original contributions

Mobile Applications: Breaking Barriers to Early Breast and Cervical Cancer Detection in Underserved Communities

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QUESTION ASKED: Is a free mobile application (mApp) able to gather information on user misconceptions about cancer screening, identify those at risk for breast cancer (BC) and cervical cancer (CC), and engage them to participate in screening programs in Colombia?

SUMMARY ANSWER: We found that a free mApp is a promising and accessible tool that can reach hundreds of women located in specific areas, deliver customized and understandable information about BC and CC care, gather data to identify cancer misconceptions, stratify user cancer risk based on national clinical practice guidelines, and help to coordinate healthcare services when associated with a patient navigation program.

WHAT WE DID: We designed a user-friendly mApp that has simple content about BC and CC written in Spanish. The mApp is interactive and consists of two modules (one for BC and the other for CC) each consisting of 20-25 questions with brief feedback to teach the correct response. The randomly prompted questions fall into one of three types: basic concept, evaluative, and risk factor questions that address specific aims and allow data classification for further analysis. Risk factor questions follow an algorithm based on the Colombian clinical practice guidelines for cancer control to determine cancer screening indications. After completing both modules, a notification informs the users if they need a screening mammogram and/or pap smear, their profile is highlighted in a patient navigation administrative platform, and they can be contacted and guided to the proper services for a screening test.

WHAT WE FOUND: Over 2 years, 1,043 women downloaded the mApp and 303 (29%) needed a screening test, of which 98 (32%) have completed the recommended screening. Several pervasive misconceptions about BC and CC included the notions that BC can be prevented (87%), pap smears should not be performed while sexually active (64%), obesity does not increase the risk of BC (49%), and vaginal pain is an early sign of CC (44%).

BIAS, CONFOUNDING FACTORS, DRAWBACKS: Topics that need to be addressed to leverage information technologies for early cancer detection include building trust around the use of mApps for health promotion, creation of patient navigation services to guide women throughout the process from scheduling to completing the screening test, costs associated with the mApp development and continuous IT support, and partnership with insurers and healthcare facilities to promptly address increased demand for cancer screening.

REAL-LIFE IMPLICATIONS: Information technologies have the potential to positively affect cancer prevention programs on a large scale. This is the first mApp that not only provides cancer education, but also uses an algorithm based on national guidelines for cancer control to determine whether a screening test for BC and/or CC is indicated paired with a patient navigation program to help users obtain the necessary screening. This new technological approach is a novel way to begin addressing health disparities, enhance health empowerment, and overcome barriers to prevention and early detection of BC and CC. This technology that combines patient education and navigation has widespread applications and may be useful in other underserved communities.

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abstract

BACKGROUND Although potentially curable with early detection and timely treatment, breast cancer (BC) and cervical cancer (CC) remain leading causes of death for Colombian women. Lack of education, complicated administrative processes, and geographic limitations hinder early cancer detection. Today, technological tools permeate the society and could assess user risk, deliver customized information, and provide care coordination. We evaluated the effectiveness of a free mobile application (mApp) to reach women, understand misconceptions, identify users at risk for BC and/or CC, and coordinate screening tests in Cali, Colombia.

METHODS The mApp was developed and advertised in four healthcare facility waiting rooms. It used educational, evaluative, and risk factor questions followed by brief explanations to assess the population's knowledge, educate on BC and/or CC, and identify users in need of screening test(s). Women who required screening were navigated and enrolled in the national cancer program.

RESULTS From August 2017 to August 2019, 1,043 women downloaded the mApp. BC misconceptions included beliefs that BC can be prevented (87%), obesity does not increase the risk of BC (49%), and deodorant causes BC (17%). CC misconceptions included that pap smears should not be performed while sexually active (64%), vaginal pain is an early sign of CC (44%), and only women contract human papilloma virus (33%). Overall, 29% (303) were identified as at risk and needed a screening test, with 32% (98) successfully screened.

DISCUSSION mApps can identify women at risk for BC and/or CC, detect barriers to early cancer detection, and help coordinate screening test(s). This technology has widespread applications and may be useful in other underserved communities.

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BACKGROUND

In Colombia, there are approximately 54,000 women diagnosed with cancer each year with an estimated age-standardized incidence of 175.9 cases per 100,000 women in 2018.[1] Breast cancer (BC) and cervical cancer (CC) are the first and fourth most frequent types of cancers in Colombian women, representing 24% of cancer-related deaths (16% [3,702 women] BC and 8% [1,775 women] CC).[2]

Mammography and cervical cytology (pap smear) are universally accepted screening methods for early detection of these cancers.[3,4] However, because of multiple factors such as poor social security coverage, excessive administrative processes, geographic limitations, lack of education, and misconceptions, the percentage of Colombian women who use these

screening tests is low, especially among the low-income population.[5-8] Although 77% of Colombian women of age 25-69 get pap smears overall, the number in low-income and suburban communities can be as low as 6.5%.[9,10] Similarly, although 49% of women of age 50-69 get screening mammograms overall, it is estimated to be around 25% in certain communities.[11] Despite efforts to overcome existing barriers to the prevention and early detection of BC and CC, including universal healthcare coverage to 94% of the population and a dedicated 10-year cancer control plan, the proposed goals have not been achieved, warranting new methodologies to address these problems.

The use of smartphones and mobile applications (mApps) has increased globally and permeated all

areas of the society. It is estimated that mApps can help reduce health system costs by up to 25%. In countries such as Japan, China, and India, digital information strategies have made it possible to expand health coverage to rural areas, surpassing geographic limitations and facilitating access to information.[12,13] Currently, it is estimated that there are more than 19 million smartphone users in Colombia, which is approximately 40% of the population.[14,15] We believe that mApps can serve as an alternative strategy to overcome barriers that limit the effective prevention of BC and CC. Thus, we aimed to answer the question: is a free mApp effective to reach women, understand misconceptions about cancer screening, identify users at risk for BC and/or CC, and coordinate screening tests in Colombia?

METHODS

Over 4 months, a mApp was developed for smartphones running Android operating system (Google LLC, Mountain View, CA) through a Colombian third-party development company. The first version was available for free download in the Google Play Store. The name Ámate | Cuida tu salud, which translates to Love yourself | Take care of your health, highlights the concept that taking care of one's health (eg, getting screening tests for BC and CC) is a way of self-love. All mApp content was written in simple and easily understandable Spanish to address the target population of all women with a smartphone from low-income regions of Cali, Colombia.

Design Scheme

The design consisted of two modules (one for BC and the other for CC) and a rewards section (Appendix Fig A1). Each module contained 20-25 multiple choice questions specific to each cancer. For each question, brief feedback appeared once an answer was selected. This methodology aimed to reinforce important concepts and clarify common misconceptions about the disease. The randomly prompted questions fall into one of the three types: (1) basic concept, (2) evaluative, and (3) risk factor questions. Each question type addresses specific aims for each cancer and allows data classification for further data analysis.

