

Digital and Remote Care among 71,619 Individuals Seeking COVID-19 Health Information and Services: A Retrospective Cohort Study

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Abstract

Background: Patient-facing digital-health tools have been promoted for managing COVID-19 related concerns, and for remote and self-care during the COVID-19 pandemic. It has also been suggested these tools may help further our understanding of the clinical characteristics of this new disease. However, there is limited information on the characteristics and patterns of use of these tools in practice.

Objective: To describe the characteristics of people using digital-health tools for COVID-19, explore self-reported symptoms and characterize those associated with COVID-19, and characterize the recommendations provided by digital-health tools.

Methods: This study used data from three digital health tools on the K-health app: a protocol based COVID-19 self-assessment, an AI-driven symptom checker, and communication with remote physicians. Deidentified data were extracted on demographic and clinical characteristics of adults seeking COVID-19 related health information between April 8th and June 20th, 2020. Analyses included exploring features associated with COVID-19 positivity, and features associated with the use of choosing to communicate with a remote physician.

Results: During the period assessed, 71,619 individuals completed the COVID-19 self-assessment, 41,425 also used the AI-driven symptom checker, and 2,485 consulted with remote physicians. Individuals using the COVID-19 self-assessment were predominantly female (72.4%), with a mean age of 34.5 (± 13.9) years. Testing for COVID-19 was reported by 2,901 users, of whom 433 (14.9%) reported testing positive. COVID-19 positive users were more likely to have reported loss of smell or taste (RR 6.66, 95% CI 5.53-7.94) and other established COVID-19 symptoms, as well as ocular symptoms. Users communicating with a remote physician were more likely to have been recommended to refer to immediate medical evaluation by the self-assessment due to the presence of severe symptoms (RR 1.19, 95% CI 1.02-1.32). Most consultations with remote physicians (76.9%) were resolved without need for referral to an in-person visit or to the emergency room.

Conclusions: These results suggest that digital-health tools can help support remote- and self-management of COVID-19, and that self-reported symptoms from digital interactions can extend our understanding of symptoms associated with COVID-19.

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Original Manuscript



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Abstract

Background: Patient-facing digital-health tools have been promoted for managing COVID-19 related concerns, and for remote and self-care during the COVID-19 pandemic. It has also been suggested these tools may help further our understanding of the clinical characteristics of this new disease. However, there is limited information on the characteristics and patterns of use of these tools in practice.

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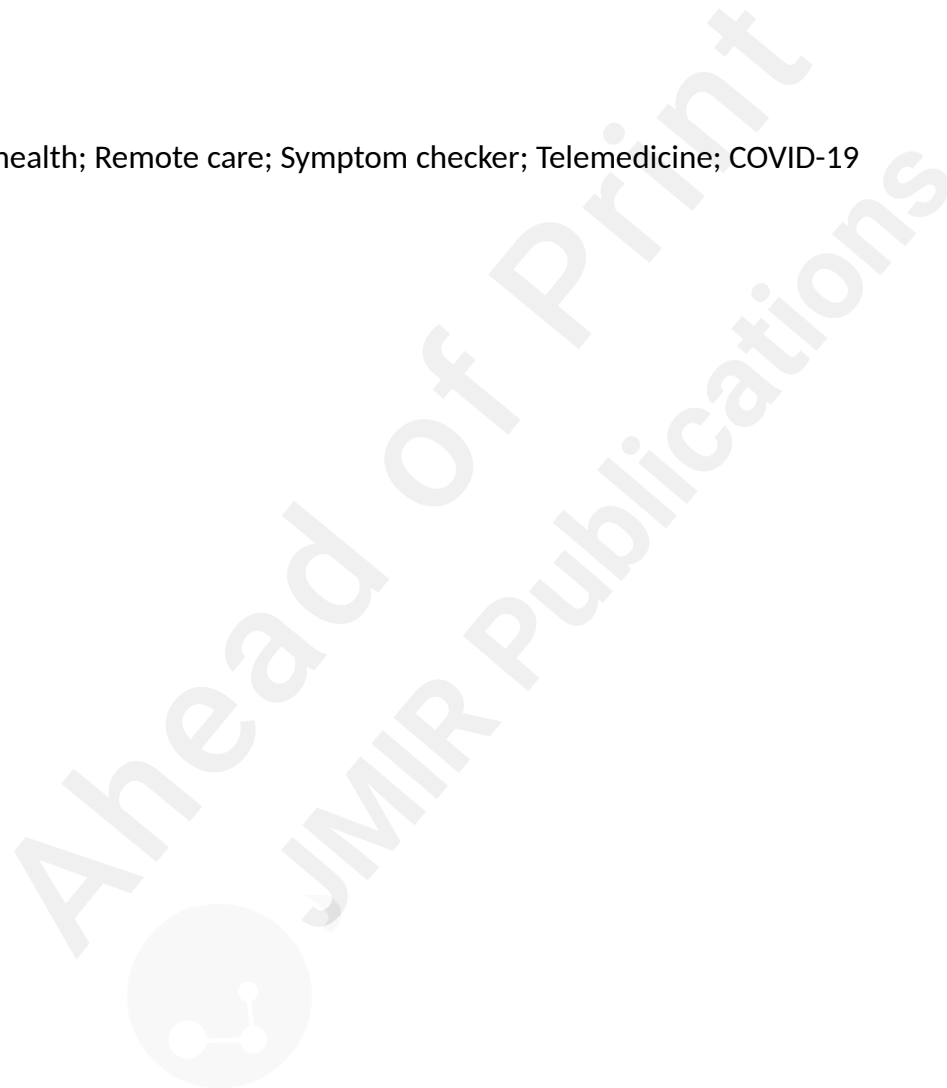
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of severe symptoms (RR 1.19, 95% CI 1.02-1.32). Most consultations with remote physicians (76.9%) were resolved without need for referral to an in-person visit or to the emergency room.

Conclusion: These results suggest that digital-health tools can help support remote- and self-management of COVID-19, and that self-reported symptoms from digital interactions can extend our understanding of symptoms associated with COVID-19.

