RESEARCH ARTICLE

UC 4-H youth spread the facts — not the disease — during COVID-19

Teen "disease detectives" learned about epidemiology, including how to reduce the spread of COVID-19 and educate their communities.

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The best part of the project was learning about how to protect myself and keep my family safe in these troubled times. (4-H youth)

I learned why masks work, I learned how hand sanitizer works, and I learned how I can help my community. (4-H youth)

The University of California 4-H Healthy Living Leadership Team ("the team") is a statewide group of county and state Coopehimrative Extension academics who focus on improving the social, emotional and physical health of participants. Early in the onset of COVID-19, the team (composed of the first three authors of this manuscript) responded to the limited pandemic information geared toward teens by quickly creating and implementing the 4-H Disease Detectives (DD) project. A 4-H "project" is a subject-specific learning experience that is at least six hours long. This project also helped meet the needs of 4-H youth during the pandemic while schools in California were closed and using an online learning format.

Abstract

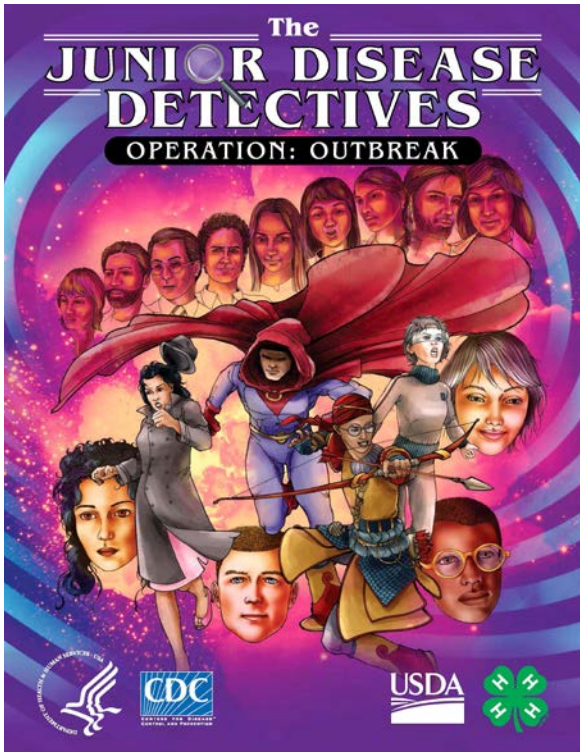
The onset of the COVID-19 pandemic highlighted the need for education in disease transmission and prevention. In response, the University of California 4-H Youth Development Program implemented a virtual epidemiology project, based on resources developed by the Centers for Disease Control and Prevention (CDC) and collaborating agencies. The teenage participants were actively engaged in group lessons focused on epidemiology, immunology, vaccination, zoology, prevention strategies, related careers, and health communication. Surveys administered before and after the program showed an increase in knowledge about vaccinations and disease transmission and improved attitudes toward, and intentions to adopt, practices that reduce the spread of disease. They also showed increased self-efficacy and positive health behaviors (hand washing and mask use, and the intention to share what they learned in their communities). These findings contribute to the development of public health and epidemiological education programs for adolescents and programming that elevates youth as messengers of health information.

A youth at a COVID-19 vaccination clinic. In the early stages of the COVID pandemic in 2020, the authors administered a 4-H project online to help educate youth about epidemiology and pandemic response protocols. *Photo*: Godji10, iStock.

Misinformation, disinformation and myths about the pandemic's causes, consequences and treatments were circulating on social media platforms and news sources (Srivastava et al. 2020). Education on preventive measures that can decrease community transmission gives people greater confidence in their ability to protect themselves and reduces anxiety (Evans and Bufka 2020). The 4-H DD project aimed to educate youth on the science of epidemiology, the roles and careers of decision-makers, and standardized worldwide pandemic response protocols. This helped reduce their fears and provided knowledge they could use to protect themselves and their communities. These teens created and shared messages of disease prevention and health information. This allowed them to act as on-the-ground providers of research-based information, in keeping with the Cooperative Extension model. As well as empowering 4-H youth, this project harnessed the power of younger citizens during a time of crisis.

