Public Acceptance of and Willingness to Pay for Mosquito Control, Texas, USA

Katherine L. Dickinson, Natalie Banacos, Ester Carbajal, Nina Dacko, Chris Fredregill, Steven Hinojosa, Jose G. Juarez, Caroline Weldon, Gabriel L. Hamer

Mosquito control is essential to reduce vectorborne disease risk. We surveyed residents in Harris, Tarrant, and Hidalgo Counties, Texas, USA, to estimate willingness-to-pay for mosquito control and acceptance of control methods. Results show an unmet demand for expanded mosquito control that could be funded through local taxes or fees.

Public health responses are not purely technical undertakings; these responses happen within and are affected by their social and economic contexts. Whether or not these efforts succeed depends on public acceptance and response and on financial viability (*1*). To fully assess which vectorborne disease control methods will be sustainable and effective, public health practitioners and researchers must understand public perceptions and acceptance of different approaches.

Vector control is a particularly salient public health topic in Texas. The state had one of the highest rates of West Nile virus (WNV) in 2002–2019 (*2*); Texas and Florida are the 2 US states with periodic local transmission of *Aedes* spp. mosquito–borne viruses such as dengue virus (DENV), Zika virus (ZIKV), and chikungunya virus (CHIKV) (*3*). Although Texas shares a border with Mexico, which has had outbreaks of these 3 viruses, and despite the substantial impact of mosquitoborne disease on public health across the state, very few of its cities or counties have organized vector control programs. Those that do focus primarily on nuisance mosquitoes, and disease-carrying mosquitoes are usually targeted in response to cases rather than preventively (*4*). State law requires a petition and a vote to create a new mosquito control district, but establishing such districts requires raising taxes, which is rarely popular among the Texas electorate (*5*).

The objective of this study was to determine public attitudes toward and willingness to pay for mosquito control in Harris, Tarrant, and Hidalgo Counties, regions with varying risk for mosquitoborne pathogens, socioeconomic conditions, and current mosquito control practices (Appendix 1 Figure 1, https://wwwnc.cdc.gov/EID/article/28/2/21-0501-App1.pdf). Participants provided written consent to take the survey. The Colorado Multiple Institutional Review Board (COMIRB) approved the study on March 2, 2018 (protocol no. 18-0348), and the Texas A&M University Institutional Review Board approved the study on July 2, 2018, after determining the proposed activity was not research involving human subjects (protocol no. 2018-0774).

The Study

We conducted a public survey (Appendix 2, https://wwwnc.cdc.gov/EID/article/28/2/21-0501-App2.pdf) to answer 2 research questions: 1) How much are residents willing to pay for increased mosquito control, and how does willingness to pay vary across counties and with individual characteristics?; 2) To what extent do residents support or oppose different methods for controlling mosquitoes, and how does level of support vary across counties and with individual characteristics?

Author affiliations: University of Colorado Anschutz, Aurora, Colorado, USA (K.L. Dickinson); Boston University School of Public Health, Boston, Massachusetts, USA (N. Banacos); Texas A&M University, College Station, Texas, USA (E. Carbajal, J.G. Juarez, G.L. Hamer); Tarrant County Health Department, Fort Worth, Texas, USA (N. Dacko); Harris County Public Health, Houston, Texas, USA (C. Fredregill); Hidalgo County Health and Human Services, Edinburg, Texas, USA (S. Hinojosa); University of Texas Medical Branch, Galveston, Texas, USA (C. Weldon)

DOI: https://doi.org/10.3201/eid2801.210501

To measure willingness to pay, we used a triple-bounded dichotomous choice contingent valuation question design (*6*). We presented participants with background information about current mosquito control methods in their county, including the annual budget per person. We then asked whether they would support a proposal to expand mosquito control efforts in their county at different annual fees; their answers enabled us to estimate a WTP range for each respondent.

We then presented participants with fact sheets on 6 mosquito control methods: adulticides, larvicides, traps, and mass releases of genetically modified mosquitoes, sterile male mosquitoes, or mosquitoes artificially infected with *Wolbachia* bacteria. After viewing information about the control methods, participants were asked to indicate their level of support or opposition to the use of each method as part of an expanded mosquito control program in their area; responses were strongly oppose, oppose, neutral/no opinion, support, strongly support.

In total, 1,831 Texas residents participated in this survey: 610 from Harris County, 609 from Tarrant County, and 612 from Hidalgo County (Appendix 1 Table 1). Participants were willing to pay $53.15 (95% CI $50.09–$56.21) per year on average to expand mosquito control in their area. Harris County residents expressed the highest WTP values at an average of $56.74 (95% CI $50.91–$62.57), followed by Hidalgo County residents at $51.87 (95% CI $46.60–$57.14) and Tarrant County residents at $51.74 (95% CI $46.72–$56.76). Differences in WTP values across counties were not statistically significant ($\chi^2 = 1.22$; $p = 0.54$).

Women were willing to pay $9 less for vector control than men (Figure 1). Persons with graduate degrees were willing to pay $25 more than those with a high school or lower education level, and participants were willing to pay more with increasing income (controlling for education). Participants who identified as politically liberal were willing to pay about $12 more than those who identified as moderate. On average, persons who reported knowing someone who had had WNV, DENV, or ZIKV were willing to pay $21 more than those who did not, and persons who noticed many mosquitoes outdoors at the time of the survey were willing to pay $12 more than those who did not (Figure 1).

Levels of support for the 6 different control methods were similar across counties (Figure 2). Lethal traps were the most favorable mosquito control method. Releasing genetically modified (GM) mosquitoes was the least favorable approach, although most participants still supported it. Support for different control methods varied with individual characteristics (Appendix 1 Figure 2). Women were less supportive of the 3 modified mosquito control methods (GM mosquitoes, sterile males, and *Wolbachia* infected) than men. Compared with White respondents,

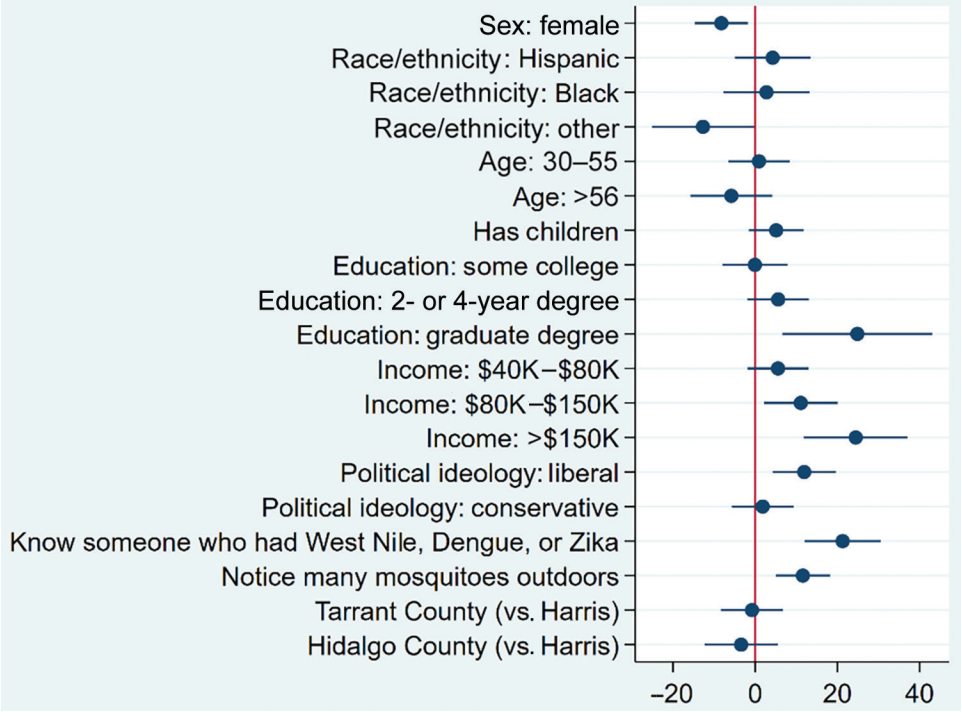


Figure 1. Interval censored regression results showing variation in public willingness to pay for vector control as a function of individual characteristics and county, Harris, Tarrant, and Hidalgo Counties, Texas, USA. Dots represent point estimates and bars 95% CIs. Red line represents the reference category (e.g., male sex, non-Hispanic White race/ethnicity, respondents <30 years of age, respondents without children) (Appendix 1 Table 1, https://wwwnc.cdc.gov/EID/article/28/2/21-0501-App1.pdf).

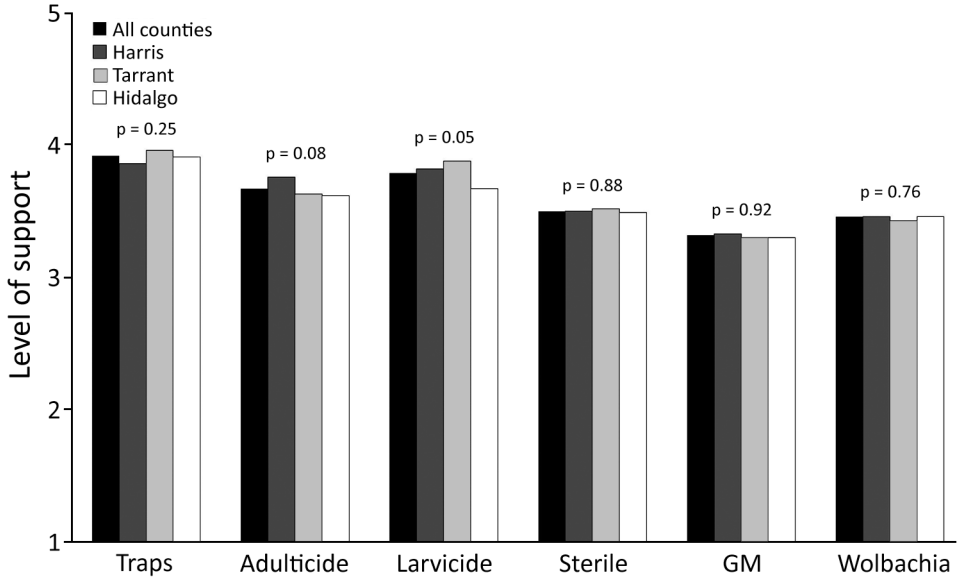


Figure 2. Average (mean) level of public support for mosquito control methods by county, Harris, Tarrant, and Hidalgo Counties, Texas, USA. Level 1, strongly oppose; 2, oppose; 3, neutral; 4, support; 5, strongly support. Kruskal-Wallis test used for differences in level of support across counties. GM, genetic modification.

Black respondents were less supportive of the sterile-male method. Respondents >30 years of age tended to be more supportive of several control methods than younger respondents. Higher education was somewhat predictive of support for adulticides, larvicides, and the sterile male method; respondents in the highest income group were more supportive of traps, adulticides, and larvicides. Respondents who identified as politically conservative were more supportive of adulticides compared with the politically moderate, whereas liberal respondents were somewhat more supportive of GM mosquitoes. Support for adulticides and the *Wolbachia* and GM approaches was also higher among respondents who knew someone who had had WNV, DENV, or ZIKV; respondents who reported noticing many mosquitoes outdoors were more supportive of adulticides and larvicides. Compared with Harris County respondents, Tarrant County participants were more supportive of traps and less supportive of adulticides.