Keywords: Digital health; Remote care; Symptom checker; Telemedicine; COVID-19



Introduction

Contemporary healthcare has limited capacity for managing epidemics. It is structured on the model of in-person interactions between patients and clinicians, resulting in the congregation of patients in emergency departments and waiting areas during crises.[1] During the COVID-19 pandemic, it has been suggested that digital technologies can deliver rapid urgent assessments, management of non-urgent conditions, and reduce the risk of iatrogenic COVID-19 exposure.[1–3] Indeed, several medical associations have encouraged the use of these tools during the COVID-19 epidemic, including the American Medical Association and the American Academy for Family Physicians.[4,5] Moreover, it has been suggested, that these technologies can provide novel insights regarding the epidemiology and clinical characteristics of this new disease,[6] especially in early stages and in community settings, as most published studies focus on hospitalized patients[7].

Digital tools have been promoted and deployed in previous infectious disease outbreaks, such as SARS and Ebola.[8,9] These tools focused primarily on surveillance, contact tracing, case management, and lab result management.[10] In recent years a wide range of patient-facing digital health modalities have emerged. These include protocol-based triage tools, AI-driven tools for diagnosis and self-assessment, utilization of at-home remote monitoring devices, and virtual consultations by remote physicians. These tools are rapidly being deployed to support the medical management of the current epidemic.[2] However, despite the rapid growth in patient-facing digital and AI-driven technologies, other than reports of user satisfaction,[11–13] there is limited data on the usage patterns and characteristics of these technologies in the management of COVID-19, and of their utility for advancing clinical research of COVID-19. Examining digital technology users' characteristics and symptoms can help identify novel features associated with positivity and/or

severity of COVID-19 and advance our understanding of the disease. Analysis of use patterns of digital tools can provide insight regarding their utility in the management of COVID-19 as well as highlight opportunities for further development.

During the pandemic, K Health, a novel AI-driven digital health platform deployed in the U.S.,[14] offered three tools: a protocol based COVID-19 self-assessment tool, an AI-driven symptom-checker, and a text-based telemedicine visit. This study aims to further our understanding of the use of digital health technologies in the management and research of COVID-19. Specifically, the study describes the demographic and clinical characteristics of people using digital health tools for COVID-19 related concerns, explores self-reported symptom patterns among digital health users with COVID-19 compared to those without, and characterizes the information and management recommendations provided by different digital health tools.

Methods

Population and settings

K Health is a novel AI-driven digital health app, that at the time this manuscript was written is available for download in the U.S., Mexico, Indonesia, and Israel.[14] The app was built using a data-driven approach in collaboration with Maccabi Health Services (MHS) - the second largest health maintenance organization (HMO) in Israel, with over 2 million members.[15,16] The data from MHS health-records were used to develop an AI-driven symptom-checker, whose methodology has been described elsewhere K Health app was launched in the U.S. in 2018 and has been used by over 4 million adults. [14] The app is free for download and the symptom-checker is available for free to adults over 18 years old, providing the public with reliable and personalized information on diagnoses related to their symptoms and medical history.

K Health began offering a service which allows users to consult directly with a remote physician in June 2019. The platform allows users the option to receive a diagnosis, prescriptions, lab referrals, referral to remote management of mental health concerns, or referral to primary or emergency care. Consulting with a remote physician involves a fee or enrollment in a relevant health plan.

Early in April 2020, a protocol based COVID-19 self-assessment was added to the app, to provide users with up-to-date guidance for managing suspected cases of COVID-19. The self-assessment was developed by a team of board-certified physicians, and based on guidance issued by the WHO and the CDC.[17,18] It asked the user to report on the presence and severity of COVID-related symptoms, as well as the presence of concomitant conditions known to increase risk of severe disease. Following the self-assessment, users were provided with one of four recommended actions based on their risk profile: social distancing, quarantine, isolation, and seek immediate medical evaluation. Users were also informed if they were at increased risk for COVID-19 complications; and users with risk factors and symptoms were encouraged to consult a physician. For further details including the full questionnaire see appendix.

Design

This study describes use of three digital tools, a protocol based COVID-19 self-assessment tool, an AI-driven symptom-checker, and communication with a remote physician, by adults (>18 years of age) seeking COVID-19 related health information and services during the 10-week period between the launch date of April 8th to the date of data extraction on June 20th, 2020. Seeking COVID-19 related health information was defined as use of the COVID-19 self-assessment tool. This self-assessment tool can be activated by the user, and is also activated automatically when users begin a symptom-checker with a complaint of cough, dyspnea, or fever. The study did not include repeated

self-assessments.

Following using the COVID-19 self-assessment, users are prompted to use the AI-driven symptom-checker to receive additional information about other conditions potentially related to their symptoms. After receiving the results and information regarding these conditions, users can choose to communicate with a remote physician for definitive medical management.

This study analyzed de-identified data. The study's protocol was reviewed by Western IRB and qualified for exemption in accordance with 45 CFR § 46.104(d)(4). K-Health is a HIPAA and GDPR compliant health service. Encrypted transportation and storage is used at all stages of data management.

Variables

De-identified data on the characteristics of digital interactions in the app were collected, including:

1. User inputted demographic and clinical characteristics, COVID-19 exposure reporting, report of COVID-19 testing including results, and symptoms.
2. The output provided by the three digital modalities: risk categories according to the protocol-based COVID-19 self-assessment, the most common conditions for similar people and symptoms ("potential diagnoses") provided by the AI-driven symptom-checker, and diagnoses, management, and disposition by the remote physicians.

User characteristics included age, sex, risk factors and comorbidities. Comorbidities included hypertension, smoking, obesity, diabetes (type 1 and type 2), cardiovascular disease, chronic lung disease (asthma, COPD, and interstitial lung disease), chronic renal and liver disease, cancer, and immune suppression.

Symptoms were obtained from two types of interactions on the platform. First, as part of the structured protocol-based COVID-19 risk-assessment. Second, as part of the dynamic AI-driven health-dialog.

The COVID-19 self-assessment included questions regarding symptoms known to be associated with COVID-19 (such as cough, dyspnea, fever), as well as symptoms hypothesized to be related and which were inquired about for further research and development of the COVID-19 protocol (such as eye symptoms). The symptom-checker dialog allows the user to spontaneously discuss a wider array of 331 symptoms, and queries the user regarding additional symptoms, and symptom specific attributes - such as the severity, timing, duration, and quality of a symptom (e.g. "dry" or "productive" cough), as previously described.⁶

Analysis

Analyses assessed user characteristics, symptoms reported, and the output of the aforementioned digital services: 1. self-assessment protocol, 2. AI and data-driven symptom-checker, and 3. remote physician consultation. This was done using descriptive statistics and bivariate analyses.

