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Students' preferences for returning to colleges and universities during the COVID-19 pandemic: A discrete choice experiment

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A R T I C L E I N F O

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A B S T R A C T

Importance: When an emerging infectious disease outbreak occurs, such as COVID-19, institutions of higher education (IHEs) must weigh decisions about how to operate their campuses. These decisions entail whether campuses should remain open, how courses should be delivered (in-person, online, or a mixture of the two), and what safety plans should be enacted for those on campus. These issues have weighed heavily on campus administrators during the on-going COVID-19 pandemic. However, there is still limited knowledge about how such decisions affect students' enrollment decisions and campus safety in practice when considering compliance.
Objectives: To assess 1) students' willingness to comply with health protocols and contrast their perception of their classmates' compliance, 2) whether students prefer in-person or online learning during a pandemic, and 3) the importance weights of different aspects of campus operations (i.e., modes of course delivery and safety plans) for students when they decide to enroll or defer.
Design, setting, and participants: An internet-based survey of college students took place from June 25, 2020 to July 10, 2020. Participants included 398 industrial engineering students at the Georgia Institute of Technology, a medium-size public university in Atlanta, Georgia. The survey included a discrete choice experiment with questions that asked students to choose whether to enroll or defer when presented with hypothetical scenarios related to Fall 2020 modes of course delivery and aspects of campus safety. The survey also asked students about expected compliance with health protocols, whether they preferred in-person or online courses, and socio-demographic information.
Main outcomes and measures: We examine students' willingness to comply with potential health protocols. We estimated logistic regression models to infer significant factors that lead to a student's choice between in-person and online learning. Additionally, we estimated discrete choice models to infer the importance of different modes of course delivery and safety measures to students when deciding to enroll or defer.
Results: The survey response rate was 20.8%. A latent class model showed three classes of students: those who were "low-concern" (comprising a 29% expected share of the sample), those who were "moderate-concern" (54%) and those who were "high-concern" (17%). We found that scenarios that offered an on-campus experience with large classes delivered online and small classes delivered in-person, strict safety protocols in terms of mask-wearing, testing, and residence halls, and lenient safety protocols in terms of social gatherings were broadly the scenarios with the highest expected enrollment probabilities. The decision to enroll or defer for all students was largely determined by the mode of delivery for courses and the safety measures on campus around COVID-19 testing and mask-wearing. A logistic regression model showed that a higher perceived risk of infection of COVID-19, a more suitable home environment, being older, and being less risk-seeking were significant factors for a person to choose online learning. Students stated for themselves and their classmates that they would comply with some but not all health protocols against COVID-19, especially those limiting social gatherings.
Conclusions and relevance: The majority of students indicated a preference to enroll during the COVID-19 pandemic so long as sufficient safety measures were put in place and all classes were not entirely in-person. As IHEs consider different options for campus operations during pandemics, they should consider the

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heterogeneous preferences among their students. Offering flexibility in course modes may be a way to appeal to many students who vary in terms of their concern about the pandemic. At the same time, since students overall preferred some safety measures placed around mask-wearing and COVID-19 testing on campus, IHEs may want to recommend or require wearing masks and doing some surveillance tests for all students, faculty, and staff. Students were expecting themselves and their fellow classmates to comply with some but not all health protocols, which may help IHEs identify protocols that need more education and awareness, like limits on social gatherings and the practice of social distancing at social gatherings.

1. Introduction

During the Spring term of 2020, many institutions of higher education (IHEs) closed their campuses due to the COVID-19 pandemic. Administrators had to grapple with challenging decisions about when and how to reopen their campuses for the Fall 2020 and Spring 2021 terms. For the COVID-19 pandemic, these concerns continued into the Fall 2021 semester as new variants of the coronavirus spread. When an emerging infectious disease outbreak, such as the COVID-19 pandemic, or other on-going disasters occur, college administrators similarly need to make decisions that balance the health and safety of students, faculty, and staff with other competing factors such as the long-term financial viability and the quality of education of their institutions.

