

Dengue prevention community engagement

1 Community engagement through “student-led science” for dengue
2 prevention during the COVID-19 pandemic in Córdoba, Argentina.

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27 Abstract

28 Background

29 During 2019-2020 while COVID-19 pandemic, the Americas were facing the biggest
30 dengue fever epidemic in recent history. Traditional vector control programs, based on
31 insecticide application have been insufficient to control the spread of dengue fever.
32 Several studies suggest refocusing on education with the aim of an integrated vector
33 management strategy within the local ecological-community context. We aim to assess
34 community perceptions, knowledge, attitude, preventive practice, and action through
35 student-led science assignments regarding dengue fever, prevention, and socio-
36 ecological factors in temperate Córdoba, Argentina.

37 Methods

38 The study was conducted during the COVID-19 quarantine when schools switched to
39 online education for the first time. Several activities through Google Classroom
40 platform included a survey to one student's family member, and an outdoor activity to
41 assess their attitudes and to clean the backyard and gardens.

42 Results

43 Significant number of respondents developed good preventive practices and increased
44 their knowledge about the vector and disease highlighting that 75% of responders knew
45 that dengue fever was transmitted by a mosquito, 81.96% declared having obtained
46 knowledge regarding dengue and vector through television, 56% affirm that dengue is
47 a severe illness, 67% of respondents admitted that individuals play an important role in
48 the prevention of dengue. Regarding mosquito control activities, 90% of respondents
49 reported turning containers.

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50 Conclusions

51 This highlights the need for school programs with curricula to address vector biology
52 and the prevention of vector-borne diseases not only during activity periods when
53 mosquitoes bother people but all year long to do real prevention.

54 **Key Words:** dengue prevention, vector-borne disease, community perception,
55 quarantine, Argentina.

56

57 Introduction

58 Since 2020 the COVID-19 pandemic has affected countries around the world. Argentina
59 has been in mandatory quarantine since March 20, 2020, being extended several times in
60 the year [1] with online school and the emergence of online education and opportunities
61 and challenges faced. At the same time, the Americas were also facing the biggest
62 dengue fever (DEN) epidemic in history [2]. Dengue fever is caused by dengue virus
63 (DENV), transmitted by *Aedes aegypti* mosquito to humans, with a wide geographic
64 spread of the virus and its vector in tropical, subtropical, and even temperate areas [3, 4].
65 During the season 2019-2020 Argentina has reported 58,889 DEN cases, with 3
66 circulating serotypes in the country (1, 2, 4) and 26 deaths. This season exceeded by
67 almost 40.5% accumulated cases in the 2015-2016 season, being the largest dengue
68 outbreak that has been recorded in the history of the country so far [5]. It should be
69 noted that the temperate central region of Argentina has been one of the most affected,
70 with almost 40% of the cases reported. In Córdoba province, located in the temperate
71 central area, 3,631 DEN cases were reported with two circulating serotypes (1 and 4) [3,
72 5]. Unlike the 2019-2020 season, during the last season, 2020-2021 were reported 4,653
73 DEN cases (serotypes 1, 2, 4) in all the country [6]. Several challenges must be sorted
74 by the local health system, such as the focal control, because of the preventive isolation,

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75 as well as the difficulty of the clinic diagnostic by the physicians due to similar febrile
76 symptoms (Federico Layun, from Cordoba municipality epidemiological system,
77 personal communication).

78 Rapid human development, changes in demographics, population, rural-urban
79 migration, inadequate basic urban infrastructure, an increase of solid waste, such as
80 discarded plastic containers and other abandoned items such as cars wheels, plastic
81 bags, unused objects that can provide larval mosquito habitats, and become a risk factor
82 when DENV is circulating. These risk factors combined with appropriate environmental
83 conditions enhance the likelihood of viral transmission [7, 8].

84 Traditional vector programs, based on chemical intervention, are not enough [9],
85 therefore several studies suggest focusing on education with aim of an integrated
86 management strategy (IMS) within the ecological-community context. In temperate
87 areas like Cordoba, education is focused just during the high vector activity and not all
88 year long as could be observed in some tropical countries. The IMS seeks to modify the
89 behavior of individuals and the community in such a way as to reduce risk factors for
90 transmission with coordinated measures both within and outside the health sector [10].

91 Indeed, there is evidence that education can lead to behavior changes related to DEN,
92 revealing that knowledge scores were significantly increased after health education
93 programs, barring a language communication gap [11, 12]. Prior studies have involved
94 student's community and their families, focusing on dengue prevention, health
95 promotion, and action, as in Honduras, where educational interventions were applied as
96 part of a comprehensive plan for the control of *Ae. aegypti*, allowing the teachers and
97 families in the program, inducing their participation in reducing sources at home [13].
98 In Mexico through the implementation of an educational strategy, knowledge, attitudes,
99 and practices about self-care in their schools engaged students as dengue promoters'

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100 changers in their homes [14]. The effectiveness of educational interventions was also
101 evaluated in Colombia, where a high percentage of the participants change behavior
102 related to vector breeding places, washing, and covering water storage tanks, containers,
103 as well as collecting unusable potential breeding places in their homes [15]. In
104 Argentina, research in Buenos Aires conducted surveys, interviews, home search for
105 immature mosquitoes, placement of ovitraps (manufactured by students), workshop
106 series, and illustrative classes with teachers and students involving their families and
107 neighbors [16].