Descriptive univariate summary statistics were developed to assess user characteristics, symptoms reported, diagnoses, and dispositions. Symptoms were described both for the COVID-19 self-assessment, and for the symptom-checker. Bivariate analyses were conducted for between-group comparisons of characteristics and symptoms. These included two primary analyses:

1. The first analysis explored the potential utility of self-reported data from digital health tools to identify symptoms associated with COVID-19. This analysis compared self-reported symptoms among digital health users who reported testing positive for COVID-19, compared to those who reported testing negative. In order to ensure the symptoms of cough, fever,

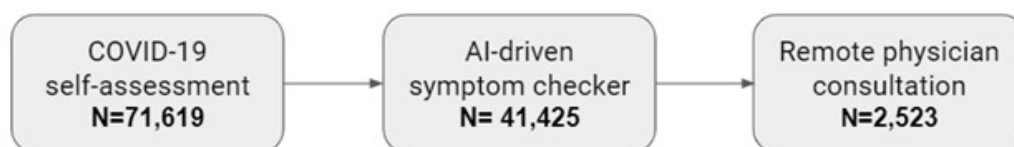
and dyspnea were optimally captured, the presence of these symptoms was collected both from the self-assessment as well as from the symptom-checker dialog. See appendix for details.

2. The second aimed at identifying predictors related to choosing to consult with a remote physician. This analysis compared Individuals who opted to consult with a remote physician and those of the entire cohort. Specifically, this comparison aimed to evaluate whether consultation with a physician was related to risk of COVID-19, symptom severity, or comorbidity.

Appropriate statistical tests were used to assess the significance of between-group differences - Chi-square tests for differences in proportions, t-tests for differences in continuous measures. Test assumptions were assessed analytically and graphically and judged to be adequately met. We considered p values of 0.05 or less to be significant and did not correct for multiple comparisons. Analyses were conducted using Python version 3.6.9.

Results

During the time-frame assessed, 71,619 individuals completed the COVID-19 self-assessment. The self-assessment included questions on COVID-19 exposure, testing, comorbid conditions, and the presence of a COVID-19-related symptoms. The self-assessment output, provided users with protocol-based information and recommendations on their COVID-19 risk. Of the individuals completing the self-assessment, 41,425 also completed a more detailed AI-driven symptom-checker. The symptom-checker provides the option to evaluate a wide range of 331 symptoms, and to receive information about non-COVID-19 conditions which may be related to these symptoms. Following use of the symptom-checker, a subset of 2,523 proceeded to consult with remote physicians who provided guidance on their disposition and management. (Figure 1).

Figure 1 - Study Flow-Chart

Flow-chart describes cohort of U.S. individuals using the COVID-19 self-assessment between April 8th - June 20th, 2020

Individuals using the COVID-19 self-assessment were predominantly female (72.4%), with a mean age of 34.5 (± 13.9) years. The most commonly reported comorbidities were chronic lung disease (primarily asthma) and hypertension, each reported by one in five individuals (Table 1). The self-assessment results provided users with information and recommendations related to their risk of COVID-19, with the most common recommendations involving social distancing (29.3%) and isolation 33.3%) (Table 2).

Table 1: Cohort characteristics of COVID-19 self-assessment users (n=71,619)

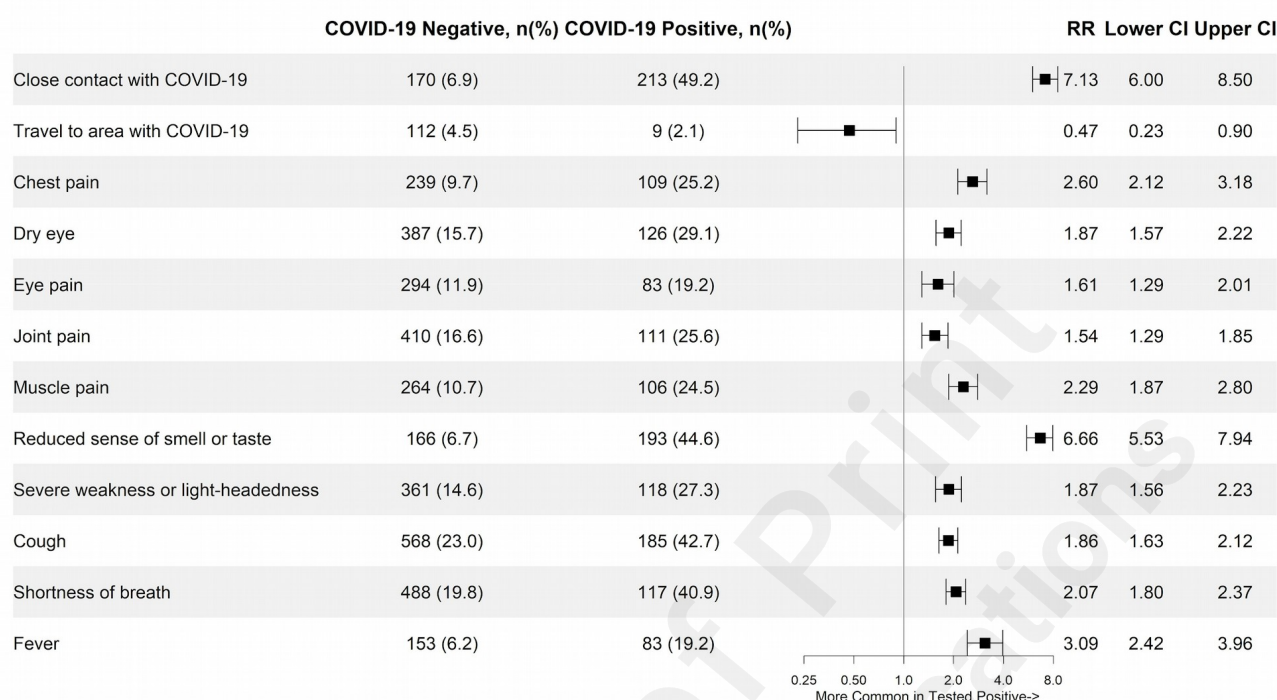
		Value ^a
Demographics		
	Age, mean (SD)	34.5 (13.9)
	Female	51,845 (72.4)
Chronic Conditions		
	Hypertension	13,952 (19.5)
	Morbid obesity	7,676 (10.7)
	Smoking	13,505 (18.9)
	Stroke	897 (1.3)
	Cancer/Immuno suppressed	1,868 (2.6)
	Chronic kidney disease	1,313 (1.8)
	Chronic lung disease	16,080 (22.5)
	Cardiovascular disease	3,835 (5.4)
	Diabetes	5,958 (8.3)
Tested for COVID-19 (n=2,901)		
	Tested, positive	433(14.9)
	Tested, negative	2,468(85.0)