Some operational decisions, such as moving some courses online and reducing capacity in campus housing, may provide a balance between these competing objectives, but they may not be the best practice. According to data collected by The Chronicle of Higher Education [1] at the start of the COVID-19 pandemic, around 67% of the 910 IHEs that were tracked were planning for in-person course instruction as of June 8th, 2020. Of the remaining IHEs, 9% were considering a range of scenarios, 8% were proposing a hybrid model (a mixture of in-person and online courses), 8% were planning for online instruction, and 7% were waiting to decide. As of October 1st, 2020, the Chronicle of Higher Education reported that about 27% of nearly 3000 colleges reported were fully in-person or primarily in-person, another 21% were operating in a hybrid mode, and 44% being fully online or primarily online (and the remaining 8% either undetermined or operating in another instructional mode). With the availability of vaccines, most U.S. colleges are planning to return to “normal” operations in the Fall 2021 term with various degrees of mandated safety protocols [2].

While weighing decisions on how to deliver courses during the COVID-19 pandemic, student enrollment has weighed heavily on IHE administrators. According to a survey of 192 college and university presidents conducted by the American Council on Education, 78% strongly agreed that they were concerned about student enrollment due to COVID-19 [3]. In fact, a report from the National Student Clearinghouse Research Center states that undergraduate enrollment in Fall 2020 is 4.0% below Fall 2019’s enrollment and that enrollment of first-time students is down 16.1% compared to Fall 2019 [4]. The same report’s preliminary data on Spring 2021 enrollment (as of March 25) suggests that spring undergraduate enrollment is down 5.9% compared to Spring 2020. With these declines, revenue from room and board, meals and other auxiliary services were negatively impacted [5] confirming some IHE administrators’ concerns about financial viability of their institutions [3].

Throughout the course of the COVID-19 pandemic, IHEs’ plans for campus reopening, including course delivery and campus safety, evolved as more information about the disease was learned and adapted in attempts to maintain enrollment and keep students, faculty, and staff safe. Modeling studies have been used to investigate how effective these different non-pharmaceutical interventions such as testing, contact tracing, isolation, and remote instruction are in terms of mitigating disease spread on campus [6–8]. Network analysis has been used to investigate the influence of remote instruction policies on the co-enrollment networks of students which may inform reopening policies [9]. There has also been guidance issued for mitigating disease risk when conducting face-to-face instruction, which suggests that the use of quarantine and remote instruction, social distancing techniques, mask-wearing and handwashing, and frequent cleaning in common spaces are useful mitigation tools [10,11].

However, largely missing from the literature is an understanding of how the proposed course delivery and campus safety policies affect students’ decisions to enroll or defer and whether students would comply with these intervention policies. Meanwhile, previous research suggests that outbreaks of diseases that cross over from animals to humans, such as COVID-19, have increased in the past decades [12] and may continue to pose threats to IHEs. With the growing risk of emerging epidemics, it is important to understand students’ preferences and behavior in response to such situations to better predict the effectiveness of different interventions on college campuses. For universities that are using or planning a hybrid mode of course delivery, it is unknown what factors would influence a student to choose in-person or online courses under the current circumstances. These factors may help them better allocate limited academic resources. Furthermore, universities and colleges may want to propose plans that include safety protocols such as social distancing, testing, and masks, but it is unclear whether students will adhere to these protocols or will, instead, partake in behavior that puts themselves at risk of being infected with and spreading COVID-19.

While many institutions have returned to full in-person residential instruction as of Fall 2021, they have done so under a variety of approaches. With the arrival of several COVID-19 vaccines, and full FDA approval of one vaccine as of August 2021 [13], some campuses have mandated vaccines for faculty and staff [14] as well as mandating some non-pharmaceutical mitigation measures, such as mask wearing. Other institutions are recommending, but not requiring, either vaccines or masks. As our study was designed and survey administered prior to any vaccines being available, we are focusing on non-pharmaceutical mitigation measures institutions could adopt. The ongoing discussion about the potential waning of vaccine-induced protection and rising breakthrough infections indicate that non-pharmaceutical approaches will remain part of the toolkit used to mitigate COVID-19 and potential future pandemics of infectious diseases [15].