When asked an open-ended question about why they supported or opposed different control methods, many participants said they were in favor of anything that would eliminate mosquitoes, to get rid of the nuisance or protect their families and communities from disease. Others emphasized that they would prefer a control method that was proven safe for humans and other animals. Whereas some expressed skepticism about the safety of GM mosquito options, others simply did not want more mosquitoes released in their area. "Oppose anything with genetically modified anything," wrote one participant. "That's how *Jurassic Park* began." In contrast, a participant who was in favor of the GM methods responded, "… I love the idea of using mosquitoes to fight mosquitoes."

Conclusions

Measuring public demand and support for mosquito control is crucial to successful vectorborne disease prevention strategy. Our results show a demand for expanded mosquito control that could be met through programs funded with local taxes or fees. Follow-up work should assess the feasibility of establishing such programs, examining policies that could enable or prevent local programs from emerging. Community engagement can promote mutual understanding and guide sustainable public health strategies to address the threat of vectorborne disease.

Acknowledgments

We thank the persons who were interviewed to help develop the survey and the persons who helped revise the survey questionnaire. We thank the Texas Department of State Health Services for their assistance with the interviews and questionnaire and the Centers for Disease Control and Prevention for reviewing the questionnaire and manuscript. We thank Scott Weaver for reviewing a draft of this manuscript.

This work was supported by the US Centers for Disease Control and Prevention (cooperative agreement no. U01CK000512). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention or the Department of Health and Human Services.

About the Author

Dr. Dickinson is an assistant professor of environmental and occupational health in the Colorado School of Public Health. Her research focuses on risk perceptions and responses; policy impacts on environmental, health, and social outcomes; and environmental justice issues.

References

1. Spiegel J, Bennett S, Hattersley L, Hayden MH, Kittayapong P, Nalim S, et al. Barriers and bridges to prevention and control of dengue: the need for a social–ecological approach. EcoHealth. 2005;2:273–90. https://doi.org/10.1007/s10393-005-8388-x
2. Centers for Disease Control. Final cumulative maps and data for 1999–2019. 2020 [cited 2021 January 14]. https://www.cdc.gov/westnile/statsmaps/cumMapsData.html
3. Martin E, Medeiros MCI, Carbajal E, Valdez E, Juarez JG, Garcia-Luna S, et al. Surveillance of *Aedes aegypti* indoors and outdoors using Autocidal Gravid Ovitraps in South Texas during local transmission of Zika virus, 2016 to 2018. Acta Trop. 2019;192:129–37. https://doi.org/10.1016/j.actatropica.2019.02.006
4. Ward HM, Qualls WA. Integrating vector and nuisance mosquito control for severe weather response. J Am Mosq Control Assoc. 2020;36(2s):41–8. https://doi.org/10.2987/19-6879.1
5. State of Texas. State of Texas health and safety code, title 5: sanitation and environmental quality, subtitle A: sanitation. Sec 344. 1989 [cited 2021 Dec 27]. https://statutes.capitol.texas.gov/Docs/HS/htm/HS.344.htm
6. Langford IH, Bateman IJ, Langford HD. A multilevel modelling approach to triple-bounded dichotomous choice contingent valuation. Environ Resource Econ. 1996;7:197–211. https://doi.org/10.1007/BF00782145

Address for correspondence: Katherine Dickinson, Colorado School of Public Health—Environmental and Occupational Health, 13001 E 17th Pl, Aurora, CO 80045, USA; email: katherine.dickinson@cuanschutz.edu

Article DOI: https://doi.org/10.3201/eid2801.210501

Public Acceptance of and Willingness to Pay for Mosquito Control, Texas, USA

Appendix 1

A lack of community, political, or bureaucratic support can hinder effective mosquito control efforts. For example, the 2012 West Nile virus (WNV) outbreak in Dallas County, TX, resulted in 398 WNV-related illnesses and 19 deaths. Aerial adulticide applications are uncommon in Dallas and it had been 45 years since the last aerial spray event (*1*,*2*). Accordingly, the approval process to use aerial adulticides amid the epidemic was extensive and spraying was delayed until Aug. 16, when rates of *Culex* spp. mosquito infection with WNV and human West Nile neuroinvasive disease (WNND) were already declining (*3*). Furthermore, 13 of 44 municipalities opted out of aerial spraying (*4*), due in part to public opposition to control efforts (*5*). In total, aerial spraying cost about $1.6 million, well below the estimated WNV morbidity-related costs of $274.3 million across Texas (*6*), with Dallas County and surrounding counties leading the nation in the number of cases (*7*). Clearer criteria for initiating emergency vector control practices, along with sustained public education and support, may have averted many cases and deaths.

Local representatives and taxpayer-funded vector control authorities may have different perceptions of mosquito control than the publics they serve. Following a 2009–2010 dengue outbreak in Florida, Key West officials sought to launch a trial of genetically modified (GM) mosquitoes that would reduce wild populations by producing offspring that died before reaching maturity. While vocal opponents organized in opposition to this approach, a 2012 survey of Key West residents showed that the majority were supportive of this idea (*8*). However, a subsequent survey in 2015 showed that most residents did not support this proposition (*9*). In 2016, residents of Key Haven, where a trial was proposed, rejected a ballot measure to move forward with this trial, while another ballot measure open to all surrounding Monroe County residents passed (*10*). In August 2020, despite vocal public opposition, the Florida Keys Mosquito Control Board voted to initiate a trial release of GM mosquitoes in 2021 – the strategy for executing this trial and addressing community concerns remains to be seen (*11*). To overcome opposition to potentially

effective mosquito control methods, a better understanding of what motivates public opinion is needed. In the Key West example, survey results showed that people opposed to the GM mosquito trials tended to cite concerns about disturbing ecosystems and using unproven technologies (*8*,*9*) whereas some who supported the trial said they thought this method was more natural and less harmful than chemical-based controls (*8*). Perceptions of the risks that mosquitoes pose, and their general nuisance level, can also be important motivators of support for control efforts. A survey of Madison, Wisconsin residents showed that dislike for nuisance mosquitoes was a stronger driver of willingness-to-pay for mosquito control than concerns about disease (*12*). Concerns about the environmental impacts of mosquito control were found to decrease willingness to pay for mosquito control in Key West, Florida (*13*). Recent studies have also found that residents would be willingness to pay more to expand mosquito control programs in New Jersey (*14*) and North Carolina (*15*).

This study protocol was reviewed and approved by the Colorado Multiple Institutional Review Board (COMIRB) (Protocol #: 18-0348, approved March 2, 2018) and the Texas A&M University Institutional Review Board determined the proposed activity was not research involving human subjects on July 2, 2018 (Protocol #: 2018-0774). Participants provided written consent to take the survey.

Methods

Survey Design and Administration

To inform the design of our survey, we interviewed key stakeholders involved in mosquito control at state level and in Harris, Tarrant, and Hidalgo counties in Texas (Appendix 1 Figure 1).

Using findings from these interviews, we developed a survey to address the following: 1) household characteristics, 2) perceived impacts of mosquitoes on quality of life, 3) vectorborne disease knowledge and concerns, 4) mosquito avoidance and control behaviors, 5) willingness-to-pay for expanded mosquito control, and 6) opinions on specific control methods (e.g., adulticides, traps). The full survey is available below. After a pilot study to recruit by mail that resulted in a low response rate (~10%), we contracted Qualtrics, a software and analytics

company, to recruit survey participants. Qualtrics uses multiple actively managed panels of survey participants recruited for academic and market research. While relying on Qualtrics panels limited our ability to recruit at random from specific geographic areas within each county, it did allow us to set quotas for gender, race/ethnicity, and median household income to obtain samples that largely reflect the demographic makeup of each county. The survey was administered to a total of 1,831 persons during October 24–November 15, 2019. Participants could choose to take the survey in English or Spanish.

Measuring Willingness to Pay

Appendix 1 Figure 2 depicts the design of our triple-bounded WTP question format. A key benefit of this approach over alternative dichotomous choice contingent valuation question formats is that it gathers more information from each respondent, allowing us to estimate WTP more precisely for a given sample size (*16*). Our approach is largely consistent with recommended best practices in WTP measurement (e.g., the NOAA Blue Ribbon panel report (*17*)). For example, we use a referendum format (yes or no vote on a proposed ballot measure), allow a "don't know" option, emphasize that all answers are reasonable and valid, and remind the respondent that money used toward mosquito control would not be available for other uses. A sample question is below:

> Suppose that there were a proposal on the next election ballot to expand mosquito control across the county. If the proposal passes, the number of mosquitoes in this area would be cut in half. To fund this expansion, your household and others in the county at your income level would be charged a fee of $XX once per year. Would you support this proposal?

The fee amount for this initial question was randomized across respondents ($5, $10, $25, $50, or $100). Participants who said yes to the initial fee were then asked if they would support a fee of twice that amount. If they said yes to that, the fee doubled again. Participants who said no to the initial fee were asked if they would support a fee that was half the initial amount. If they said no again, the fee was halved again (Appendix 1 Figure 2).

Resulting data include upper and lower bounds on WTP for each participant. The exceptions are for participants that answered "Yes" to all questions (in this case, we do not know the upper bound on their WTP) or "No" to all questions (in this case, we do not know the lower

bound because WTP can be negative, meaning participants would need to be compensated to accept increased levels of mosquito control).

Data Analysis

Respondent Characteristics

Participant characteristics and corresponding census data for a subset of variables are presented by county in Appendix 1 Table 1. Overall, the average participant was 41 years of age and had lived in their county for ≈22.5 years. A little over half of participants were women. Approximately 37% of respondents identified as Hispanic or Latino/a/x, and 56% identified as a race other than White, with substantial racial and ethnic variation across counties. About a quarter of participants had a high school education or less, while 37% had a bachelor's degree or higher. Regarding income, ≈40% of respondents earned <$40,000 per year, whereas <10% earned >$150,000. A little less than half of participants had children.

To analyze relationships between WTP and respondent characteristics within each county, we use an interval censored regression model in which the dependent variable is the respondent's WTP range and independent variables were gender, race/ethnicity, age, education, income, political ideology, whether or not the respondent knew someone who had had WNV, dengue, or Zika, whether the respondent noticed many mosquitoes outdoors at the time of the survey, and county.

To analyze variation in support for each control method by sociodemographic characteristics, we used ordered logistic regression models for each of the 6 control methods. In these analyses, the dependent variable was the 5-point Likert scale response to the level of support for the method in question and independent variables were gender, race/ethnicity, age, education, income, political ideology, whether or not the respondent knew someone who had had WNV, dengue, or Zika, whether the respondent noticed many mosquitoes outdoors at the time of the survey, and county (Appendix 1 Table 3; Appendix 1 Figure 3).