^a *Values are presented as n (%) unless otherwise indicated.*

Testing for COVID-19 was reported by 2,901 users, of whom 433 (14.9%) reported testing positive. Users tested for COVID-19 were predominantly female (69.7%), with a mean age of 38.1 (\pm 13.8) years. Of those tested, those reporting testing positive were of similar age (37.5 ± 13.8 vs. 38.2 ± 13.8 , p -value=0.320), less often female (62.4% vs. 69.9%) and much more likely to have reported a close contact with known COVID-19 (RR 7.13, 95% CI 6.00-8.49), compared to those who tested negative. The symptoms reported by users as part of the COVID-19 self-assessment, differed between those reporting positive and negative test results. Most notably, the relative prevalence of reporting loss of smell or taste was significantly higher among COVID-19 positive individuals (RR 6.65, 95% CI 5.53-7.94), as was fever (RR 2.58, 95% CI 2.04-3.26), and chest pain (RR 2.59, 95% CI 2.12-3.18). Cough, difficulty eating or drinking, dry eye, eye pain, feeling weak and lightheaded, and chest pain, were significantly associated with COVID-19 positivity as well (Figure 2).

Figure 2

Relative rate of characteristics among individuals tested positive VS negative for COVID-19



Fore

st plot presents the relative rate and 95% confidence interval of each item in the self-assessment questionnaire among users reporting testing positive for COVID-19 compared to those testing negative. Users could report cough, fever, and shortness of breath at the end of the self-assessment or as part of the symptom-checker dialog. See appendix for details. Muscle pain was not present in early versions of the self-assessment. Proportions were calculated for self-assessments where this symptom was reportable.

Abbreviations: RR - relative rate, CI - confidence interval

Individuals using the COVID-19 self-assessment were prompted to use the AI-driven symptom-checker to receive additional information about other conditions potentially related to their symptoms. This tool includes the possibility to input a wide range of symptoms which is not systematically collected as part of the COVID-19 self-assessment and thus recorded a wide range of additional symptoms which had not already been included in the protocol based self-assessment. Among these, the top additional symptoms reported by COVID-19 positive individuals were headache, sore throat, fatigue, diarrhea, chest pain, nausea, nasal congestion, runny nose and

sweating (Supplementary Table 1). The AI-driven algorithm provided users with information about the most common conditions people like them were diagnosed with (“potential diagnoses”), based on their symptoms and personal characteristics. The most common non-COVID-19 conditions classified as relevant for users were Upper respiratory infection (36.7%), anxiety disorder (5.9%), gastroesophageal reflux disease (GERD) (5%) and dehydration (3.6%) (Table 2).

Table 2. Output provided by digital health tools

COVID-19 assessment disposition N=71,619		
	Practice social distancing	20,984(29.3%)
	Isolate yourself	23,706(33.1%)
	Quarantine yourself	7,735(10.8%)
	Seek immediate evaluation	19,194(26.8%)
Symptom checker potential diagnosis (top 10) (n=41,425)		
	Upper Respiratory Infection	15,232(36.7%)
	Anxiety Disorder	2,457(5.9%)
	Gastroesophageal Disease (GERD)	Reflux 2,075(5.0%)

	Dehydration	1,512(3.6%)
	Tension-type Headache	1,152(2.8%)
	Allergic Rhinitis	957(2.3%)
	Depressive Mood Disorder	833(2.0%)
	Pulmonary Embolism	783(1.9%)
	Pneumonia	721(1.7%)
	Acute Food Poisoning	708(1.7%)
Remote physician management and disposition* (n=2,523)		
	Medications or lab tests	1,072(42.5%)
	Information and Reassurance	431(17.1%)
	Others	363(14.4%)
	Referred to primary care or specialist	325(12.9%)
	Referred to ER	257(10.2%)

	Referred to Covid-19 test	169(6.7%)
	Referral to remote behavioral health service	73(2.9%)

**Dispositions are not mutually exclusive*

Among individuals initially evaluating their COVID-19 risk, a small subset (N=2,523, 3.5%) chose to communicate with a remote physician. Those choosing to communicate with a remote physician were older (34.3 ± 13.9 vs 38.6 ± 13.2 , $p < .001$) and more likely to be male compared to those who did not (37.9% vs 27.2%, $p < .001$), but less likely to have comorbidity (RR 0.88, 95% CI 0.82-0.95). These individuals were more likely to report severe symptoms such as severe chest pain (RR 1.13, 95% CI 1.03-1.25) and encouraged by the self-assessment to seek immediate evaluation (RR 1.19, 95% CI 1.02-1.32). Additionally, features and symptoms supporting higher suspicion of COVID-19 were also more common among those communicating with a remote physician. These included exposure to a close contact with COVID-19 (RR 1.21, 95% CI 1.1-1.35), fever (RR 1.56, 95% CI 1.43-1.72), shortness of breath (RR 1.25, 95% CI 1.16-1.33), and loss of smell and taste (RR 1.22, 95% CI (1.09 -1.37), among others (Table 3).

The remote physicians provided a wide range of evaluation and counseling, including assessment and referral of severe cases to the emergency room (10.2%) or to ambulatory care in the community (12.9%), advising on and prescribing medications (42.5%), providing remote behavioral health services to individuals with mild to moderate anxiety or depression (2.9%), providing additional information and reassurance (17.1%), and referral to COVID-19 testing (6.7%) (Table 2).