The objectives of this study were (1) to assess the relative contribution of different attributes related to course modes and safety plans to students’ preferences for enrolling or deferring, (2) to analyze stated choices for in-person or online learning during a pandemic, and (3) to estimate students’ self-reported and expected compliance behavior related to campus mitigation efforts of COVID-19. We sought to inform decisions around university campuses’ modes of course delivery and safety plans during the pandemic and evaluate whether students’ enrollment decisions are sensitive to these aspects; to point out what features of students should be considered by IHEs when offering in-person and online courses; and how effective prevention strategies are likely to be given students’ compliance behavior.

2. Methods

2.1. Sample and study design

We conducted an online survey of a sample of 398 college students in the United States from June 25, 2020 to July 22, 2020. Participants were sampled from the Georgia Institute of Technology (Georgia Tech), a medium-sized public university in an urban region in Georgia. Participants received the survey link through an email to their department listserv. For this survey, we sampled undergraduate students (≥ 18 years old) from an industrial engineering program.

2.2. Survey instrument

The survey asked students about their preferences for enrollment or deferral when presented with combinations of different aspects of campus operations amid the COVID-19 pandemic, and other information like their concern over the pandemic as well as demographic information. The full survey instrument is provided in Appendix C. This survey began with an introduction section which included information that the survey was intended to learn more about the impact of the COVID-19 pandemic on student views related to the reopening of university campuses in Fall 2020. This section also asked about students' levels of concern about COVID-19 as well as questions to gauge their risk attitudes.

The Introduction section was followed by a discrete choice experiment (DCE) designed to elicit student preferences for their university's operations amidst COVID-19 during the Fall 2020 term. DCEs are a subset of conjoint analysis methodologies that are used to elicit stated preferences about decisions that require trade-offs among multiple attributes. They have been commonly used in transportation and marketing research [16,17], and these methods are also applied to valuation in healthcare [18]. In DCEs, respondents are presented with a series of choice sets, and in each choice set, respondents are asked to choose between 2 or more options (alternatives). Each option is defined by certain characteristics (attributes) which can be assigned different values (levels). The choices made by respondents are then used to infer the importance of each level of the various attributes to those choices.

We identified several important attributes of campus operations by surveying opinion editorials written by university presidents, consultations with undergraduate students, and discussions with members of the COVID-19 campus recovery taskforce at the university where the survey was conducted. After identifying a candidate list of attributes, we chose to vary five attributes in the DCE to limit the cognitive burden on participants [19], and asked about other factors in the remainder of the survey. The final attributes included in our DCE were *Mode of Course Delivery*, *Safety on Campus*, *Residence Hall Operating Capacity*, *Tuition Reduction*, and *Limits on Events and Social Gatherings*. Each of these attributes was assigned 4 levels based on the latest recommendations from the Centers for Disease Control and Prevention's interim guidance to institutions of higher education to prepare for COVID-19 [20], as well as discussions with IHE administrators. The attributes and their levels are shown in Table 1. In addition to two unlabeled enrollment options for each choice set, the respondents were also presented with a third option, "Defer enrollment for at least one term." An example question is shown in Fig A1 in Appendix A.

All discrete choice sets were generated using a fractional factorial design in which all five attributes were considered for each choice set. The design was restricted to eliminate comparisons that included dominated options. In this process, forty-eight choice sets were created, and the design was evaluated based on the D-efficiency statistic to evaluate the balance and orthogonality of the experimental design. These choice sets were then evenly and randomly distributed into six blocks, and respondents were randomized to one of the six blocks. The experimental design was created using macros in SAS 9.4 [21] and then the choice tasks were converted to questions in Qualtrics [22] which was used to administer the survey. More details about the design are provided in Appendix B.

After the discrete choice experiment, students were asked about their intended compliance with COVID-19 health protocols and their expectations around their classmates' compliance. We also asked a series of other questions related to other preferences around campus operations and perceived risk of COVID-19. In addition, the survey included questions about demographic characteristics of the students.

Table 1
Attributes and levels for campus operations discrete choice questions.

