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1-Check UNMC Mobile App Usage: A Quantitative Analysis of the Data

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ABSTRACT

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As COVID-19 cases continued to rise in Nebraska, universities and colleges were faced with unique challenges in the effort to continue providing quality education for students. The University of Nebraska Medical Center (UNMC) took on especially difficult challenges due to its status as an academic medical center. By the Fall of 2021, students, faculty, and staff were beginning to return to campus. The 1-Check UNMC app was created to help keep sick people from coming to campus. The UNMC community was expected to screen themselves for COVID-19 using this app each day before coming to campus. This thesis is an exploration of the data that has been stored on the app. The data explored include symptoms and screening outcomes specific to UNMC students, faculty, and staff.

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Introduction

COVID-19 in Nebraska

Nebraska experienced its first travel-related case of COVID-19 in Douglas County on March 6, 2020, approximately one and a half months following the first confirmed case of COVID-19 in the United States. One week later, the first case of COVID-19 involving community transmission was confirmed. By the end of March, four Nebraska residents had died due to COVID-19. Governor Ricketts announced his plan to order restrictions on establishments throughout the state in the first week of April, including the closure of restaurants and bars. However, three weeks after implementing regulations, the governor publicized a plan to relax restrictions. Consequently, Douglas County reached a summer peak of cases during the last week of May 2020(*Coronavirus COVID-19 Information April 2020 - Douglas County*, *Nebraska*, 2020).

As the fall months of 2020 approached, health experts informed Nebraska residents of a steady rise in case counts and called for the continued use of nonpharmacological interventions when in public. Throughout the fall and winter months of 2020, cases in Douglas County continued to rise, reaching a peak of 1,377 new cases on November 16, 2020. Similarly, Nebraska cases peaked two days following Douglas County with 2,824 new cases. By the end of December, the Pfizer COVID-19 vaccine had been distributed to mission essential personnel, including healthcare workers. Since the public distribution of vaccines, Douglas County continues to grapple with substantial community transmission.

UNMC 1-Check App

At the same time, government and public health officials were responding to the pandemic on a county level, college campuses in the United States were working to respond to COVID-19 on a smaller level. The continuity of higher education proved to be a unique yet critical problem created by COVID-19. Universities produce future professionals, adding to the workforce in communities. More specifically, academic medical centers hold a crucial role in societies by molding future health care professionals. Additionally, medical campus infrastructure contains vital research, which plays a pivotal role in contributing to the forward movement of science. Healthcare infrastructure, including hospitals and clinics, relies on the success of future healthcare professionals and new and innovative research. For instance, a lapse in both classroom and clinical learning can delay graduation dates for students. An exponential delay in graduation can create a shortage of healthcare personnel, affecting the quality and timing of patient care in a community. Furthermore, a pause in critical research can delay the development of new medical treatments. Given the critical role medical universities have, they should be steadfast in continuing essential operations such as education and research.

COVID-19 forced institutes of higher education to change learning, teaching, and working operations completely. Universities were expected to make decisions that would impact the way students learn, instructors and professors teach, and university employees' work. Moreover, these decisions had to be made swiftly and often as COVID-19 continued to evolve daily. Students, faculty, and staff quickly adapted to new environments and avenues, giving the university continuity. In their assessment, UNMC decided to transition all in-person classes to an online format ten days (March 16, 2020) after the first diagnosed COVID-19 case in Douglas County. Shortly following the decision to move courses online, UNMC issued a 'stay at home directive' that would continue until June 1st, 2020.

Ultimately, the university decided to transition most operations back to campus beginning in the fall semester. Consequently, UNMC leadership began developing a comprehensive guide to promoting a safe return to on-campus operations for the Fall 2020 semester and beyond. Students, staff, and faculty were provided with a Recovery Implementation Plan (RIP) detailing the precautions that the university planned to implement and the safeguards expected of each person on UNMC's campus. Following the dissemination of the RIP, several communications were sent out to university personnel, ensuring they were apprised of the constantly changing environment.

To control the transmission of COVID-19 on campus, UNMC implemented nonpharmacological interventions as recommended by both public health and medical professionals to slow the spread of COVID-19. Such interventions included face coverings, physical distancing, and increased hand hygiene. Based on previous literature, these preventive measures can slow the spread of infectious diseases without a safe and effective vaccine (Ebrahim et al., 2020).

Although nonpharmacological efforts were proven to slow the spread of COVID-19, individuals exposed to COVID-19 and individuals experiencing COVID-19 symptoms were asked to stay home. However, there were still several unknown features regarding the presentation of COVID-19 clinical symptoms. For instance, the virus shares several clinical symptoms with other upper respiratory infections such as influenza. Also notable, the severity of symptoms was inconsistent across populations.

In an effort to offer the UNMC community an efficient and effective way to screen for symptoms and assess the likelihood of a COVID-19 infection before coming to campus, a mobile app known as 1-Check UNMC was created. To provide another way to protect and monitor the UNMC community for COVID-19 transmission, the mobile app collects data that includes awareness of the number of symptomatic COVID-19 cases on campus (Burbach et al., 2020). UNMC medical and public health experts contributed to developing the app's clinical algorithms to achieve the highest accuracy in screening results and guidance.

