Spring 4-5-2022

COVID-19 Vaccine Uptake Among College Students

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Date of Submission:	April 5, 2022

Table of Contents

Abstract

Background: Public health strategies to improve COVID-19 vaccine uptake among college students living in residential communities varied, some universities opted to mandate COVID-19 vaccines while other universities opted to promote and influence the choice for vaccination. ***Purpose:*** This descriptive, cross-sectional study examined the voluntary uptake of COVID-19 vaccines among residential students on a college campus in the southeastern U.S. that elected an evidence-driven health promotion strategy which included strong health promotion messaging coupled with coordinated efforts to make the vaccine accessible and appealing to students on campus. ***Methods:*** Analysis of vaccine uptake was derived from campus electronic health records during the fall of 2021 (N=2,867). The Vaccine Uptake Continuum and the Diffusion of Innovation Theory were used to explore patterns of vaccine uptake in the residential undergraduate population by date of vaccination, class, college of study, and residence hall. ***Results:*** On a college campus where voluntary COVID-19 vaccination was promoted and accessibility of the vaccine was both free and convenient, vaccination rates reached almost 80% amongst undergraduate students living in residential communities by October 15, 2021 (78.7%, N=2,867). The largest uptake in vaccinations occurred between March 7, 2021, and May 9, 2021 (69.7%, N=1,998), when the vaccine was first promoted and made accessible to students at large, coordinated vaccine events on campus. For students who were classified as late adopters or laggards, campus protocols related to vaccination status coupled with persistent messaging from leadership and readily accessible vaccine influenced an additional 5.1% (N=147) of students to get vaccinated after return campus on August 19th. Although vaccine coverage expressed as a percentage was relatively even across residence halls, those residence halls with the largest total population and rooms with double or triple occupancy also had high absolute numbers of

students who did not upload proof of vaccination. Analysis by residence hall highlighted transmission risk and outbreak vulnerability. ***Conclusion:*** The project findings support the need for vaccine accessibility on campus and incentivizing vaccination through university protocols. Accessibility and convenience had a clear impact on students' uptake of the COVID-19 vaccine on campus. However, accessibility is not enough to guarantee receipt of vaccination, campus culture, policies and protocols can positively influence students' perceptions of the acceptability of public health interventions. Analysis of vaccine uptake variability between dormitories and colleges on campus helped inform public health strategies to promote campus health and safety. Residential communities with lower vaccination rates may benefit from targeted health promotion messaging related to vaccination as well as the application of other public health tools including surveillance testing, frequent sanitization of highly trafficked areas, and mask wearing to promote and protect the health of students in residential communities and the broader campus community.

Keywords: COVID-19; vaccines; Vaccine Uptake Continuum; college students; Diffusion of Innovation

Introduction and Background

Vaccination programs decline morbidity and mortality of infectious diseases through direct protection of those vaccinated and indirect protection to the community (CDC, 2021a). However, vaccines are only effective when vaccine uptake levels are high (CDC, 2021a; Dube et al., 2013). The use of vaccines to prevent the spread of infectious diseases in congregate settings is not new (Dube et al., 2013). Like other highly infectious diseases, including measles, mumps, rubella, and influenza, COVID-19 is spread from person to person through respiratory droplets after an infected individual coughs or sneezes, close personal contact with an infected individual, or touching a virus-infected object or surface (WHO, 2021). Becoming vaccinated against COVID-19 is a multi-level, beneficial, health promotion recommendation (CDC, 2021a; Dube et al., 2013). The first vaccines for the prevention of COVID-19 were authorized for emergency use by the FDA and recommended for use by the CDC in December of 2020, and by April of 2021, any American who was 16 years of age or older was eligible for vaccination against COVID-19 (CDC, 2021a; FDA 2020b).

COVID-19 vaccines have been widely available and accessible to all college-age individuals since April of 2021, but uptake among this population remains low (Baack et al., 2021; CDC, 2021e). According to the CDC, adults aged 18 to 24 in the United States were most likely to report being unsure about getting vaccinated when compared to older age groups and were least likely to report receiving a COVID-19 vaccine between March and May of 2021 (Baack et al., 2021; CDC, 2021d). By August 2021, 44.3% of adults aged 18 to 24 were fully vaccinated in the U.S. (CDC, 2021d). By the first of October, approximately 1,058 public and private colleges in the U.S. mandated COVID-19 vaccination and many of these campuses have achieved vaccination rates of at least 90% or higher in their student population (Thomason &

O'Leary, 2021). For college campuses that have opted not to mandate vaccines, campus vaccination rates are more variable, ranging from 24% to greater than 80% (Thomason & O'Leary, 2021).

The American College Health Association (ACHA), which makes recommendations to colleges and universities, endorsed COVID-19 vaccination requirements for all on-campus university students for the fall 2021term (2021). Per the ACHA, the return to pre-pandemic classroom conditions and on-campus housing was contingent upon high levels of campus vaccination (ACHA, 2021). The prevention of campus outbreaks, allowing safe in-person learning, the reappearance of spectators at athletic events, and the engagement in socializing activities around campus are dependent upon population protection by high vaccination coverage (ACHA, 2021). Furthermore, high vaccination rates on a college campus are an important public health measure for the community in which the university is embedded (ACHA, 2021). Preventing viral transmission from the university population to the wider community ultimately prevents community outbreaks and spread of COVID-19 to vulnerable populations at greater risk for severe disease, which evades the feared outcome of overwhelming local healthcare systems (ACHA, 2021).

Prior to the availability of a safe, effective, COVID-19 vaccine, universities were associated with increased COVID-19 cases in their surrounding community (ACHA, 2021). For example, a university in North Carolina and its surrounding community had rapid increases in COVID-19 cases that occurred within two weeks of re-opening the university in the fall of 2020, even with the utilization of CDC COVID-19 guidelines of mask wearing and social distancing to prevent the spread of the virus (Wilson et al., 2020). Student gatherings and congregate living

both on and off campus were the likely contributor to the rapid spread of the virus and the subsequent increase in community prevalence (Wilson et al., 2020).

Individuals 18 to 29 years of age have the highest cumulative number of COVID-19 cases when compared to other age groups in the U.S. (CDC, 2021b). Viral transmission of SARS-CoV-2 occurs in asymptomatic, symptomatic, and pre-symptomatic individuals and preventing the transmission of SARS-CoV-2 at universities is challenging because students are highly social and live in congregate settings such as dormitories and apartments, share practice spaces, classrooms, and participate in athletics. (ACHA 2021; WHO, 2021; Wilson et al., 2020). While younger individuals are more likely to remain asymptomatic or develop only minor symptoms, they occupy shared spaces with older age groups or individuals with immunosuppression or underlying chronic illnesses who are the most vulnerable for COVID-19 complications and death (ACHA, 2021; CDC, 2021b). All authorized COVID-19 vaccines have demonstrated a high efficacy rate of ≥89% against COVID-19 severe enough to require hospitalization (CDC, 2021d). Therefore, high vaccine coverage among students is a public health imperative for community members, campus faculty, and staff who are older or have health problems that place them at a higher risk for severe COVID-19 infection (ACHA, 2021).