Table 3. Users characteristics and self-assessment protocol answers associated with consulting with a remote physician

		Consulted with remote physician NO N=69,096 ^a	Consulted with remote physician YES N=2,523 ^a	RR (95% CI)
Self-assessment items				
	Close contact	7431 (10.8)	331 (13.1)	1.21 (1.10-1.35)
	Travel	1908 (2.8)	59 (2.3)	0.82 (0.66-1.09)
	Eye pain	6257 (9.1)	218 (8.6)	0.95 (0.84-1.09)
	Dry eye	7242 (10.5)	269 (10.6)	1.02 (0.93-1.17)
	Joint pain	61741 (89.4)	2271 (90.0)	1.01 (0.83-1.06)
	Smell taste	6051 (8.8)	270 (10.7)	1.22 (1.09-1.37)
	Weak/light-headed	11101 (16.1)	462 (18.3)	1.14 (1.05-1.24)
	Chest pain	8279 (12.0)	343 (13.6)	1.13 (1.03-

				1.26)
	Muscle pain	7643 (11.1)	289 (11.5)	1.04 (0.93-1.16)
	Cough ^b	21832 (31.60)	859 (34.05)	1.07 (1.02-1.14)
	Shortness of breath ^b	14424 (20.8)	656 (26.0)	1.25 (1.16-1.33)
	Fever, ^b n (%)	7147 (10.34)	409 (16.21)	1.57 (1.43-1.72)
	Testing for COVID-19	660 (1.0)	34 (1.3)	1.30 (1.00-2.00)
Disposition of self assessment				
	Practice social distancing	17827(25.8)	777 (30.8)	1.19 (1.15-1.13)
	Isolate yourself	24118 (34.9)	781 (30.9)	0.89 (0.67-0.96)
	Quarantine yourself	9016 (13.1)	176 (6.9)	0.53 (0.34-0.65)
	Seek immediate	18135 (26.3)	789 (31.3)	1.19 (1.02-

	evaluation			1.32)
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^a Values are presented as n (%).

^b Users could report these symptoms at the end of the self-assessment or as part of the symptom-checker dialog. See appendix for details

Discussion

Principle findings & interpretation

This study describes the characteristics and management of over 71,000 individuals seeking health information and services related to COVID-19 using digital tools. These individuals were relatively young and predominantly female. Users received information regarding COVID-19 risk and management, AI-driven information about other relevant diagnoses, and consulted with remote physicians. Users choosing to communicate with a remote physician were more likely to have been classified as requiring immediate medical evaluation by the COVID-19 self-assessment. Correspondingly, these users were also older, more likely to report severe symptoms, and more likely to report characteristics cognate with risk of COVID-19 (such as known exposure to COVID-19 and loss of sense of smell or taste). The majority of consultations with a remote physician (76.9%) were resolved without need for referral to an in-person health visit or to the emergency room.

Taken together, the differential communication with remote physicians according to severity, and the high resolution rates without need for referral to in-person visits, suggest that the digital tools provided information and advice which assisted users in their health decisions. These tools may therefore reduce the burden on healthcare during times of limited resources, and help in minimizing unnecessary physical interactions which could lead to iatrogenic COVID-19 exposure.

However, research on healthcare utilization and health outcomes following digital health use is needed to conclusively demonstrate this potential.

In addition, individuals choosing to communicate with a remote physician tended to have somewhat lower rates of comorbidity. This may suggest these individuals were more likely to have an established relationship with a healthcare provider with whom they consult regularly, and that these individuals may be more likely to require an in-person evaluation and more complex care when presenting with significant symptoms.

This study also highlighted differences in self-reported symptoms between users reporting testing positive for COVID-19 and those testing negative. The symptom most strongly associated with positive testing for COVID-19 compared was loss of sense of taste or smell (RR 6.66, 95% CI 5.53-7.93). Surprisingly, travel to an area with COVID-19 appeared to be associated with a lower rate of positive testing (RR 0.47, 95% CI 0.23 - 0.90), however this estimate is based on a relatively small number of subjects and should therefore be interpreted with caution. As the decision to test or be tested is driven by the presence of risk factors for COVID-19, travel to an area with COVID-19 could appear protective as individuals tested due to this risk factor may be less likely to have other stronger predictors of positivity - such as exposure to an individual with COVID-19 and/or the presence of COVID-19 symptoms. Additional features associated with COVID-19 included other widely recognized COVID-19 symptoms, including fever and cough. These results emphasize the potential utility of taste and smell as a strong signal of COVID-19 positivity in the community setting, and are similar to those reported in recent studies of self-reported symptoms among COVID-19 positive individuals.[19,20]

Lastly the study found dry eye (RR 1.87, 95% CI 1.57-2.22) and eye pain (RR 1.61, 95% CI 1.29-2.01)

were more common among individuals reporting testing COVID-19 positive. These symptoms were added to the self-assessment to explore the possible link between COVID-19 and eye symptoms, and the utility of such symptoms in evaluating suspicion of COVID-19. While some hospital-based early studies have reported low rates of ocular symptoms in COVID-19,[20] several other studies have suggested that ocular symptoms are common among individuals with COVID-19[21-23]. Ocular symptoms have been documented in some cases as the first[24] and even only[25] symptomatic manifestation of COVID-19, and studies have documented RT-PCR COVID-19 positive results from ocular secretions.[23,26] This study adds to the body of evidence suggesting manifestations of COVID-19 include ocular symptoms, and that these may be a more common symptom of COVID-19 than generally recognized.

Seen from a wider perspective, these results demonstrate that self-reported symptoms on a digital app can replicate symptoms known to be associated with COVID-19, that they can help distinguish between COVID-19 positive and negative individuals, and that they may add to our understanding of symptoms associated with COVID-19. This exemplifies the potential of data generated from digital tools to improve our understanding of the clinical manifestations COVID-19, and of patient reported experiences in general.

Comparison with Prior Work

The potential benefits of digital tools during the COVID-19 epidemic have been noted in multiple health policy commentaries.[1-3,19,27] This stance has been adopted by several leading medical associations, including the American Medical Association, and the American Academy for Family Physicians.[4,5] However, to-date there is limited research on the actual usage patterns and impact of these tools during the COVID-19 epidemic. The body of literature on digital health for COVID-19 primarily features perspectives and opinion pieces, guidance papers, and a few studies. These tend

to be small, focus on a single digital tool, and/or report primarily on survey results of user satisfaction. Two larger studies provide some additional insight. The first reported on results of a satisfaction survey among 6,194 people following wide-scale deployment of digital tools for COVID-19 education, self-assessment, and symptom monitoring in the Netherlands, and reported high satisfaction rates.[11] The second study reported on the treatment and the high satisfaction rates among 4,589 patients in China using online physician consultation for COVID-19 concerns.[13]

The demographic characteristics of digital health users described in this study match previous reports on digital health users. While the use of digital health technologies among seniors has been reported to be increasing,[28] users of digital health applications are still predominantly younger adults.[29] The current low level of adoption of digital health by older adults is unfortunate, as digital health technologies have the potential to improve communication and collaboration, and promote healthy and independent ageing. Indeed, recent research suggests digital solutions tailored for older adults improves health management.[30] Barriers to the adoption of digital health by older adults include visual impairment, limitations in dexterity, and lack of self confidence in using technology. Several solutions are being developed to circumvent these barriers, including the development of voice-based applications and unobtrusive sensors and trackers.[31]

Strength & limitations

This study has a number of strengths. First, it utilizes a large sample of over 71,000 individuals to provide timely information on the use of a number of different digital health tools for managing COVID-19 related concerns. Second, the study reported on the differential use of these tools by these individuals, as well as on both self-reported variables and physician-reported disposition and management. Third, the study was able to provide insight on self-reported symptoms individuals tested for COVID-19, highlighting the strong link between COVID-19 and loss of sense

of smell and taste, and adding to the body of evidence that ocular symptoms may be a more common feature of COVID-19 than is widely recognized.