The 1-Check UNMC app assesses the possibility of COVID-19 infection after a user answers a series of questions related to symptoms, demographics, and comorbidities. The app will then issue a low, urgent, or high risk (green, yellow, red, respectively) and campus-specific guidance towards possible next steps. For example, the app can issue guidance for the continued monitoring of symptoms, contacting a healthcare provider to obtain testing, or seeking emergency medical attention.

Throughout the pandemic, the use of mobile apps as screening tools has gained popularity. The ability for individuals to screen themselves for COVID-19 symptoms can reduce the burden on already overwhelmed hospitals and clinics in a community setting. At a university level, systematic screening tools such as the 1-Check UNMC app can store public health data that offers insight into the disease burden on campus. Additionally, the app can offer advice to individuals who have been exposed or think they may have COVID-19 to stay home and get tested. If exposed or symptomatic individuals who would otherwise come to campus choose to stay home due to their screening results, disease transmission can be reduced.

Given the need for universities to remain open during infectious disease outbreaks, students, staff, and faculty must be protected. To achieve continuity of operations, universities' pandemic preparedness plans should include a detailed approach to containing disease transmission on campus. Several public and private organizations have implemented the adoption of technology as a screening tool. However, to increase the effectiveness of such technology for current and future use, an in-depth exploration of app use should be conducted. Significant discoveries can offer leadership and decision-makers insight regarding decision-making. For example, an increase in high-risk screens during a specific period can inform the need to limit large gatherings on campus. This study will examine the frequency of 1-Check UNMC app use, screening outcomes, and symptoms associated with medium and high-risk outcomes.

Purpose

Although the adoption of mobile applications used for screening tools, including symptom tracking, has increased substantially since the beginning of COVID-19, publications exploring the public health data they contain are scarce. This study will analyze the data stored on the 1-Check UNMC app. More specifically, we will seek to answer three research questions. First, we will explore how the 1-Check UNMC app use changes over time. The following two objectives are two-fold. Low, medium and high-risk outcomes within the 1-Check UNMC app will be explored in terms of frequencies, and the symptomology of individuals whose results yielded a medium or high risk of having COVID-19 will be examined in more detail. The lack of literature in these areas is a gap in knowledge and demonstrates the need for more research related to COVID-19 symptoms among students, faculty, and staff on college campuses.

Exploring 1-Check UNMC app adoption can help inform stakeholders of significant increases or decreases in in-app use, thus equipping them with helpful information for decision-making. Characterization of usage trends, along with potential confounding variables, can inform mobile application creators to implement in-app changes (current and future) based on results. Finally, understanding how app use frequency changes over time lays a foundation for future qualitative exploration. For example, implementing focus groups of students, staff, or faculty may help determine a hypothesized cause for the substantial decrease in app use.

Equally important, 1-Check UNMC screening outcomes and respective COVID-19 symptoms will be identified to help individuals understand common symptoms related to a possible COVID-19 infection. While there are several previously identified symptoms related to COVID-19, the extreme variation in the clinical presentation can confuse individuals who have little experience with COVID-19 symptoms.

Limitations

When analyzing self-reported data, some limitations exist. First, individuals with privacy concerns may not be willing to answer demographic questions due to the fear of identification. Furthermore, answers to symptomology questions are also at risk of bias because of health privacy concerns and societal expectations. Additionally, a negative stigma regarding a positive test result for COVID-19 has gained prevalence. Consequently, individuals may wish to answer questions in the app based on their ideals.

Several data had to be discarded caused by difficulty in differentiating terms found in the logic tree provided by the creators of the app. While the missing data did not impact the results of this analysis, it is possible that including the data can provide better insight for studies done in the future.

Literature Review

COVID-19 Mobile Apps

Generally, mobile apps have created opportunities to stay connected to healthcare at a distance and continue to receive vital healthcare services (Davalbhakta et al., 2020). For instance, mobile apps developed to slow the spread of COVID-19 can conduct contact tracing, evaluate symptoms, and provide guidance from healthcare providers without the need for face-to-face interaction (Davalbhakta et al., 2020). COVID-19 has highlighted the need to develop unique strategies regarding the delivery of healthcare to minimize infection risk, leading to the creation of COVID-19 based apps in several countries (Alanzi, 2021).

Intawong et al. examined the creation and implementation of mobile applications in Thailand during the first months of the pandemic. Thailand was the first country, other than China, to encounter COVID-19, identifying the index case on January 13, 2020 (Intawong et al., 2021). The virus quickly spread over the following weeks and months, leading to concerned agencies under Thailand's Ministry of Public Health. Consequently, public health faculty at Chiang Mai University developed a series of applications to lessen the burden on hospitals and other healthcare centers. Intawong et al. studied three apps identified as Self-Screening for COVID-19, Self-Health Check for COVID-19, and Chiang Mai COVID-19 (CMC-19).