Attributes	Levels
Mode of Course Delivery:	All classes delivered entirely in-person[a]
	All classes deliver large lectures online & small group activities in-person
	Some classes delivered entirely in-person & some classes delivered entirely online
	All classes delivered entirely online
Safety on Campus:	Masks required & extensive COVID-19 testing
	Masks required & some COVID-19 testing
	Masks recommended & some COVID-19 testing
	No masks & no testing[a]
Residence Hall Operating Capacity:	Closed, 0%
	Open, 25% capacity (no roommates & no shared bathrooms)
	Open, 50% capacity (no roommates, but shared bathrooms)
	Open, 100% capacity[a]
Tuition Reduction:	None[a]
	10%
	20%
	30%
Limits on Events and Social Gatherings:	20 people
	50 people
	100 people
	No limit[a]

[a] Reference level.

At the time of our survey, students were making their own enrollment and on-campus housing decisions for the Fall 2020 term without full knowledge of the mode of course delivery and details of how housing would operate. These details were announced by the university after the close of this survey.

2.3. Data analysis

The data analysis had three main components. First, we evaluated expected compliance with health and safety protocols by analyzing students' stated intention to comply with health and safety protocols, as well as students' expectations about whether their classmates would comply or not. Second, we analyzed students' stated preferences for in-person or online learning. Finally, we inferred the relative importance of the mode of course delivery, safety plans, and tuition reduction on students' choice to enroll or defer through analysis of the responses to the DCE. Additional details are provided below.

2.3.1. Students' intentions and expectations to comply with health protocols

We analyzed students' responses to questions asking them to state their intended compliance with various health protocols (e.g., mask-wearing, testing, social distancing at gatherings) and their expectations around their classmates' compliance (Sections 3 and 4 in Appendix C).

2.3.2. Students' choices between in-person and online learning

We analyzed students' stated choices between learning online compared to learning in-person. First, we analyzed responses to questions that asked students to state whether they preferred an online offering of a course or an in-person offering of a course. The questions specified whether the course was a lecture-based course or a lab-based course (Questions 5.5 and 5.6 in Appendix C). We also analyzed responses to questions that asked students whether they preferred to start the semester in-person or to start the semester online given a specific probability that there would be an outbreak on campus which would cause the college to move to entirely online course delivery during the Fall 2020 semester (Questions 5.2, 5.3, and 5.4 in Appendix C). We relied on logistic regressions to explore if there were features that could explain whether a student would prefer the in-person or online option within each scenario and to evaluate the correlations between those features.

All logistic regressions were run in Python using the SciKit-Learn package version 0.23.2 [23] and correlations between features were determined in Python using the Nominal Dython package version 0.6.1. We used dummy coding for all categorical variables in the logistic regression models. Recursive feature elimination was used to determine the most influential features of each logistic regression model. We determined statistically significant differences from 0 for the coefficients for all logistic regression models using a $p < 0.05$ level.

2.3.3. Students' preferences for enrollment and deferral using the latent class model

In the DCE block of the survey, we collected student preferences to defer or to enroll in one of two hypothetical alternatives that varied in terms of attributes corresponding to campus operations (i.e., *Mode of Course Delivery*, *Safety on Campus*, *Residence Hall Operating Capacity*, *Tuition Reduction*, and *Limits on Events and Social Gatherings*). We analyzed DCE responses to estimate the importance of the different levels of these attributes in terms of their contribution to the utility of alternatives to students, which is represented by the coefficient in a discrete choice model. As a reference, all coefficients of levels of each attribute were assumed to be zeroes for the deferral alternative (giving it zero observed utility). Because the enrollment alternatives were unlabeled, we assumed the coefficients for the levels of each attribute are the same for all enrollment alternatives and estimated them using discrete choice models. We first fitted a model to the entire sample as a single group, and then performed subgroup analyses to examine differences in coefficients across groups described by attitudinal/sociodemographic variables (e.g., *current concern level*, *race*) using a conditional logit model. Results are included in Table A1 and Fig. A2 - Fig. A7 in Appendix A. We determined that there were heterogeneous importance weights and therefore changed to using a latent class model (LCM) to conduct the DCE analysis. The LCM assumes a finite number of classes and allows coefficients of levels of attributes to be the same within each class but different across classes, which therefore helps to identify potential heterogeneous importance placed on the different attributes of the decision to enroll or defer among respondents.