The study has a number of limitations as well. The population of this study is not representative of the entire population, and utilizes data from digital tools developed by a single provider. However, the characteristics of the study population, and the COVID-19 symptoms reported, correspond with those reported in previous reports on digital health tools.[11,20–22] In addition, data on COVID-19 test status was based on self-report and may not accurately capture test results. Furthermore, the data is limited to individuals using a tool for initial COVID-19 assessment. Tools allowing for longitudinal logging and monitoring of symptoms can both provide additional utility to users, as well as improve our understanding of disease progression and the time course of symptoms. Allowing users to provide unsolicited data on their experience may provide important insight as well, as the self-assessment tool described focused on a predefined list of questions. Lastly, while we had data on the disposition of users who chose to consult with a remote physician, the disposition of individuals who did not consult with a remote physician following use of the automated tools is unknown. Research on healthcare utilization and health outcomes of digital health users is needed in order to conclusively demonstrate the utility of these services in assisting individuals health decision making, and reducing the burden on the health system.

In conclusion, this study describes the integration of three digital health tools for the direct management of COVID-19 related concerns. The study suggests that automated, data-driven, digital solutions, as well human-physician remote care can help provide health information and guidance during an epidemic. In addition, interactions across digital services can provide insight regarding the characteristics of new diseases. The integration of such tools can be an important resource for healthcare providers and policy makers.

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Acquisition, analysis, or interpretation of data: Perlman, Vodonos Zilberg, Bak, Dreyfuss, Leventer-Roberts, Vurembrand, Jeffries, Fisher, Steuerman, Namir, Goldschmidt, Souroujon

Drafting of the manuscript: Perlman and Vodonos Zilberg

Critical revision of the manuscript for important intellectual content: Bak, Dreyfuss, Leventer-Roberts, Vurembrand, Jeffries, Fisher, Steuerman, Namir, Goldschmidt, Souroujon

Statistical analysis: Vodonos Zilberg, Bak, Namir

Supervision: Namir, Goldschmidt, Souroujon

Conflict of Interest Disclosures: All authors are salaried employees or consultants at K-Health Inc.

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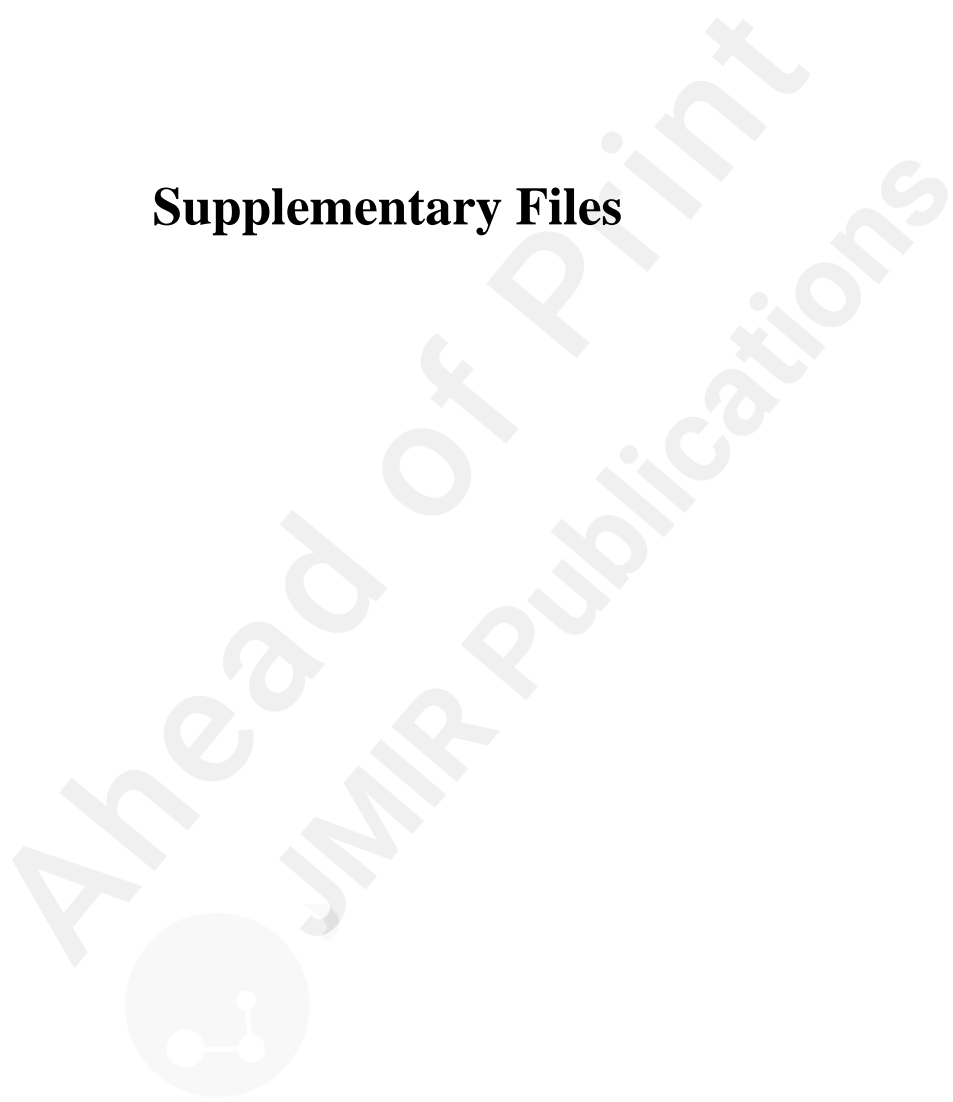
Role of Funder: All authors are salaried employees or consultants at K-Health Inc.