Junior disease detectives

The CDC partnered with National 4-H to develop the *Junior Disease Detectives: Operation Outbreak* graphic novel (CDC 2018). Teachers participating in the CDC's Science Ambassador Fellowship developed educational activities to accompany the graphic novel (CDC 2019). Although the material was developed for in-school delivery, the team adapted and expanded it for experiential learning in a virtual setting. The team contacted CDC and education activity authors to gain support for the work and to learn whether others were adapting the material; none of them were aware of others adapting the material for virtual delivery.



The UC 4-H Healthy Living Leadership Team adapted the Junior Disease Detectives graphic novel for experiential learning in a virtual environment. *Photo*: CDC.

The team adapted the science-based educational activities for experiential hands-on learning in a virtual environment, developed nine sequential one-hour lessons, constructed an evaluation instrument, conducted statewide 4-H outreach, and developed a 4-H DD project website. There were several experiential, hands-on activities, including (a) tissue blowing (with and without a mask) from varying distances to illustrate physical distancing in disease prevention, (b) youth pretending to unknowingly spread diseases in a virtual format to discover disease transmissibility, and (c) youth learning about and developing public service announcements (PSAs) in the form of disease prevention educational materials targeting 4-H youth. These have been used in California's statewide 4-H messaging and at the local level of each youth's 4-H club.

The free, open-access DD website was a flexible way to organize materials and provide participants with downloadable documents such as discussion questions, lesson objectives, and health education materials. Educator lesson plans, slides and additional resources were included on a separate password-protected page, which allowed for controlled access to potential 4-H project leaders nationally.

By mid-June 2020, the team held 4-H DD orientation meetings to provide youth with the technology skills to engage fully in meetings. Not all youth had internet access, so they used their smart devices (phones and/or tablets) as needed to ensure inclusive programming. The team added additional platforms for specific use: Google Maps to illustrate disease spread and the John Hopkins COVID-19 database to explain the severity of the pandemic.

The DD project focused on behavior change at the individual, family and community levels. The evaluation included an assessment of content knowledge (terminology, vaccines, media literacy and preventative procedures), attitudes (career aspirations, advocacy beliefs), self-efficacy (belief in ability to influence disease transmission), intentions (advocacy) and behaviors (hand washing, mask wearing, disinfecting/cleaning and physical distancing). Additionally, the team hoped that participating teens would serve as advocates for health in their communities.

Learning by doing

Positive youth development (PYD) theory addresses the development of characteristics in youth that lead to positive outcomes and behaviors (Lerner et al. 2011). This theory framed the pedagogical approach and delivery of the DD project. This experiential and inquiry-based learning approach supported the youths' direct involvement in their learning process; each lesson provided them with an opportunity to actively engage and experience content, reflect on that content with their peers and mentors, and apply new knowledge and skills to real-life situations (Kolb 1984).

The integrative model of behavior change (IMBC) (Fishbein and Yzer 2003) framed the project's impacts and outcomes. The IMBC states that people act on their intentions when they have the skills and means to do so. According to this model, behaviors are more likely to occur when an individual has a strong intention to perform the behavior, has the skills and abilities to perform the behavior, and faces no environmental

limitations preventing the behavior (Fishbein and Yzer 2003). For this project, the authors focused the content on impacting youth behaviors by targeting improvements in their knowledge, skills and intentions — specifically, on their attitudes and self-efficacy (table 1).

The 4-H DD project combined the best practices of virtual delivery with those of PYD theories (Arnold 2018; Lerner et al. 2011), experiential learning (Kolb 1984), and the integrative model of behavior change (Fishbein and Yzer 2003) to address relevant public health concepts.

Evaluation methods

Pre- and post-project surveys were developed and implemented to measure several outcomes. One set of measures involved participants' knowledge of content, including terminology, role definitions, vectors (living organisms that carry and transmit an infectious pathogen to another living organism), fomites (inanimate objects, such as doorknobs, that can spread diseases), vaccine facts, and preventative procedures. Attitudes and behaviors also were surveyed. Attitudes included career aspirations and advocacy beliefs, as well as self-efficacy (for instance, media literacy and an understanding of the role of individuals in disease transmission). Behaviors included hand washing, mask wearing, disinfecting/cleaning and physical distancing.