Discussion

As public health risks from vector-borne disease continue to evolve in the U.S. and around the world, understanding public attitudes and support for control programs can help guide

effective policies and interventions. Results from our survey offer key insights into the public's willingness to pay for expanded mosquito control in Texas, as well as their support for a range of different control measures. Across all three counties surveyed, we found that residents were willing to pay much more for mosquito control than is currently allotted per capita in each of their respective county budgets. On average, participants were willing to pay an additional $53.15 in annual fees for mosquito control while current taxes and grant funding allocate $2 per person per year to vector control in Harris County, $0.27-$0.30 per person in Tarrant County, and $0.05 per person in Hidalgo County. These results suggest that options for scaling up control programs should be explored further. This will require looking at a range of different funding models and approaches and grappling with legal and policy barriers that have constrained control efforts in the past.

In this vein, a 2017 bill introduced in Texas (S.B. 1695) sought to establish mosquito control districts for counties on the Mexico border that either 1) had experienced ≥1 locally-transmitted case of Zika, or 2) were located adjacent to a county that had experienced such a case (*18*). These districts would conduct vector surveillance, support county public health work on communicable diseases, and educate the community about vectorborne disease prevention. The bill died in committee, but our results suggest that public opinion is in favor of similar efforts.

In assessing options, Texas officials may find it helpful to examine programs in other states. There is substantial heterogeneity in the scale, scope, and funding of organized vector control activities at the national level (*19*). Legislation varies across states and counties, and policies can either facilitate or prevent revenue collection through property taxes, services charges, or other contracts. California and Florida allow for abatement districts, mostly at the county level, with some county vector control programs having annual budgets of >$10 million per year (*20*). As an example, the Orange County Mosquito and Vector Control District in California has an annual budget of $15,651,880 and a population of 3,190,000, equating to $4.90 per person per year. This is significantly higher than the funding levels in the Texas counties we surveyed, but still lower than our estimated WTP. Property taxes derived from millage rates are not the only revenue source for funding local mosquito and vector control programs. For example, Illinois and Florida both collect fees for tire disposal that fund vector surveillance, control, and research activities (*21–23*).

In terms of control methods, we found that participants were most supportive of lethal traps as a form of mosquito control, which involve neither chemicals nor the release of additional mosquitoes. Ongoing research is shedding light on the effectiveness and feasibility of scaled up mosquito control using such traps (*24*). Participants were also in support of traditional methods of mosquito control (adulticides and larvicides). Consistent with prior work in Key West, Florida (*9*), participants were somewhat more skeptical of methods involving the release of genetically modified mosquitoes or mosquitoes infected with *Wolbachia* bacteria. However, more respondents were in favor of these methods than those in opposition. With intentional community engagement, education, and outreach, these methods may serve as an effective tool in control programs going forward.

Vector control programs have historically been either top-down, bottom-up, or a combination (*25–27*). Top-down approaches led to effective control of *Ae. aegypti* over much of the Americas in the 1950s, but political instability and a lack of sustained efforts caused these programs to fail over time (*1*,*26*,*28*). Currently, many area-wide operational vector control programs are organized at the city or county level. Some counties house multiple mosquito control districts (e.g., Cook Co., Illinois) while others have multi-county programs (e.g., the Metropolitan Mosquito Control District in St. Paul, Minnesota). In some instances, states take on vector control activities: in addition to performing vector-borne disease surveillance, Arizona's state health department runs annual vector control workshops (*29*). In light of the strain that the COVID-19 pandemic is putting on health departments, vector control programs around the country have faced cutbacks, and recently, there has been a call for a national vector surveillance program (*30–32*). A hybrid approach including top-down and bottom-up elements will likely be advantageous. Critically, the funding for this program needs to have bottom-up support through tax-based revenue aligned with the willingness and preferences of local citizens. Support from local communities is key to ensure feasibility and cooperation.

This study is limited in scope to three counties in the large state of Texas, and we cannot generalize our results beyond these counties. While our sampling strategy created a sample that is largely representative of the populations of the selected counties in terms of observable characteristics, the fact that respondents were selected from survey panels recruited for marketing purposes likely results in some unobserved differences between this sample and the general population (e.g., more internet-savvy persons). In addition, stated preference methods

such as the WTP protocol we employed here are subject to hypothetical bias and may result in overestimates of true WTP.

References

1. Newman S. Dallas deploys old weapon in new mosquito fight. 2012 [cited 2019 May 26]. https://www.npr.org/2012/08/19/159013034/dallas-deploys-old-weapon-in-new-mosquito-fight.

2. Luby JP. St. Louis encephalitis. Epidemiol Rev. 1979;1:55–73. PubMed https://doi.org/10.1093/oxfordjournals.epirev.a036214

3. Chung WM, Buseman CM, Joyner SN, Hughes SM, Fomby TB, Luby JP, et al. The 2012 West Nile encephalitis epidemic in Dallas, Texas. JAMA. 2013;310:297–307. PubMed https://doi.org/10.1001/jama.2013.8267

4. Dallas Morning News Staff. Summer of 2012 officially the worst season in Texas for West Nile virus. 2012. Sep 5 [cited 2021 Dec 27]. https://www.dallasnews.com/news/2012/09/06/summer-of-2012-officially-the-worst-season-in-texas-for-west-nile-virus

5. Ropeik D. What's behind the West Nile panic? (Opinion). Dallas Morning News. 2012: Dallas, TX.

6. Limaye VS, Max W, Constible J, Knowlton K. Estimating the health-related costs of 10 climate-sensitive US events during 2012. Geohealth. 2019;3:245–65. PubMed https://doi.org/10.1029/2019GH000202

7. Petersen LR, Fischer M. Unpredictable and difficult to control—the adolescence of West Nile virus. N Engl J Med. 2012;367:1281–4. PubMed https://doi.org/10.1056/NEJMp1210537

8. Ernst KC, Haenchen S, Dickinson K, Doyle MS, Walker K, Monaghan AJ, et al. Awareness and support of release of genetically modified "sterile" mosquitoes, Key West, Florida, USA. Emerg Infect Dis. 2015;21:320–4. PubMed https://doi.org/10.3201/eid2102.141035

9. Adalja, A., Sell, T.K., McGinty, M. and Boddie, C. Genetically modified (GM) mosquito use to reduce mosquito-transmitted disease in the US: a community opinion survey. PLoS Curr 2016 May 25;8:ecurrents.outbreaks.1c39ec05a743d41ee39391ed0f2ed8d3. https://doi.org/10.1371/currents.outbreaks.1c39ec05a743d41ee39391ed0f2ed8d3

10. Joseph A. Florida Keys voters split on genetically modified mosquito trial. Stat 2016 [cited 2020 Nov 6]. https://www.statnews.com/2016/11/08/florida-keys-voters-split-on-genetically-modified-mosquitoes/.

11. British Broadcasting Corporation. Florida mosquitoes: 750 million genetically modified insects to be released. 2020 [cited 2020 Oct 23]. https://www.bbc.com/news/world-us-canada-53856776.

12. Dickinson K, Paskewitz S. Willingness to pay for mosquito control: how important is West Nile virus risk compared to the nuisance of mosquitoes? Vector Borne Zoonotic Dis. 2012;12:886–92. PubMed https://doi.org/10.1089/vbz.2011.0810

13. Dickinson KL, Hayden MH, Haenchen S, Monaghan AJ, Walker KR, Ernst KC. Willingness to pay for mosquito control in Key West, Florida and Tucson, Arizona. Am J Trop Med Hyg. 2016;94:775–9. PubMed https://doi.org/10.4269/ajtmh.15-0666

14. Halasa YA, Shepard DS, Wittenberg E, Fonseca DM, Farajollahi A, Healy S, et al. Willingness-to-pay for an area-wide integrated pest management program to control the Asian tiger mosquito in New Jersey. J Am Mosq Control Assoc. 2012;28:225–36. PubMed https://doi.org/10.2987/12-6243R.1

15. Richards SL, Balanay JAG, Byrd BD, Reiskind MH, Styers DM. Regional survey of mosquito control knowledge and usage in North Carolina. J Am Mosq Control Assoc. 2017;33:331–9. PubMed https://doi.org/10.2987/17-6669.1

16. Langford IH, Bateman IJ, Langford HD. A multilevel modelling approach to triple-bounded dichotomous choice contingent valuation. Environ Resour Econ. 1996;7:197–211.

17. Arrow K, Solow R, Portney PR, Leamer EE, Radner R, Schuman H. Report of the NOAA panel on contingent valuation. Federal Register. 1993;58: 4601–14.

18. State of Texas. Senate Bill 17-1965. An act relating to mosquito control districts established for an urgent public health purpose. 2017 [cited 2021 Dec 27]. https://legiscan.com/TX/text/SB1695/2017

19. Hamer GL. Heterogeneity of mosquito (*Diptera: Culicidae*) control community size, research productivity, and arboviral diseases across the United States. J Med Entomol. 2016;53:485–95. PubMed https://doi.org/10.1093/jme/tjw020

20. Mosquito and Vector Control Association of California (MVCAC). 2020 yearbook. Sacramento, CA: Government of California; 2020.

21. Illinois Environmental Protection Agency. Used tire management fund. 2020 [cited 2020 Nov 24]. https://www2.illinois.gov/epa/topics/waste-management/waste-disposal/used-tires/Pages/fund.aspx.

22. Tabachnick WJ. Florida's state support budget for mosquito control: tough times may undermine Florida public health. 2008 [cited 2020 Nov 24]. https://fmel.ifas.ufl.edu/publication/buzz-words/buzz-words-archive/floridas-state-support-budget-for-mosquito/.

23. Tabachnick WJ. Status of Florida State Aid for Mosquito Control (SAMC). Vero Beach, FL: University of Florida; 2010.

24. Barrera R, Harris A, Hemme RR, Felix G, Nazario N, Muñoz-Jordan JL, et al. Citywide control of *Aedes aegypti* (Diptera: Culicidae) during the 2016 Zika epidemic by integrating community awareness, education, source reduction, larvicides, and mass mosquito trapping. J Med Entomol. 2019;56:1033–46. PubMed https://doi.org/10.1093/jme/tjz009

25. Gubler DJ. *Aedes aegypti* and *Aedes aegypti*–borne disease control in the 1990s: top down or bottom up. Charles Franklin Craig Lecture. Am J Trop Med Hyg. 1989;40:571–8. PubMed https://doi.org/10.4269/ajtmh.1989.40.571

26. Camargo S. History of *Aedes aegypti* eradication in the Americas. Bull World Health Organ. 1967;36:602–3. PubMed

27. Schliessmann DJ. *Aedes aegypti* eradication program of the United States—progress report 1965. Am J Public Health Nations Health. 1967;57:460–5. PubMed https://doi.org/10.2105/AJPH.57.3.460

28. Texas Mosquito Control Association. History of the Texas Mosquito Control Association: the first 25 years (1956–1981). 2020 [cited 2021 January 14]. https://bd043703-f168-425e-90d8-9088d6ede459.filesusr.com/ugd/5282e9_9f5441ddedce4e32b39da908037e2b85.pdf.

29. Arizona Department of Health Services (ADHS). Vector-borne and zoonotic diseases. 2020 [cited 2021 January 13]. https://www.azdhs.gov/preparedness/epidemiology-disease-control/vector-borne-zoonotic-diseases/index.php.