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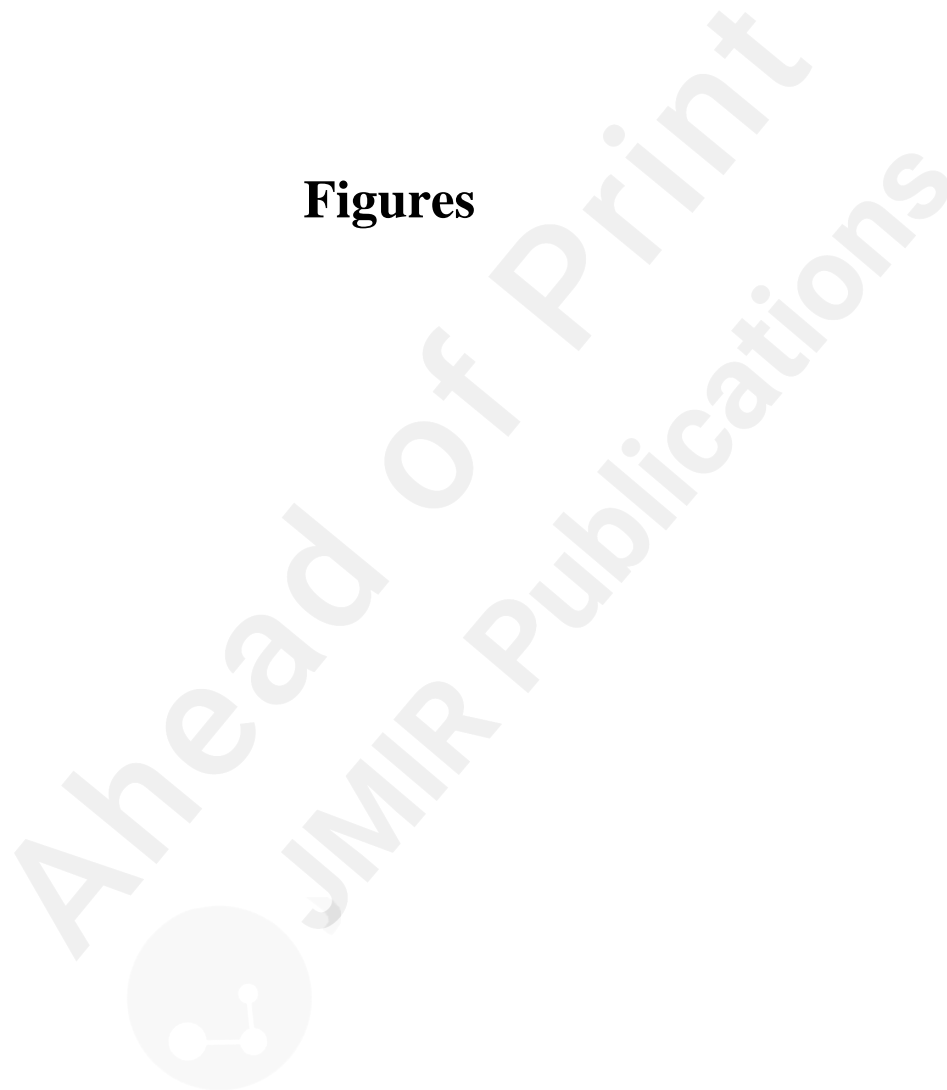
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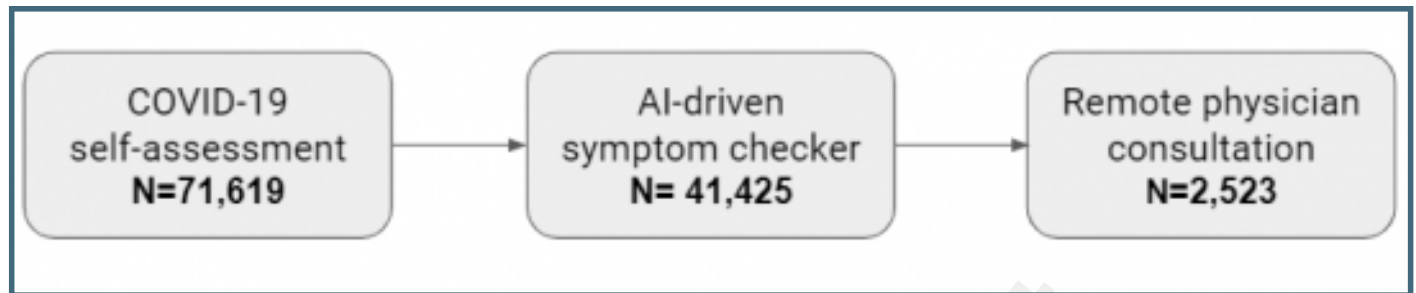
Supplementary Files