There were 17 survey questions before the project and 25 afterward. The questions included matching, true/false, multiple choice, a Likert scale, and open response. Questions about "intent to change" assessed the extent to which youth believed they could impact the spread of disease through individual behavior, by identifying reputable sources of information, serving as advocates, and engaging in other local involvement. A set of retrospective behavior questions were added to the post-project survey for the participants to reflect back and report their current practices compared to practices prior to their participation (table 2). The authors developed the survey questions using available and continuously updated disease prevention guidelines from the CDC, expert opinions, and a review of the CDC Science Ambassador Epidemiology–related lesson plan objectives (CDC 2018; CDC 2019). Pilot testing and follow-up of the survey were not feasible due to the immediate need to address pandemic misinformation, youth

Education on preventive measures that can decrease community transmission gives people greater confidence in their ability to protect themselves and reduces anxiety.

TABLE 1. Disease Detectives intervention approach and theoretical framework

Objectives	Educational methods	Evaluation questions
Knowledge		
• Improved understanding of infectious diseases, disease transmission, and pandemics • Understanding the purpose of vaccines	• Problem solving human/animal disease infection and transmission case studies • Modeling and tracking disease spread and intervention effectiveness • Learning how vaccines work • Analyzing county-level disease transmission and vaccination data	• Each disease has its own specific vaccine, true or false? • Which of these help slow the spread of disease: (1) Wearing a face mask, (2) Keeping your bedroom organized, (3) Using a toilet seat cover, (4) Sneezing into a tissue instead of sneezing uncovered into the air, (5) Keeping sick animals separate from others, (6) Cleaning grooming items between use, (7) Eating an apple a day, (8) Sunshine, (9) Staying away from other people or animals when sick, (10) Using sunscreen, (11) Using hand sanitizer, (12) Using medications as prescribed, (13) Washing your hands, (14) Doing your homework on time, (15) Circulating fresh air in closed spaces as much as possible
Skills		
• Ability to abstractly measure six feet of distance • Recognizing and interpreting reputable sources of health information	• Simulation of effectiveness of mask wearing and distancing • Policy analysis of pros and cons of public health measures	• Current recommendations are for people to remain six feet apart in public. How do you determine what would be about six feet long? (open-ended question)
Intentions		
• Willingness to practice public health safety measures • Confidence and motivation to share information • Improved belief in one's ability to impact disease transmission	• Creation of an educational/social marketing material	• Can you envision yourself getting involved in your local community to help slow the spread of disease? (6 point Likert-scale*) • Would you choose to quarantine yourself if you started to get sick with a fever, cough, runny nose, extreme tiredness, were not hungry, or felt really bad? (6-point Likert scale*)
Behavioral change		
• Ability to abstractly measure six feet of distance • Recognizing and interpreting reputable sources of health information	• Simulation of effectiveness of mask wearing and distancing • Policy analysis of pros and cons of public health measures	• Current recommendations are for people to remain six feet apart in public. How do you determine what would be about six feet long? (open-ended question)

* The 6-point Likert scale ranged from "I definitely cannot" (1) to "I definitely can" (6). The percentage was calculated by combining the percentages for the top 3 positive options: "I maybe can, I probably can, I definitely can."