A mutation of the SARS-CoV-2 virus, known as the delta variant, surged in summer months preceding the planned return to campus (CDC, 2021f). In July of 2021, the ACHA recommended that universities implement a COVID-19 vaccine mandate for all on-campus students arriving for the fall term as the CDC issued updated guidance on vaccination efforts due to a significant increase in COVID-19 cases and hospitalizations (ACHA, 2021; CDC, 2021a). The ACHA deemed maximizing COVID-19 vaccinations in college-age students as the most

effective way for universities to return to a safe on-campus experience to prevent transmission of SARS-CoV-2 (AHCA, 2021; CDC, 2021f).

After the FDA granted full approval of the Pfizer vaccine on August 23, 2021, universities across the United States enforced vaccine mandates and reported strong compliance, achieving vaccination rates of at least 90% or higher in their campus population (CDC, 2021d; Thomason & O'Leary, 2021). Simultaneously, universities that mandated COVID-19 vaccination faced public and legal scrutiny regarding their requirements (Haeder, 2021; Thomason & O'Leary, 2021). A university's decision to mandate vaccines could jeopardize enrollment targets and operating budgets in the short term, which could translate to compromised financial health of institutions in the long run (Kim et al., 2020; Thomason & O'Leary, 2021).

Universities needed to balance financial implications with student concerns, while maintaining safety on campus, to successfully return to campus in the fall of 2021 (ACHA, 2021; Kim et al., 2020). In the absence of an institutional vaccine mandate, the decision to receive or not receive a COVID-19 vaccine falls to each individual student, and vaccination coverage for the wider university community depends largely on the uptake at the level of the student population (ACHA, 2021). Student motivation to receive vaccination is influenced by social processes such as family members, health care providers, information sharing, rumors, social norms, and what they think and feel in terms of perceived risk, fear, confidence, trust, and safety concerns (Kahn et al., 2020). These factors impact an individual's readiness, willingness, reluctance, and intention to become vaccinated (Kahn et al., 2020). With three COVID-19 vaccines widely available by the start of the fall 2021 semester, students not only had a choice to become vaccinated but a choice on which vaccine to receive. Further understanding the demographic differences in students who have quickly adopted or postponed a COVID-19

vaccine may provide insight on students with high receptivity towards voluntary vaccination, could help identify characteristics of particularly influential students, and expand voluntary vaccination efforts where need is greatest by tailoring strategies based on student demographics (Rogers, 1983).

Problem Statement

Strategies to improve COVID-19 vaccination coverage in university communities for the start of the 2021-2022 academic year have varied. Some universities opted to mandate COVID-19 vaccines, while other universities opted to promote and influence the choice for vaccination. Voluntary vaccination on college campuses preserves students' freedom of choice, but the choice of vaccination can be variable, influencing community health on and off campus and the risk for an outbreak (Bednarczyk et al., 2018; Delve & Wilkins, 2002).

Purpose

The purpose of this study was to examine the uptake of COVID-19 vaccines among residential students on a college campus that opted for vaccine choice over vaccine mandate. The demographic characteristics of student vaccine adopters as it pertains to the Diffusion of Innovation Theory offered a framework to better understand the continuum of vaccine uptake in this population by exploring demographic differences of receptivity based on time of reported vaccination. Secondly, analyzing the uptake of COVID-19 vaccines among residential students allowed for the assessment of residential community vaccination rates to help identify potential vulnerable residential communities at risk for an outbreak on a college campus.

Review of Evidence

The obtainability of a COVID-19 vaccine during a pandemic is multifaceted. The process that leads to the receipt of vaccination can be depicted through a comprehensive examination of

vaccine progression using The Vaccine Uptake Continuum (Piltch-Loeb & DiClemente, 2020). The Vaccine Uptake Continuum is derived from the 5A's framework, which identifies and characterizes barriers needed to effectively promote a solution, such as a vaccine (Delve & Wilkins, 2002; Piltch-Loeb & DiClemente, 2020). In the 5A's framework, each "A" represents an important step that must be met so the user might adopt a product, which includes awareness, availability, accessibility, affordability, and acceptability (Delve & Wilkins, 2002). Similar to successful marketing, public health efforts require a coordinated implementation to effectively promote vaccines. The Vaccine Uptake Continuum adapted the 5A's framework to systematically evaluate and address the 5A's that are key vaccine promotion factors: 1) awareness of the health threat, 2) availability of the vaccine, 3) accessibility of the vaccine, 4) affordability of the vaccine, and 5) acceptability of the vaccine (Piltch-Loeb & DiClemente, 2020). See Figure 1 for a visual representation of The Vaccine Uptake Continuum.

Awareness of the Health Threat

The first factor of The Vaccine Uptake Continuum is an individual awareness of the health threat, which depends upon knowledge of the foreseen risk of contracting the disease, the severity of the disease, and the social and economic impact of the disease (Piltch-Loeb & DiClemente, 2020). College life dramatically changed for over 14 million students when universities took emergency measures to prevent the spread of the virus at the start of the pandemic by abruptly shutting down their campuses, canceling events, closing dorms, and forcing students to complete their schoolwork remotely online (Thomason & O'Leary, 2021).

In the fall of 2020 and spring of 2021, returning students encountered the persistent social impact of the virus when, in order to balance learning and public health, most universities required all students to wear facemasks, practice social distancing, reduced in-person class sizes

or continued online learning, allowed minimal campus activities, and decreased occupancy of residence halls (Fox et al., 2021). A study conducted by the ACHA surveyed undergraduate students on their perceived susceptibility to SARS-CoV-2 and found that 60% of students with no prior symptoms of COVID-19, considered it very likely, likely, or somewhat likely that they would eventually become infected (2021). Sixty-five percent of students also reported being very or extremely concerned about how long the pandemic will last and 86% reported concerns about their health (ACHA, 2021). Students reported high levels of stress and anxiety from the COVID-19 pandemic, worrying about personal health or the health of loved ones, increased difficulty in concentrating and learning, poor academic performance, altered sleeping habits, depression, and social isolation, all of which compounded the strained mental health that has been reported in this population before the pandemic (Fox et al., 2021). Awareness of the ongoing health threat posed by COVID-19 was inescapable and the social, emotional, and academic impact of the disease was pronounced for college students (ACHA, 2021; Fox et al., 2021).

Availability

The second factor of The Vaccine Uptake Continuum is the availability of the vaccine, which pertains to the existence of a vaccine for a particular disease (Piltch-Loeb & DiClemente, 2020). The first COVID-19 vaccines were approved for emergency authorization in December of 2020, the two mRNA vaccines manufactured by Pfizer and Moderna (FDA, 2021a). The third vaccine produced by Johnson and Johnson was approved for emergency authorization by the FDA in February of 2021 (FDA, 2021a). The COVID-19 vaccine supply was initially limited, and vaccine prioritization was based on individual risk and age (CDC, 2021d). Distribution began in December 2020, making the vaccine available in the first phase to those at the highest risk of infection, which included healthcare workers and residents of long-term care facilities

(CDC, 2021d). In April of 2021, the last phase of vaccination distribution allowed anyone over 16 years of age access to vaccination (CDC, 2021d). The majority of undergraduate university students were classified under the last phase of vaccination distribution due to having the lowest risk for infection (CDC, 2021d).