Basic concept questions included information about incidence, prevention, early detection, screening test availability, risk factors, treatment, and prognosis. These questions aimed to measure the population's baseline knowledge, identify common misconceptions, and educate users about the disease and the importance of regular screening.

Evaluative questions tested the knowledge presented in the basic concept questions. Users earned points for answering these questions correctly, which could be redeemed for cellular data. These questions aimed to assess the user's level of knowledge and evaluate the learning curve. A reward for correct answers reinforced major

concepts and encouraged users to continue to engage with the mApp.

Risk factor questions ask users about their demographics, health, and family history to determine if they require a screening mammogram and/or pap smear. These questions follow an algorithm based on the Colombian clinical practice guidelines for cancer control to determine screening indications.[16,17] These guidelines recommend screening mammograms every two years for women of age 50-69 or annually for women of age 30-49 with a first-degree relative with BC.[16] In addition, for sexually active women, a pap smear is recommended every 3 years for ages 25-30 and a human papilloma virus (HPV)-DNA test is recommended every 5 years for women of age 30-65.[17]

After completing both modules, the mApp produces several key messages. First, a notification informs the users if they are in need of a screening mammogram and/or pap smear. Second, the total number of points earned from evaluative questions and information regarding the level of knowledge on the tested topics are displayed, followed by a tailored message that encourages users to continue learning and taking care of their health. Third, in the administrative platform, it highlights users who have screening indications (Appendix Fig A2). Administrators can then contact women via phone calls to navigate them to the proper services for screening tests.

Content Development

Questions and feedback were prepared by a team of primary care physicians, a surgical oncologist, psychologist, sociologist, and social worker. The initial draft was tested on women with various levels of education from the community, as well as women with previous cancer diagnosis. Modifications were made based on feedback from the tested women to enhance clarity/understandability and guarantee that any individual could understand the basic health concepts.

Additional strategies to ensure understandability and improve user experience included adapting medical and technical jargon to everyday language; using personal pronouns, such as you; using short sentences, present tense, active voice, and action words; limiting paragraph size; avoiding clutter with white spaces; centering content on the screen; and including bold colors with contrast (Appendix Fig A1). Ámate content design was based on literate principles to reach individuals from low-income communities, following strategies on designing health-literate mApps.[18]

Implementation

Ámate's project was approved by the management and institutional research boards of four healthcare facilities in Cali. Project implementation occurred in three phases with unique players, which guaranteed the adequate functioning of the program (Fig 1). Phase I entailed an
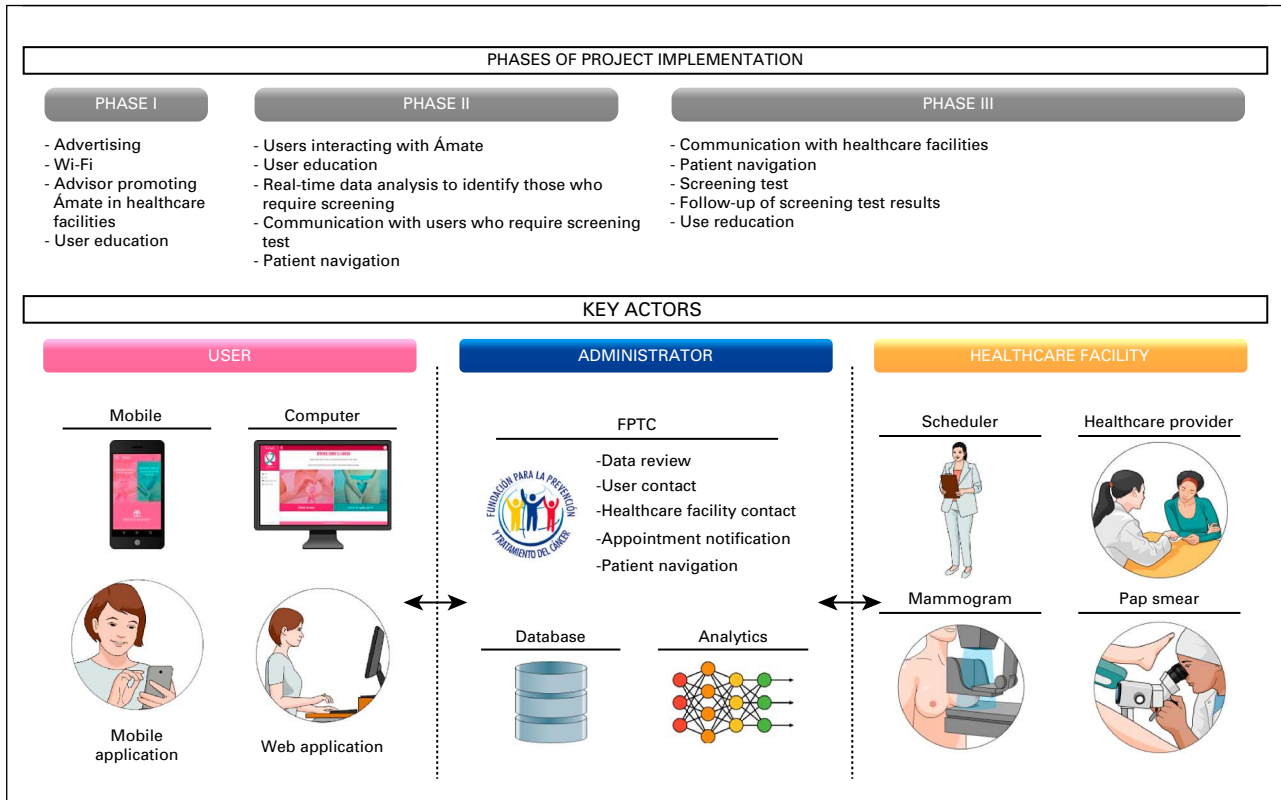
FIG 1. Ámate's three phases of project implementation and key actors. Ámate's project implementation occurred in three phases with unique players who guaranteed the adequate functioning of the program. Phase I entailed an advisor promoting the app and providing cellular data to download the app. Phase II occurred once there were women using the app and entailed automatic real-time data gathering and analysis to identify those who require screening. During this phase, patient navigation was key to contact users with screening indication and healthcare facilities to streamline scheduling of screening tests. Phase III represented the period of time from scheduling to completion of the screening test at an appropriate healthcare facility. FPTC, Fundación para la Prevención y Tratamiento del Cáncer.

advisor promoting and providing cellular data to download the mApp to women in healthcare facility waiting rooms. Phase II occurred once there were women using Ámate. It entailed automatic, real-time data gathering and analysis to identify those who require screening. During this phase, patient navigation services were necessary for streamline communication between users and healthcare facilities for scheduling. Finally, phase III represents the period of time from scheduling to completion of the screening test at an appropriate healthcare facility.

Patient Navigation Program

Since 2012, Fundación para la Prevención y Tratamiento del Cáncer (FPTC) has been developing and implementing the first Colombian patient navigation program to overcome health disparities and unify a fragmented system of care in Cali.[5] The purpose of the program is to integrate the healthcare system by coordinating services, expediting administrative procedures, and providing guidance for patients during cancer diagnosis and treatment. This program was essential to contact women identified by the mApp for screening, coordinate appointments with healthcare facilities, and guide

women throughout the process from scheduling to completing the screening test.