108 Community engagement, through “student-led science”, is a novelty in the area, and
109 could fill the gap on getting to the households, leading to a change in attitudes in the
110 home due to students becoming good household health educators. This study aims to
111 assess household perceptions, knowledge, attitude, preventive practice, and action
112 through student assignments regarding dengue fever, prevention, and socio-ecological
113 factors during the concurrent dengue and COVID-19 pandemic in the city of Cordoba,
114 Argentina, a temperate region where dengue has emerged over the last decade.

115

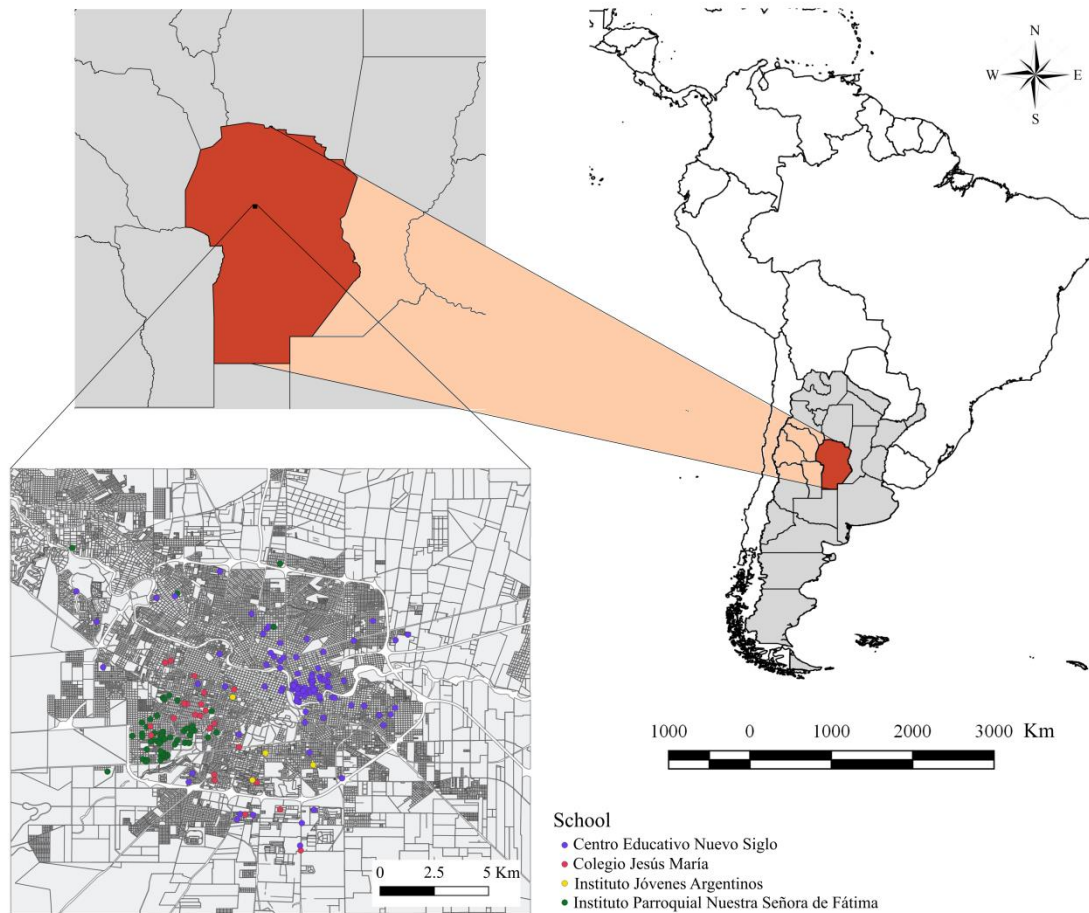
116 Methodology

117 Study area

118 The city of Córdoba is in the central area of Argentina with the Suquía River crossing it
119 from northwest to east (Fig.1). It has an area of 576 km² with a population of 1.3
120 million people, being the second-largest city in the country, following Buenos Aires.
121 Córdoba is in a temperate region that experiences dry winters, annual rainfall of 800
122 mm, and an average annual temperature of 18 °C(maximum of 27 °C and minimum of
123 11 °C) [17].

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126 **Fig. 1.** Study area. Location of the Córdoba city (Argentina) where the surveys were
127 conducted during 2020. The points show the approximate location of the respondents
128 and the colors indicate the school to belong the students who conducted the surveys.