30. US Centers for Disease Control. A national public health framework for the prevention and control of vector-borne diseases in humans. September 28, 2020 [cited 2021 Feb 10]. https://www.cdc.gov/ncezid/dvbd/framework.html.

31. Dykstra L, Gardner A, Spence Beaulieu M. Vector-borne disease: CDC report outlines key steps for prevention and control in U.S. Entomology Today. 2020 Nov 12 [cited 2021 Dec 27]. https://entomologytoday.org/2020/11/12/vector-borne-disease-cdc-report-prevention-control-united-states/

32. Santoro H. COVID-19 is stripping resources from mosquito control programs. Slate. 2020 [cited 2021 Dec 27]. https://slate.com/technology/2020/06/coronavirus-mosquito-vector-control-programs.html

Appendix 1 Table 1. Characteristics of survey participants and comparisons with census characteristics (where available) in study of willingness to pay for mosquito control measures, Texas, United States

	Full	Harris County		Tarrant County		Hidalgo County	
Characteristic	sample	Sample	Census	Sample	Census	Sample	Census
n	1,831	610	—	609	—	612	—
Age (median)	37	38	33.9	44	34.8	30	29.6
Gender, %*							
F	56.8	50.0	50.2	50.6	51.0	69.6	52.1
M	42.6	49.3	49.8	48.4	49.0	30.1	47.9
Other/declined	0.7	0.7		1.0		0.3	
Race, %							
Non-Hispanic White	44.6	49.8	28.5	67.2	45.2	16.5	5.6
Hispanic	38.0	20.8	43.7	12.6	29.5	81.0	92.5
Non-Hispanic Black	12.1	20.	18.5	14.8	16.8	1.2	0.4
Non-Hispanic Asian/Pacific Islander	3.2	6.8	7.0	2.2	5.8	0.7	0.9
Non-Hispanic American Indian/Alaska Native/other	2.1	1.8	0.5	3.2	0.6	0.7	0.5
Education, %							
Less than high school	3.3	3.3	17.4	1.8	12.7	5.1	29.9
High school or equivalent	22.2	19.0	25.0	22.8	25.8	25.5	25.3
Some college/2-y degree	37.7	35.4	28.2	35.6	30.5	42.0	28.1
Bachelor's degree or higher	36.7	42.1	29.4	37.7	31.0	27.4	16.7
Annual Income, sample | census%†							
<$40K | <$35K	38.9	33.6	27.5	34.0	22.6	50.5	43.3
$40K–$80K | $35K–$75K	32.1	32.8	30.8	33.3	31.0	30.6	30.5
$80K–$150K | $75–$150K	20.3	22.1	26.1	23.0	30.1	15.5	20.4
>$150,000	7.8	10.7	15.7	9.4	16.3	3.4	5.8
Households with children, %	47.1	46.6	32.8	39.2	31.4	56.1	41.3
Political Ideology							
Liberal	23.5	23.0	—	20.2	—	27.9	—
Moderate	31.6	33.6	—	30.2	—	31.2	—
Conservative	29.0	29.5	—	36.1	—	20.9	—
Know person infected with WNV, Dengue, or Zika, %	13.1	12.1	—	15.1	—	12.3	—
Noticed many mosquitoes outdoors, %	33.2	33.4	—	25.9	—	39.4	—

*Characteristics for which Qualtrics instituted recruitment quotas to align with county census demographics. The gender quota was relaxed for Hidalgo because the response rate had fallen behind the other two counties after a week, resulting in a larger proportion of female participants relative to the proportion of women in the county.
†We categorized our response options differently from the presentation of the income data at data.census.gov.

Appendix 1 Table 2. Interval censored regression results for selected variables in model without covariates (model 1) and with covariates (model 2) in analysis of public willingness to pay for mosquito control, Texas*

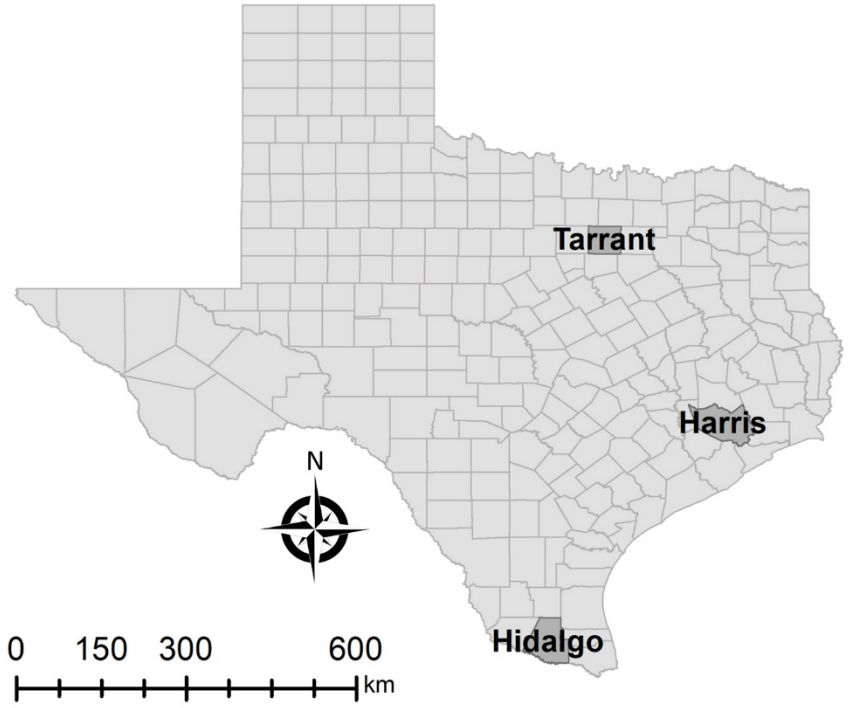
Variable	Model 1 result (robust standard error)	Model 2 result (robust standard error)
Constant	55.9 (2.74)*	38.6 (5.93)*
Tarrant County	−3.49 (3.86)	−0.81 (3.86)
Hidalgo County	−3.86 (3.85)	−3.44 (4.55)
Gender: Female		−8.26† (3.28)
Race/Eth: Hispanic		4.24 (4.69)
Race/Eth: Black		2.72 (5.34)
Race/Eth: Other		−12.7† (6.35)
Age: 30–55		0.89 (3.79)
Age: 56+		−5.83 (5.09)
Has Children		5.09 (3.40)
Education: Some college		−0.084 (4.03)
Education: 2 or 4 y degree		5.58 (3.81)
Education: Graduate degree		24.8* (9.31)
Income: $40K–$80K		5.53 (3.79)
Income: $80K–$150K		11.1† (4.58)
Income: More than $150K		24.4* (6.45)
Political ideology: Liberal		11.9* (3.92)
Political ideology: Conservative		1.81 (3.84)
Know someone who had West Nile, Dengue, or Zika		21.3* (4.71)
Notice many mosquitoes outdoors		11.6* (3.38)
Observations	1,831	1,821
AIC	9,226	9,083
Joint significance of county, χ^2 (p value)	1.22 (0.54)	0.58 (0.75)

*p<0.01
†p<0.05

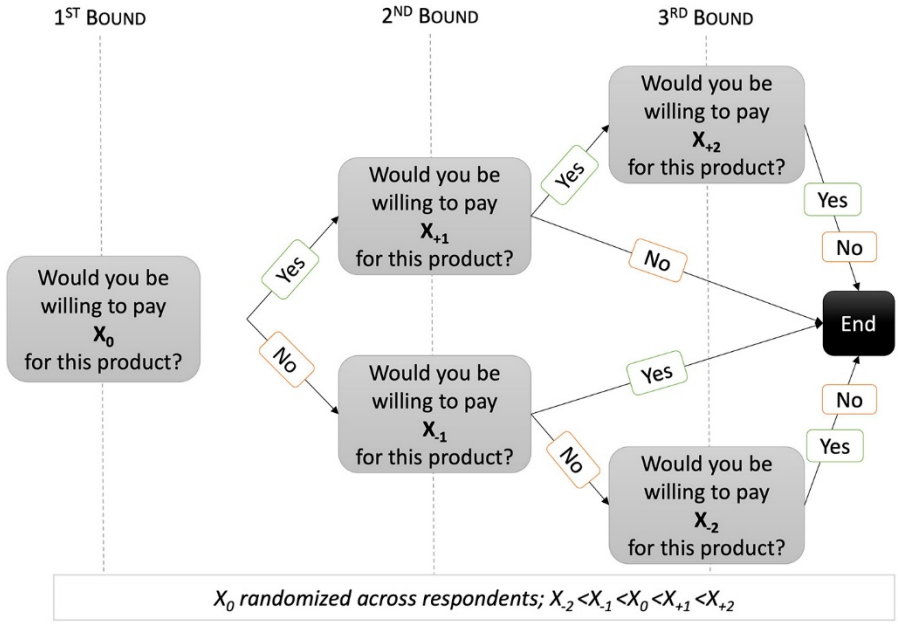
Appendix 1 Table 3. Ordered logistic regression results for level of support of different mosquito control methods, Texas*

	(1)	(2)	(3)	(4)	(5)	(6)
Category	Traps	Adulticide	Larvicide	Sterile Male	Wolbachia	GM
Gender: Female	0.14 (0.091)	−0.068(0.090)	0.016 (0.090)	−0.21‡ (0.090)	−0.22‡ (0.089)	−0.31§ (0.090)
Race/Eth: Hispanic	−0.069 (0.14)	−0.043 (0.14)	−0.078 (0.14)	−0.057 (0.13)	0.019 (0.13)	0.086 (0.13)
Race/Eth: Black	−0.18 (0.15)	0.13 (0.16)	−0.054 (0.14)	−0.43§ (0.15)	−0.090 (0.15)	−0.12 (0.15)
Race/Eth: Other	−0.26 (0.16)	−0.20 (0.16)	−0.30* (0.16)	−0.18 (0.17)	−0.25 (0.18)	−0.17 (0.17)
Age: 30–55	0.25‡ (0.11)	0.19* (0.11)	0.38§ (0.11)	0.14 (0.10)	−0.15 (0.10)	0.080 (0.10)
Age: 56+	−0.19 (0.14)	0.36§ (0.13)	0.61§ (0.14)	0.48§ (0.13)	0.11 (0.13)	0.54§ (0.13)
Has Children	−0.057 (0.096)	−0.016 (0.097)	0.15 (0.098)	0.041 (0.095)	−0.073 (0.093)	0.087 (0.093)
Education: Some college	0.16 (0.11)	0.25‡ (0.11)	0.24‡ (0.11)	−0.013 (0.11)	−0.12 (0.11)	−0.12 (0.11)
Education: 2 or 4 y degree	0.13 (0.11)	0.092 (0.11)	0.29† (0.11)	0.24‡ (0.11)	0.080 (0.11)	0.10 (0.11)
Education: Graduate degree	0.26 (0.28)	0.36 (0.26)	0.52* (0.27)	0.38 (0.25)	0.040 (0.23)	0.19 (0.23)
Income: $40K– $80K	0.081 (0.10)	0.052 (0.10)	0.014 (0.11)	0.012 (0.10)	−0.011 (0.10)	−0.054 (0.10)
Income: $80K – $150K	0.38† (0.13)	0.0066 (0.13)	0.039 (0.13)	−0.053 (0.13)	−0.10 (0.13)	−0.11 (0.13)
Income: More than $150K	0.45‡ (0.19)	0.50† (0.18)	0.33* (0.18)	0.28 (0.20)	0.20 (0.19)	0.11 (0.19)
Political ideology: Liberal	0.047 (0.11)	0.054 (0.11)	0.068 (0.11)	0.13 (0.11)	0.12 (0.10)	0.18* (0.11)
Political ideology: Conservative	0.15 (0.11)	0.29† (0.11)	0.18 (0.11)	0.025 (0.11)	0.20* (0.11)	0.074 (0.11)
Know someone who had West Nile, Dengue, or Zika	0.16 (0.14)	0.45† (0.15)	0.21 (0.14)	0.21 (0.14)	0.24* (0.14)	0.38† (0.14)
Notice many mosquitoes outdoors	0.15 (0.10)	0.48† (0.10)	0.32† (0.099)	0.12 (0.096)	0.17* (0.095)	0.092 (0.096)
Tarrant County	0.22‡ (0.11)	−0.24‡ (0.11)	0.094 (0.10)	0.0022 (0.11)	−0.083 (0.11)	−0.087 (0.11)
Hidalgo County	0.18 (0.13)	−0.019 (0.14)	−0.022 (0.14)	0.093 (0.12)	0.054 (0.12)	0.0095 (0.13)
Observations	1,821	1,821	1,821	1,821	1,821	1,821
Pseudo R^2¶	0.01	0.02	0.02	0.01	0.01	0.01
Joint significance of county: χ^2 (p value)	4.34 (0.11)	5.41 (0.07)	1.13 (0.57)	0.65 (0.72)	1.30 (0.52)	0.87 (0.65)