Data Privacy and Handling

A privacy policy and terms of service were available after downloading the mApp. These documents detailed how data were used, stored, and protected and must be read and accepted prior to using the mApp. Data were encrypted and stored in a cloud server with access exclusively through administrative accounts on Ámate's web administrative platform. Women identified for a screening test in the administrative platform were enrolled in the FPTC patient navigation program, initiating the process to receive the indicated test.

Statistical Analysis

User data including sociodemographic characteristics, response to each question, type of screening indicated, screening status, and reasons for no screening were automatically extracted from the administrative platform into a Microsoft Excel file. Descriptive analysis was performed using the same software with categorical variables presented as frequencies and proportions and continuous variables as medians and interquartile

ranges (IQRs). Bar and pie charts were used for data visualization.

RESULTS

Ámate's Outreach

From August 2017 to August 2019, 9,155 women were solicited to download Ámate in four healthcare facilities in Cali, Colombia (Fig 2). There were 1,215 (13%) downloads with 1,124 (93%) completed profiles. Reasons for not downloading the mApp included disinterest (n = 5,353, 58%), no mobile phone (n = 691, 8%), no smartphone (n = 653, 7%), full storage (n = 527, 6%), noncompatibility (n = 504, 6%), and others (n = 212, 2%). There were 162 (13%) users who downloaded Ámate from locations other than Cali, including the cities Bogota, Cartagena, and Medellin and the countries Mexico, Argentina, Spain, and the United Kingdom. These user profiles were excluded from analysis, and the following results are exclusively from users from Cali with complete profiles (n = 1,043 users).

Downloaders had a median age of 34 years (IQR, 25 to 47) and a median body mass index of 25.9 kg/m^2 (IQR, 22.9 to 29.2). A total of 185 (18%) women over age 50 downloaded the mApp with a median age of 55 years (IQR, 52 to 59) in this subgroup. Overall, 797 (76%) women reported having children with 30%, 28%, 13%, and 6% having one, two, three, and > three children, respectively.

BC Misconceptions

In the BC module, there were 25 questions (11 basic concept, eight evaluative, and six risk factor questions) including six branching questions. Approximately 5% of women did not answer all questions.

Basic concept questions that were answered incorrectly included beliefs that BC can be prevented (87%), obesity does not increase the risk of BC (49%), deodorant causes BC (17%), and only women with a relative with BC can get the disease (16%) (Fig 3). Evaluative questions testing knowledge about BC care revealed that 67% of women did not know that mammograms are only free at age 50 or older, 28% thought that early BC is detected when there is a lump or breast pain instead of with a mammogram, 23% did not know that a mammogram is recommended every 2 years starting at age 50, and 15% believed that one should never get a mammogram before age 50 (Appendix Fig A3).

CC Misconceptions

In the CC module, there were 27 questions (12 basic concept, 10 evaluative, and five risk factor questions) including three branching questions. Approximately 11% of women did not complete the entire module.

Basic concept questions that were answered incorrectly included the beliefs that pap smears should not be performed while sexually active (64%), vaginal pain is an early sign of CC (44%), and only women contract HPV (33%)

(Fig 3). Evaluative questions testing knowledge about CC care showed that 41% of women did not realize that early CC has no symptoms, 17% thought that HPV infects only women, and 9% believed that the HPV vaccine is used to prevent other diseases such as HIV/AIDS or BC instead of CC (Appendix Fig A4).

Screening Test Indication

Screening tests were indicated in 29% (303) of women who downloaded Ámate, completed the entire profile, and answered the entire BC and/or CC modules (Fig 4). Mammograms, pap smears, and HPV DNA tests were indicated in 59, 127, and 153 women, and there were 36 women who needed multiple tests.

Through FPTC's patient navigation program, women were contacted and provided assistance to navigate the healthcare system to receive the needed screening tests. A total of 20 mammograms, 72 pap smears, and 14 HPV DNA tests were performed at appropriate healthcare facilities for a total of 98 (32%) women who were successfully navigated and screened. Main reasons for not getting a screening test included women using fake contact information, they were already screened at another healthcare facility, and unwillingness/fear to receive screening tests (Fig 4).
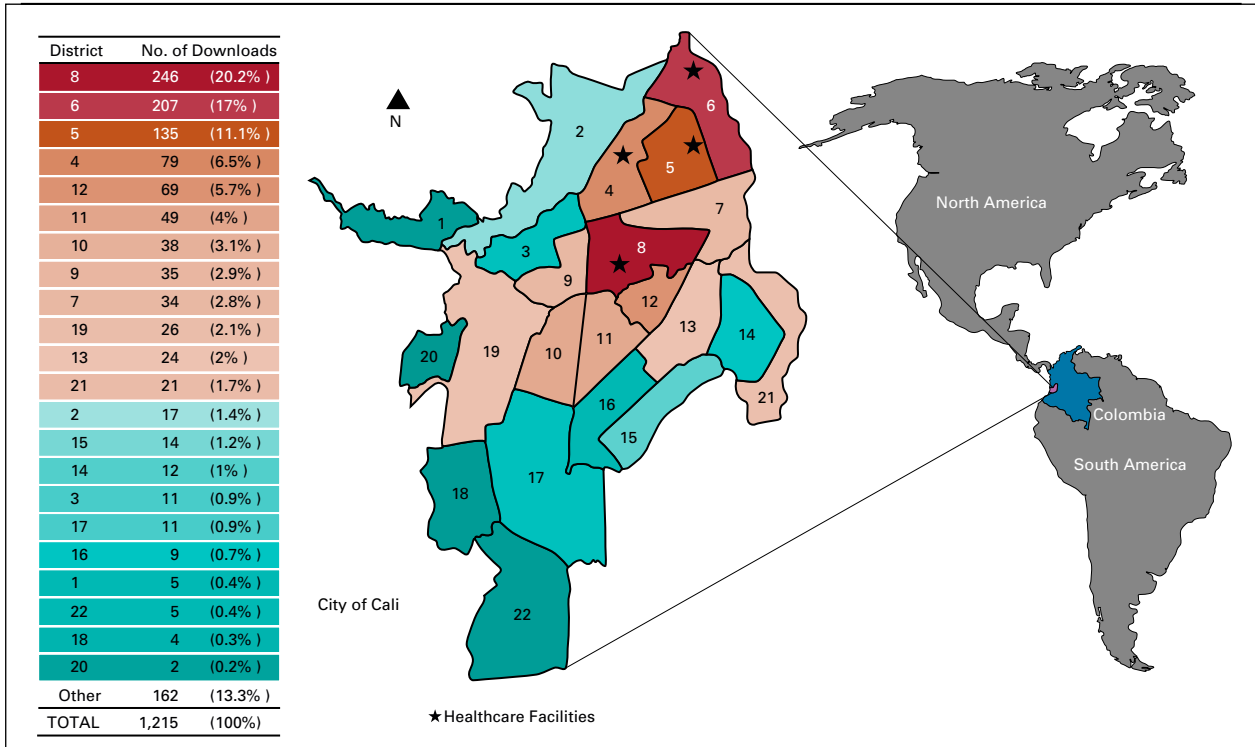
DISCUSSION

Information technologies have the potential to positively affect cancer prevention programs on a large scale.[19-21] In this study, we demonstrated that a free mApp can reach women located in specific geographic areas, deliver customized and understandable information about BC and CC care, gather data to realize cancer misconceptions, stratify user cancer risk based on national clinical practice guidelines, and help to coordinate healthcare services when associated with a patient navigation program.