The LCM consists of a class membership model and a class-specific choice model. The class membership model predicts the probability that a given individual belongs to each class, as a function of attributes expected to influence class membership, while the class-specific choice model predicts the probability of choosing each enrollment alternative or the deferral alternative, as a function of the pertinent levels of each attribute and other variables. In our analysis, we first selected all attitudinal/sociodemographic variables which were regarded as being potentially influential in determining respondent's classes and conducted a variable selection process to identify variables that were statistically significant and showed distinctions across classes. We also considered a model which included the response date as a potentially influential variable given the rising case counts in Georgia during the study period. We tested several choices for the number of classes in the LCM and iteratively evaluated the resulting models in terms of convergence, fit criteria, and interpretability. We used dummy coding for categorical variables in all components of the LCM. In the class membership model, ordinal variables were converted into dichotomous variables after investigating whether there were major significant differences between using all levels rather than just two synthesized levels. In the class-specific choice model, three dummy variables were used for each attribute besides *Tuition Reduction* to represent the non-reference levels so that they can be compared to the reference levels with respect to their relative contributions to the choice outcome. The attribute *Tuition Reduction* was transformed into *Tuition Paid* where, for instance, 30% *Tuition Reduction* equals 70% *Tuition Paid.* The transformed value was then treated as a ratio-scaled variable with just a single coefficient, rather than as an ordinal variable with different coefficients for each level. Thus, the coefficient of this variable can be interpreted as the contribution to the utility of a given alternative that is associated with a one percentage-point increase in tuition paid. The purpose of this transformation was to make it easier to calculate the importance of a given level of another attribute relative to the tuition charge (i.e., in percentage points relative to the regular tuition), and therefore to support comparing the tuition-normalized importance of that level among different classes. We denote this as the "tuition percentage point equivalent" (TPPE).

Post-estimation analysis included calculating TPPE and class profiles. TPPE was calculated as the ratio of the coefficient of a specific level of another attribute to the coefficient of *Tuition Paid* in the class-specific choice model. When coefficients of a level in some classes all had the same sign and all of them were statistically significant, we relied on TPPE to identify heterogeneities of importance weights since taking the ratios of coefficients cancelled out scale differences across classes [24]. We investigated each class to determine the average characteristics for members in that class (i.e., class profiles). Expected values of key variables were calculated here, which included several aspects like *Stated Concern*, *Student's Self-Reported Intentions to Comply with Health Protocols*, *Expectations for Classmates' Compliance Behavior*, *Choice of Course Delivery Mode*, *Living Situation in Fall 2020*, *Perceived Risks* and *Demographic Information* (see Appendix C). When we calculated class profiles, we quantified ordinal variables with 5 levels by using integers from 1 to 5 with 1 representing the lowest level and 5 representing the highest level (e.g., 1 = "not at all concerned" and 5 = "extremely concerned" for *current concern level*, which is Question 1.1 in Appendix C). We quantified binary variables with a 0 or a 1.

All discrete choice analyses were performed in R statistical software version 4.0.2 using the Apollo package version 0.1.0 [25]. We determined statistically significant differences from 0 for all coefficients using a $p < 0.05$ level for the LCM.

Table 2
Characteristics of student respondents (N = 398).

Characteristic	No (%)
Female	201 (50.50%)[a]
Age (year)	
18-19	112 (28.14%)
20-21	153 (38.44%)
22-23	108 (27.14%)
24-30	18 (4.52%)
>30	0 (0.00%)
Did not answer	7 (1.76%)
Race/ethnicity	
Asian/Pacific Islander	144 (36.18%)
Black/African American	11 (2.76%)
Hispanic/Latino	47 (11.81%)
Native American	1 (0.25%)
White/Caucasian	220 (55.28%)
Other	5 (1.26%)
Did not answer	10 (2.51%)
Academic standing as of Fall 2020	
Freshman	61 (15.33%)
Sophomore	54 (13.57%)
Junior	92 (23.12%)
Senior	189 (47.49%)
Did not answer	2 (0.50%)
International student	59 (14.82%)[b]
Receiving financial aid	213 (53.52%)[a]
Highest level of parents' education	
Some grade/high school	8 (2.01%)
Completed high school or GED	17 (4.27%)
Some college/technical school	20 (5.03%)
Bachelor's degree	133 (33.42%)
Some graduate school	22 (5.53%)
Completed graduate degree(s)	194 (48.74%)
Did not answer	4 (1.01%)

[a] 3 students did not answer.
[b] 2 students did not answer.