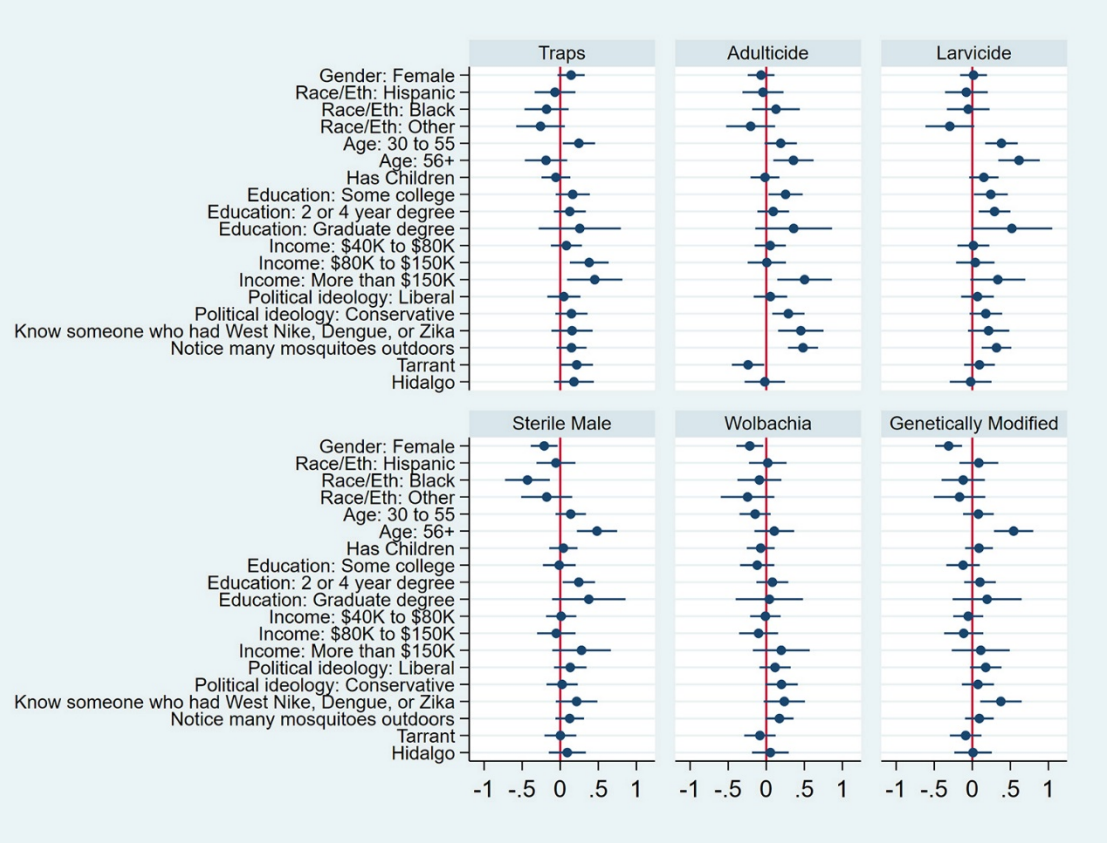
*Robust standard errors in parentheses. The dependent variable in each of these ordered logistic regressions is the level of support for each specified control method (1=Strongly Oppose, 2= Oppose, 3=Neutral/No Opinion, 4=Support, 5=Strongly Support), and rows show regression coefficients and standard errors for each independent variable. . GM, genetic modification.
†p<0.01
‡p<0.05
§p<0.1
¶Goodness-of-fit measure for nonlinear regression (logit) model.



Appendix 1 Figure 1. Map of Texas showing Harris, Tarrant, and Hidalgo counties, in which residents were surveyed for willingness to pay for mosquito-control measures.



Appendix 1 Figure 2. Triple-bounded dichotomous-choice framework to measure willingness-to-pay for mosquito control, Texas, US.



Appendix 1 Figure 3. Ordered logistic regression results showing variation in support for mosquito control methods by individual characteristics. Dots indicate point estimates and lines indicate 95% CI. Red line represents the reference category, e.g., male sex, non-Hispanic white race/ethnicity, respondents under age 30, respondents without children (Appendix 1 Table 1).

Article DOI: https://doi.org/10.3201/eid2801.210501

Public Acceptance of and Willingness to Pay for Mosquito Control, Texas

Appendix 2

The following pages show a survey given to residents of Harris, Tarrant, and Hidalgo Counties in Texas, USA, to determine public attitudes toward and willingness to pay for mosquito control, regions with varying risk for mosquitoborne pathogens, socioeconomic conditions, and current mosquito control practices.

English

Informed Consent

You have been invited to take a research survey. This form provides you with information about the survey and how this information will help our research study. Please read the information below. If you have questions about anything you don't understand before deciding whether or not to participate, please contact the study investigator, Dr. Katherine Dickinson of the Colorado School of Public Health at (303) 724-4093 or email her at katherine.dickinson@cuanschutz.edu.

Why is this survey being done?
To learn more about mosquitoes and mosquito control in this area. It is important that the opinions and attitudes of Texas residents dealing with mosquitoes and their diseases be understood and considered to develop more effective surveillance and control programs. Therefore, final survey results will be made available to local, state, and federal groups considering mosquito control programs.

What happens if I take this survey?
Your experiences and opinions surrounding mosquito-borne disease and control will contribute to a valuable data set that will help determine the burden of mosquitoes in this area and how they should be managed. This survey will take approximately 15 minutes.

What are the possible discomforts or risks?
There are no foreseeable risks associated with your participation in this survey.

What are the possible benefits of the study?
There are no known benefits directly resulting from your participation in this survey.

Who is paying for this study?
The US Centers for Disease Control and Prevention.

Will I be paid for being in the study? Will I have to pay for anything?

No, you will not be paid, and it will not cost you anything to participate in this survey.

Is my participation voluntary?
Yes. You have the right to choose not to participate in this study. If you choose to participate, you have the right to stop at any time, or to skip any questions you do not wish to answer. If you refuse or decide to withdraw later, you will not lose any benefits or rights to which you are entitled.

Who do I call if I have questions?
The researchers leading this study are Dr. Katherine Dickinson (Colorado School of Public Health) and Dr. Gabriel Hamer (Texas A&M University). If you have questions, you may call Dr. Dickinson at (303) 724-4093 or email her at katherine.dickinson@cuanschutz.edu.

You may have questions about your rights as a participant in this study. You can also call the Colorado Multiple Institutional Review Board (COMIRB) at 303-724-1055.

Who will see my research information?
We will make every effort to maintain the confidentiality of the survey data. No information about individuals who participate in the study will ever be published; all results will be presented in summary form. All records and data will be kept secure to the best of our ability. Individual data may be viewed by the following people:

- *Federal agencies that monitor human subject research*
- *Human Subject Research Committee*
- *The group doing the study*
- *The group paying for the study*
- *Regulatory officials from the institution where the research is being conducted who want to make sure the research is safe*

Survey results will be shared in meetings, reports, and published articles. Your name will be kept private when information is presented.

Agreement to take this survey

I have read the previous description about the survey. I understand the possible risks and benefits of this survey. I know that taking this survey is voluntary. I choose to take this survey.

Yes

No

Sociodemographic Information

We are almost done with this survey. We would just like to ask a few questions about you that will help us better understand the results!

What is your age?

What is your gender?

Male

Female

Non-binary/third gender

Prefer to self-describe:

Prefer not to say

Do you consider yourself Hispanic or Latino?

Yes

No

Prefer not to answer

How would you classify yourself in regards to race?

American Indian/Alaska Native

Asian/Pacific Islander

Black/African American

White

Multi-racial

Other

Prefer not to answer

When it comes to politics, do you usually think of yourself as:

Very Liberal
Liberal
Moderate
Conservative
Very Conservative
Have not considered this/prefer not to answer

What is your political affiliation?

Democrat
Republican
Libertarian
Green Party
Unaffiliated/Independent

Other

Prefer not to answer

What is your marital status?

Married
Cohabitating/common law
Single
Divorced/Separated
Widowed
Prefer not to answer

What is the highest level of education you have completed?

Less than high school

High school graduate

Some college

2 year degree

4 year degree

Master's degree

Professional degree

Doctorate

Prefer not to answer

What was your household's income last year?

Less than $20,000

$20,000-$39,999

$40,000-$59,999

$60,000-$79,999

$80,000-$99,999

$100,000-$149,999

$150,000-$199,999

More than $200,000

Prefer not to answer

Respondent Type Screening

Please enter your county.

Harris County

Tarrant County

Hidalgo County

Please enter your zip code.

Household Characteristics

How many adults (over the age of 18) live in your home?

How many children live in your home?

How many years have you lived in Harris County?

How many years have you lived in Hidalgo County?

How many years have you lived in Tarrant County?

Do you have air conditioning?

Yes

No

How often do you use your air conditioning during the summer months?

Every day

Multiple times per week

About once a week

Less than once a week

Other

Do your windows or outside doors have screens?

Yes, all of them

Yes, some of them

No, none of them

Perceived impacts of mosquitoes on quality of life

On a typical weekend or non-working day at this time of year, how many hours do you spend outdoors?