User privacy and information quality are important issues to address when delivering and gathering health information.[22] We included a privacy policy and terms of service following Colombian legal requirements and Google Play policies that must be read and accepted by users before using the mApp to protect user data.[23-25] mApp content was developed by medical doctors with expertise in the oncology field and with consideration of the Colombian clinical practice guidelines for BC and CC care.[16,17] Once developed, the content was reviewed by a variety of health providers including a psychologist, a sociologist, and a social worker, as well as individuals from the community with various levels of education to guarantee clarity and understandability.

Four healthcare facilities in low socioeconomic areas were selected to test the mApp. This approach allowed us to reach the target population, while their response to this technology was evaluated and navigation routes were generated. Partnerships with insurers and healthcare facilities through FPTC's patient navigation program were essential to

District	No. of Downloads	
8	246	(20.2%)
6	207	(17%)
5	135	(11.1%)
4	79	(6.5%)
12	69	(5.7%)
11	49	(4%)
10	38	(3.1%)
9	35	(2.9%)
7	34	(2.8%)
19	26	(2.1%)
13	24	(2%)
21	21	(1.7%)
2	17	(1.4%)
15	14	(1.2%)
14	12	(1%)
3	11	(0.9%)
17	11	(0.9%)
16	9	(0.7%)
1	5	(0.4%)
22	5	(0.4%)
18	4	(0.3%)
20	2	(0.2%)
Other	162	(13.3%)
TOTAL	1,215	(100%)

★ Healthcare Facilities

City of Cali

N

North America

Colombia

South America

FIG 2. Ámate downloads by district in Cali, Colombia. The public health system in Cali is decentralized into five major health networks, called Empresas Sociales del Estado or E.S.E., including the Northern, Eastern, Southern, Midtown, and Hillside networks. These E.S.E.s cover 22 geographic districts, known as Comunas. Ámate was promoted in four healthcare facilities: three from the Northern network, which covers the districts 2 and 4-7, and one from the Midtown network, which covers the districts 8-12. Although 75% of women reported living in those districts (36% Northern network and 39% Midtown network), there were downloads across the entire city. Users who did not enter a valid district or lived in other cities (ie, Bogotá, Medellín, Cartagena, etc) or countries (ie, Mexico, Argentina, Spain, the United Kingdom, etc) were categorized as Other and represented 13% of users.

address increased screening demands. The critical role of patient navigation services in overcoming barriers for cancer care has gained increasing attention in the last few years and is demonstrated in this experience.[5,26,27]

More than 9,000 women were solicited to download the mApp over a 2-year period with more than half of them refusing to download citing lack of interest in this new technological approach to promote cancer awareness and screening. We hypothesize that women declined downloading the mApp because of fear of having an application on their cellphone they have never heard of before. Using this technology to learn about cancer and promote screening tests is a novel healthcare approach that requires time to build familiarity and understand the safety and potential benefits. Nevertheless, more than 1,000 women downloaded the mApp with 93% completing both modules. Additionally, although advanced age and low socioeconomic status have been reported as barriers to using mApps, all our users belonged to the low- and middle-socioeconomic status with almost 20% over age 50.[28,29]

The mApp methodology of asking questions followed by brief feedback and evaluative questions to randomly test

the provided information seems promising to identify misconceptions and educate women about BC and CC. Interestingly, 33% of users answered that only women contract HPV, but in the subsequent evaluative questions, only 17% selected that response, demonstrating a fast, promising learning curve. There is great potential for this methodology to track user improvement and even tailor information based on specific misbeliefs. The current administrative platform offers the capability to create new questions and remove old ones, allowing dynamic content that can be modified according to population needs.