3. Results

In this section we discuss the results of the survey. We begin by describing the respondents to our survey. Then, we describe the results from the three sets of analyses, which investigate (i) students' intentions and expectations for compliance with health protocols, (ii) students' choices between in-person and online classes, and (iii) students' preferences for enrollment and deferral in relation to course modes and safety protocols.

3.1. Study participants

Among the 1,917 students who were invited to complete the survey, 398 students participated for a response rate was 20.8%. Of those, 295 students completed the entire survey. The demographic characteristics of the participating students are shown in Table 2. Comparing the demographic information of the non-respondent group to that of the entire invited cohort, there was slightly less participation among Black/African American students and international students. Table A3 in Appendix A provides a comparison of the survey respondents to the industrial engineering undergraduate majors and the overall undergraduate population of Georgia Tech. Compared to the overall undergraduate population, the survey respondents had a higher percentage of students that were female, seniors, or white. Students who participated in the survey tended to complete questions from each block. Only four questions related to Spring 2020 had a high non-response rate (>20% non-response) which was largely due to incoming freshmen not responding as they were not enrolled at Georgia Tech in Spring 2020.

3.2. Students' intentions and expectations for compliance with health protocols

Students reported that they intended to comply with health protocols, as shown in Table 3. However, they were less confident in their classmates' complying with the same protocols. In some cases, students' expectations of their classmates were mostly consistent with their own intentions. 96% of students stated that they were either extremely likely or somewhat likely to wear a mask in instructional space and around campus if required and 79% of students believed a majority of their classmates would do the same. However, in other cases, students' own intentions were much higher than their stated expectations for their classmates. When masks were recommended but not required, 88% of students stated that they were extremely likely or somewhat likely to wear a mask, but only 37% of students believed that almost all or a majority of their classmates would wear them.

There were also large discrepancies in students' own intentions and their expectations for their classmates regarding social gatherings. 74% of students stated they would comply with a policy to limit social

Table 3
Students' stated likelihood of complying with health protocols compared to the expected compliance of their classmates (N = 396).

Safety Protocol	How likely are you?	%	Percentage of classmates?	%
Wear a cloth face covering while moving around campus and in instructional space if required	Extremely likely	88.7	Almost all	31.7
	Somewhat likely	7.8	A majority	47.0
	Neither likely nor unlikely	1.2	About half	15.0
	Somewhat unlikely	0.5	A minority	4.3
	Extremely unlikely	1.8	Almost none	2.0
Wear a cloth face covering while moving around campus and in instructional space if recommended, but not required.	Extremely likely	67.6	Almost all	8.3
	Somewhat likely	20.1	A majority	29.2
	Neither likely nor unlikely	5.3	About half	38.2
	Somewhat unlikely	4.3	A minority	20.1
	Extremely unlikely	2.8	Almost none	4.3
Comply with a policy that requires me to be tested for COVID-19 every week, assuming that the university would make tests available free of charge to students.	Extremely likely	63.6	Almost all	9.1
	Somewhat likely	20.1	A majority	27.1
	Neither likely nor unlikely	5.3	About half	35.2
	Somewhat unlikely	5.8	A minority	24.9
	Extremely unlikely	5.3	Almost none	3.8
Expect to be willing to comply with updated health and safety protocols being put in place.	Extremely likely	76.4	Almost all	9.1
	Somewhat likely	17.6	A majority	33.2
	Neither likely nor unlikely	4.3	About half	39.2
	Somewhat unlikely	0.5	A minority	14.6
	Extremely unlikely	1.3	Almost none	4.0
Stay home from class if you had a fever or other concerning symptoms	Extremely likely	69.4	Almost all	17.1
	Somewhat likely	19.4	A majority	35.4
	Neither likely nor unlikely	5.8	About half	25.1
	Somewhat unlikely	4.5	A minority	15.1
	Extremely unlikely	1.0	Almost none	7.3
Comply with a policy that limit social gatherings to small groups (no more than 20 people)	Extremely likely	49.0	Almost all	4.8
	Somewhat likely	25.3	A majority	13.3
	Neither likely nor unlikely	7.0	About half	32.7
	Somewhat unlikely	12.0	A minority	37.7
	Extremely unlikely	6.5	Almost none	11.6
Maintain 6 feet of social distance at social gatherings (regardless of size)	Extremely likely	23.1	Almost all	3.3
	Somewhat likely	31.2	A majority	7.0
	Neither likely nor unlikely	13.3	About half	21.4
	Somewhat unlikely	19.9	A minority	41.7
	Extremely unlikely	12.6	Almost none	26.6