Self-Screening for COVID-19 served as a preliminary screening tool for the general public of Chiang Mai. The app was meant to assist people in their self-assessments and their risk exposures related to COVID-19 (Intawong et al., 2021). After user input, the app provided results and guidance based on individual results. Results indicated a significant use of the application because it was user-friendly. The app was available in three languages and was easy to access by a QR code or a link (Intawong et al., 2021). According to Intawong et al., the app helped to reduce telephone calls to health officers, reducing their workload. The app also assisted in reducing the number of visitors to public health centers which may have led to the spread of COVID-19 (Intawong et al., 2021).

In the Netherlands, an observational cohort study was used to assess app use by citizens during a 20-day period. The app is an existing app created by Elisabeth Twee Steden (ETZ) hospital, in which a COVID-19 self-assessment was built. Besides self-assessment, the app can also provide a symptom diary and the latest COVID-19 education and guidelines (Timmers et al., 2020). The app asked users three demographic questions, including age, gender, and geographical location. Users were then offered a series of options, including *"I want to check my health."* After selecting this option, users were asked about their symptoms and past medical history, such as comorbidities (Timmers et al., 2020).

In their analysis, Timmers et al. found that 87% of users shared data about their gender, and 86% shared data about their age (Timmers et al., 2020). Of the 6,194 downloads, 5,154 people answered questions about severe symptoms, while 4,929 responded to questions about mild symptoms. Additionally, 2,929 responses were recorded regarding underlying diseases, in which 22.3% of users indicated a positive relationship with comorbidities (Timmers et al., 2020).

When asked to evaluate the app, an overwhelming number of users noted their satisfaction with the app's information and the self-assessment. Researchers found that the geographical location tool could be applied to an interactive map of hospital data based on postal code information (Timmers et al., 2020). According to Timmers et al., the ability to associate hospital data and geographical locations of users with symptoms may assist in the evaluation of disease spread in a region (Timmers et al., 2020).

Ramakrishnan et al. attempted to assess COVID-19 apps based on accessibility, app origin, features and app use, privacy policies and harm, and turbulence and turnover (Ramakrishnan et al., 2020). Accessibility was identified as a hindrance due to the number of apps that required special codes to access. Governmental organizations created many app assessments, with academic institutions accounting for a minor part of origination. The most common features were education, updated statistics, local news, and screening tools that helped users determine the next steps (Ramakrishnan et al., 2020). Many apps were found to share personal health information and aggregate data.

Additionally, only a few apps provided users with a working privacy policy. Researchers noted high turnover rates throughout their assessment period, with the number of educational institution apps decreasing from 10 in May to 5 in June. Privacy policies and app accessibility were highlighted as the most imperative changes app developers should consider in the future.

Distance Learning

As campuses switched to online and remote teaching, university grounds became desolate, with only mission-essential personnel allowed on most campuses. Day et al. described this phenomenon as possibly the “largest unplanned educational experiment ever undertaken” (Day et al., 2021). Day et al. studied the transition to online learning, specifically for geographers based at universities in North America and East Asia that included undergraduate studies and research-intensive, lab-driven operations.

In an overview of response efforts, only some faculty were fully prepared to switch to remote teaching, while many required proper technical training (Day et al., 2021). Furthermore, most faculty emphasized concerns about the quality of online teaching compared to face-to-face instruction (Day et al., 2021).

Infection Risks on Campuses

Literature discussing the prevalence of COVID-19 symptomology on college campuses was scarce. Additionally, the literature could not adequately capture COVID-19 symptomology on college campuses due to sample restrictions. For example, Altman et al. captured symptoms of a small sample of college students over a short period. However, faculty and staff were not included in the sample, thus creating a gap in their findings.

The closure of most universities in the United States made it difficult for researchers to accurately determine infection spread on college campuses. Several previous publications employed previously established methods to model COVID-19 spread in university settings. Li et al. attempted to evaluate the risk of infection transmission in different university settings, such as classrooms and libraries within a university campus in China. Researchers used the established viral load distribution and droplet concentration fitted curve while quanta generation rates were estimated using the forward calculation method. Finally, researchers were able to quantify infection risk using the Wells-Riley equation (Li et al., 2021).

Researchers found that activity level and respiratory intensity significantly influenced quanta generation rates, also called airborne infection risk. Depending on time exposure, dormitories and classrooms yielded higher infection risks than confined spaces (Li et al., 2021). Researchers suggest that places with high mobility should control the susceptible flow but note that further emphasis should be put on transmission risk caused by the random movement of people (Li et al., 2021). Final recommendations for implementing engineering measures such as HEPA filters and enhanced ventilation were discussed (Li et al., 2021).

College students are innately more susceptible to exposure and transmission of COVID-19 due to daily close contact among campus populations (Altman et al., 2021). Additionally, students who traveled for spring break in March 2020 were more likely to contract COVID-19. A study of University of Florida (UF) students immediately returning to in-person learning following spring break assessed students who reported COVID-19 symptoms at the onset of illness and throughout the duration of illness (Altman et al., 2021).