Accessibility

The third factor of The Vaccine Uptake Continuum is the accessibility of the vaccine, which depends upon vaccine supply and distribution (Piltch-Loeb & DiClemente, 2020). Key pandemic partners in vaccine distribution have included pharmacies, community health centers, hospitals, home health agencies, K-12 schools, institutes of higher education, and clinics (CDC, 2021d; TNDOH, 2021b). Accessibility of the vaccine was limited at first when the vaccine supply was low and the demand was high, and as the vaccine supply increased and the expansion of vaccination sites developed, vaccination became more convenient (CDC, 2021d; TNDOH, 2021b). Convenience involves eliminating access barriers and bridging the gap between vaccination providers and individuals who need vaccinated (Kahn et al., 2020). Access challenges were reduced when vaccination sites became geographically located near supporting transportation, the hours of operation at vaccination sites were increased, no appointments were needed, and mobile vaccination sites were utilized (Kahn et al., 2020).

Affordability

The fourth factor of The Vaccine Uptake Continuum is the affordability of the vaccine (Piltch-Loeb & DiClemente, 2020). The federal government provided the vaccine free of charge to every American, regardless of health insurance status (CDC, 2021a). Vaccine providers could not charge for the vaccine, administration fees, copays, or coinsurance (CDC, 2021a). No out-of-pocket cost to the vaccine recipient ensured that no one desiring the vaccine would be faced with

an economic barrier (CDC, 2021a). To facilitate both accessibility and affordability of the vaccine, many universities provided access to the COVID-19 vaccine on campus so students had convenient access and would not encounter any additional financial burden related to transportation (CDC, 2021a; Piltch-Loeb & DiClemente, 2020).

Acceptability

The final factor of The Vaccine Uptake Continuum is the acceptability of the vaccine (Piltch-Loeb & DiClemente, 2020). When the other four "A's" of the vaccine continuum are met, receipt of vaccination is increasingly dependent on an individual's decision to elect vaccination based on a personal perception of acceptability (Piltch-Loeb & DiClemente, 2020). Vaccine acceptability is the extent to which an individual will receive a health care intervention, such as a COVID-19 vaccine, once it is considered appropriate based on reasons of perceived value, personal vulnerability, rationality, and ethicality (Sekhon et al., 2017).

Based on March 2021 data from a nationally represented Household Pulse Survey of 5,082 young adults aged 18 to 25, 56% of respondents stated they planned to "wait and see if the vaccine is safe and may get it later" and 53% of young adults stated they were "concerned about the possible side effects of COVID-19 vaccines" (Adams et al., 2021). College-age students who indicated caution and safety concerns over COVID-19 vaccines may wait to adopt vaccination or may choose to never become vaccinated (Adams et al., 2021). The level of acceptance of a COVID-19 vaccine in college-age students could be influenced by vaccine safety concerns, which creates hesitancy (Adams et al., 2021). Confidence in vaccines may build over time in young adults who are hesitant at first when more of their peers, family, and friends become vaccinated (Adams et al., 2021).

Factors Influencing Vaccine Acceptance

Social Processes. As of April 1, 2021, approximately 154 million COVID-19 vaccines were administered in the United States (CDC, 2021d). The month of April was a milestone for the majority of undergraduate students when they finally became eligible to receive a COVID-19 vaccine, four months after the initial vaccine rollout in December of 2020 (CDC, 2021d). With most students being the last to have vaccine access, students' intent to become vaccinated may have been influenced by those already vaccinated or by individuals involved in their medical decision-making, such as their parents (Sharma et al., 2021). Even though college is a time for gaining autonomy for most students, a study conducted at a U.S. university surveyed its undergraduate students' perspectives and hesitancies on the influenza vaccine and found that 56.5% relied on family members for their medical decision-making (Ryan et al., 2019). Another study that evaluated HPV vaccine decision-making in students aged 18 to 26 found that these students' decision-making was also largely influenced by their parents (Ragan et al., 2018). Besides parents, students may turn to health care professionals for vaccine recommendations, making the health communication by university health services critically important (ACHA, 2021). A recent study on COVID-19 vaccines surveyed a sample of college students and found that 50% of the individuals reported being encouraged by their healthcare provider to receive the COVID-19 vaccine, which could enhance vaccine acceptance (Sharma et al, 2021).

Misinformation. Recommendations by health care providers are being challenged by misleading information from media sources. Although 84% of university students reported that public health agencies are their most trusted source of information, the influences of social media have been strongly associated with public vaccination patterns (ACHA, 2021; Chan et al., 2020). A 2020 survey of 1,136 undergraduate students at a U.S. university reported two main sources of COVID-19 information, the Internet and social media (Chesser et al., 2020).

Misinformation on COVID-19 vaccines has circulated the Internet including the belief that COVID-19 vaccines contain microchips, the vaccine will alter a person's DNA, or the belief that if someone has already had COVID-19 they will not benefit from the vaccine (CDC, 2021e). In December of 2020 when COVID-19 vaccines Pfizer and Moderna were approved for Emergency Use Authorization, a misconception was circulating regarding COVID-19 vaccines causing infertility, which at the same time, there was also an increase in Internet searches for "infertility and COVID vaccine" (Sajjadi et al., 2021). Students can seek information quickly through Internet sources but with access to so much information, students must judge the accuracy of the information they receive to make an informed decision (Sajjadi et al., 2021).

Mistrust. Alongside the media misinformation, the COVID-19 vaccine has become increasingly politicalized. (Limaye et al., 2021). A federal government effort known as Operation Warp Speed was aimed to accelerate the development and distribution of the COVID-19 vaccines at the start of the pandemic (HHS, 2021). A perception that these vaccines have been fast-tracked to meet political timelines has existed amongst some Americans, with an increase in political ideology influencing vaccine hesitancy (Limaye et al., 2021). Public perception of the COVID-19 vaccines may be influenced by the level of governmental trust and/or conflicts with religious tenets or practices (CDC, 2021e; Latkin et al., 2021; Zimmerman, 2021).

Theoretical Model

The last aspect of The Vaccine Uptake Continuum is acceptability of vaccination and to further explain the concept of acceptability, The Diffusion of Innovation Theory developed by Everett Rogers in 1962, will be used (Rogers, 1983). According to this theory, diffusion is the process of communicating information about an innovation, which is defined as an idea or object perceived as new, in this case, COVID-19 vaccines, amongst members of a social system over a

period of time (Rogers, 1983). Diffusion begins with knowledge of an innovation and ends with adoption or rejection of the innovation (Rogers, 1983). Rogers realized that innovations are not adopted by a social system all at once, varying lengths of time are required for different members of a social system to voluntarily adopt the innovation, due to the newness aspect creating uncertainty and hesitancy (Rogers, 1983). The Diffusion of Innovation Theory has been used to study a variety of ideas, practices, and products in many disciplines and fields of study over the years and has demonstrated the predictability of adoption as an innovation gains momentum and spreads amongst people of a social system (Dearing, 2009; Rogers, 1983).