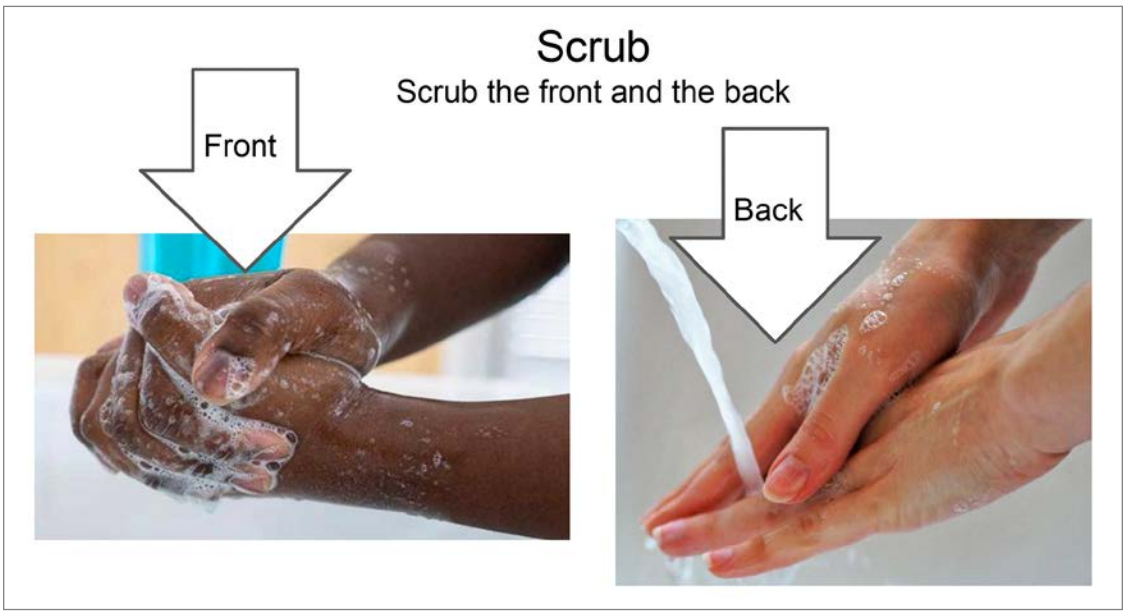


FIG. 1. As part of the 4-H Disease Detectives project, UC 4-H youth participants created a step-by-step guide on how to properly wash hands.

concerns, and acute community needs. As Cooperative Extension, our primary focus was to educate the community on the latest emerging scientific information, which limited the development of a validated survey instrument. The UC Davis Institutional Review Board approved the evaluation of the project.

We administered the pre/post surveys through an email with a Qualtrics link. The pre- survey was completed at the beginning of the project in June 2020 and the post- survey at the end of the project in July 2020. The response rate was 94% (n = 45) for the pre- survey and 69% (n = 33) for the post- survey. All non-responses and missing data in the pre- and post- survey data were eliminated before data analysis. The authors used SPSS version 23 software for data analysis and performed descriptive statistical analysis to calculate the pre/post change in responses, including inferential statistics with a paired sample t-test on the repeated pre- and post- survey questions for a sample size of 28 participants (58%).

Creating experiential learning opportunities allowed youth to be directly involved and engaged in their learning.

The post-project survey included four open-response questions to solicit youth meanings and experiences. The questions were related to what youth learned from and enjoyed about the project, identified as the best part of the project, and thought were areas for improvement. The authors applied a thematic analysis to these data (Braun and Clarke 2006). Three of the four authors coded the youth responses independently and then met to discuss the development and application of the codes. The team analyzed code applications through a systematic process to ensure that diverse perspectives were shared until consensus was reached; this is a form of accountability to reach inter-coder agreement (Cornish et al. 2013). A final list of seven parent codes included careers in epidemiology, learning new knowledge, project activities, social activities, teamwork activities, health resources, and prevention of disease transmission. The qualitative analyses presented in this article are from all but one of the codes, omitting health resources.

What did youth learn?

A recruitment email was sent to all 4-H participants (approximately 19,000). As is standard practice in 4-H, 81 youth self-selected to participate. Of these, 74 were sent an introductory email with project information; there were seven who were not age eligible (12–19 years of age). Demographic data is collected through annual 4-H enrollment and was not analyzed for this study. Forty-eight 4-H youth ages 12 to 18 from 15 counties across California enrolled and completed the virtual 4-H DD project. The team divided participants into three groups, which allowed for close social networking, focused conversations with the youth, better classroom management, and increased emotional bonding with adults. The project included nine one-hour lessons, all delivered by the team twice a week with each group of youth over a five-week period. For all Likert-scale questions, the results are presented as the sum of the percentages of the top three choices in the six-point scale. For example, the results were combined for "I maybe would," "I probably would" and "I definitely would" for the question, "Would you choose to quarantine yourself if you started to get sick?"