Researchers conducted a retrospective chart review of all students tested for COVID-19 in the six weeks following students' return from spring break. Results revealed an 8.4% positivity rate among 296 students tested for COVID-19. Symptomology between COVID negative and COVID positive students was analyzed using Fisher's exact test. Results showed positive cases experienced significantly more excessive fatigue, congestion, nausea, chest pain, loss of smell and taste, anorexia, trouble sleeping, and abdominal discomfort (Altman et al., 2021). Conversely, COVID negative students reported more symptoms of sore throat, trouble breathing, and headache.

Ultimately, the study found substantial overlap in symptoms of COVID-19 with other respiratory illnesses such as influenza, amplifying the difficulty of clinically distinguishing COVID-19 from other viral respiratory diseases (Altman et al., 2021). Given the high risk of transmission on college campuses, screening tools should ensure that symptomatic students, faculty, and staff do not report to work. As the study by Altman et al. shows, the presence of symptomatic individuals on campus can easily cause an outbreak because of the nature of transmission rates on college campuses.

Methodology

The data used was provided by the UNMC 1Check App in June of 2021, including data only from October 2020 to June 2021. App compliance, duplicate uses, pathways to red outcomes, and symptomology were analyzed separately. Entries from UNMC faculty, staff, and students were included in each process, using unique identifiers to protect individual privacy.

1Check App Compliance

To understand the frequency of app use, each app entry was sorted into its respective month. Each unique user ID represents a unique individual entry, while duplicate IDs represent repeat app usage by one individual. Using the' identify duplicates' function, duplicate IDs were automatically identified in SPSS. The number of duplicates and overall uses in each month was compared to find the percentage of duplicate uses. Duplicate IDs were identified for all months combined using the same SPSS function, and an overall rate of duplicate IDs was determined.

Frequency of Use

A frequency table was set up in SPSS using the descriptive statistics function to understand 1Check app use. The frequency table compared percentages of app usage between October 2020 to June 2021. To show app use between months and identify trends, percentages of overall use by month were displayed on a simple bar graph (*Figure 2*).

Pathways to Red Screens

A logic tree provided by the creators of the 1Check app was used to identify six different pathways that lead to a red screen. Only pathways that required individuals to be unvaccinated were used to account for the confounding variable of vaccination status. Of those pathways, four related to unvaccinated individuals, pathways three to six. However, pathways 4 and 5 did not provide clear data regarding requirements for a red outcome. Therefore, only pathways three and six were included. Additionally, of the five categories of criteria under each pathway, one was discarded because of a lack of a definitive definition. Pathways three and six included four criteria necessary to generate a red screen (*Figure 4*, *Figure* 5). Criteria 1 includes shortness of breath, fatigue, and headache. Criteria 2 includes cough, fatigue, and headache. Criteria 3 includes nausea/vomiting, diarrhea, and any other minor symptoms. Criteria 4 only includes loss of taste and smell. Symptoms were categorized into ‘major symptoms’ and ‘minor symptoms' (*Figure 3*). Symptoms used in the calculations included shortness of breath, cough, fever, loss of taste or smell, sore throat, chest pain, nausea or vomiting, diarrhea, fatigue, body aches, headache, and chills.

Several possible combinations of symptoms can lead to a red outcome. Both pathways three and six required the same combination of symptoms. However, pathway three required no COVID-19 test and pathway six required a negative COVID-19 test, as demonstrated in *Figure 4* and *Figure 5*. After pathways were identified, logic statements were set up in Excel to determine the number of times each pathway (three and six) occurred. Logic statements were written in Excel using the =AND(logic1='TRUE',logic2='TRUE', etc.....) function. For and/or statements, =AND(logic1='TRUE',logic2='TRUE') =OR(logic1='TRUE',logic2='TRUE') was used. Logic statements were used for each of the four criteria. A 'TRUE' or 'FALSE' result was automatically calculated based on the logic statement. The number of 'TRUE' results was counted for each possible criterion. A 'TRUE' result indicated that the specific entry in the data met the criteria used in the logic statement. A total of four logic statements for each pathway were used to identify the most common combinations associated with a red screen.

Symptomology

A wide range of symptoms was included in the 1Check app questionnaire. The symptoms analyzed included shortness of breath, cough, fever, loss of taste or smell, sore throat, chest pain, nausea or vomiting, diarrhea, fatigue, body aches, headache, and chills. Individuals were asked to answer 'TRUE' or 'FALSE' for each symptom. To calculate the most frequently occurring symptoms, all symptom data were entered into SPSS, and frequency tables were generated where 0 = FALSE and 1 = TRUE. The results were then used to create a table to show the frequency of occurrence of each symptom from October 2020 to June 2021(*Figure 8*). Additionally, symptoms were compared between months to understand the most common symptoms in each month. At the same time, the rate of occurrence of symptoms was compared between months.