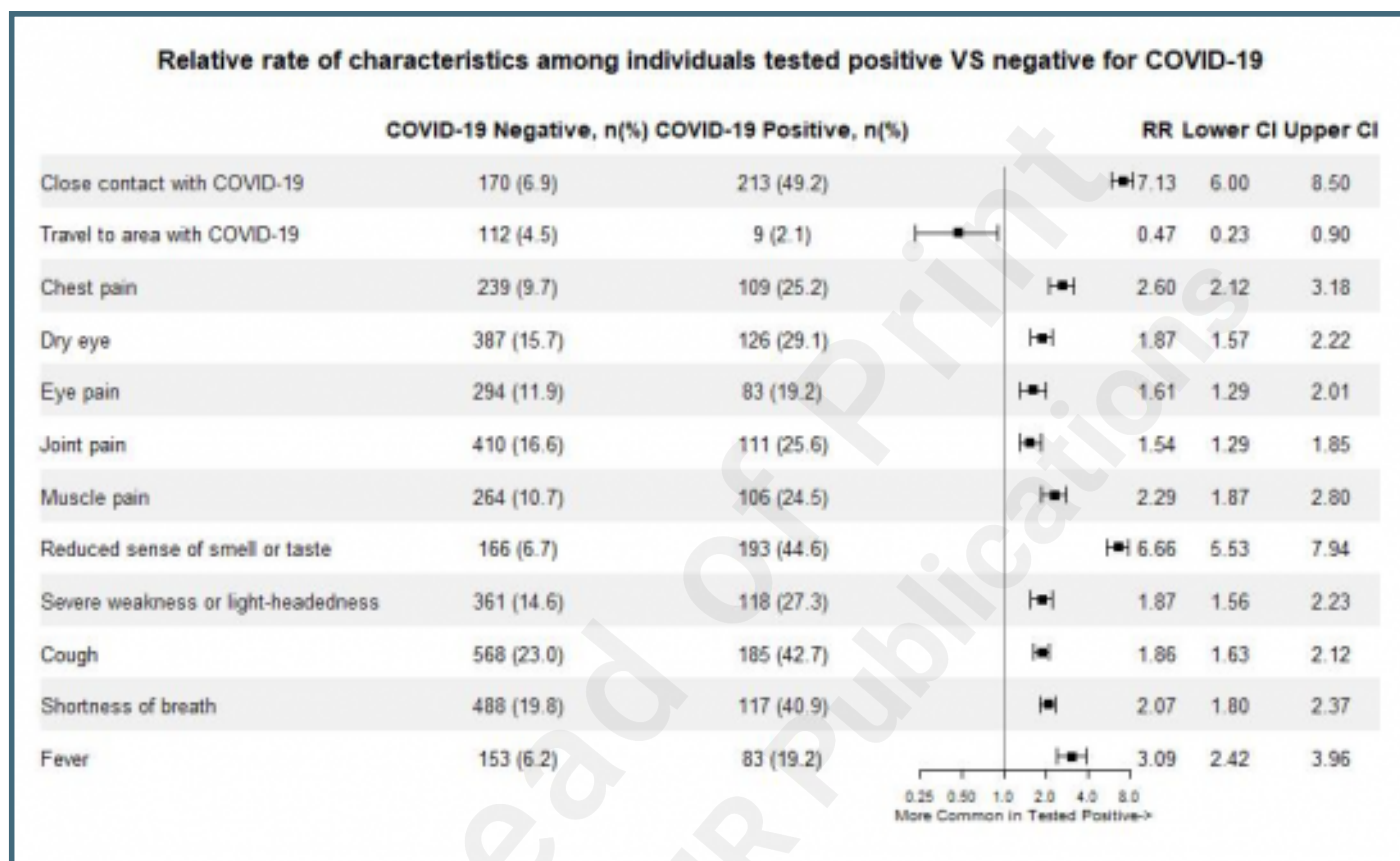
Figures



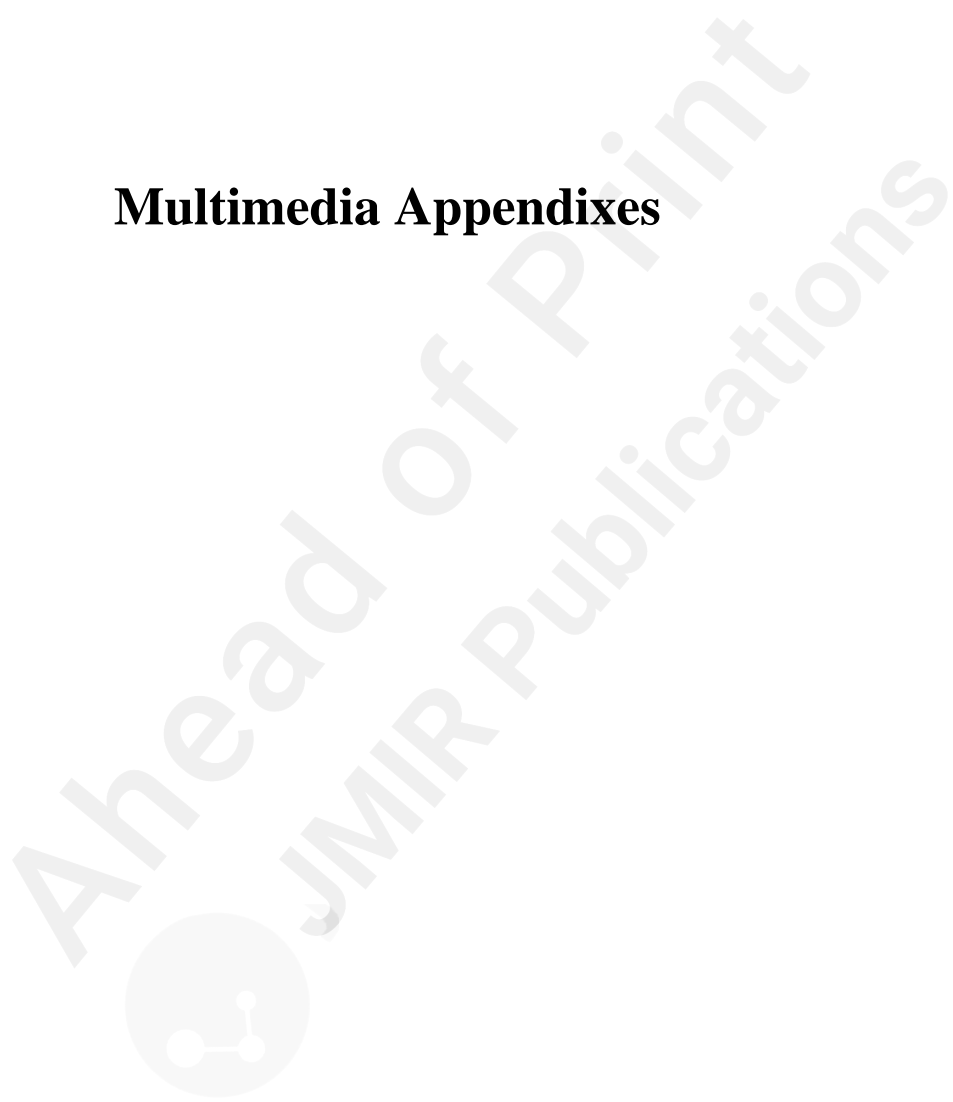
Flow-chart describes cohort of U.S. individuals using the COVID-19 self-assessment between April 8th - June 20th, 2020.



Forest plot presents the relative rate and 95% confidence interval of each item in the self-assessment questionnaire among users reporting testing positive for COVID-19 compared to those testing negative. Users could report cough, fever, and shortness of breath at the end of the self-assessment or as part of the symptom-checker dialog. See appendix for details. Muscle pain was not present in early versions of the self-assessment. Proportions were calculated for self-assessments where this symptom was reportable. Abbreviations: RR - relative rate, CI - confidence interval.



Multimedia Appendixes



Supplementary appendix.

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