One of the revolutionary features of this mApp is its ability to identify women in need of BC and CC screening. To the best of our knowledge, this is the first mApp that uses an algorithm based on the national clinical practice guidelines for cancer control, along with personalized user information to determine whether a screening test for BC and/or CC is indicated. mApps usually offer basic educational information about these cancers but do not identify individual risk.[30,31] Moreover, the association of the mApp with FPTC's patient navigation program within the Colombian health system that provides universal coverage to more than 94%
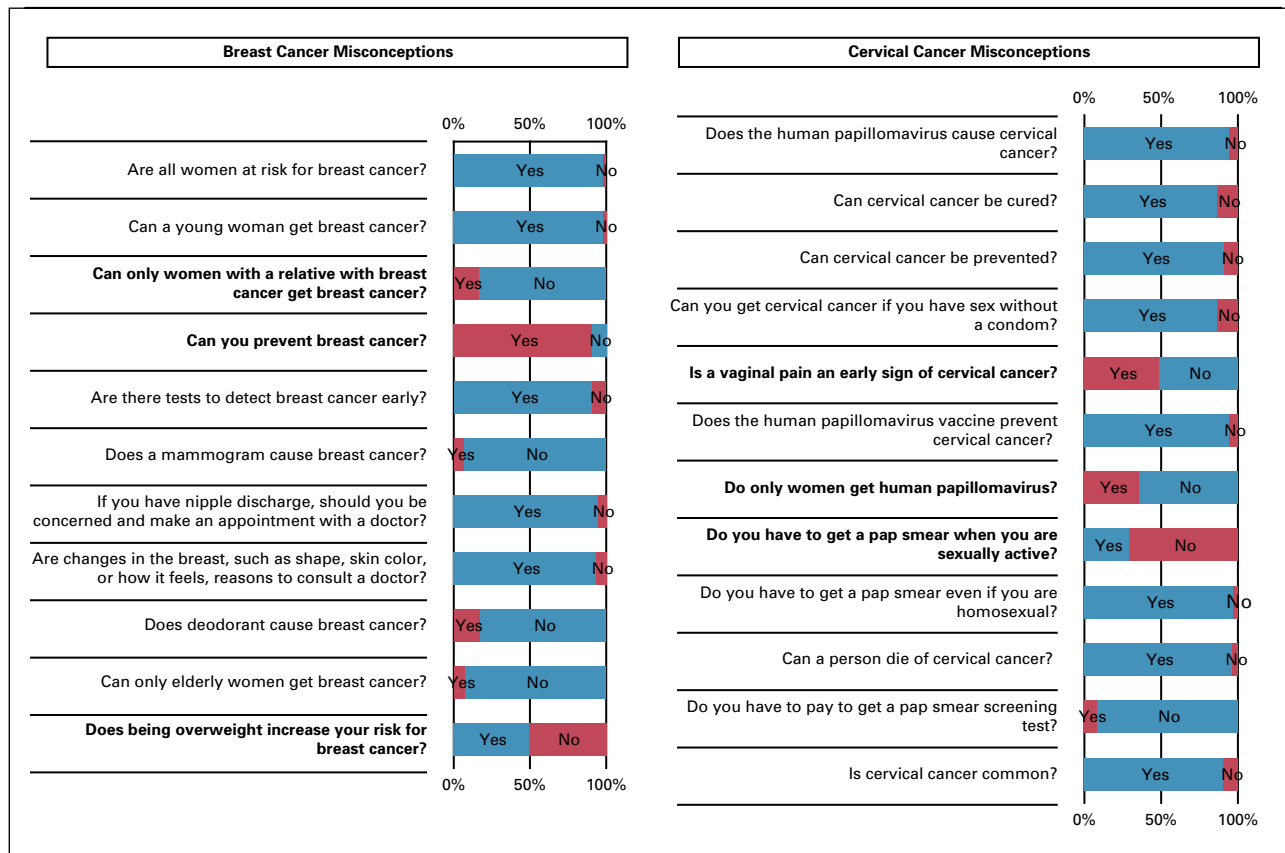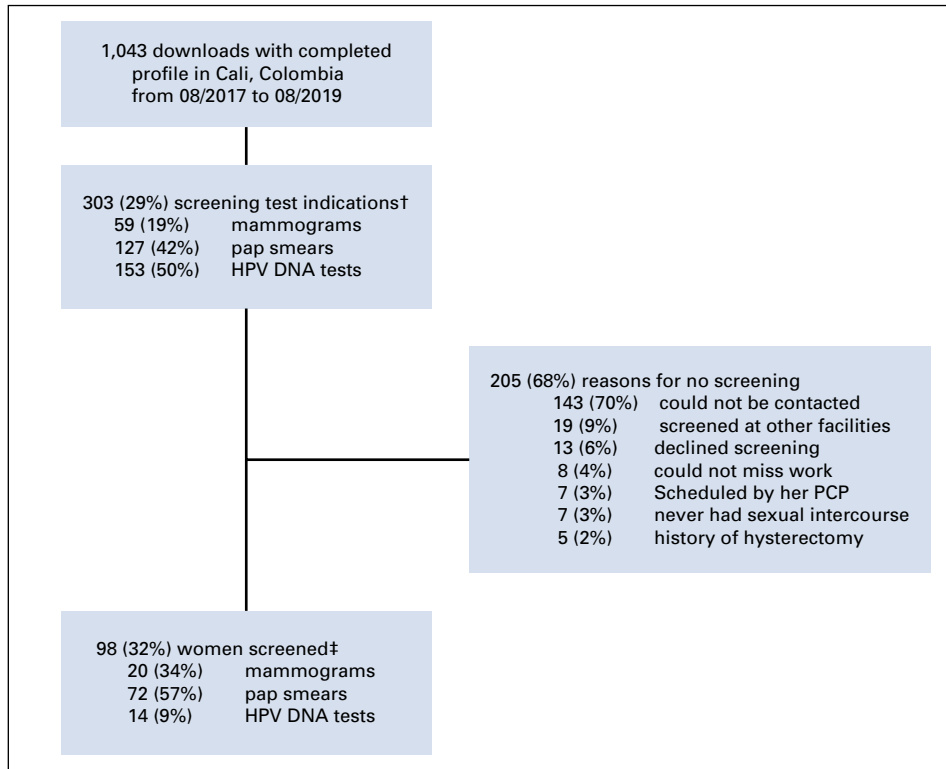
FIG 3. Breast and cervical cancer misconceptions among women using Ámate in Cali, Colombia. The blue bar indicates the proportion of women who responded to the question correctly, while the red bar indicates the proportion of women who responded incorrectly.

of the population is a desirable setting to use information technologies to improve cancer care.[5,32] Of note, results of screening tests are tracked by FPTC's patient navigation program, and of the 98 screened women, no abnormal mammograms or pap smears have been documented. Nevertheless, as the number of screened women increases, abnormal report will likely occur and the great impact of this innovative approach is appreciated.

Although Ámate was able to identify women with screening test indication, there are still barriers that need to be addressed to leverage information technologies for early cancer detection. First, trust needs to be built around the use of mApps for health promotion. A significant proportion of women with screening indication could not be contacted because of providing false contact information in the mApp. Women are suspicious about entering contact information because of fear of being charged for services they cannot afford or fraud. Advertising with government entities along with verification codes sent to the user's cellphones is a strategy that can mitigate this barrier. Second, administrative obstacles, such as limited available appointments or insurance denying access to services at specific locations, still exist. Patient navigation services can serve as a bridge between insurers and healthcare facilities, managing administrative barriers and assisting in care coordination.[33] Nonetheless, patient navigation programs did not exist in Colombia and FPTC has been developing this initiative since 2012 to demonstrate its importance and improve community healthcare.[5]

There are important considerations when developing mApps to promote cancer screening in developing countries. First, there are significant costs associated with mApp development and the continuous IT support required to maintain functionality. Moreover, new versions are often needed to improve user experience or exploit new functionalities. Financial support is critical to the mApp's smooth operation. Second, a readily available and knowledgeable contact system should be in place to properly address user health concerns. Third, a partnership with insurers and healthcare facilities is essential to promptly address the increased demand for cancer screening and provide patients with timely diagnostic and/or treatment options. Studies to validate the effectiveness of this approach on increasing the number of cancer screening tests compared with conventional methodologies of health promotion are currently being planned.

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┌─────────────────────────────────────┐
│  1,043 downloads with completed      │
│      profile in Cali, Colombia       │
│      from 08/2017 to 08/2019         │
└─────────────────────────────────────┘
                  │
┌─────────────────────────────────────┐
│  303 (29%) screening test indications†│
│  59 (19%)     mammograms             │
│  127 (42%)    pap smears             │
│  153 (50%)    HPV DNA tests          │
└─────────────────────────────────────┘
                  │
                  │        ┌──────────────────────────────────────────────┐
                  │        │  205 (68%) reasons for no screening          │
                  │        │   143 (70%)   could not be contacted         │
                  ├────────│   19 (9%)     screened at other facilities   │
                  │        │   13 (6%)     declined screening             │
                  │        │   8 (4%)      could not miss work            │
                  │        │   7 (3%)      Scheduled by her PCP            │
                  │        │   7 (3%)      never had sexual intercourse    │
                  │        │   5 (2%)      history of hysterectomy         │
                  │        └──────────────────────────────────────────────┘
                  │
┌─────────────────────────────────────┐
│  98 (32%) women screened‡            │
│   20 (34%)    mammograms             │
│   72 (57%)    pap smears             │
│   14 (9%)     HPV DNA tests          │
└─────────────────────────────────────┘
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FIG 4. Diagram showing the number of breast and cervical cancer screening tests indicated and performed and reasons for no screening among women using Ámate in Cali, Colombia. †There were 36 patients with double screening test indication. ‡Eight women had both screening tests performed. DNA, deoxyribonucleic acid; HPV, human papilloma virus; PCP, primary care physician.