Results

1Check App Compliance

Duplicate uses were calculated between months and overall. They were then summarized as percentages to account for each month's different numbers of entries. Students, staff, and faculty were asked to complete a screening every day before arriving on campus. A high percentage of duplicate uses was expected even though most UNMC operations were operating remotely. Conversely, duplicate uses were less than 2% each month, while the total percentage of duplicate uses was only 1.4%.

The lowest percentage of duplicates occurred in November at 1.1%. December, January, February, March, and June had the highest rate of duplicates at 1.5%. April and May both had a percentage of 1.4%. December had the most duplicate uses at 150, while May only had 25 duplicate uses. Notably, the number of duplicates and the total number of uses lowered each month, with May to June being the only exception. However, the number of total uses increased more than the number of duplicates, with an increase of only five duplicate uses from May to June (*Figure 1*).

Frequency of Use

A total of 52,093 entries were created between October 2020 and June 2021. The percentage of frequency of app use steadily decreased with each month (*Figure* 2).

October had the least uses because the app was released in the last week of October. November accounted for 24.5% of general use with a total of 12,769 uses. May and June had the least number of uses at 1,844 and 1,974, respectively. The most significant drop in use occurred from April to May, with a decrease of 2,465.

Pathways to Red Screens

Pathway three requires individuals to be unvaccinated and not have tested within the last 14 days before their screening completion. To generate a red outcome, individuals must meet one of five different criteria. However, only four were examined. Pathway three resulted in 325 instances of red outcomes related to criteria 3. Criterions 1,2 and 4 generated lower numbers at 1, 2, and 12 instances, respectively. A significantly large portion of red screens in pathway three resulted from a combination of minor symptoms only. Although major symptoms were present in three of the four criteria categories, they only accounted for 15 red screens. Pathway three accounted for 340 of the possible 867 red screens from October through December.

Pathway six requires individuals to be unvaccinated and to have a negative test within 14 days of their screening. Pathway six contains the same criteria as pathway three, with the only difference being either no test or a negative test. Pathway six generated similar results to pathway three as criteria three accounted for 320 instances of red outcomes. Additionally, criteria 1, 2, and 4 generated 2, 4, and 6 red screens, respectively. In leaving out criteria 5, it may be assumed that the remaining 195 screens can be attributed to either pathway three or six and criterion category 5.

Symptomology

Figure 7 shows the number of 'TRUE' screens for each symptom associated with the 1Check app. Out of over 52,000 total entries, 4,177 reported one or more symptoms in the app. *Figure 8* shows the number of 'TRUE' entries compared to 'FALSE' entries for each symptom. The highest reported symptom was a sore throat, accounting for 18.3% of individuals who reported one or more symptoms. The most common symptoms were sore throat (18.3%), headache (16.9%), and fatigue (13.5%). The least common symptoms were blue lips (0.05%), chest pain (1.3%), and loss of taste/smell (1.7%).

November accounted for most of the symptoms as entries in November made up 24.5% of the total entries. Consistent with overall usage trends, symptoms tended to drop off as the months continued. February accounted for a few spikes in body aches, chills, and fatigue. Compared to May, June had more total symptoms with spikes in headaches, nausea/vomiting, sore throat, body aches, diarrhea, and fever. Overall, symptom trends stay moderately consistent between months.

Discussion

1Check App Compliance

The percentage of duplicate use consistently remained below 2%, while the overall rate of duplicate uses was 1.4%. Amid the app's public release to the campus community, students, staff, and faculty were asked to use the app every day before coming to campus. The app was released in October during a time when on-campus operations were limited to mission essential personnel only, providing a possible explanation for the low duplicate usage. However, the total number of uses far exceeds the number of duplicate uses, suggesting the assumption that a significant number of campus personnel still reported to their physical work location on campus each day.

The frequency of communication to the campus community regarding the app must also be considered when looking at app compliance. Communication to the campus population regarding the 1Check app throughout the academic year was inconsistent. Given the many responsibilities of individuals who work and learn in a campus environment, as well as the extra stress added by COVID-19, forgetfulness was likely a significant factor in the low rates of app compliance.

More consistent communication should be considered to increase usage compliance in the future. Initial communication should include the importance of the app for the individual and mitigate the spread of COVID-19 on campus. Regular communications should be sent to personnel reminding them to use the app before coming to campus, even if they are not symptomatic. The method(s) of communication used should ensure every group on campus has access to the communications.

Usage frequency

Figure 2 shows a steady decline in usage from November to May, indicating the app's popularity decreased over a chronological period. The highest number of uses was in November, exceeding 12,000 entries. Usage reduced to 1,844 entries in May, accounting for only 3.5% of overall use. While COVID-19 apps should not be assessed on usage frequency alone, a consistent decline over a long period should be evaluated more closely. Explanations for the consistent decrease in app use can be attributed to multiple factors.