Best part of the process

Providing experiential learning opportunities allowed youth to be directly involved and engaged in their learning. The qualitative results indicate that youth learned new concepts, that "fun" played a role in their process of learning, and that team-building and engaging activities reinforced their learning. Youth responded to the questions "What was fun and engaging?" and "What was the best part of the project?" with comments about the interactive, experiential activities:

> *I really liked the disease transmission activity, where we 'interacted' with others and spread viruses. (Disease Transmission activity)*

> *The most fun and engaging project was when we tried to blow the tissue. (Mask Effectiveness activity)*

Youth teams developed social marketing materials using several educational formats: posters, memes or flyers (figs. 1–5). Some answers to the question "What was the best part of the project?" demonstrated that the activities related to educational material development created an avenue for current and future advocacy work. The material developed by the youth was shared with the California 4-H state office, social media sites, and 4-H advisors, to utilize in COVID-related informational material. Participants were encouraged to share the material at their virtual 4-H club and project meetings and on their 4-H social media sites.

> *The best part was getting to learn more about the current situation in order to potentially educate others.*

> *I loved everything, but probably making the flyer in our group.*

> *Collaborating with others on making the poster.*

Health science knowledge

Participants showed increased knowledge of epidemiology terms, such as health communication specialists, epidemiologist, zoonotic and vaccine. They also showed that they had learned about epidemiology concepts, such as practices that slow the spread of diseases, including hand washing, circulating fresh air, and keeping sick animals separate from others. When asked to match five epidemiology terms to their correct description, the average number of correctly matched terms increased from 4.25 (sd = 1.14) on the pre- survey to 4.39 (sd = 1.1) on the post- survey. For another set of matching questions related to practices that stop the spread of diseases, the change was not statistically significant at the 0.05 alpha level (mean difference = 0.43, t = 1.84, 90% confidence interval, $P = 0.076$).

Qualitative results, in the form of the participants' self-reported learning, showed an increased understanding of epidemiology concepts. Some of their responses to the question "What did you learn as a result of the project?" included:

> *What a pandemic is.*

> *What a disease consists of and why vaccines take so long to find.*

> *Animals can spread viruses to us.*

> *I learned about ways to prevent disease spread.*

> *More ways to prevent myself from catching anything.*

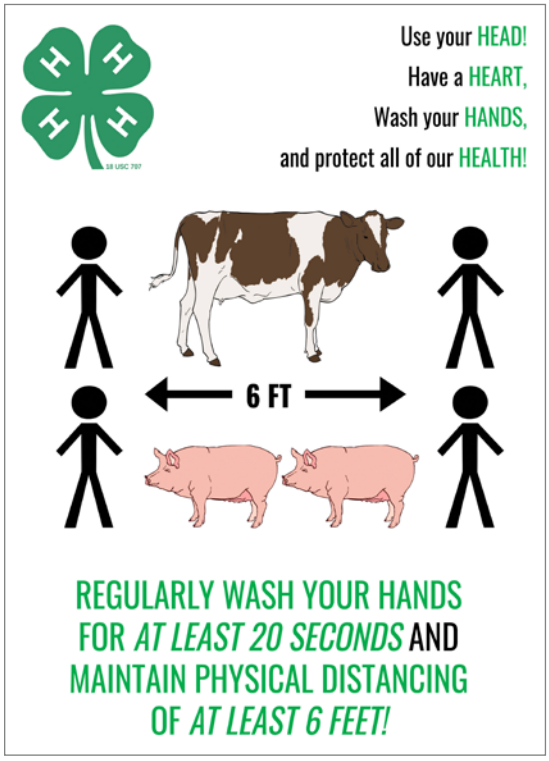


FIG. 2. An educational poster developed by UC 4-H youth as part of the Disease Detectives virtual epidemiology project.

FIG. 3. UC 4-H youth created this educational meme to encourage mask wearing.

Health advocacy

Youth reported a desire and perceived ability to advocate for health in their communities — for instance, by supporting actions to reduce the spread of disease. Toward this goal, the educational materials that the youth teams created were shared within the California 4-H community. Participants' responses to the question "What did you learn as a result of the project" and "What part of this project was fun and engaging?" included:

The most fun and engaging part was when we made posters as a pandemic PSA.

I really liked making a poster/Powerpoint on a [sic] handwashing for 4-H meetings.

Making the social distancing memes.

Skills that will last

Physical distancing is a crucial component in reducing the spread of airborne infectious diseases. As part of the lessons, the authors taught youth how to gauge six feet of distance, the recommended indoor spacing. When responding to the question "Current recommendations are for people to remain six feet apart in public. How do you determine what would be about six feet long?" youth indicated an ability to abstractly measure this distance. For example:

If both people have their arms in a T position they should not be able to touch each other.