In conclusion, mApps are promising and accessible tools that can reach women from different locations, help to understand misconceptions about BC and CC, identify women at risk for these conditions, and aid in navigating women to complete cancer screening tests. Ámate mApp is currently being tested in other areas of Colombia and may be useful in other underserved communities.

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Manuscript writing: All authors
Final approval of manuscript: All authors
Accountable for all aspects of the work: All authors

REFERENCES

1. World Health Organization: Cancer country profiles, 2020

2. World Health Organization International Agency for Research on Cancer (IARC). GLOBOCAN 2018: population fact sheet, 2018

3. Franceschi S, Wild CP: Meeting the global demands of epidemiologic transition—The indispensable role of cancer prevention. Mol Oncol 7:1-13, 2013

4. Smith RA, Andrews KS, Brooks D, et al: Cancer screening in the United States, 2017: A review of current American Cancer Society guidelines and current issues in cancer screening. CA Cancer J Clin 67:100-121, 2017

5. Sardi A, Orozco-Urdaneta M, Velez-Mejia C, et al: Overcoming barriers in the implementation of programs for breast and cervical cancers in Cali, Colombia: A pilot model. J Glob Oncol 5:1-9, 2019

6. Bermedo-Carrasco S, Pena-Sanchez JN, Lepnurm R, et al: Inequities in cervical cancer screening among Colombian women: A multilevel analysis of a nationwide survey. Cancer Epidemiol 39:229-236, 2015

7. de Vries E, Arroyave I, Pardo C, et al: Trends in inequalities in premature cancer mortality by educational level in Colombia, 1998-2007. J Epidemiol Community Health 69:408-415, 2015

8. Ginsburg OM: Breast and cervical cancer control in low and middle-income countries: Human rights meet sound health policy. J Cancer Policy 1:e35-e41, 2013

9. Murillo R, Wiesner C, Cendales R, et al: Comprehensive evaluation of cervical cancer screening programs: The case of Colombia. Salud Publica Mex 53: 469-477, 2011

10. PiñerosM, CendalesR, MurilloR, et al: Cobertura de la Citología de Cuello Uterino y Factores Relacionados en Colombia, 2005 [in Spanish]. Revista de Salud Pública 9:327-341, 2007

11. Angarita FA, Acuña SA, Tawil M, et al: Uso de la mamografía de tamizaje en las pacientes con diagnóstico con cáncer de seno en el Hospital Universitario San Ignacio, Centro Javeriano de Oncología [in Spanish]. Universitas Médica 51:155-166, 2010

12. Socio-economic impact of mHealth: An assessment report for the European Union, 2013

13. West DM: How Mobile Devices Are Transforming Healthcare, Issues in Technology Innovation. Washington, DC, Center for Technology Innovation at the Brookings Institution, 2012

14. Meloan M, Castells P: Country overview: Colombia. Mobile industry collaborating with government to promote entrepreneurship and innovation, 2017

15. Newzoo global mobile market report 2018llight version, 2018

16. Colombia, Ministerio de Salud y Protección Social: Guía de Práctica Clínica para tratamiento integral, seguimiento y rehabilitación del cáncer de mama. 2da edición. Guía No 19 [GPC en internet]. Bogotá D.C., Colombia, El Ministerio, 2017. gpc.mimsalud.gov.co

17. Ministerio de Salud y Protección Social: Guía de Práctica Clínica para la detección y manejo de lesiones precancerosas de cuello uterino. Guía para profesionales. Bogotá D.C., Colombia, Ministerio de Salud y Protección Social, 2014

18. Broderick J, Devine T, Langhans E, et al: Designing Health Literate Mobile Apps. NAM Perspectives. Washington, DC, National Academy of Medicine, 2014

19. Zhang D, Advani S, Waller J, et al: Mobile technologies and cervical cancer screening in low- and middle-income countries: A systematic review. JCO Glob Oncol 6:617-627, 2020

20. DiCarlo JM, Gopakumar S, Dhillon PK, et al: Adoption of information and communication technologies for early detection of breast and cervical cancers in low- and middle-income countries. J Glob Oncol 2:222-234, 2016

21. Kao CK, Liebovitz DM: Consumer mobile health apps: Current state, barriers, and future directions. PM R 9:S106-S115, 2017

22. Bates DW, Landman A, Levine DM: Health apps and health policy: What is needed? JAMA 320:1975-1976, 2018

23. Fundación para Prevención y Tratamiento del Cáncer: ÁmatelCuida tu salud. Google Play, 2017

24. Google: Privacy and device abuse

25. Congreso de la República de Colombia: Ley Estatutaria 1581 de 2012: "Por la cual se dictan disposiciones generales para la protección de datos personales". Diario Oficial No. 48.587

26. Lee HY, Lee MH, Gao Z, et al: Development and evaluation of culturally and linguistically tailored mobile app to promote breast cancer screening. J Clin Med 7: 181, 2018

27. Farha M, Hill MA, Rosendall K, et al: mHealth for breast cancer patient navigation: What patients want—What clinicians need. J Clin Oncol 38:e19244, 2020

28. Potdar R, Thomas A, DiMeglio M, et al: Access to internet, smartphone usage, and acceptability of mobile health technology among cancer patients. Support Care Cancer 28:5455-5461, 2020

29. Girault A, Ferrua M, Lalloue B, et al: Internet-based technologies to improve cancer care coordination: Current use and attitudes among cancer patients. Eur J Cancer 51:551-557, 2015

30. Giunti G, Giunta DH, Guisado-Fernandez E, et al: A biopsy of breast cancer mobile applications: State of the practice review. Int J Med Inform 110:1-9, 2018

31. Ginossar T, Shah SF, West AJ, et al: Content, usability, and utilization of plain language in breast cancer mobile phone apps: A systematic analysis. JMIR Mhealth Uhealth 5:e20, 2017

32. Arroyave I, Cardona D, Burdorf A, et al: The impact of increasing health insurance coverage on disparities in mortality: Health care reform in Colombia, 1998-2007. Am J Public Health 103:e100-e106, 2013

33. Falk D: A mixed methods review of education and patient navigation interventions to increase breast and cervical cancer screening for rural women. Soc Work Public Health 33:173-186, 2018

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

Mobile Applications: Breaking Barriers to Early Breast and Cervical Cancer Detection in Underserved Communities