Adopting an innovation depends upon an individual's innovativeness, or the degree an individual will accept an innovation voluntarily when compared to other members of the social system (Rogers, 1983). According to this theory, members of any social system can be classified into five adopter categories based on their innovativeness, with each category having their own dominant personality, behaviors, and characteristics (Rogers, 1983). The percentage of people who have adopted an innovation over time tends to follow a predictable pattern in the shape of a bell curve, known as the diffusion curve (Rogers, 1983). See Figure 2 for a visual depiction of the diffusion curve. Based on this diffusion curve, the rate of adoption tends to begin slow, then accelerates, but eventually declines and levels off (Dearing, 2009; Rogers, 1983). The five adopter categories included in The Diffusion of Innovation Theory are the innovators, early adopters, early majority, late majority, and the laggards (Rogers, 1983).

Innovators

The first adopter category are the innovators, who are eager to try new innovations, comprising 2.5% of the population (Rogers, 1983). The innovators are rash, daring, and risky, and can cope with a high degree of uncertainty about an innovation at the time of adoption

(Rogers, 1983). The innovators are the first to adopt the innovation and play an important role in the diffusion process by importing the innovation into their social system (Rogers, 1983). The innovators are not considered the role models of the social system but are gatekeepers and change agents for the innovation (Rogers, 1983).

Early Adopters

The second adopter category based on the Diffusion of Innovation theory is the early adopters, who make up 13.5% of the population (Rogers, 1983). They are considered the role models in the social system and potential adopters look to this adopter category for innovation information and advice (Rogers, 1983). The early adopters are more integrated into their social system than the innovators (Rogers, 1983). Members of this category are respectable influencers who adopt an innovation just before the average member of the social system (Rogers, 1983). The early adopters decrease uncertainty about an innovation by adopting it and relaying information to peers (Rogers, 1983).

Early Majority

The early majority make up 34% of the population and are considered practical and deliberate (Rogers, 1983). The early majority interact frequently with peers and are an important link in the diffusion process by connecting those who are very early to adopt and those who are relatively late to adopt an innovation (Rogers, 1983). The early majority consider an innovation for some time before adopting, much longer than the innovators and early adopters, and usually adopt an innovation after seeing evidence of its success (Rogers, 1983).

Late Majority

The late majority also make up 34% of the population and are considered skeptics (Rogers, 1983). This group adopts an innovation after the average member of a social system

because they are cautious about the innovation (Rogers, 1983). They do not adopt until most of the social system has already done so and most of their uncertainty must be removed before the late majority feels that it is safe to adopt the innovation (Rogers, 1983).

Laggards

The last to adopt an innovation is the laggards, making up 16% of the population (Rogers, 1983). The laggards are the last members of the social system to adopt an innovation because they are suspicious of the innovation, resistant, and take much longer to make a decision than the rest of the social system (Rogers, 1983). Laggards may be influenced by traditional values and interact with others who are considered conservative, such as parents (Rogers, 1983). Those in this group must be relatively certain that the innovation will not fail or cause bodily harm (Rogers, 1983). Members in this group usually adopt an innovation because they were obligated (Rogers, 1983).

Application

When using The Diffusion of Innovation Theory, the aim is to understand the characteristics of each adopter group to promote the innovation tailored to each group's unique personality and behavior (Rogers, 1983). By categorizing undergraduate students into the five adopter categories who attend a university where COVID-19 vaccines are voluntary, the identification of students most willing to embrace vaccination and those who are resistant to vaccination can be recognized. Based on the five adopter categories, the characteristics of students who other students go to for advice, guidance or modeling can also be identified (Rogers, 1983). Future health promotion on campus could be tailored based on each adopter category's innovativeness, characteristics, and values through the creation of distinct communication and adaption strategies.

Project Design

A descriptive, cross-sectional analysis of vaccine uptake was derived from campus electronic health records known as MEDICAT to populate data on vaccinated residential students at Belmont University during the fall of 2021. This design was realistic and feasible as the data was electronically accessible to populate reports and offered pertinent information to Belmont University and Belmont Health Services for vaccine efforts, the prevention of campus outbreaks, and the potential need for asymptomatic COVID-19 testing on-campus. This project was reviewed and verified as exempt by Belmont University Institutional Review Board in April 2021.

Project Setting

Beginning April 26, 2021, Tennessee schools of higher education began mandating COVID-19 vaccination for the fall 2021 term, including Vanderbilt University, American Baptist College, Christian Brothers University, Maryville College, Meharry Medical College, Rhodes College, and The University of the South (Thomason & O'Leary, 2021). This project was implemented at Belmont University, located two miles from downtown Nashville, Tennessee. Belmont University is a private four-year, 93-acre Christian-centered university with programs including business administration, entertainment and music, health sciences and nursing, law, theology and Christian ministry, music and performing arts, architecture, art and design, and education. The University requires all full-time, undergraduate students with fewer than 60 credit hours by the start of fall semester to live in campus housing, unless the student is 21 years of age or older, married, has children, or has living arrangements with a family member ("Residence Life", n.d.). See Graph 1 for undergraduate race and ethnicity breakdown at Belmont University for the 2020-2021 academic year with enrollment of 6,614 students.

In the fall of 2021, Belmont welcomed 7,150 undergraduate students, representing all 50 U.S. states and more than 28 countries, opting for vaccine choice over vaccine mandate, but strongly recommended COVID-19 vaccination to any student wishing to be part of the Belmont community, ("Belmont", n.d.). After encountering reduced in-person opportunities during the Spring of 2021, which included minimal campus activities, reduced in-person class sizes, the utilization of online learning, and reduced capacities of residential housing, normal semester operations were resumed. In-person classes were at full capacity, all indoor spaces were at full capacity, fitness facilities were open, in-person meetings, events, gatherings, campus activities were resumed, and residence halls were at max capacity ("Campus Plan", n.d.).

A week after the start of fall 2021 semester, the Davidson County pandemic vulnerability index rose to 0.5786, meaning the surrounding community transmission for COVID-19 was significantly elevated (TNDOHa, 2021). By September, the state of Tennessee had the highest number of COVID-19 cases by population in the United States (CDC, 2021e). Davidson County metropolitan area had consistently reported higher counts of COVID-19 cases compared to other Tennessee metro areas (TNDOH, 2021a). Numerous clinics, pharmacies, and vaccination sites offered COVID-19 vaccinations in the metro area and by October 5, 2021, 56.95% of Davidson County Tennesseans were fully vaccinated (TNDOH, 2021a). On campus, Belmont University Health Services (BUHS), a clinic that provides non-emergent outpatient medical care for students, faculty, and staff, monitors health and immunization requirements of students, offered all three COVID-19 vaccines, at no charge, in clinic and through pop-up campus vaccination events to students, faculty and staff.

Project Population

This study is an analysis of the demographic characteristics of the undergraduate student population living on campus in the fall of 2021 by reported vaccination status. Students were considered vaccinated if they provided proof of receiving at least one dose of Pfizer, Moderna, or Johnson and Johnson vaccine to Belmont University Health Services by the time of data collection on October 15, 2021. A total of 3,644 residential undergraduate students were assigned to live on-campus and a list of Belmont's residential communities can be seen in Table 1.