0-2

2-4

4-6

6-8

8+

On a typical weekend or non-working day at this time of year, how many hours do your kids spend outdoors (if applicable)?

0-2

2-4

4-6

6-8

8+

What do you think about mosquitoes in your community?

1 - Not a problem

2 - Small problem

3 - Moderate problem

4 - Big problem

5 - Very big problem

Currently, do you notice mosquitoes when you are outdoors in your neighborhood?

None
Very few
Moderate amount
Quite a few
Very many
Not applicable

Have you noticed mosquitoes biting you in the past week OUTSIDE your home?

Yes
No

Have you noticed mosquitoes biting you in the past week INSIDE your home?

Yes
No

In the past month, have mosquitoes caused you to avoid or shorten the amount of time you spent doing any of the following activities? Select all that apply.

Cooking out
Dining outside or picnicking
Gardening
Yard or home maintanence
Walking in the neighborhood
Playing in the yard with a child
Talking with neighbors
Other
None

During which months do mosquitoes bother you the most?

January

February

March

April

May

June

July

August

September

October

November

December

Please list any diseases that are spread by mosquitoes in this area.

Have you heard of West Nile Virus?

Yes

No

How concerned are you about West Nile Virus in your area?

1 - Not at all concerned

2 - Slightly concerned

3 - Somewhat concerned

4 - Very concerned

5 - Extremely concerned

Don't know / Not sure

Have you heard of Dengue virus?

Yes

No

How concerned are you about Dengue virus in your area?

1 - Not at all concerned
2 - Slightly concerned
3 - Somewhat concerned
4 - Very concerned
5 - Extremely concerned
Don't know / Not sure

Have you heard of Zika?

Yes
No

How concerned are you about Zika in your area?

1 - Not at all concerned
2 - Slightly concerned
3 - Somewhat concerned
4 - Very concerned
5 - Extremely concerned
Don't know / Not sure

Have you known anyone personally who has had any of the following mosquito-borne diseases?

	Yes	No	Don't know / Not sure
West Nile Virus	O	O	O
Dengue Virus	O	O	O
Zika	O	O	O

Mosquito Avoidance

Which of the following methods do you use to avoid being bitten by mosquitoes? Select all that apply.

Using repellent
Burning citronella candles
Wearing long sleeves
Draining standing water
Removing containers (tires, bottles, plant saucers, bird baths) that collect water
Calling mosquito control
Burning coils
Burning "tiki torches"
Spraying insecticide
Staying indoors
Plant mosquito-repellent plants (ex. lemon balm, rosemary)
Fans
None
Other

About how much do you think you spent on products to avoid mosquitoes in the past month?

$0
$1-$5
$5-$10
$10-$15
$15-$20
$20-$30
More than $30

Rating Current Programs

How would you rate the current mosquito control programs in your area?

1 - Not at all effective
2 - Slightly effective

3 - Somewhat effective

4 - Very effective

5 - Extremely effective

6 - I am not aware of any control programs in my area

In your opinion, should mosquito control efforts in your area:

Be expanded

Be reduced

Be maintained at current levels

Not sure

Do you have any concerns about the possible side effects of mosquito control in your county? Select all that apply.

I have concerns about the effects of insecticides on the environment, including plants, animals, and other insects

I have concerns about the effects of insecticides on human health

I have concerns about mosquitoes developing resistance to insecticides used in mosquito control (i.e. control methods become ineffective)

I have concerns about the possible impacts of using genetically modified mosquitoes for mosquito control

I have concerns about mosquito control invading my privacy (too much government)

I don't have any concerns about mosquito control

Other

In general, please indicate your level of support for a county-wide mosquito control program:

I am very supportive of a county-wide mosquito control program

I am somewhat supportive of a county-wide mosquito control program

I don't really care if there is a mosquito control program or not

I am somewhat opposed to a county-wide mosquito control program

I am strongly opposed to a county-wide mosquito control program

Don't know/not sure

Willingness to Pay

The Harris County Public Health Mosquito & Vector Control Division currently coordinates all mosquito control activities in this county including the city of Houston. Some municipalities also collaborate with Harris County to enhance control. Activities include:

- Surveillance (trapping mosquitoes to see how many and what types of mosquitoes are present in different areas) and testing for mosquito-borne diseases;

- Mosquito control using adulticides (spraying chemicals to kill adult mosquitoes) and minimal larvicides (treating mosquito breeding sites to kill immature mosquitoes);

- Insecticide resistance testing, mosquito inspections, virology testing, bird surveillance, alternative mosquito control applied research, other vector surveillance (i.e. ticks and kissing bugs);

- Education and outreach.

These activities are focused on mosquitoes that can spread West Nile virus, St. Louis encephalitis, and more recently, mosquitoes that can transmit dengue, Zika, and chikungunya viruses. Funding for mosquito control comes mainly from taxes and bonds, and federal grants during emergencies. The total annual budget for mosquito control in Harris County is about $6 to 8 million, or roughly $2 per person per year.

The Tarrant County Public Health Department currently coordinates mosquito control activities in this county, and some municipalities also carry out their out mosquito control activities. These activities include:

- Surveillance (trapping mosquitoes to see how many and what types are present in different areas); testing people and mosquitoes for disease;

- Mosquito control using adulticides (spraying chemicals to kill primarily disease-carrying adult mosquitoes) and larvicides (treating mosquito breeding sites to kill immature mosquitoes);

- Education and outreach.

Mosquito control activities are largely focused on trapping and testing Culex mosquitoes that can spread West Nile Virus and St. Louis encephalitis, and spraying the area if positive. More recently, the county has also been doing surveillance for mosquitoes that can transmit dengue, Zika, and chikungunya viruses and testing people for these diseases.

Funding for mosquito control comes from the county's general tax fund, as well as grants. The annual budget for mosquito control in Tarrant County is about $700,000 or roughly $0.27-$0.30 per person, per year. This estimate does not include the funds that individual cities in Tarrant County have in their budgets for mosquito control activities.

Mosquito control activities in Hidalgo County are mainly run by each city's health department. Hidalgo County Health and Human Services supports the cities and helps with mosquito control in cities without a health department. Depending on the city, activities that are conducted may include:

- Surveillance (trapping mosquitoes to see how many and what types are present in different areas)

- Mosquito control using adulticides (spraying chemicals to kill adult mosquitoes) and larvicides (treating mosquito breeding sites to kill immature mosquitoes)

- Education and outreach.

Mosquito control activities in the past have focused on mosquitoes that can transmit West Nile Virus and dengue. More recently, the county has also begun conducting targeted surveillance for mosquitoes that can transmit Zika and chikungunya viruses.

The county-wide vector control program has an annual budget of about $10,000 and covers the 200,000 people in Hidalgo County that do not fall under one of the other 23 city vector departments in the area. This equates to about $0.05 per person each year.

We’re now going to ask you about whether you’d be willing to pay to increase mosquito control at the county level. Suppose that there were a proposal on the next election ballot to expand mosquito control across the county. If the proposal passes, the number of mosquitoes in this area would be cut in half. To fund this expansion, your household and others in the county

would be charged an annual fee. The next questions will ask you whether or not you would vote in favor of this ballot measure.

Please consider these questions and answer honestly. Your responses may inform future policy in this area. Any response (yes, no, or not sure) is valid. Some reasons people might support this proposal are that they value mosquito control and think it is worth the money to reduce mosquitoes. Some reasons people might oppose this proposal are that they think the fee is too high or do not think it's worth the money to expand mosquito control activities.

WTP Block 1

Suppose that there were a proposal on the next election ballot to expand mosquito control across the county. If the proposal passes, the number of mosquitoes in this area would be cut in half. To fund this expansion, your household and others in the county at your income level would be charged a fee of $25 once per year. Would you support this proposal?

No

Yes

Not sure

Now suppose that instead of $25, the fee for this program (which would still reduce the number of mosquitoes by half) was $50 per year. Would you still support this proposal?

No

Yes

Not sure

Now suppose the fee for this same program were even higher: $100 per year. Would you still support this proposal?

No

Yes

Not sure

Now suppose that instead of $25, the fee for this program (which would still reduce the number of mosquitoes by half) was $10 per year. Would you support this proposal?

No

Yes

Not sure

Now suppose the fee for this same program were even lower: $5 per year. Would you support this proposal?

No

Yes

Not sure

We are interested in knowing why you indicated that you are not willing to pay for mosquito control programs. Please select all reasons that apply.

Mosquitoes don't bother me

I don't trust government intervention

I can't afford it/it's too expensive

I don't like paying additional fees

I don't think the program would be successful

Other

Don't know

We are interested in why you indicated that you are willing to pay for mosquito control programs. Please choose all reasons that apply.

I think mosquitoes are a nuisance

I'm worried about disease risk

I think the program would be successful

I want to show support for such a program

Other

Don't know

We are interested in why you are unsure whether or not you would be willing to pay for mosquito control programs. Please choose all reasons that apply.

I would need more information

I did not understand the questions

Other

Don't know

What additional information would you need in order to make a decision?

To what extent do you believe that these survey results will be taken into consideration by county policymakers making decisions about mosquito control programs?

I don't think policymakers will consider these surveys

I think it is unlikely that policymakers will consider these surveys

I don't know whether or not policymakers will consider these surveys

I think it is likely that policymakers will consider these surveys

I think policymakers will consider these surveys

WTP 5 ($100)

Suppose that there were a proposal on the next election ballot to expand mosquito control across the county. If the proposal passes, the number of mosquitoes in this area would be cut in half. To fund this expansion, your household and others in the county at your income level would be charged a fee of $100 once per year. Would you support this proposal?

No

Yes

Not sure

Now suppose that instead of $100, the fee for this program (which would still reduce the number of mosquitoes by half) was $200 per year. Would you still support this proposal?

No
Yes
Not sure

Now suppose the fee for this same program were even higher: $400 per year. Would you still support this proposal?

No
Yes
Not sure

Now suppose that instead of $100, the fee for this program (which would still reduce the number of mosquitoes by half) was $50 per year. Would you support this proposal?

No
Yes
Not sure

Now suppose the fee for this same program were even lower: $25 per year. Would you support this proposal?

No
Yes
Not sure

We are interested in knowing why you indicated that you are not willing to pay for mosquito control programs. Please select all reasons that apply.

Mosquitoes don't bother me
I don't trust government intervention
I can't afford it/it's too expensive

I don't like paying additional fees

I don't think the program would be successful

Other

Don't know

We are interested in why you indicated that you are willing to pay for mosquito control programs. Please choose all reasons that apply.

I think mosquitoes are a nuisance

I'm worried about disease risk

I think the program would be successful

I want to show support for such a program

Other

Don't know

We are interested in why you are unsure whether or not you would be willing to pay for mosquito control programs. Please choose all reasons that apply.

I would need more information

I did not understand the questions

Other

Don't know

What additional information would you need in order to make a decision?

To what extent do you believe that your vote and that of other survey participants will be taken into consideration by county policymakers?

