6,491 (15.0 (11.0–19.1) | —*                    |
| Don’t know/None                                 | 1,440 (3.3 (1.1–5.6)    | 3,011 (7.0 (3.9–10.0)    | —*                    |

** Abbreviations: CI = confidence interval; HH = household; VIDOH = USVI Department of Health.
* Responses from the Zika outbreak and hurricane response CASPERs are not directly comparable to responses from the hurricane recovery CASPER because the questions were asked differently. Questions asked in the Zika outbreak and hurricane response CASPERs were “What actions do your HH members believe the health department should take to prevent mosquito diseases?” and “If spraying, which type(s) would you support?” The questions asked in the hurricane recovery CASPER was “Would your HH support any spraying for mosquitoes?” and “If yes, which type(s) would you support?”
†† Multiple responses were permitted.
§ Two geographically distinct districts were used for the hurricane response CASPER, but the same questionnaire was used, and the presented results had no significant differences; therefore, they are considered and analyzed as one CASPER, resulting in the larger “n” than in the Zika outbreak response and hurricane recovery CASPERs.
† Estimated number of USVI households.
‡ Number of responses was too few to be weighed.
†† Other includes property services, social services or assistances, material aid, etc.

What is added by this report?
Community assessments conducted in the U.S. Virgin Islands during the Zika outbreak response, hurricane response, and hurricane recovery found similar support for mosquito spraying, but support for specific spray methods varied. Concern about acquiring Zika decreased over time.

What are the implications for public health practice?
Mosquito prevention and control community assessment questions can provide rapid, actionable information to advise both community education and mosquito control in emergency response and recovery efforts. Assessments can also be used by vector control programs to enhance routine operations.

Not only is CASPER an important tool for emergency response and recovery, it is also useful for collecting community public health information unrelated to an emergency (4,9). Vector control programs can use CASPERs during nonemergency situations to enhance and increase operation efficacy by evaluating the effectiveness of community campaigns and understanding community knowledge, attitudes, and practices.
discrete points in time, which should be considered when interpreting the results to guide outbreak and hurricane response and recovery efforts. Second, the age distribution of the survey respondents is skewed, with a larger proportion of persons aged ≥65 years represented in the CASPERs than that reported by the U.S. Census; therefore, households without persons aged ≥65 years might be underrepresented. Finally, some questions were asked differently or not at all among the three CASPERs presented and are not directly comparable.

CASPERs that include mosquito prevention- and control-related questions are an important tool to inform both routine and response vector control operations and to understand how a community’s perceptions and behaviors might vary by adverse event and over time.

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References

1. CDC. Community Assessment for Public Health Emergency Response (CASPER) toolkit: 2nd ed. Atlanta, GA: US Department of Health and Human Services, CDC; 2012. https://www.cdc.gov/nceh/hsb/disaster/casper/docs/cleared_casper_toolkit.pdf
2. Schnall AH, Rorh JJ, Ellis B, Seger K, Davis M, Ellis EM. Addressing community needs during the hurricane response and recovery efforts through Community Assessments for Public Health Emergency Response (CASPER)—United States Virgin Islands, 2017–2018. Disaster Med Public Health Prep 2019;13:53–62. https://doi.org/10.1017/dmp.2019.6
3. Smitherman S, Hammond T, Goldberg D, Horney J. Developing a CASPER survey to assess the prevalence of risk factors for neglected tropical diseases in Texas. Health Secur 2017;15:238–43. https://doi.org/10.1089/hs.2016.0075
4. Schnall A, Nakata N, Talbert T, Bayleyegn T, Martinez D, Wolkin A. Community Assessment for Public Health Emergency Response (CASPER): an innovative emergency management tool in the United States. Am J Public Health 2017;107(S2):S186–92. https://doi.org/10.2105/AJPH.2017.303948
5. Long Beach Department of Health and Human Services. Long Beach Zika Community Assessment for Public Health Emergency Response (CASPER). Long Beach, CA: Long Beach Department of Health and Human Services; 2017. http://www.longbeach.gov/globalassets/health/media-library/documents/diseases-and-condition/information-on/zika/lb-zika-casper-final-report
6. Platz L. Final report: Zika virus Community Assessment for Public Health Emergency Response (CASPER). Round Rock, TX: Williamson County and Cities Health District; 2017. http://www.wcchd.org/about_us/docs/WCCHD%20Zika%20CASPER%20Report_Final.pdf
7. Horney J, Goldberg D, Hammond T, Stone K, Smitherman S. Assessing the prevalence of risk factors for neglected tropical diseases in Bexar County, Texas. PLoS Curr 2017;9:9.
8. Choudhary E, Chen TH, Martin C, et al. Public health needs assessments of Tutuila Island, American Samoa, after the 2009 tsunami. Disaster Med Public Health Prep 2012;6:209–16. https://doi.org/10.1001/dmp.2012.40
9. Bayleyegn TM, Schnall AH, Ballou SG, et al. Use of Community Assessments for Public Health Emergency Response (CASPERs) to rapidly assess public health issues—United States, 2003–2012. Pcheph Disater Med 2015;30:374–81. https://doi.org/10.1017/S1049023X15004938