The following represents disclosure information provided by authors of this manuscript. All relationships are considered compensated unless otherwise noted. Relationships are self-held unless noted. I = Immediate Family Member, Inst = My Institution. Relationships may not relate to the subject matter of this manuscript. For more information about ASCO's conflict of interest policy, please refer to www.asco.org/rwc or ascopubs.org/op/authors/author-center.
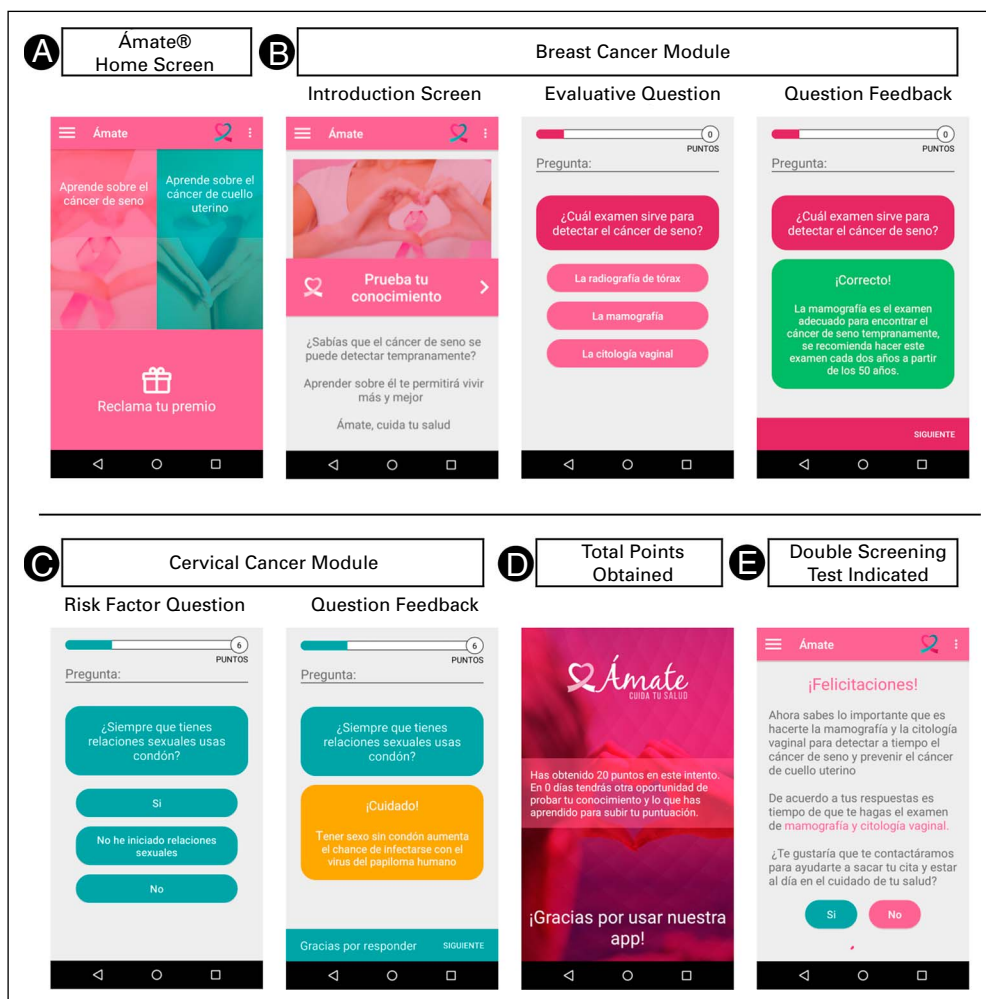
Open Payments is a public database containing information reported by companies about payments made to US-licensed physicians (Open Payments).

Armando Sardi
Stock and Other Ownership Interests: Celgene

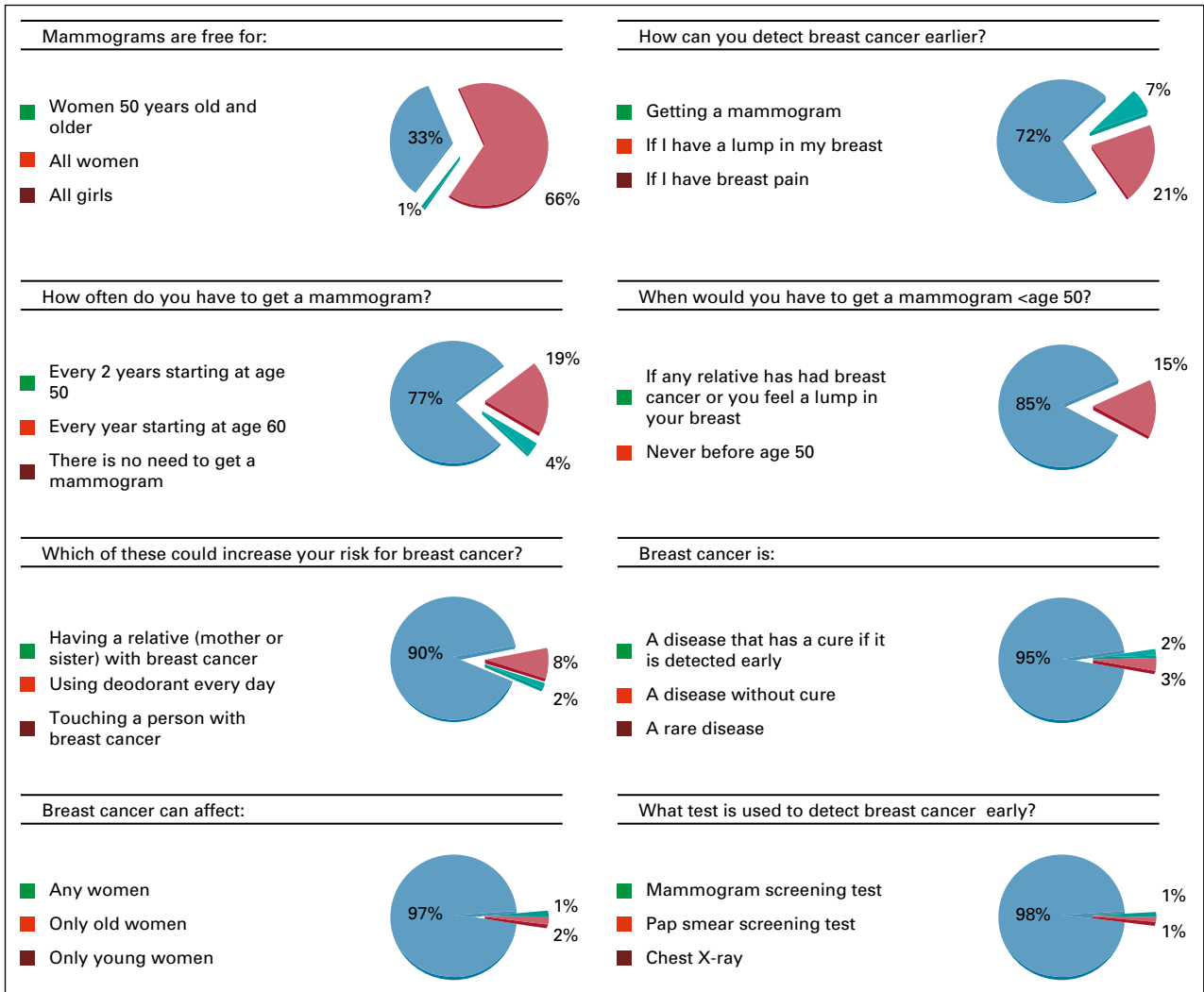No other potential conflicts of interest were reported.