129

130 Dengue fever emerged in Córdoba over the last decade, with the first dengue outbreak
131 occurring in 2009 [18]. The emergence of dengue has raised concern due to the rising
132 public health burden [3, 19]. Vector control is conducted by the National Health
133 Minister and consists mostly of focal control around homes with dengue cases, including
134 indoor and outdoor fumigation, larviciding with *Bacillus thuringiensis israelensis* (BTI),
135 and eliminating standing water [20]. In general terms, there have been public education
136 campaigns to prevent dengue transmission; however, in some cases, campaigns have

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137 resulted in greater confusion by naming the mosquito as the disease and not
138 differentiating between the virus and vector. In 2014 the government of Cordoba issued
139 a strategic plan called “Plan estratégico de abordaje integral para la prevención y el
140 control del dengue y de la chikungunya en Córdoba” (Strategic plan for integral
141 management for the prevention and control of dengue and chikungunya in Córdoba)
142 [21] that included in the need to strengthen education on dengue and chikungunya in the
143 elementary, middle and high schools, as well as universities and teacher career training
144 (in objective 5 section 6.5.2). Today there are no formal education programs that involve
145 the students and the community and aim to cause a behavioral change to reduce disease
146 risk. Some high schools with specialized Natural Science educational orientations do
147 include in the 4th year of high school (students around 15 years old) some information
148 about the transmission and prevention of relevant diseases in the country, like chagas,
149 hemorrhagic fever, dengue, among others. In February 2020 the provincial government
150 through the memorandum 02/2020 [22] informed school principals of the need for
151 activities related to the dengue epidemic ongoing in the province, where they mention
152 the school as the place to do prevention against dengue and advise to use pedagogical
153 materials that were made available by the education minister of the Cordoba province
154 government.

155 Ethics

156 This study was approved by the ethical committee from National University of
157 Córdoba, Hospital Nacional de Clínicas (Clínicas National Hospital), General
158 coordinator Dra. Susana del Carmen Vanoni. This study was an educational intervention
159 implemented in schools and developed with teachers as part of the curriculum with
160 informed consent signed by each of the school’s principals involved in this research;
161 Lic. Natalia Magalí Carbo (Centro Educativo Nuevo Siglo), Lic. María Inés Buffa

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162 (Instituto Jóvenes Argentinos), Prof. Lic. Carlos E. Carranza (Instituto Parroquial
163 Nuestra Señora de Fátima) and Elsa Ferrer (Instituto Jesús María). The study complies
164 with all regulations and confirmation that informed consent was obtained from the
165 participants.

166 Field data collection

167 Because of the mandatory quarantine during the COVID-19 pandemic, the program for
168 developing community engagement by the schools through “student-led science” had
169 three main activities that were labeled as “Dale Block al Dengue” (Spanish) that in
170 English loosely translates to “Let’s Block Dengue,” playing with the social media
171 meaning of blocking a person when you don’t like what they post and translating this
172 to the role of mosquito as dengue vector, knowing that we can block dengue circulation
173 if we eliminate the breeding places for mosquitos to develop. The student science,
174 therefore, consisted of:

175 1-Survey about perceptions and knowledge regarding dengue fever, prevention, and
176 socio-ecological factors; 2-Activity in their backyards to assess attitude; 3-The activity
177 involving the action of cleaning backyard and gardens to remove unused artificial
178 containers that were potential mosquito habitat. The three activities were developed
179 using the Google Classroom platform. These activities were developed in cooperation
180 and coordination between researchers and high school teachers to assess student science
181 engagement. We worked with four private schools in the city (Fig. 1). One of the school
182 principals decided to involve all classes, therefore every student had to be involved and
183 do the activity as part of the school cooperation and engagement. Each of the other three
184 schools involved only one class related to ecology, environment, and social development
185 science for the natural science orientation high schools. This methodology was

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186 developed considering the ongoing dengue outbreak situation in the city and the
187 concomitant mandatory quarantine faced in the country.

188 **The survey**

189 The survey was generated by Google Forms and put inside the Google Classroom
190 platform to be implemented by the students of the four different private high schools
191 involved in the program. According to the protocol established, each student surveyed a
192 family member >18 years of age, living together in the same home, and one person was
193 surveyed per household. The instructions included not to look in a book or the internet
194 for the answers as it is important to know what is really known about the subject by the
195 respondents. Based on prior field experience in the city and years of collaboration with
196 the province of Córdoba Ministry of the Health (MOH) on the dengue program [23], we
197 determined which variables to include in the survey for community engagement
198 (Additional file 1). **Socio-ecological factors** covered the socio-demographic
199 characteristics consisting of age, highest education degree, relationship with the student
200 doing the survey, self-reported prior dengue infections in household members or
201 knowledge of any person with the infection, people living in the household, travel
202 history to neighboring countries or any other with the vector-borne transmission.

203 Questions focused on **Vector-borne diseases knowledge** included whether they were
204 aware of dengue, symptoms, and *Ae. aegypti* vector knowledge. We also asked questions
205 regarding their **perception of dengue risk**, the perception of prevention responsibility,
206 and how they carry out the **household control activities**. We asked questions about the
207 **environment surrounding the household** to have better information about proximity to
208 potential vector breeding places within 500 meters from the surveyed homes. These
209 include garbage dumps, depots, water channels, and the Suquía River [8], also we asked
210 people where they have seen mosquitoes in their homes. A radius of 500 meters was

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211 selected because several studies have shown that females *Ae. aegypti* mosquitoes
212 generally fly 100-500m [24, 25]. Any man-made discarded container in that range, such
213 as abandoned items in urban public areas, could be a potential breeding place for the
214 vector. For each category of the survey, we generated hypotheses to test (Table 1).