Sources of Data/ Instruments/ Measurements

Students who received a COVID-19 vaccine off-campus were encouraged to upload vaccine documentation to Belmont's University Health Services online portal. Specific instructions on how to upload vaccination records to the Belmont University Health portal was sent to every student via email and directions were also found on the university website. Once a student uploaded proof of vaccination, Belmont University Health Services staff verified the uploaded file and entered the date of vaccination into the university's online health records. Students who received the COVID-19 vaccine on-campus through Belmont University Health Services did not need to enter their vaccine information online, as it was already in the Health Services medical records.

Data Collection Process/Procedures

An anonymous report of undergraduate residential students captured sectional data points across the dates of December 14, 2020, through October 15, 2021. Information was only obtained during this period of time since December 14, 2020, was the start date for vaccine distribution nationwide, and the earliest date a student would have had access to a vaccine if they qualified (CDC, 2021d). The end data point was October 15, 2021, which was the date the report was

generated. MEDICAT was accessed by Belmont University Health Services team members who provided the project leader with the obtained data on undergraduate residential students. Data elements were automatically collected for vaccine variables of vaccine manufacturer and initial date of vaccination. Automatically collected demographic variables included college of study, year of school, and campus housing. These computerized reports were then exported into an Excel spreadsheet.

Results

SPSS statistical software version 28 was used to compute descriptive statistics. The majority of undergraduate residential students provided proof of vaccination to Belmont University by October 15, 2021 (78.7%, N=2,867). A summary of vaccine status by class can be viewed in Graph 2 and a summary of vaccine manufacturer is depicted in Graph 3. The mean reported date of vaccination was April 30, 2021 (*SD* = 51.8 days). A surge in vaccine uptake occurred between March 7, 2021, and May 7, 2021. See Graph 4 for vaccination date frequency beginning the week of December 13, 2020 and ending the week of October 17, 2021.

To assess vaccine uptake by college, vaccine rates were calculated per 100 students and compared. Students were grouped by their college of study. See Table 2 for college breakdown of undergraduate residential students. Vaccination rates for each college varied from 65.1 vaccinations per 100 students for undeclared students to 84.5 vaccinations per 100 students for students in the College of Education.

Diffusion of Innovation

To apply the Diffusion of Innovation Theory to the study sample, vaccinated students were arranged by chronologically based on the date of their first vaccine. Then, vaccinated students were grouped into one of the five adopter categories (innovators, early adopters, early

majority, late majority, laggards) and mapped to the Diffusion of Innovation Theory adoption curve. After grouping vaccinated students into one of the five adopter categories, students were categorized by their college of study to compare vaccination rates. See Table 3.

Innovators

A total of 72 (2.5%) students were classified as innovators out of 2,867 vaccinated students. See Table 3 for college breakdown of vaccinated undergraduate residential students classified as innovators. The innovators date of initial vaccination ranged from the weeks of December 13, 2020, to February 7, 2021. The College of Health Sciences compromised 37 (43.0%) of the innovators, which included the undergraduate programs of public health, nursing, social work, and exercise science. Of the 37 innovators in the College of Health Sciences, 34 belonged to the School of Nursing. There were no identified innovators from the College of Interdisciplinary Studies, College of Liberal Arts and Social Sciences, O'More College of Architecture and Design, and College of Education.

Early Adopters

A total of 387 (13.5%) students were classified as early adopters. See Table 3 for college breakdown of vaccinated undergraduate residential students classified as early adopters. The early adopters date of initial vaccination ranged from the weeks of February 7, 2021, to March 28, 2021. Each college of study had at least five students classified as an early adopter. The College of Education compromised the highest relative percentage of the early adopters.

Early Majority

A total of 974 (34.0%) students were classified as early majority. See Table 3 for college breakdown of vaccinated undergraduate residential students classified as early majority adopters. The early majority date of initial vaccination ranged from the weeks of March 28, 2021, to April

18, 2021. The College of Sciences and Math compromised the highest relative percentage of the early majority. The College of Business Administration, the College of Sciences and Math, College of Liberal Arts and Social Sciences, and the College of Entertainment and Music Business had more students classified as late majority adopters when compared to the number of these students in other adopter groups.

Late Majority

A total of 974 (34.0%) students were classified as late majority. See Table 3 for college breakdown of vaccinated undergraduate residential students classified as late majority adopters. The late majority adopters' date of initial vaccination ranged from the weeks of April 18, 2021, to June 27, 2021. The College of Interdisplinary Studies compromised the highest relative percentage of the late majority. The College of Interdisplinary Studies, the College of Theology and Ministry, the College of Music and Performing Arts, O'More College of Architecture and Design, and the College of Health Sciences had more students classified as late majority adopters when compared to the number of these students in the other adopter groups.

Laggards

A total of 460 (16.0%) students were classified as laggards out of 2,867 vaccinated students. See Table 3 for college breakdown of vaccinated undergraduate residential students classified as laggards. The laggards date of initial vaccination ranged from the weeks of June 27, 2021, to October 17, 2021. The O'More College of Architecture and Design compromised the highest relative percentage of the laggards.

Residential Communities

Students were grouped by campus residence to compare the total number of residential students with the number vaccinated in each residential community. See Graph 5 for a

comparison of vaccinated undergraduate residential students to the total undergraduate residential students by residential community. Vaccination coverage among residential students by campus residence ranged from 62% to 83%. The lowest vaccination rates included female only freshmen residential community Heron Hall at 62% and coed freshmen residential community Thrailkill Hall at 63%. The highest vaccination rate was female only freshmen residential community Hail Hall at 83%. The coed upperclassmen residential community Tall Hall Apartments and Suites resides the highest number of campus residents and reported a vaccination rate of 71%.

Discussion

Findings from the study support a generalization from The Diffusion of Innovation Theory which states that the degree of interconnectedness in a social system is positively related to the rate of adoption (Rogers, 1983). Based on the findings, Belmont University has a close social system linked with communication networks from every college of study that contributed to the 78.7% voluntary vaccination rate of the campus. Findings from the study also support the theory's claim that the relative advantage of an innovation by members of a social system is positively related to its rate of adoption (Rogers, 1983).

When vaccinated students were grouped into the five adopter categories and mapped to the adoption curve, every college of study appeared to follow similar rates of adoption in a discernable pattern. The trajectory of the rate of adoption for each college began to level off as fewer students remained within each college who were not yet vaccinated. According to the Diffusion of Innovation Theory, the social system has a direct effect on diffusion and can either facilitate or impede the diffusion of innovation in its social system (Rogers, 1983). Belmont

University facilitated the diffusion of vaccination through accessibility and promoting vaccination.