UNMC's status as an academic medical institution meant that vaccinations were available to most students, staff, and faculty before the general public. The UNMC community received vaccinations towards the end of December 2020, but most UNMC personnel were vaccinated beginning in January 2021. Vaccine creators failed to properly communicate the intent of their vaccine, possibly leading to the incorrect assumption that the COVID-19 vaccine provided complete protection and, if infected, prevented the infected individual from spreading the virus. This false sense of security likely facilitated the drop in app usage. As vaccination rates increased, individuals' overconfidence in their safety and the safety of those around them also increased. Additionally, the vaccine was seen as another layer of protection, adding to the belief that the 1Check app was unnecessary if fully vaccinated.

It is also essential to consider that UNMC provides education for future medical professionals, many of whom are well-versed in all healthcare and public health areas. The notion that, as future medical professionals, students already know what symptoms to watch for and what to do if those symptoms arise likely hindered usage numbers. Additionally, as the pandemic continued, the concept of pandemic fatigue became a stark reality. Individuals grew weary of nonpharmacological interventions such as mask-wearing and social distancing. More specifically, individuals at UNMC likely experienced high levels of pandemic fatigue, resulting in regressed 1Check app use. The accessibility of the app may have also contributed to low usage numbers. The app was available on smartphones, the internet, and hard copies at select locations on campus. However, 1Check was marketed as the '1Check UNMC app', leading to false assumptions that 1Check was only available on smartphones. Individuals without smartphones who were unaware of the other methods of 1Check accessibility were unable to use 1Check.

In the future, improved and more consistent risk communications regarding available vaccines and susceptibility to virus transmission should be considered. It is imperative that the public, specifically the UNMC community, know that virus transmission still occurs regardless of vaccination status. Additionally, pandemic fatigue should be addressed to encourage students, staff, and faculty to continue to use the app. Finally, more widespread communication regarding the different methods of accessing the 1Check app should be considered.

Red Screens

In total, there were six pathways created, each including five criteria, that led to red screens. Two pathways (three and six) and four criteria were considered for the scope of this study. Both pathways required individuals to be unvaccinated and to either not have taken a test in the last 14 days (pathway three) or to have a negative test within the previous 14 days (pathway six). After creating logic statements to study the pathways, both had similar results. Criteria three yielded a significantly larger number than criteria one, two, and three at 325 and 320, respectively. While criteria three required one of the most symptoms to be answered ‘TRUE,’ only minor symptoms were needed. According to *Figure 3*, there are four possible major symptoms and eight possible minor symptoms. It should be assumed that ‘major’ and ‘minor’ symptoms do not signify the seriousness of the symptom but rather how likely it is to lead to a positive COVID-19 test or clinical diagnosis.

Criteria three required the symptoms of nausea/vomiting, diarrhea, and at least one other minor symptom. Generally, the minor symptoms included less severe symptoms like headache and fatigue that could also be symptoms of stress or environmental factors such as allergies. Further, nausea/vomiting and diarrhea have many other causes, such as food poisoning and norovirus. Given different reasons for these minor symptoms, it can be assumed that these symptoms yielded more ‘TRUE’ results than major symptoms, making it the most common pathway to a red screen.

Cough, loss of taste/smell, shortness of breath, and fever were the criteria for major symptoms. Cough and fever can be attributed to other viruses; however, loss of taste/smell is a significant clinical indicator of COVID-19. Moreover, shortness of breath was one of the first symptoms associated with COVID-19 as most of the virus variants attack the lungs. Equally important, a persistent cough was also one of the first symptoms attributed to COVID-19.

Criteria one required shortness of breath, fatigue, and headache, while criteria two included cough, fatigue, and headache, with shortness of breath and cough being the major symptoms. Given the specificity of the symptoms needed to generate a red screen, criteria one and two were statistically less likely to be the cause of a red outcome. Criteria four only required the major symptom of loss of taste/smell to be checked. As the clinical presentation of COVID-19 continued to evolve, loss of taste and smell was considered a significant clinical indicator of the virus without other symptoms present. Conversely, loss of taste and smell was not common among 1Check app users, as only a total of 18 individuals answered ‘TRUE.’

In the future, follow-up questions regarding users' testing behaviors and test results may prove beneficial to inform common symptoms that yield a positive test at an academic medical center. The ability to statistically identify the most common symptoms associated with a positive COVID-19 test can help inform the UNMC community about when to get tested. Further, it could influence UNMC community members to stay home and quarantine if they begin to experience those pre-identified symptoms.

Symptomology

Over 52,000 app uses between October 2020 and June 2021, with approximately 4,000 individuals reporting at least one symptom. Two of the most common reported symptoms included headache and fatigue. Students, staff, and faculty are dedicated to their learning, working, teaching, and research at an academic medical center. Consequently, many individuals may suffer from chronic or acute stress, arguably more than what is considered normal. Chronic and acute stress brings on many symptoms, including headaches and fatigue. Most of the individuals who answered 'TRUE' to headache and fatigue may have been experiencing an episode of acute stress or may suffer from chronic stress. Research efforts to provide a baseline amount of individuals who suffer from these conditions can help decipher how many 'TRUE' answers can be attributed to a COVID-19 infection.