215

216 **Table 1 The hypothesis to test the different survey sections developed during the student-**
217 **let-science study**

Survey section	Hypothesis to test
Socio-ecological factor	<ul style="list-style-type: none">- Large percentage of surveyed know of dengue cases in their neighborhoods.- Most trips to risk areas are made in summer vacations.
Vector-borne diseases knowledge	<ul style="list-style-type: none">-In the population, the correct knowledge of the symptoms of dengue disease depends on the educational level reached by each person.- The source of information about <i>Ae. aegypti</i> and the diseases it transmits are electronic means rather than formal educational ones.
Perception of dengue, household vector prevention and control practices	<ul style="list-style-type: none">- Dengue is perceived as a moderate risk disease.- Dengue prevention is a simple task and carrying it out depends on each individual.- The activities related to eliminating containers that are potential breeding sites are the most frequent practices-The use of repellents is not frequent to avoid the presence of mosquitoes.

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Household environmental surrounding	-knowing the conditions of the surrounding environment could help with prevention attitudes. -knowing proximity to abandoned areas or rivers could lead to taking preventive actions.
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218

219 **Attitude Activity**

220 The second activity involved the students' attitude of exploring their backyards, gardens
221 and inside their homes to search for containers that hold water and could be potential
222 mosquitoes breeding places. The students received training through lectures and a
223 mosquitoes workshop showing them eggs, larval, pupa, and adult conversed stages to
224 observe in the class. All this training was done during 2019, with the same schools and
225 teachers involved in a citizen science project with our research group. Although,
226 students were trained and taught again online during quarantine about mosquito *Ae.*
227 *aegypti* life cycle and potential breeding places (Additional file 2). Each one of the
228 students took photographs of their backyards/gardens showing if there were or were not
229 potential mosquito breeding sites. Also, they take photographs of each one of the
230 containers with or without water as well as the mosquito's stages inside of the water
231 containers. We assess their attitude with the activity done and the photographs sent to
232 the teacher class involved.

233 **Getting in the action**

234 The last activity involved having the students remove found containers with water that
235 held any arthropod or could be a potential place for mosquitoes to lay eggs becoming a
236 breeding place around their homes. This activity was done once for the school activity
237 requirement, following the survey done before. The students send photographs of each

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238 found container, as well as the number of containers in their homes, discriminating
239 between containers with water and without water.

240 Analysis

241 We analyzed each section of the survey using descriptive statistics to show the
242 percentage of responses according to each section above described and we tested several
243 hypotheses for each group of survey sections (Table1).

244 Survey responses were coded and grouped as variables: Adequate responses about
245 symptoms (ARS), Adequate responses about dengue and vector knowledge (ARK), and
246 Educational level (EL). For Adequate responses about symptoms (ARS) in relation to
247 Educational level (EL), the ARS was worth 1 point when the respondent answered
248 correctly and 0 points in another case. We tested for the association between ARS and
249 the EL of the respondent using logistic regression analysis. For adequate responses
250 about dengue and vector knowledge (ARK), analyzing the question about how dengue is
251 spread, a score was applied to the answers obtained, attributing a score of 2 points to the
252 answers that included as a response: "through a mosquito bite", or the response "that
253 mosquito should be previously infected", and a score of 5 was assigned to the
254 respondents who answered included the scientific name of the mosquito that transmits
255 dengue, and a value of 10 points when they clarified that "it is the female that bites".

256 In the same way, a differentiated score was also applied according to the response
257 obtained from the respondents about what *Ae. aegypti* is. We gave a 2 point score to
258 those answers that only mentioned that it was a mosquito or a vector, or that it
259 transmitted Dengue. We gave a 4-point score when they mentioned that *Ae. aegypti* is
260 the scientific name of the mosquito, which transmitted other diseases in addition to
261 Dengue, or specified the physical characteristics of the species.

262 Finally, a sum of the obtained scores was made, and those respondents who had

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263 obtained between 10 and 28 points were considered as answers with sufficient
264 knowledge. And those who had obtained less than 10 points as answers with insufficient
265 knowledge. These results were analyzed according to the age of the respondent and the
266 educational level reported.

267 Preventive practices refer to the interviewee's self-reported actions to avoid breeding
268 mosquitoes and mosquito bites in their dwellings. Among actions declared were mowing
269 the grass, the use of mosquito's coils as repellents and spirals, fumigation, physical
270 elimination of habitats to reduce breeding sites, and chemical products applied in
271 swimming pools. According to the expert consensus regarding *Ae. aegypti* control [26],
272 not all the mentioned actions have the same weight. Therefore, we calculated a weighted
273 score of control actions: $V = 10R + 5B + 5P + 2F + S$

274 Where V is the total points assigned to the surveyor according to the declared actions,
275 represented with letters (R, B, P, F, S) receiving 1 point if the action was declared in the
276 answer as done, or 0 points if the action wasn't declared.

277 The R indicated the action against containers (physical elimination of habitats, cover
278 containers, put down artificial containers to reduce breeding sites) which was scored
279 with 10 points because is the most action to reduce *Ae. aegypti* population. B indicated
280 bite protection against mosquitoes through the use of insecticides like repellents and
281 spirals, and this action was valued with 5 points. P corresponds to applied chemicals in
282 swimming pools that were valued with 5 points. F refers to fumigation or spraying the
283 dwelling and peri-dwelling with insecticides, which was valued with 2 points. Even
284 though with this practice it is possible to eliminate mosquitoes, other insects are
285 affected as well as human health and pets. S is assigned to grass mowing, which gets 1
286 point because the only impact is a reduction of a possible refuge for male or female
287 mosquitoes.