Belmont University's Voluntary COVID-19 Vaccination Policy

It is already known that vaccines decline morbidity and mortality through direct protection of those vaccinated and indirect protection to the community, but vaccines are only effective when vaccine uptake levels are high (CDC, 2021b). The American College Health Association stated that the return to pre-pandemic classroom conditions and on-campus housing was contingent upon high levels of campus vaccination and recommended COVID-19 vaccination requirements for all on-campus university students returning in the fall of 2021 (ACHA, 2021). In the Spring of 2021, Belmont University released a statement advocating for the resumption of a more traditional learning and living experience in the fall of 2021 but noted this choice for normalcy would be highly influenced by the vaccination rate of the campus community. Belmont University administration and leadership issued clear statements that COVID-19 vaccination was the most effective strategy in managing the SARS-CoV-2 virus and a vaccinated campus was the easiest path to a fall semester with minimal restrictions and inconvenient protocols.

As mentioned earlier in the text, universities that mandated COVID-19 vaccination faced public and legal scrutiny regarding their requirements (Haeder, 2021; Thomason & O'Leary, 2021). The literature states that mandating vaccination risks turning an effective public health intervention into a contentious matter that could jeopardize enrollment rates and operating budgets of a university in the short term and later translate to compromised financial health of an institution in the long term (Kim et al., 2020; Thomason & O'Leary, 2021). For the fall 2021 semester, Belmont University strongly recommended vaccination and opted for vaccine choice

over vaccine mandate, creating university protocol decisions based on status to incentivize vaccination. On a college campus where voluntary COVID-19 vaccination was promoted and accessibility of the vaccine was convenient, vaccination rates reached almost 80% amongst undergraduate students living in residential communities. Belmont students may have found advantages towards vaccination, which increased vaccination rates, such as the factors that were previously identified in the literature as the return to pre-pandemic life, preventing missed classes, or being concerned about their own health.

Promoting Vaccine Accessibility on Campus

To increase accessibility of the free vaccine, Belmont University Health Services proactively responded to the challenge of vaccine accessibility by becoming a designated vaccine provider and worked together by contacting state officials, requesting vaccine allocation to the campus community. Initially, the Johnson and Johnson vaccine was the only vaccine being allocated to Tennessee colleges and universities. Belmont received their first allocation of 500 doses of Johnson and Johnson's single-dose COVID-19 vaccine on March 29, 2021, and with the partnership of Tennessee Department of Health, the campus was able to provide vaccine distribution to their campus community beginning April 1, 2021. An additional 1,000 doses of Johnson and Johnson vaccine was allocated to Belmont University on April 6, 2021. The campus offered vaccine clinics on April 8th and April 9, 2021, of the single-dose Johnson and Johnson vaccine before the end of spring semester on April 24th.

Belmont offered Moderna and Johnson and Johnson vaccinations during the fall 2021 semester beginning August 19, 2021. Belmont University's first day of classes was on August 25, 2021, and 116 students received a vaccine after the start of the semester. These students could have had accessibility issues over the summer months. The accessibility of vaccination for

students may have varied based on a student's home residence and financial status, resulting in some students returning to campus in the fall that may not have had convenient access over the summer months (ACHA, 2021). International students may not have had access to a vaccine in their home countries before arrival on campus (ACHA, 2021).

Vaccine Acceptability on Campus

For the fall 2021 semester Belmont University strongly recommended vaccination and opted for vaccine choice over vaccine mandate, creating university protocol decisions based on vaccination status. Incentivizing vaccination, Belmont specified that any vaccinated student who was two-weeks post-vaccination and remained asymptomatic would no longer be subject to quarantine requirements after close contact with a positive case, based on the advice from the CDC. Unvaccinated residential students would have to provide their own place for isolation or quarantine that was away from campus for a minimum of five days and would not be allowed to attend class. University policy stated that students who did not provide proof of vaccination would be required to wear masks when indoors and would be required to fill out a daily COVID-19 symptom form before reporting to class. University-sponsored travel would be limited only to vaccinated students. Students would also be subject to the requirements and protocols of off-campus learning experiences and stated that unvaccinated students may not be able to participate, and a similar replacement experience may not be available, which would jeopardize gaining course credits. Vaccine acceptability was influenced by university protocols and the ultimate choice to become vaccinated was solely up to each individual student. Despite university efforts to promote vaccination, social processes, mistrust, and misinformation was identified in the literature as factors that may contribute to vaccine hesitancy and resistance towards vaccine

acceptability (Chan et al., 2020; Chessner et al., 2020; Ryan et al., 2019; Sajjadi et al., 2021; Sharma et al., 2021; Zimmerman, 2021).

Another generalization of The Diffusion of Innovation Theory is that individuals who adopt an innovation earlier than the rest of the social system have a more favorable attitude toward science than later adopters (Rogers, 1983). This generalization is evident for Belmont University because students from the College of Health Sciences were amongst the first to become vaccinated and comprised the majority of the innovators. Also, the first phase of vaccine distribution began in December 2020 and was available to all healthcare workers which students in the College of Health Sciences may have held jobs in the healthcare field making them eligible to receive vaccination. The College of Health Sciences had 82.0% vaccination rate and receiving the vaccine may have been a requirement of clinical placement in order to complete their program of study. Students from the College of Health Sciences played an important role as gatekeepers in the diffusion process by importing COVID-19 vaccination into the residential student social system.

Innovators from the College of Health Sciences interacted with students classified as early adopters. Each college of study had at least five students classified as an early adopter and these early adopter students are considered the role models of the residential student social system. Per the Diffusion of Innovation Theory, these students contributed towards increasing vaccine acceptability by decreasing vaccine uncertainty through conveyance of their subjective evaluation of vaccination to their near peers in their social networks on campus

Implications for Practice

As the literature suggests, the project findings support the need to encourage and increase accessibility for preventive health promotion on a college campus that opted for vaccine choice

over vaccine mandate. Accessibility is not enough to guarantee receipt of vaccination, as the Vaccine Uptake Continuum exemplifies the other "A's" of the continuum such as awareness of the health threat, availability of the vaccine, and affordability must also be met. The largest uptake in vaccinations occurred between March 7, 2021, and May 9, 2021, which reflects when the vaccine was accessible, when it was promoted on campus, and when the vaccine was made readily available to students. The analysis of vaccine uptake variability between dormitories and colleges on campus identified areas of need for increased public health strategies to promote campus health and safety. Residential communities with lower vaccination rates may benefit from the use of other public health tools including surveillance testing, frequent sanitization of highly trafficked areas, and mask wearing to promote and protect the health of residential students.

University protocols motivated students' choice to uptake vaccination to access in-person learning, engage in social connections around campus, and attend athletic events. Health promotion strategies that promote both accessibility and acceptability can leverage the power of social influence and meet it with easy access to care. The combination of accessibility and acceptability enhances uptake and compliance with public health measures. Alternatively, vaccination mandates can inspire mistrust and animosity amongst students, which is opposite of the intended effect, causing delays and resistance to vaccination. Elements from the Diffusion of Innovation Theory can improve vaccination efforts that are tailored based on each adopter category's innovativeness.