The most common reported symptom was a sore throat, a familiar symptom of COVID-19. However, causes for a sore throat can include other bacterial or viral illnesses and common allergies. Provided the data studied are primarily from the winter and spring months, allergies can likely explain a sore throat. Further investigation into this may be warranted, given the number of individuals who reported a sore throat. Also, notable sore throat was more reported than headaches and fatigue, which can be more common in otherwise healthy individuals.

Conclusion

This pandemic has proven that the impossible is possible, and preparedness for the unattainable is essential to protect human life, infrastructure, and business continuity. The adaptive use of technology in both public and private sectors has created a world in which individuals have more options for access to medical care or advice. More specifically, the UNMC 1Check app provided a peace of mind for students, staff, and faculty while tracking the burden of disease on campus.

The fields of emergency preparedness and public health are constantly evolving, creating an environment that fosters action on lessons learned. Therefore, improvements to plans, policies, technology, and others are constantly being made. The pandemic should be no exception to this. The UNMC 1Check app has the potential to remain relevant as COVID-19 continues to mutate and the transmission of other viral illnesses like influenza begins to increase.

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Tables and Figures

Month	Duplicates	Primary Uses	Total	Percentage
November	144	12,625	12,769	1.1%
December	150	10,153	10,303	1.5%
January	118	7,831	7,949	1.5%
February	98	6,411	6,509	1.5%
March	90	5,770	5,860	1.5%
April	61	4,248	4,309	1.4%
May	25	1,819	1,844	1.4%
June	30	1,944	1,974	1.5%

Figure 1

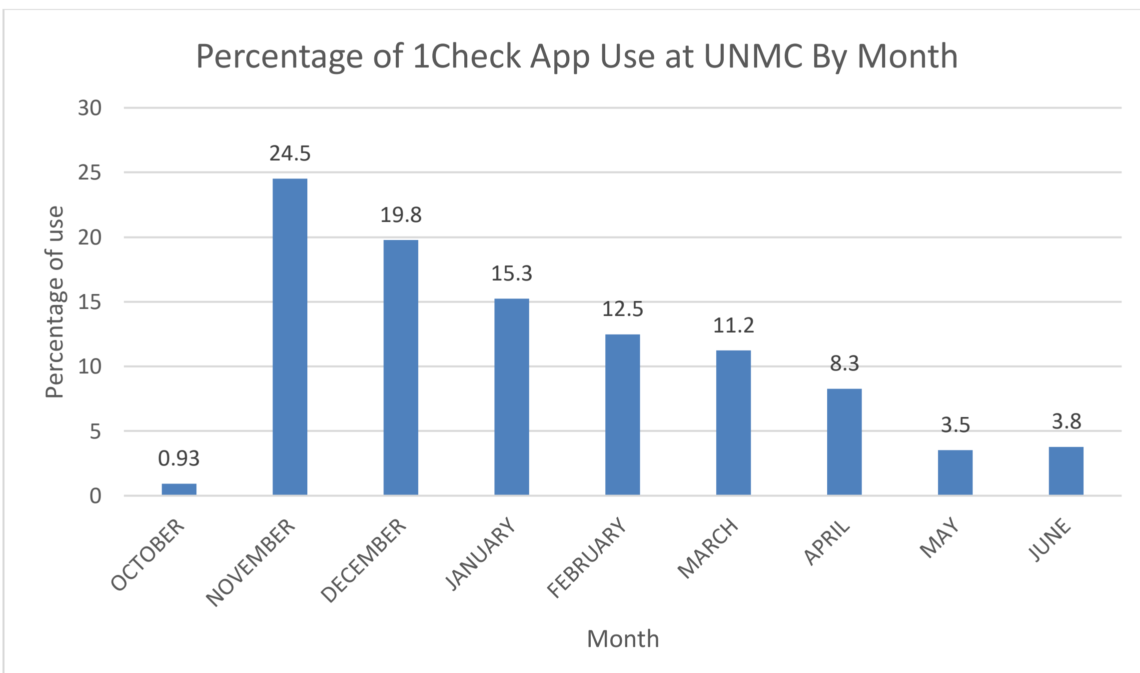

Figure 2

Major Symptoms	Minor Symptoms
Shortness of Breath	Sore Throat
Cough	Chest Pain
Fever	Nausea/Vomiting
Loss of Taste/Smell	Diarrhea
	Fatigue
	Body Aches
	Headache
	Chills

Figure 3

	Neg. Test	Unvaccinated	SOB	Loss of Taste/Smell	Cough	Nausea	Diarrhea	Fatigue	Headache	All Minor Symptoms
Criteria 1	X	X	X					X	X	
Criteria 2	X	X			X			X	X	
Criteria 3	X	X				X	X			X
Criteria 4	X	X		X						

Figure 4

	No Test	Unvaccinated	SOB	Loss of Taste/Smell	Cough	Nausea	Diarrhea	Fatigue	Headache	All Minor Symptoms
Criteria 1	X	X	X					X	X	
Criteria 2	X	X			X			X	X	
Criteria 3	X	X				X	X			X
Criteria 4	X	X		X						