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288 Therefore, the V value could be from 0 to 23, and the actions were qualified as sufficient
289 if they scored equal to or greater than 12 points, and insufficient if less than 12
290 preventive practices were associated with age and education level through logistic
291 regression analysis. All statistical analyses were conducted in Infostat software [27].
292

293 Results

294 A total of 240 students conducted the surveys, but only 188 accomplish the condition of
295 surveying one family member >18 years of age, living together in the same home.
296 Therefore 188 surveyors were considered in this study, and 52 participants were
297 excluded because either they did not live together in the same home or they were not
298 >18 years of age, with a remaining 188 study participants included in the analysis.

299 Socio-ecological factors

300 Table 2 provides a summary of socio-ecological factors including socio-demographic
301 characteristics of the participants. Most participants were 30 years of age or older
302 (88.2%). Most homes had 4 inhabitants. Although the study was conducted amidst the
303 biggest dengue outbreak in history, more than 90% were unaware of dengue cases in
304 their neighborhoods. Most of the responders had completed high school. Among the
305 people that travel outside the country, most traveled during the months of January and
306 February, the southern hemisphere summer vacation period, to neighboring countries
307 (Table 2).

Table 2 Information provided by respondents on socio-ecological factors

Variable	Number	Percentage (%)
<i>Age</i>		
18-29	21	11.2
≥30	167	88.9
<i>Number of inhabitants for house</i>		
1	1	1.0
2	19	9.8

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3	32	16.5
4	86	46.4
5	35	18.6
≥ 6	15	7.7
<i>Respondents with knowledge of dengue cases in their neighborhood</i>		
Yes	17	9.0
No	171	91.0
<i>Education level</i>		
Primary	4	2.1
Secondary	62	33.0
Tertiary	41	21.8
Graduate	71	37.8
Postgraduate	8	4.3
Doesn't answer	2	1.1
<i>Recent travel destinations</i>		
Don't travel	150	79.8
Brazil	25	13.3
Caribbean/ Middle América	4	2.1
Bolivia	1	0.5
North of the country	13	6.9
<i>Year of trips to risk areas</i>		
2020	39	43.8
2019	20	22.5
2018	14	15.7
2017	5	5.6
<2016	11	12.4
<i>Frequency of trips to risk areas</i>		
Annual	83	97.6
Monthly	2	2.4
<i>Months of trips to risk areas</i>		
January	51	27.1
February	30	16.0
March	5	2.7
April	2	1.1
June	1	0.5
July	5	2.7
August	2	1.1
September	2	1.1
October	2	1.1
November	3	1.6
December	21	11.2

308

309 **Vector-borne diseases knowledge**

310 Most of the responders (75%; 141/188) knew that dengue fever was transmitted by a

311 mosquito. For knowledge on dengue symptoms, fever, body ache, and shivering were

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312 the most frequently mentioned as dengue symptoms (Table 3). In general, the responders
 313 showed knowledge about dengue as a disease, but few knew that the dengue virus has
 314 the same name as the disease (Table 3). Furthermore, most were aware that dengue is
 315 spread due to the mosquito bite (Table 3). Few knew that although the mosquito must be
 316 infected to transmit the disease, not all mosquitoes are infected (Table 3). Not many
 317 people specified that the *Aedes* mosquito is the mosquito involved in dengue virus
 318 transmission. The sources of acquiring the knowledge were mainly the television and the
 319 internet, highlighting the need for effective school programs to bring knowledge to the
 320 community (Table 4 provides the responder's source of information about dengue and
 321 *Ae. aegypti* mosquitoes). Respondents declared having obtained knowledge regarding
 322 dengue and *Ae. aegypti* through television (159, 81.96%) internet (151, 77.84%) and
 323 school (64,32.99%).

324

325 **Table 3 Information provided by respondents on vector-borne diseases knowledge**

Question		Responses	Number of responses	%
<i>What is dengue?</i>				
Correct		A disease	167	88.83
		An infection	4	2.13
		A virus	7	3.72
		TOTAL	178	94.68
Not correct		A mosquito	9	4.79
		Doesn't know	1	0.53
		TOTAL	10	5.32
<i>How is dengue spread?</i>				
	Adequate	Through the bite of a mosquito	178	94.64

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		The mosquito must have been infected with the virus	56	29.79
		The mosquito must first become infected (noting that not all mosquitoes are infected)	10	5.32
		The mosquitoes involved in transmission correspond to <i>Aedes aegypti</i> .	28	14.43
		Only the females who can transmit the virus	6	3.19
	Not correct	Sexually transmitted	1	0.53
		Blood transfusion	1	0.53
		Doesn't know	1	0.53
<i>Do you know what Aedes aegypti is?</i>				
	Adequate	A mosquito	137	72.68
		Transmitter of Dengue	103	54.79
		A transmitter of dengue and other diseases	14	7.45
		The species of the mosquito	16	8.51
		The scientific name	18	9.57
		Mention of some category in the style of taxonomy	37	19.70
	Not correct	Only "yes"	13	6.91
		Doesn't know	12	6.38
		The scientific name of the disease	3	1.6
		Dengue in its scientific term	1	0.53
		The infected mosquito called dengue	1	0.53
		The virus	1	0.53
<i>Are all the biting mosquitoes Aedes aegypti?</i>				