APPENDIX

FIG A1 Ámate Design Screenshots and Functioning Scheme. Ámate has content about breast and cervical cancer written in Spanish in an interactive user-friendly design. The home screen (A) consists of two modules, one for breast (B) and one for cervical cancer (C), and a reward section. Each module has 20-25 questions, each with a brief feedback to teach the correct answer. There are three types of questions: educational, evaluative, and risk factor questions. Evaluative questions randomly assess information from the educational questions and awards points for correct answers (D). Points are used to assess the user's level of knowledge, encourage continued learning about breast and cervical cancers to promote women empowerment for better health, and can be redeemed for cellular data. Finally, after the user completed each module, an algorithm identifies users in need of a screening test on the basis of the answers from the risk factor questions. A message is generated with a screening indication should the user meet requirements for the test (E).

FIG A2. Ámate's administrative web page. The left menu (A) presents options to visualize in the right area (B) to list all users, customize questions, download the database, obtain descriptive statistics, add new locations (eg, towns, counties, and cities), and create reward codes (C). There are also two buttons that allow filtering users on the basis of the type of screening indication (D). The filter view allows further classification of users into five categories (E) that include waiting for screening classification (gray tab), without screening indication (red tab), excluded for screening (yellow tab), in screening process (blue tab), and screened (green tab). When a category is selected, users' information is presented with colored icons that allow for better and faster status visualization (F). In this view, patient screening status can be modified and reasons for staying on the waiting list or being excluded can be recorded and tracked throughout the time.

Mammograms are free for:

- Women 50 years old and older
- All women
- All girls

33% | 1% | 66%

How can you detect breast cancer earlier?

- Getting a mammogram
- If I have a lump in my breast
- If I have breast pain

7% | 72% | 21%

How often do you have to get a mammogram?

- Every 2 years starting at age 50
- Every year starting at age 60
- There is no need to get a mammogram

19% | 77% | 4%

When would you have to get a mammogram <age 50?

- If any relative has had breast cancer or you feel a lump in your breast
- Never before age 50

15% | 85%

Which of these could increase your risk for breast cancer?

- Having a relative (mother or sister) with breast cancer
- Using deodorant every day
- Touching a person with breast cancer

90% | 8% | 2%

Breast cancer is:

- A disease that has a cure if it is detected early
- A disease without cure
- A rare disease

95% | 2% | 3%

Breast cancer can affect:

- Any women
- Only old women
- Only young women

97% | 1% | 2%

What test is used to detect breast cancer early?

- Mammogram screening test
- Pap smear screening test
- Chest X-ray

98% | 1% | 1%

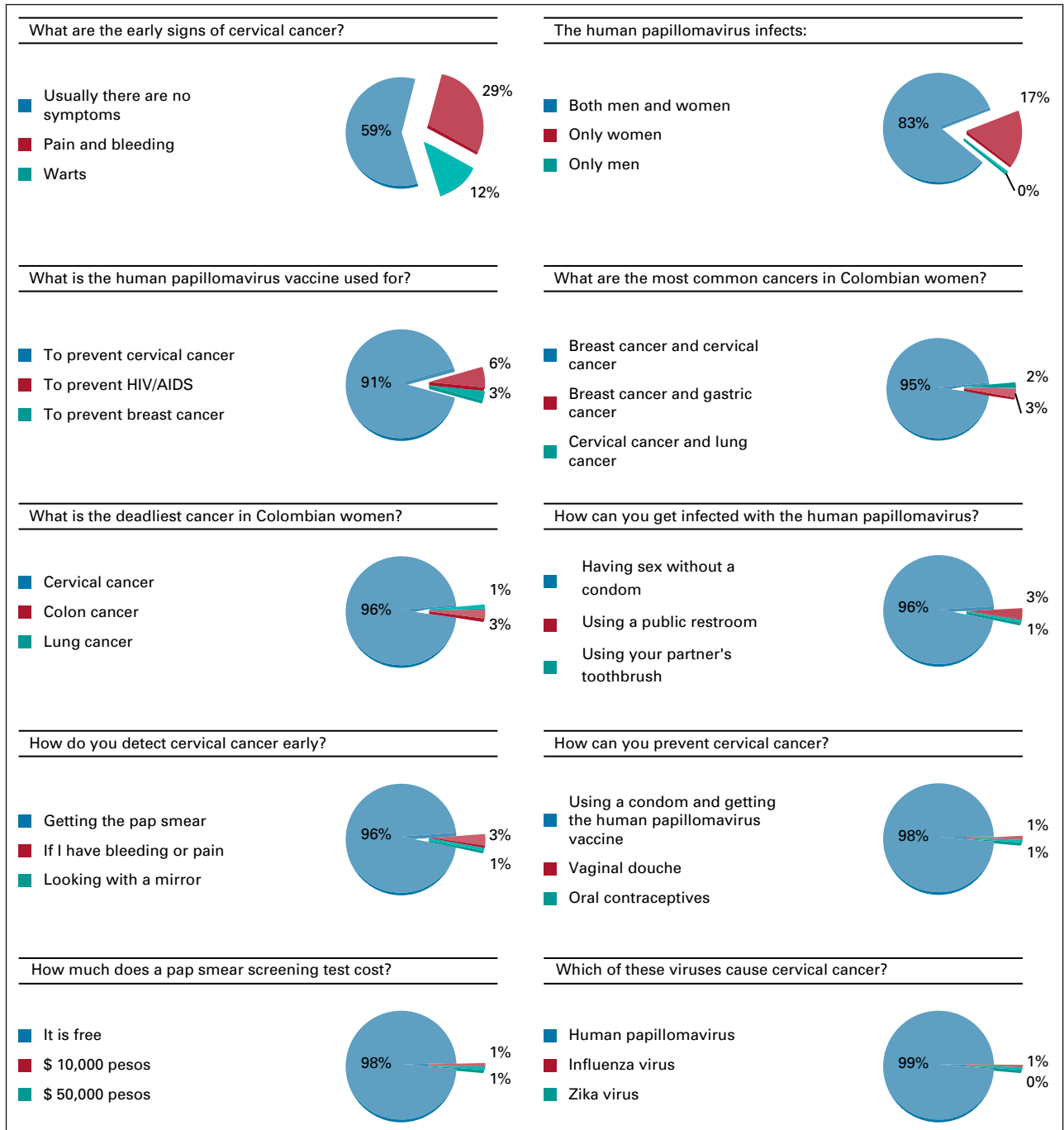**FIG A3.** Breast cancer knowledge of women using Ámate in Cali, Colombia.

FIG A4. Cervical cancer knowledge of women using Ámate in Cali, Colombia.