I don't think policymakers will consider these votes

I think it is unlikely that policymakers will consider these votes

I don't know whether or not policymakers will consider these votes

I think it is likely that policymakers will consider these votes

I think policymakers will consider these votes

WTP 4 ($50)

Suppose that there were a proposal on the next election ballot to expand mosquito control across the county. If the proposal passes, the number of mosquitoes in this area would be cut in half. To fund this expansion, your household and others in the county at your income level would be charged a fee of $50 once per year. Would you support this proposal?

No

Yes

Not sure

Now suppose that instead of $50, the fee for this program (which would still reduce the number of mosquitoes by half) was $100 per year. Would you still support this proposal?

No

Yes

Not sure

Now suppose the fee for this same program were even higher: $200 per year. Would you still support this proposal?

No

Yes

Not sure

Now suppose that instead of $50, the fee for this program (which would still reduce the number of mosquitoes by half) was $25 per year. Would you support this proposal?

No

Yes

Not sure

Now suppose the fee for this same program were even lower: $10 per year. Would you support this proposal?

No

Yes

Not sure

We are interested in knowing why you indicated that you are not willing to pay for mosquito control programs. Please select all reasons that apply.

Mosquitoes don't bother me

I don't trust government intervention

I can't afford it/it's too expensive

I don't like paying additional fees

I don't think the program would be successful

Other

Don't know

We are interested in why you indicated that you are willing to pay for mosquito control programs. Please choose all reasons that apply.

I think mosquitoes are a nuisance

I'm worried about disease risk

I think the program would be successful

I want to show support for such a program

Other

Don't know

We are interested in why you are unsure whether or not you would be willing to pay for mosquito control programs. Please choose all reasons that apply.

I would need more information

I did not understand the questions

Other

Don't know

What additional information would you need in order to make a decision?

To what extent do you believe that your vote and that of other survey participants will be taken into consideration by county policymakers?

I don't think policymakers will consider these votes

I think it is unlikely that policymakers will consider these votes

I don't know whether or not policymakers will consider these votes

I think it is likely that policymakers will consider these votes

I think policymakers will consider these votes

WTP Block 3 ($10)

Suppose that there were a proposal on the next election ballot to expand mosquito control across the county. If the proposal passes, the number of mosquitoes in this area would be cut in half. To fund this expansion, your household and others in the county at your income level would be charged a fee of $10 once per year. Would you support this proposal?

No

Yes

Not sure

Now suppose that instead of $10, the fee for this program (which would still reduce the number of mosquitoes by half) was $20 per year. Would you still support this proposal?

No

Yes

Not sure

Now suppose the fee for this same program were even higher: $40 per year. Would you still support this proposal?

No

Yes

Not sure

Now suppose that instead of $10, the fee for this program (which would still reduce the number of mosquitoes by half) was $5 per year. Would you support this proposal?

No

Yes

Not sure

Now suppose the fee for this same program were even lower: $2 per year. Would you support this proposal?

No

Yes

Not sure

We are interested in knowing why you indicated that you are not willing to pay for mosquito control programs. Please select all reasons that apply.

Mosquitoes don't bother me

I don't trust government intervention

I can't afford it/it's too expensive

I don't like paying additional fees

I don't think the program would be successful

Other

Don't know

We are interested in why you indicated that you are willing to pay for mosquito control programs. Please choose all reasons that apply.

I think mosquitoes are a nuisance

I'm worried about disease risk

I think the program would be successful

I want to show support for such a program

Other

Don't know

We are interested in why you are unsure whether or not you would be willing to pay for mosquito control programs. Please choose all reasons that apply.

I would need more information

I did not understand the questions

Other

Don't know

What additional information would you need in order to make a decision?

To what extent do you believe that your vote and that of other survey participants will be taken into consideration by county policymakers?

I don't think policymakers will consider these votes

I think it is unlikely that policymakers will consider these votes

I don't know whether or not policymakers will consider these votes

I think it is likely that policymakers will consider these votes

I think policymakers will consider these votes

WTP Block 2 ($5)

Suppose that there were a proposal on the next election ballot to expand mosquito control across the county. If the proposal passes, the number of mosquitoes in this area would be cut in half. To fund this expansion, your household and others in the county at your income level would be charged a fee of $5 once per year. Would you support this proposal?

No

Yes

Not sure

Now suppose that instead of $5, the fee for this program (which would still reduce the number of mosquitoes by half) was $10 per year. Would you still support this proposal?

No
Yes
Not sure

Now suppose the fee for this same program were even higher: $20 per year. Would you still support this proposal?

No
Yes
Not sure

Now suppose that instead of $5, the fee for this program (which would still reduce the number of mosquitoes by half) was $2 per year. Would you support this proposal?

No
Yes
Not sure

Now suppose the fee for this same program were even lower: $1 per year. Would you support this proposal?

No
Yes
Not sure

We are interested in knowing why you indicated that you are not willing to pay for mosquito control programs. Please select all reasons that apply.

Mosquitoes don't bother me
I don't trust government intervention

I can't afford it/it's too expensive

I don't like paying additional fees

I don't think the program would be successful

Other

Don't know

We are interested in why you are unsure whether or not you would be willing to pay for mosquito control programs. Please choose all reasons that apply.

I would need more information

I did not understand the questions

Other

Don't know

We are interested in why you indicated that you are willing to pay for mosquito control programs. Please choose all reasons that apply.

I think mosquitoes are a nuisance

I'm worried about disease risk

I think the program would be successful

I want to show support for such a program

Other

Don't know

What additional information would you need in order to make a decision?

To what extent do you believe that your vote and that of other survey participants will be taken into consideration by county policymakers?

I don't think policymakers will consider these votes

I think it is unlikely that policymakers will consider these votes

I don't know whether or not policymakers will consider these votes

I think it is likely that policymakers will consider these votes

I think policymakers will consider these votes

Description of Mosquito Control Options

There are many different types of mosquitoes in Texas. Some types of mosquitoes can transmit diseases. Culex is one of the main types of mosquitoes in this area that can spread diseases to humans, especially West Nile virus. More recently, health departments have also been monitoring some Aedes mosquitoes which can spread dengue, Zika and chikungunya viruses.

Some control methods specifically target disease-carrying mosquitoes. Some are more effective against Culex mosquitoes, and others are more effective against Aedes mosquitoes. All mosquitoes that feed on humans can be a nuisance!

Please read the information below about different types of control methods. We will then ask you some questions about what you think of these methods.

Adulticides

This method involves spraying insecticides to reduce the mosquito population by killing adult mosquitoes. Adulticides can be applied using handheld sprayers, or sprayers mounted on a backpack, a truck or an airplane.

Have adulticides been tested?

Yes.

Have adulticides been used in Texas?

Yes, they are widely used across the state.

Which types of mosquitoes are targeted by this method?

Nuisance mosquitoes and mosquitoes that carry disease are targeted.

Often, mosquito control entities will use adulticides when they find a mosquito that is carrying West Nile or another virus.

Recent testing in the U.S. has shown that some adulticides can successfully kill mosquitoes that can carry Zika, chikungunya and dengue.

Are adulticides expensive?

Adulticides are widely used because they are low-cost and continue to be highly effective over time.

Are adulticides harmful to human health and/or the environment?

Adulticides can be dangerous at high levels of exposure, like in the event of a spill.

It is possible for people to breathe in small amounts of adulticides when a spraying takes place. People should stay inside and close doors and windows during spraying.

Some adulticides are toxic to bees and fish, so they are often applied only at certain times and places in order to protect wildlife.

Larvicides

Larvicides kill immature mosquitoes in their water habitat before they reach the flying adult stage.

Have larvicides been tested?

Yes.

Have larvicides been used in Texas?

Yes.

Which mosquitoes does this method target?

Larvicides can target mosquitoes such as Culex and Aedes, which breed in containers. They can also be applied over wider areas to target nuisance mosquitoes that breed in flood water and salt marshes.

Are larvicides expensive?

Larvicides are generally the lowest-cost and most effective way to control mosquitoes since they kill mosquitoes before they can fly and bite people.

Are larvicides harmful to human health and/or the environment?

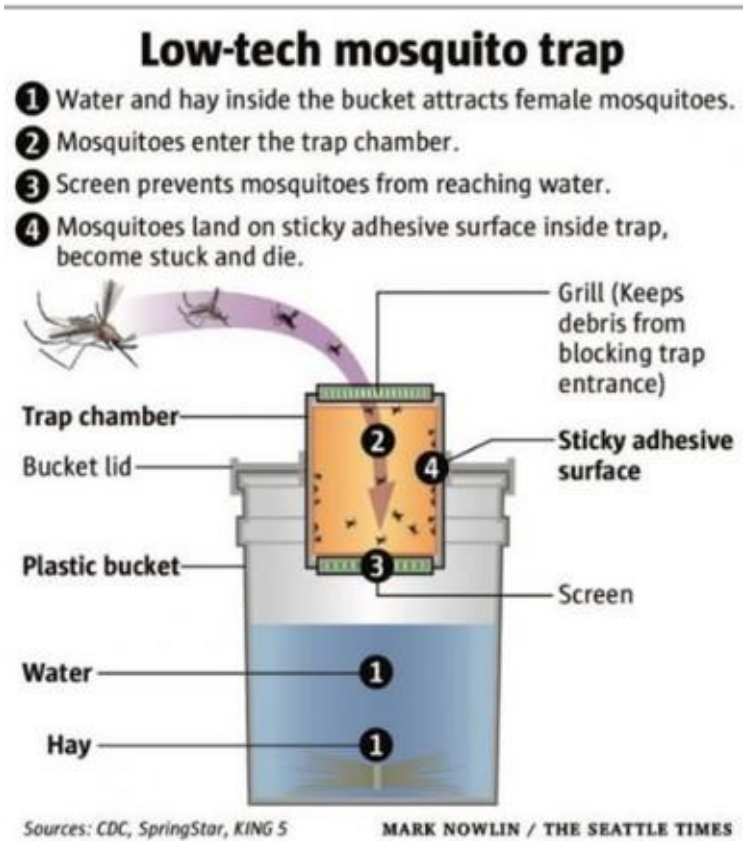
Larvicides have not been shown to be harmful to humans, but anyone using these products should wear appropriate protection to avoid skin and eye irritation.

Some larvicides can be toxic to fish and other aquatic life.

Mosquito Kill Traps

Different kinds of traps attract different types of adult mosquitoes. Once they enter the trap, mosquitoes can't escape and they die.

One type of trap attracts female mosquitoes into a water-filled bucket, where the mosquitoes want to lay eggs, but they get stuck to a glue before they reach the water.



Have these traps been tested?

Yes, they have been tested for safety and effectiveness and are still being researched. Although the traps kill only a few mosquitoes per week, it has been shown that placing 3 traps in most of the homes in a community can greatly reduce the mosquito population.

Have traps been used in Texas?

Yes.

Which mosquitoes does this method target?

These traps mainly target the container-breeding mosquitoes (*Aedes*) that can carry West Nile virus, dengue, Zika, and chikungunya.

Are traps expensive?

The price ranges from $15 to $40 per unit. Traps require maintenance every month or two.