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	Adequate	No	169	89.89
		The common mosquito too	1	0.53
	Not correct	Only females	2	1.06
		Yes	1	0.53
		Only infected mosquitoes	4	2.13
		Doesn't know	9	4.79
TOTAL		188		

326

327

328 **Table 4 Information provided by respondents on How do they know about dengue and**
 329 ***Aedes aegypti***

	TV	INTERNET	SCHOOL	OTHER	n	%
	*				19	10.11
		*			20	10.64
			*		4	2.13
	*	*	*		26	13.83
	*	*			15	7.98
		*	*		22	11.70
	*			*	54	28.72
		*		*	5	2.66
			*	*	4	2.13
n	153	118	64	56		
%	81.38	62.77	34.04	29.79	0	0

330

331

332 Perception of dengue risk

333 Regarding perceptions of dengue, the majority (56%) affirm that dengue is a severe
 334 illness and 21% a moderate one. When people were asked how feasible they think it is to
 335 prevent dengue, most (59%) answered that it is easy while 38% said that it is relatively
 336 difficult. Two-thirds (67%) of respondents admitted that individuals play an important

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337 role in the prevention of dengue.

338 **Household control activities**

339 Regarding mosquito control activities, 90% of respondents reported turning containers
340 with water upside down and/ or eliminating them, 64% mow the grass, and 33% add
341 chemicals to the pool. In addition, 92% claimed to use repellents or spirals to avoid
342 mosquitoes, while 19% fumigate their homes. Regarding physical barriers, the majority
343 (76%) acknowledged that they do not have window screens and 91% do not have door
344 screens to prevent the entry of mosquitoes into their homes.

345 In addition to the aforementioned preventive measures, the respondents also reported
346 organizing and cleaning the house and yard, disinfecting, and using insecticides. People
347 also reported cleaning containers that contain water such as water bowls for pets, vases
348 with aquatic plants, cleaning gutters, and checking that drains and garbage bags do not
349 accumulate water.

350 **The environment surrounding the household**

351 Regarding the environment surrounding households, abandoned urban land is often used
352 to discard solid waste in urban neighborhoods. One-third (36%) of the surveyed
353 households reported an informal dumping area near their dwelling. An additional 15%
354 of the respondents had a formal garbage dump near their dwelling. We considered water
355 channels and Suquia River as risk places because people throw trash along the shores,
356 generating mosquito breeding sites; one-third (31%) of the respondents lived near water
357 channels, and 21% lived near the Suquia River. Most people reported observing
358 mosquitoes both inside and outside of the home (59%); however, some reported
359 mosquitoes mostly outside their houses in the garden, backyard, or even open galleries
360 (21%); and others (20%) reported mosquitoes only inside their dwelling. The majority
361 (88%) reported seeing mosquitoes every day during the warm season in 2020, during

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362 the epidemic.

363 **Logistic regression analysis**

364 In relation to knowledge about dengue, the majority (94.68%) responded corrected that

365 dengue was either a disease (88.83%), an infection (2.13%) or a virus (3.72 %)

366 Regarding how dengue is spread, 183 (94.33%) respondents indicated that it occurs

367 through the bite of a mosquito. One-third (30.41%) indicated that the mosquito must

368 have been previously infected with the virus, and 12 respondents (6.19%) pointed out

369 that the mosquito must first become infected, noting that not all mosquitoes are infected.

370 28 (14.43%) respondents noted that the mosquitoes involved in transmission correspond

371 to *Ae. aegypti*. Few people (3.19%) mentioned that it is only the female mosquitoes who

372 can transmit the virus. When questioned whether the respondent knows what *Aedes*

373 *aegypti* is, most (72.68%) answered correctly that it was a mosquito, and most (54.12%)

374 mentioned that it was a transmitter of dengue. Several people (n=14) indicated that it

375 also transmitted other diseases and others reported (n=16) that it was the species of the

376 mosquito, or the scientific name (n=19). Most of the respondents knew that all the

377 biting mosquitoes are not *Aedes aegypti*, (90.20%). A single respondent mentioned the

378 existence of another mosquito, "the common mosquito", which would correspond to

379 *Culex quinquefasciatus*, which is very common in Córdoba.

380 Respondents correctly identified dengue symptoms such as fever, muscle pain,

381 headache, etc. (Table 5). Taking into account the WHO characterization of symptoms,

382 the variable ARS (Adequate answers about symptoms) was generated that is worth 1

383 when the respondent answered correctly and zero in another case. Based on the

384 formulated hypothesis we expected to find that the correct knowledge of the symptoms

385 of dengue disease depends on the educational level reached by each person. The

386 association between ARS (Adequate responses about symptoms) and the EL

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387 (Educational level) of the responders (Table 6) showed that was partially correct.
 388 Although it was shown that at the graduate level there is a notable tendency to correctly
 389 indicate dengue symptoms, even more than expected ($\chi^2= 21.63$, $p<0.001$), there is no
 390 significative differences between the percentage of people that answer correctly and
 391 those who do not in the rest of the levels (Table 6).