About 7 loaves of bread, a twin bed, or a tall person lying down in front of you.

The length of a cow.

An example of a youth-developed educational poster is shown in figure 4.

Belief in their power

Youth reported an increased ability and desire to become leaders in the health of their communities. Results indicated that youth believed they could help control the spread of disease (97%), envisioned themselves getting involved in their local community to help slow the spread of disease (91%), saw themselves becoming advocates for health in their community (82%), and intended to discuss disease transmission with others (97%). Most youth stated they would quarantine themselves (97%) or their animals (94%) if disease symptoms were present. These behaviors could only be measured as possible responses to events that might happen in the future, as it was not an experience they had faced at the time.

Qualitative results indicated youth were eager and willing to become advocates for health in their communities. Here are samples of their written responses to the prompt "List three things you learned as a result of this project":

We can all do something to help slow the pandemic.

I learned how I can help my community.

. . . being able to create easy habits that will keep my family safe.

I learned why masks work, I learned how hand sanitizer works, and I learned how I can help my community.

How to keep myself and others safe and healthy.

How best to educate people on how to prevent the spread.

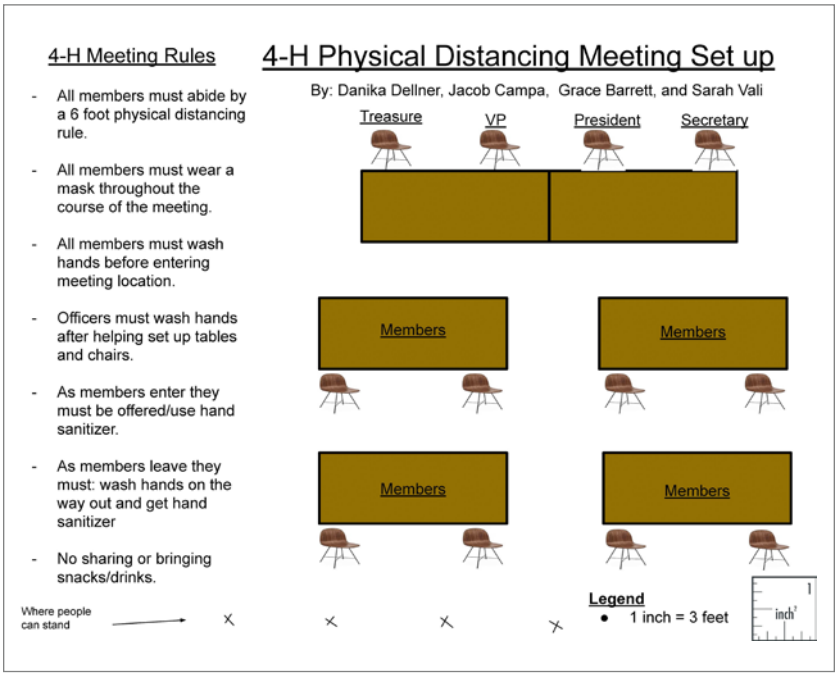


FIG. 4. An educational poster developed by UC 4-H youth with guidelines for social distancing and handwashing at 4-H meetings.

FIG. 5. UC 4-H participants in the Disease Detectives project created this meme to remind people not to touch their face.

Disease-prevention behaviors

After completing the project, all participants reported they were more likely to wash their hands or use hand sanitizer after working with animals and after using a public or school bathroom. Most youth indicated they were more likely to wash their hands before food preparation (97%) and eating at home (94%), after sneezing or coughing (94%), after using the bathroom (97%), and after shopping in a public space (97%) (table 2). All youth reported they were more likely to wear a face mask when out in public, and 96% indicated they were more likely to wear a face mask when visiting friends. Additionally, most youth indicated that they were more likely to clean and disinfect tools used to administer medication to animals (96%), as well as their cell phone (94%) and computer devices (94%).

Expanding the project to others

As a result of the success of the DD project, the team offered three trainings, one in California and two nationally, on the use and implementation of the material. The California training was for older 4-H youth and 4-H staff and volunteers interested in implementing the project, including access to the DD website and all supporting material. The training audiences included state 4-H volunteers and teen leaders, national audiences associated with the 4-H program, and the readers of the UC Healthy Communities Blog (Iaccopucci et al. 2020).