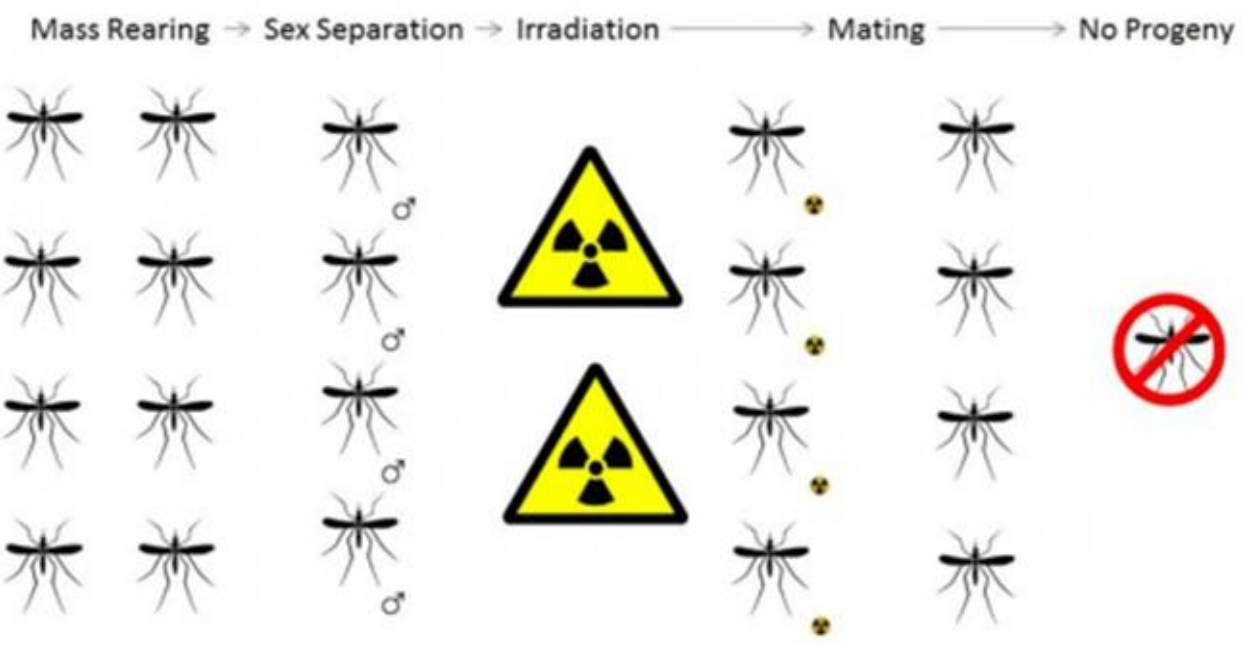
Are traps harmful to human health and/or the environment?

No.

Mass Release of Modified Mosquitoes

Some techniques involve releasing many mosquitoes that have been modified in a lab to reduce the population of mosquitoes and/or prevent the spread of disease. Generally, these mosquitoes are non-biting males.

One method involves releasing sterile male mosquitoes. When they mate with wild mosquitoes, they cannot reproduce, which shrinks the mosquito population over time.



Have sterile male mosquitoes been tested?

Yes, and research is still being done on this method.

Have sterile male mosquitoes been released in Texas?

No, but releases are planned along the Texas-Mexico border soon.

Which mosquitoes does this method target?

This method has been tested targeting *Aedes* mosquitoes that can carry West Nile virus, dengue, Zika, and chikungunya.

Is it expensive to release sterile male mosquitoes?

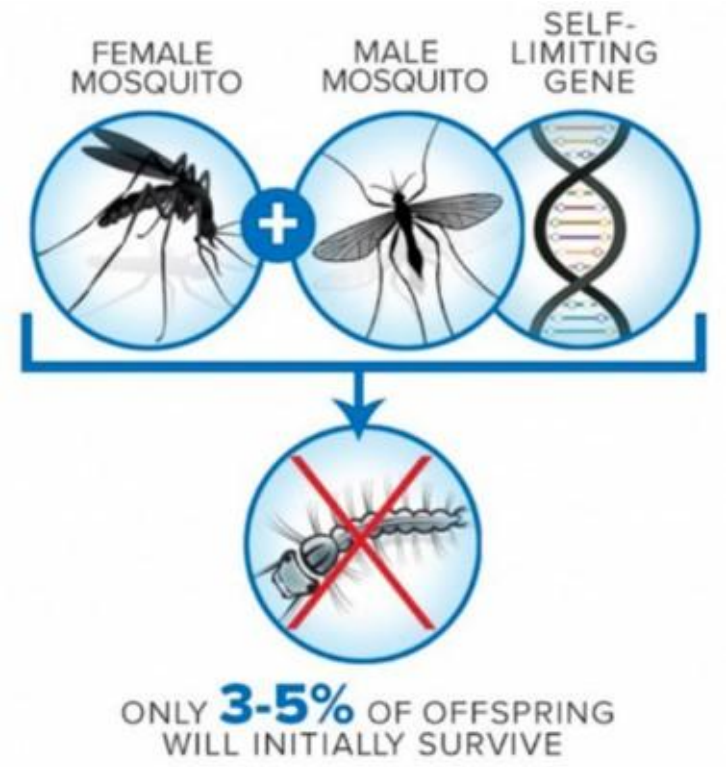
This approach is still being tested and the cost of an area-wide control program using this method has not been established yet.

Are sterile male mosquitoes harmful to human health and/or the environment?

So far, the results of testing suggest they are not harmful.

Mass Release of Genetically Modified (GM) Mosquitoes

Genetically modified mosquitoes can also be mass released. Once the genetically modified mosquitoes mate with wild ones, very few of the offspring survive. The company Oxitec uses this method.



Have GM mosquitoes been tested?

Yes, Oxitec tested this in Brazil and reported that the method worked to reduce *Aedes* mosquitoes.

Have GM mosquitoes been released in Texas?

No.

Which mosquitoes does this method target?

This method has been tested targeting *Aedes* mosquitoes that can carry West Nile virus, dengue, Zika, and chikungunya.

Is it expensive to release GM mosquitoes?

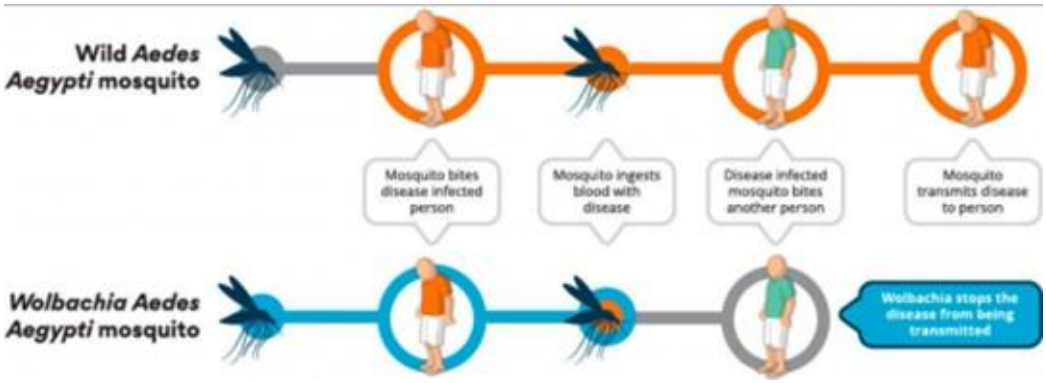
This approach is still being tested and the cost of an area-wide control program using this method has not been established yet.

Are GM mosquitoes harmful to human health and/or the environment?

The FDA has not found GM mosquitoes to be dangerous and has approved a trial. In some locations local citizens have voted to prevent the use of this technology.

Release of Mosquitoes Carrying Wolbachia

This approach involves releasing male mosquitoes containing a bacteria called Wolbachia. When these mosquitoes mate with wild mosquitoes, the bacteria spreads through the mosquito population. Wolbachia is not harmful to humans. Mosquitoes carrying this bacteria can't transmit diseases.



Have mosquitoes carrying Wolbachia been tested?

Yes.

Have mosquitoes carrying Wolbachia been released in Texas?

A trial is being conducted in Harris County, TX during the summer of 2019.

Which mosquitoes does this method target?

This method has been tested targeting *Aedes* mosquitoes that can carry West Nile virus, dengue, Zika, and chikungunya.

Is it expensive to release mosquitoes carrying Wolbachia?

This approach is still being tested and the cost of an area-wide control program using this method has not been established yet.

Are mosquitoes carrying Wolbachia harmful to human health and/or the environment?

The United States Environmental Protection Agency finds this method safe and has approved it.

Rating Mosquito Control Options

Think about the types of mosquito control described previously. Suppose that voters in this area approved a county-wide mosquito control program expansion. Would you SUPPORT or OPPOSE the use of each of the following control methods as part of this control program?

	Strongly Oppose	Oppose	Neutral / No Opinion	Support	Strongly Support
Adulticide (spraying insecticides to kill adult mosquitoes)	○	○	○	○	○
Larvicide (treating water sources to kill immature mosquitoes)	○	○	○	○	○
Mosquito traps (using traps in and around homes to kill adult mosquitoes)	○	○	○	○	○
Mass release of STERILE mosquitoes (cannot reproduce when they mate with wild mosquitoes)	○	○	○	○	○

	Strongly Oppose	Oppose	Neutral / No Opinion	Support	Strongly Support
Mass release of GENETICALLY MODIFIED mosquitoes (most offspring don't survive when they mate with wild mosquitoes)	○	○	○	○	○
Mass release of WOLBACHIA mosquitoes (prevents spread of disease when they mate with wild mosquitoes)	○	○	○	○	○

Why do you support/oppose the options you chose?

Conclusion of Survey

Is there anything else you'd like to add about mosquitoes, mosquito control, or your thoughts about this survey?

Where do you think would be the most useful place to provide resources about mosquito control and disease prevention in your community?

HOA Presentations

School Visits

Health Fairs

Town Hall Meetings

Church/Place of Worship

Websites

Social Media

Other

We appreciate the time and effort you put into this survey to help us better understand community members' knowledge and opinions on mosquitoes and mosquito control in your

area. We hope to use this information to develop better mosquito control programs.

To learn more about these issues and how to prevent the spread of mosquito-borne disease, you can check out the following websites:

Centers for Disease Control:

https://www.cdc.gov/features/stopmosquitoes/index.html

https://www.cdc.gov/niosh/topics/outdoor/mosquito-borne/default.html

Hidalgo County:

http://www.hchd.org/160/Vector-Control

To learn more about these issues and how to prevent the spread of mosquito-borne disease, you can check out the following websites:

Centers for Disease Control:

https://www.cdc.gov/features/stopmosquitoes/index.html

https://www.cdc.gov/niosh/topics/outdoor/mosquito-borne/default.html

Tarrant County:

http://access.tarrantcounty.com/en/public-health/disease-control---prevention.html

To learn more about these issues and how to prevent the spread of mosquito-borne disease, you can check out the following websites:

Centers for Disease Control:

https://www.cdc.gov/features/stopmosquitoes/index.html

https://www.cdc.gov/niosh/topics/outdoor/mosquito-borne/default.html

Harris County:

http://publichealth.harriscountytx.gov/About/Organization-Offices/Mosquito-and-Vector-Control