392

393 **Table 5 Knowledge about *Aedes aegypti*, dengue, and the main symptoms**

Knowledge about <i>Aedes aegypti</i> , dengue, and the main symptoms					
	Enough	% Enough	Insufficient	% Insufficient	Number of responses
<i>Age group</i>					
Under 30 years	8	36%	14	64%	22
Over 30 years old	66	40%	99	60%	165
	Enough	% Enough	Insufficient	% Insufficient	Number of responses
<i>Education level</i>					
1 (school)	27	40%	40	60%	67
2 (advanced)	47	39%	73	61%	120
	74		113		187

394

395

396 **Table 6 Association between ARS (Adequate responses about symptoms (1: adequate; 0:**
 397 **not adequate) variables and the Educational level (EL) of the respondent**

E L	ARS	n	%	χ^2	p-value
Primary	0	2	1.15	0.53	0.4652
	1	2	1.15		
Secondary	0	27	15.52	4.68	0.0306
	1	27	15.52		
Tertiary	0	20	11.49	3.33	0.0679
	1	20	11.49		
Graduate	0	1	0.57	21.63	<0.0001
	1	68	39.08		
Postgraduate	0	2	1.15	0.00	>0.9999
	1	5	2.87		

398 n: number of respondents in each category; %: observed percentage of respondents belonging to each
 399 category; χ^2 : comparison of observed and expected frequencies in each category.

400

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401 When comparing knowledge about dengue and the vector (Table 7), and good
402 preventive practices in relation to the educational level (EL) achieved and group age, the
403 analysis indicated no significant differences. Regardless of this, we observed that a
404 significant number of surveyors (84.5%) develop good preventive practices.

405

406 **Table 7 Knowledge about *Aedes aegypti*, dengue, and the main symptoms**

		Enough		Insufficient		χ^2	p-value
		n	%	n	%		
Age group	18–30 years	8	36.4	14	63.6	0.11	0.7432
	>30 years	66	40	99	60		
Educational level	Secondary	27	40.3	40	59.7	0.02	0.8794
	Superior	47	39.2	73	60.8		
Total		74	39.6	113	60.4	4.12	0.0423

407 n: number of respondents in each category; %: observed percentage of respondents belonging to each
408 category; χ^2 : comparison of observed and expected frequencies in each category.

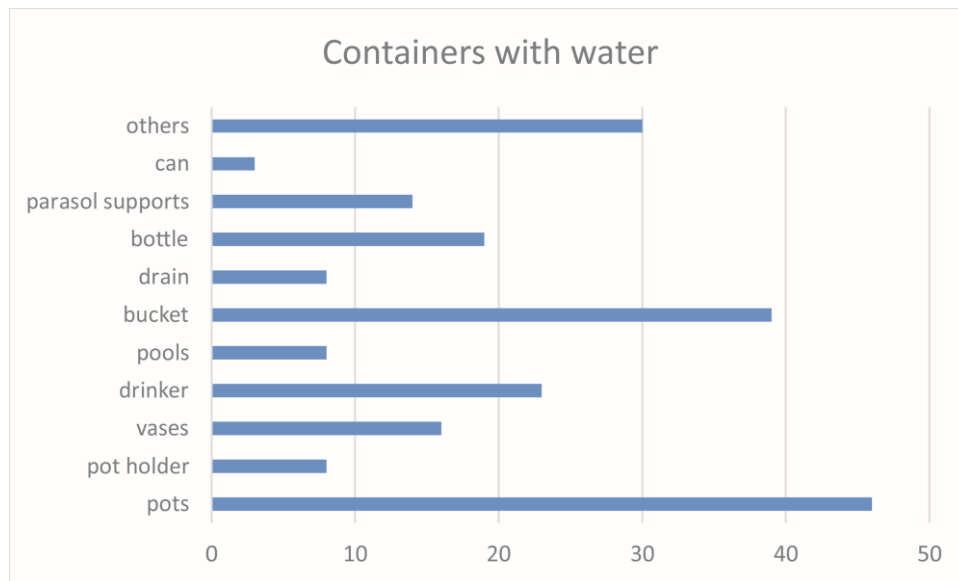
409

410 **About the Attitude Activity**

411 With regards to the activity involving students' attitude of exploring their backyards
412 and/or their gardens and even inside their homes, searching for containers that hold
413 water and could be potential mosquitoes breeding places, only 94 students (39 %) completed the activity and documented the activity with photography that was sent to
414 their teachers. The students were able to identify mosquito breeding sites such as pots,
415 buckets, bottles, drinkers, jars, vases, among others (Fig. 2). 89% of the students found
416 water inside the containers and of these, 17% found the presence of mosquito larvae,
417 although it was impossible to know if they were *Ae. aegypti*.

419

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420

421 **Fig. 2.** Potential breeding sites. Number and type of containers with water found in the
422 dwellings of the students who carried out the activity.

423

424 **About the Action**

425 Finally, students put into practice the knowledge acquired by eliminating containers as
426 well as storing them indoors without water, documenting with photos that were sent to
427 the teacher in each of the schools involved. 61 students (65%) gave their opinions about
428 the whole activity describing a positive impact on their family environment and future
429 decisions with respect to vector management.