Strengths and Limitations

This study contributed to the understanding of vaccine acceptance within the undergraduate residential communities at Belmont University and provided Belmont University

Health Services an analytical breakdown of campus vaccination coverage. Students who were vaccinated but did not report their vaccination to Belmont University Health Services were not included in this study and the vaccination rate amongst students may be higher than previously thought. The effectiveness of Belmont University's residential vaccination campaign on preventing a campus outbreak are clearly influenced by factors beyond the control of campus authority mentioned in the literature such as the type of vaccination received, the presence of virus mutations, the enforcement of COVID-19 protocols such as mask wearing and social distancing around campus, the county pandemic vulnerability index, and the vaccination rate of the larger Nashville community. Acknowledging limitations of the reach of campus policies and protocols inspires the sense that we are a community within a community and motivates awareness of our interconnectedness with the broader city and state community.

Conclusion

The Diffusion of Innovation theory offered a framework to better understand the continuum of vaccine uptake in the undergraduate residential student population. The Vaccine Uptake Continuum identifies receipt of vaccination dependent on an individual's perception of acceptability, comparable to The Diffusion of Innovation Theory which echoes the generalization that social networks influence the degree of an individual's voluntary acceptability (Piltch-Loeb & DiClemente, 2020; Rogers, 1983). This study exemplifies the appropriate decision of a campus who opted for voluntary vaccination amongst its undergraduate residential students in order to achieve a high campus vaccination rate.

Further studies investigating Belmont University's campus networks could help explore the close interactions between students based on their college of study to better understand how they obtain information and how to narrow the gaps between students with plentiful information

on preventive health care and students who lack information within the campus social system. Future efforts can be tailored based on each adopter category's innovativeness, characteristics, and values by creating distinct communication and adaption strategies. Additional research is warranted to explore the demographics of the unvaccinated student population and the effectiveness of the vaccination rate at preventing a COVID-19 outbreak.

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Appendix

Figure 1

The Vaccine Uptake Continuum

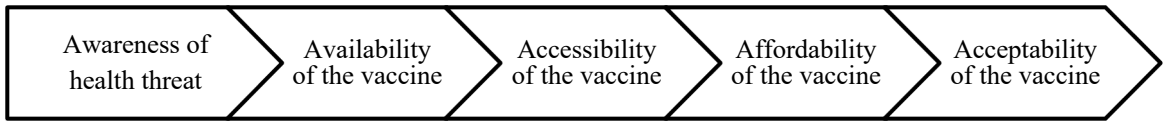
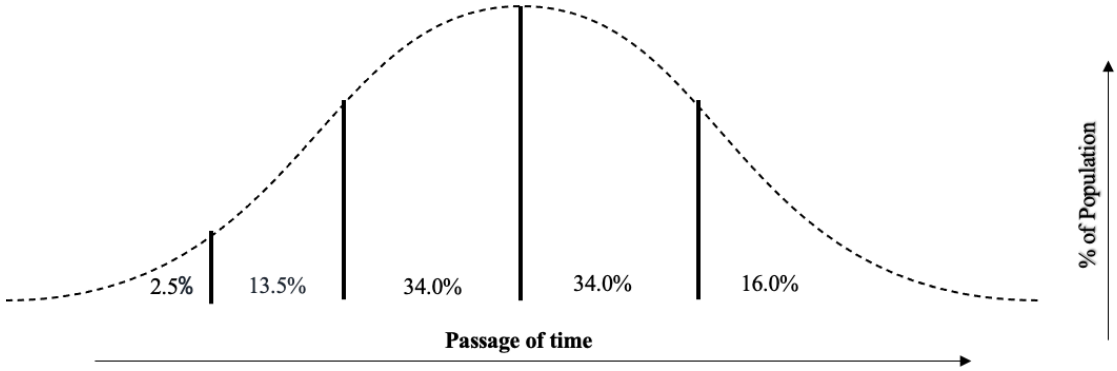