Youth spread the facts

Through the 4-H experiential learning model, educating youth helps to spread research-based information to their communities and families. The 4-H program is a trusted organization in many communities throughout the world, making it a crucial partner in education globally. Improving participants' understanding of the prevention and transmission of infectious diseases, motivation and abilities to act as advocates, and personal health behaviors was the focus of this project. Using positive youth development theories and the

TABLE 2. Youth post-project survey results from behavior change questions

How has your current hand washing (or use of hand sanitizer) behavior changed, compared to before this 4-H Disease Detectives project?		
I wash them . . .	***n***	**More often* (%)**
after working with animals	32	100
after using a public or school bathroom	29	100
after shopping in a public space, such as a grocery or retail store	32	97
after using the bathroom at home	31	97
after sneezing or coughing	32	94
before preparing food	32	97
at home before eating	31	94
after handling a delivered package or piece of mail	30	90
after coming home from school	24	88
after using a shared item, such as a computer, phone, pen, ATM keypad, etc.?	31	87
How has your current use of face masks (or coverings) changed, compared to before this 4-H Disease Detectives project?		
I use them . . .	***n***	**More often* (%)**
When out in public	30	100
While visiting with friends	27	96
While being physically active	28	93
While at work	20	90
While playing outside	30	87
When sick at home	24	83
How has your current cleaning and disinfecting practices changed, compared to before this 4-H Disease Detective project?		
I clean them . . .	***n***	**More often* (%)**
Tools used to administer medication to animals	26	96
Computer keyboard and mouse	32	94
Cell phone	31	94
TV remote	31	90

* "More often percentage" is a combination of percentages reported for "Much more often," "More often" and "Somewhat more often."

integrative model of behavior change, this project engaged youth in experiential and inquiry-based learning (Fishbein and Yzer 2003; Kolb 1984). Supporting youth to contribute to pandemic reduction in active and meaningful ways provided the opportunity for them to serve their families and communities — a service that strengthens society. The DD project demonstrates the potential to educate youth, and thus their families and communities, on infectious disease transmission and prevention.

The project participants had the opportunity to reflect on their own learning about disease prevention and transmission and to continue to address COVID-19 concerns as health advocates. Youth perspectives helped inform and influence California 4-H program policy through the participants' increased understanding of epidemiology concepts and the PSAs they developed. Contribution is an important aspect of positive youth development (Lerner et al. 2011) and helps build an adolescent's sense of competence, compassion, connection to others, confidence, and character. Through youth education, youth behavior change, and youth voices in health messaging and advocacy, this project has the potential to impact the health of Californians for years to come.

A worthwhile investment

Educating youth creates a foundation for knowledge throughout life. Teaching about disease transmission can slow the spread of disease. This project shows that youth acquire knowledge and change behaviors in disease transmission after an experiential and inquiry-based educational intervention focused on epidemiology. Materials are currently available to educate youth on these practices. Community health educators could invest in behavioral, theory-driven, and educational materials for youth when addressing broad public health issues. In addition, schools could allocate instructional time to epidemiology and public health, especially during epidemics with severe public health implications.

The limitations to our design include collecting post-project survey data from participants immediately after the intervention, thereby limiting data on future behavioral practices and the potential of an already high level of knowledge of disease transmission three months into the pandemic. This may have contributed to the lack of statistical significance in pre/post survey content knowledge questions. We believe that the survey ceiling effect, in which answers cluster at the high end of the scale (Cramer and Howitt 2004), could be one reason for the lack of statistical significance in some of our measures of knowledge change. Additionally, the surveys were administered to youth who self-selected to participate in the project, and the total sample size was relatively small, both of which limit the transferability of results.

Our findings contribute to content development of public health programs for youth, understanding virtual learning environments in delivering public health education to youth, increased virtual health education during a pandemic, and the appropriateness and applicability of teaching epidemiology to youth. CA

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We would like to acknowledge the passing of our dear colleague, Dorina, during the final reviews of this article. Her dedication to improving the health of young people is a testament, legacy and inspiration to us all.

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