430

431 **Discussion**

432 Considering that community awareness and education are critical factors for *Ae.*
433 *aegypti* mosquito's management, we thought of this pilot online experience during the
434 COVID-19 pandemic quarantine. Student-led science engaged the teachers and involved
435 students during online classes and the biggest dengue outbreak in our region's history.
436 As we already know, dengue prevention depends on effective vector management.
437 According to the World Health Organization [28], sustained community involvement

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438 can improve vector management efforts substantially. Although, mosquito educational
439 interventions by the government in temperate areas of Argentina are done just during
440 adult vector activity months when adult mosquitoes bother the people (November to
441 April mainly), they are not sustained all year long as could be in tropical areas where
442 dengue risk is all the yearlong.

443 As expressed in the surveys, people seem to have good knowledge about the vector and
444 the disease in Córdoba city. A striking case is that observed in Malaysia where despite
445 being in constant contact with the disease, since the risk of outbreaks is frequent or
446 continuous [29], research shows that there is insufficient knowledge about the cause of
447 the disease and how it is transmitted, as well as about the activity of the vector and the
448 breeding sites where it develops [30]. Our results revealed the knowledge of people
449 about *Ae. aegypti* mosquito but the lack of knowledge about *Ae. aegypti* as a vector that
450 could be infected with the dengue virus. The need for appropriate knowledge
451 transference to the community focuses on females like those who bite the humans and
452 transfer the virus if they are infected. In accordance with McNaughton et al. [31],
453 controlling dengue fever relies heavily upon the actions of residents as well as
454 community education and awareness of the risks, if people do not know the cause of the
455 disease and how it is transmitted later; therefore, appropriate practices cannot be
456 implemented to prevent it. The mosquito vector seems to be known better by television
457 and less by the school, indicating that television is an essential source of knowledge, as
458 other studies assert [30, 32]. This generates an impact on the audience. It makes us think
459 of television as a critical factor in vector-borne corrected knowledge transmission,
460 awareness and spreading information by internet.

461 In addition, these could be highlighting the need of schools to add in their programs as
462 main contents about mosquito biology and vector-borne diseases to raise awareness of a

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463 right knowledge diffusion to families and hence the community aiming to prevent
464 vector breeding sites as well as the disease in a sustainable time as suggested by WHO.
465 In fact, in accordance with previous studies, which evidenced the role of education
466 leading behavior changes and increasing community knowledge after vector-borne
467 focus education [11, 12]. About dengue perception, in Córdoba, the surveyors recognize
468 the illness's importance and severity. These findings highlight a considerable difference
469 concerning other communities in other countries like Colombia, which think it is not an
470 illness but just regular flu (mild flu) or common cold [33]. Likewise, in a study made in
471 Malaysia, most survey respondents recognized the common symptoms or signs of the
472 disease but not the complications they may manifest [30]. In tropical areas, people are
473 used to the large number of dengue cases that occur each year because of being in an
474 area where the presence of the vector and the virus circulation is constantly unlike
475 temperate Córdoba city, with vector activity during the warmer months. For this reason,
476 people could underestimate its importance.

477 Our study highlights people understanding of dengue prevention as a responsibility of
478 each individual, including schools and government, unlike other studies in which most
479 people place responsibility on the government and health care authorities besides each
480 household [32]. In fact, in our study, people affirm that school has a fundamental role in
481 raising awareness and educating. For its part, the government communicates, gives
482 information, fumigates, and takes control of the vector situation. With this, phrases like
483 "joint work" and "social responsibility" should be pointed out.

484 People movement is one of the main causes of disease expansion [34]; we reported that
485 people with travel, most travel recently to neighboring countries like Brazil, that
486 presents more than 2,226,900 dengue cases during 2019 with the highest impact in
487 history [5]. This situation increases the risk of income imported cases to the country.

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488 Indeed, areas of southern Brazil reported co-circulation of dengue virus 1, 2, and 4 until
489 epidemiological week 23 [35].

490 It is important to mention that all the prevention methods that people refer to are
491 recommendations from the media highlighting their relevance to people's awareness.

492

493 Conclusion

494 Having good knowledge alone is not sufficient for dengue control while perception
495 towards barriers, self-efficacy, and cues to act among respondents can be further
496 strengthened. As dengue is related to health behavior, future prevention and control
497 programs can be designed to encourage communities to make decisions and behavior
498 changes for dengue and dengue prevention effectively. Through this study, we
499 encourage the need of adding school programs to engage the community and transmit
500 the constant implications of the mosquito-borne disease, and the need for vector
501 mosquito management together as a community. We encourage the need for schools and
502 government campaigns together, with the engagement of journalists and television as
503 the means for people to get knowledge on mosquito *Ae. aegypti* and dengue diseases
504 massively. We need to inculcate positive attitudes on the population and cultivate better
505 preventive practices to eliminate the breeding places for mosquitoes' vectors and
506 therefore diminished the possibility of dengue fever circulating in our city.

507

508 Supplementary information

509 **Additional file 1.** Survey instrument including questions regarding the identification of
510 vector-borne diseases, socio-ecological factors, knowledge, and perception of dengue,

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511 household vector prevention and control actions, as well as the household
512 environmental surrounding. (Additional file 1.docx)

513 **Additional file 2.** Additional details about training of students to learn about the vector
514 and carry out the Attitude activity. (Additional file 2.docx)

515

516 Declarations

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534 **Francisco F. Ludueña-Almeida:** Methodology, Investigation, Formal Analysis,

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535 Writing - original draft, Writing - review & editing.

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551

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