Figure 5

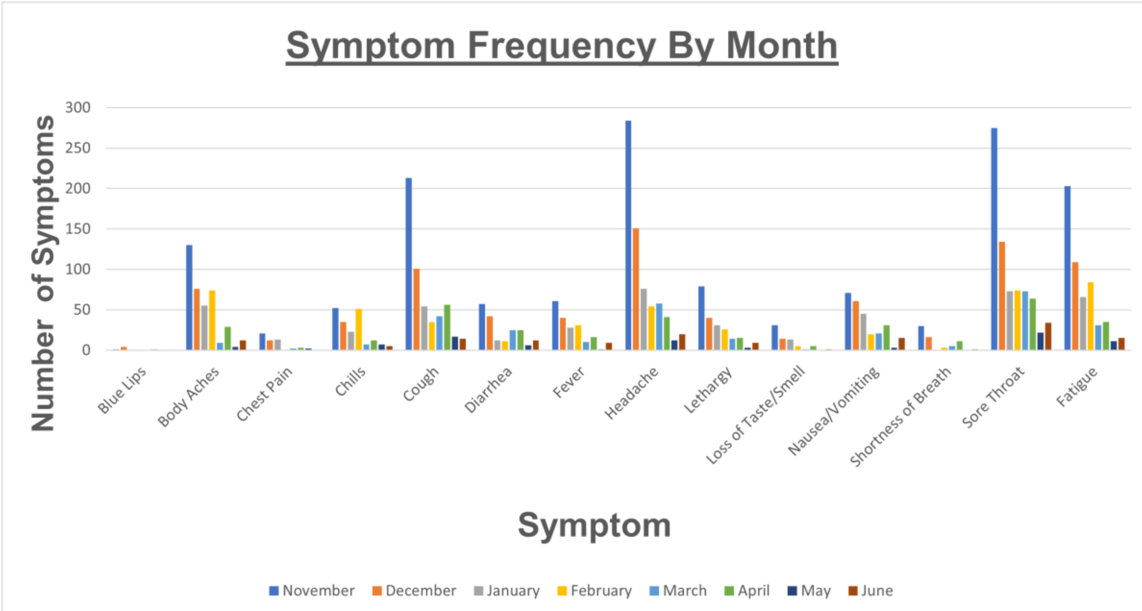

Figure 6

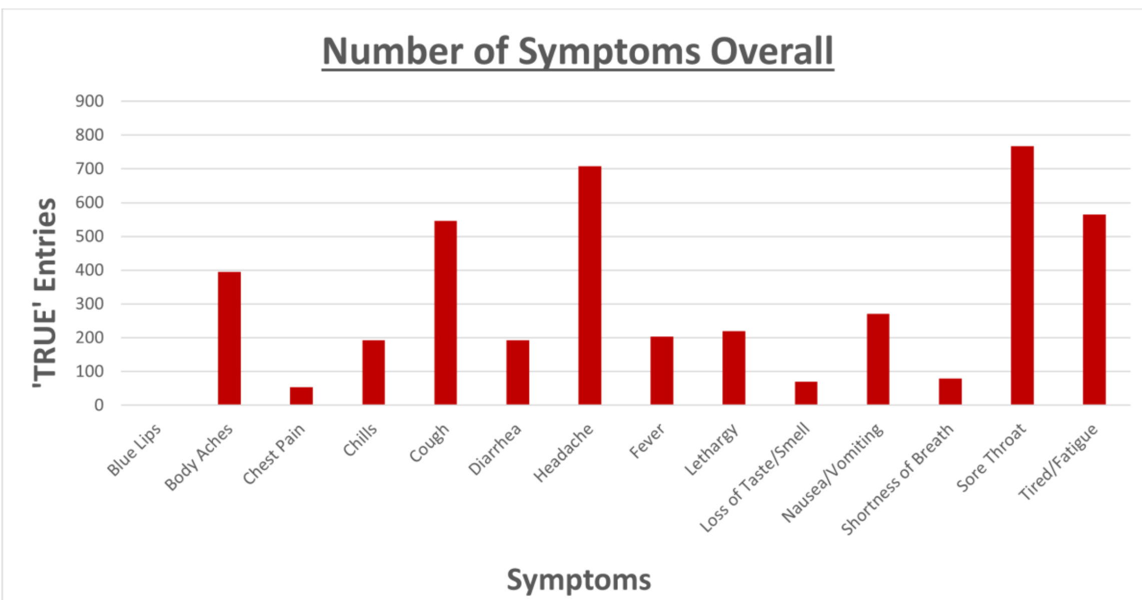

Figure 7

Symptom	TRUE	FALSE
Blue Lips	2	52086
Body Aches	395	51697
Chest Pain	54	52038
Chills	193	51899
Cough	546	51545
Diarrhea	193	51899
Headache	708	51384
Fever	203	51889
Lethargy	220	51868
Loss of Taste/Smell	70	52022
Nausea/Vomiting	271	51821
Shortness of Breath	80	52012
Sore Throat	767	51325
Tired/Fatigue	565	51527

Figure 8