Figure 2

The Diffusion of Innovation Adoption Curve



Graph 1

Belmont Academic Year 2020-2021 Breakdown of Undergradutae Race and Ethnicity

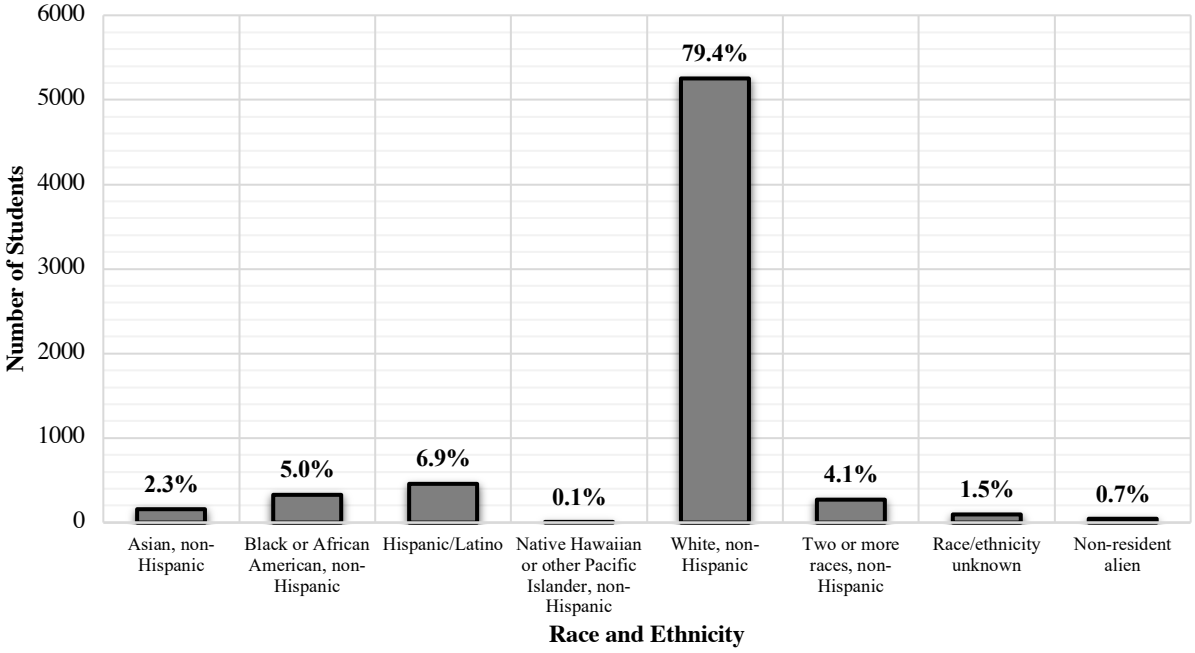


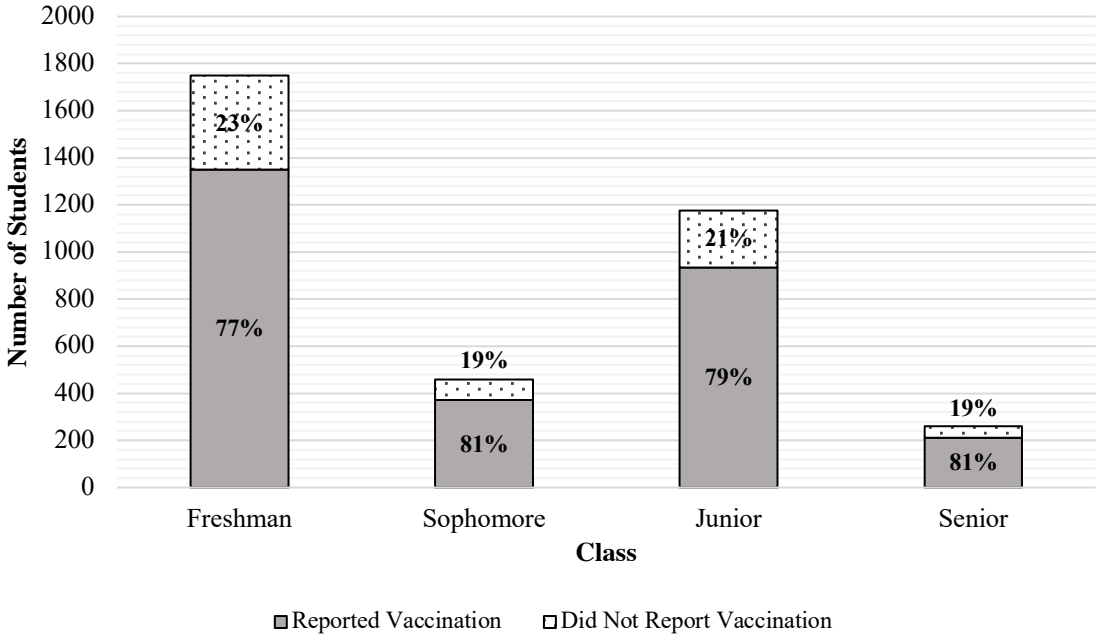
Table 1

Breakdown of Undergraduate Student Residential Occupancy at Belmont University

Female Only Freshmen Residential Communities
Hail Hall
Heron Hall
Kennedy Hall
Wright Hall
Male Only Freshmen Residential Communities
Maddox Hall
Pembroke Hall
Coed Freshmen Residential Communities
Patton Hall & Bear House
Potter Hall
Thrailkill Hall
Coed Upperclassmen Residential Communities
Belmont Commons
Dickens Hall
Hillside Apartments
Horrell Hall
Russell Hall Apartments & Suites
Tall Hall Apartments & Suites

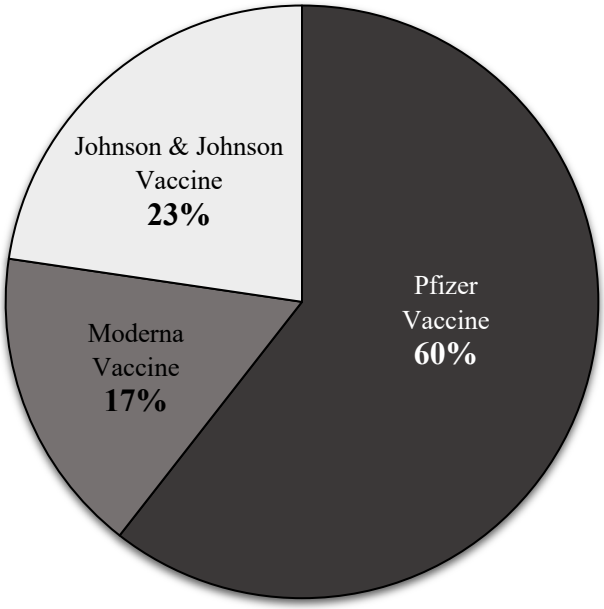
Graph 2

Vaccination Status of Undergraduate Residential Students by Class



Graph 3

Undergraduate Residential Students Reported COVID-19 Vaccine Manufacturer (N=2,867)



Graph 4

Reported Date of First Vaccination of Undergraduate Residential Students

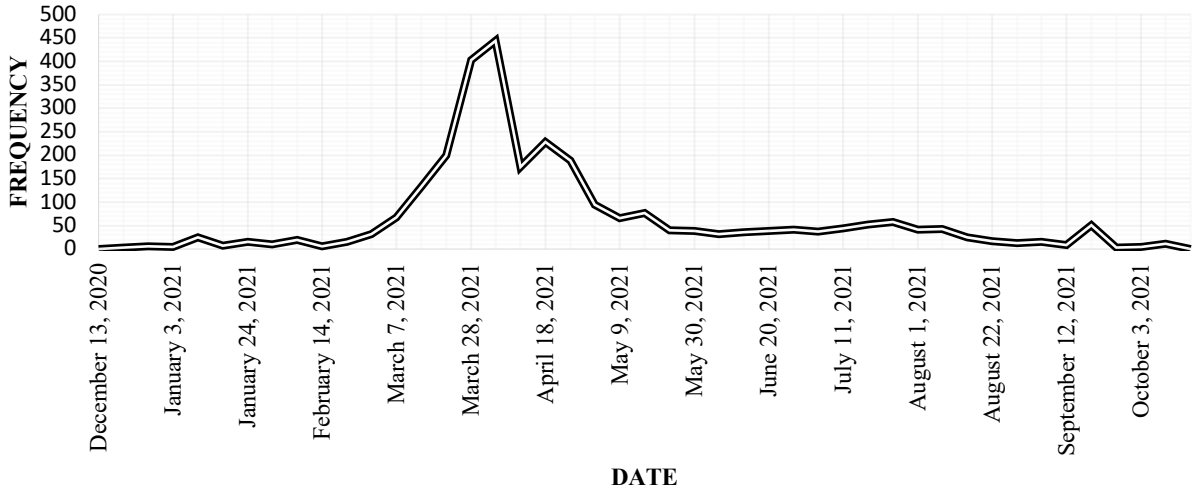


Table 2

College Breakdown of Undergraduate Residential Students

College	Total Students	% Reported Vaccination
Entertainment & Music Business	1373	79.2
Music & Performing Arts	556	82.0
Health Sciences	411	82.0
Sciences & Math	381	81.4
Business Administration	306	72.2
Lib. Arts & Social Sciences	189	79.4
Architecture	123	67.5
Undeclared	83	65.1
Art	69	72.5
Education	58	84.5
Interdisplinary Studies	53	77.4
Theology & Ministry	42	69.0
Total	3644	78.7

Table 3

Percentage of Student Adopters Based on College of Study

College of Study	Innovators	Early Adopters	Early Majority	Late Majority	Laggards
Health Sciences	43.0%	7.9%	9.0%	7.3%	9.8%
Sciences & Math	15.0%	10.6%	8.9%	7.9%	7.2%
Art	13.8%	9.2%	6.8%	8.2%	5.3%
Theology & Ministry	11.4%	5.9%	9.4%	8.3%	7.3%
Undeclared	5.7%	5.9%	5.7%	6.8%	11.0%
Entertainment & Music Business	4.5%	10.3%	8.8%	8.6%	6.4%
Music & Performing Arts	3.4%	9.6%	8.5%	9.8%	7.5%
Business Administration	3.1%	9.0%	6.2%	8.0%	7.8%
Education	0.0%	9.7%	16.3%	8.7%	5.3%
Interdisplinary Studies	0.0%	6.0%	8.9%	10.7%	9.2%
Lib. Arts & Social Sciences	0.0%	9.0%	8.3%	7.9%	11.3%
Architecture & Design	0.0%	6.9%	3.2%	7.7%	11.9%

Graph 5

Comparison of Vaccination Status by Residential Community