Table 4
Students' stated choices, current concern level, risk perception, and suitability of residence for online learning.

Choices	%
Choice of lecture-based courses (N = 398):	
In-person	46.2
Exclusively online	53.7
Choice of lab-based courses (N = 398):	
In-person	59.8
Exclusively online	40.2
Choice with 50% Chance of Outbreak during Semester (N = 397):	
Start the semester with on-campus classes and move online if needed	54.4
Deliver all courses online for the Fall 2020 semester	45.6
Choice with 100% Chance of Outbreak during Semester (N = 397):	
Start the semester with on-campus classes and move online if needed	24.4
Deliver all courses online for the Fall 2020 semester	75.6
Current Concern Level (N = 398):	
Extremely concerned	21.6
Very concerned	34.7
Moderately concerned	29.9
Slightly concerned	10.3
Not at all concerned	3.5
Perceived Risk of Infection (N = 396):	
Very high	25.0
High	23.2
Moderate	40.4
Low	9.1
Very low	2.0
I don't understand the question	0.3
Perceived Risk of Adverse Effects if Infected (N = 397):	
Very high	8.8
High	13.6
Moderate	27.0
Low	31.5
Very low	16.9
I don't understand the question	2.3
Current Living Suitability for Online Courses (N = 397):	
Excellent	32.7
Good	37.0
Average	22.4
Poor	6.0
Terrible	1.8

Percentages may not add to 100% due to rounding.

gatherings to 20 people. By contrast, 51% of students believed that most of their classmates would follow this rule. When asked about practicing social distancing at social gatherings, 54% of students stated they were extremely likely or somewhat likely to maintain 6 feet of distance. However, 32% of students believed that most of their classmates would follow this protocol.

3.3. *Students' choices between in-person and online courses*

Table 4 presents students' stated choices between in-person and online learning. When there is no assumption regarding future outbreaks on campus during Fall 2020, 47% of respondents stated that they would choose an in-person mode of instruction for lecture-based courses, and 60% of respondents chose the in-person instruction option for lab-based courses.

We estimated logistic regression models of the choice between in-person and online course delivery separately for lecture-based and lab-based courses, and we report our results in the first two columns of Table 5. We present the statistically significant odds ratios, i.e., the factors by which the odds of choosing in-person over online course delivery change with respect to the presence of (or one-unit increase in) the associated feature. For lecture-based courses, the logistic regression model shows statistical significance of the association between *current concern level*, *perceived risk of infection*, *current living suitability for online courses*, *risk-seeking* and *birthyear* (Questions 1.1, 7.3, 6.6, 1.3, 8.2 in Appendix C, respectively) and choosing an online lecture-based course. Specifically, the results of the model indicate that:

i. Students with greater *current concern level* are more likely to choose online courses than students with lower concern levels,
ii. Students with higher *perceived risk of infection* are more likely to choose online courses than those with lower *perceived risk of infection*,
iii. Students with better *current living suitability for online courses* are more likely to choose online courses than students with worse *current living suitability for online courses*,
iv. Students who are more *risk-seeking* are more likely to choose in-person courses than students who are less *risk-seeking*, and
v. Younger students are more likely to choose in-person courses than older students.

For lab course preferences, we see the *current concern level* and *current living suitability for online courses* variables both are not found to be significant but the other three indicators are still significant in the same direction as for lecture-based courses.

Table 4 also presents students' choices between starting the semester in-person or starting the semester online when there is a given probability of a future outbreak that would cause the campus to move entirely online during Fall 2020. When there was a 50% chance of a future outbreak that would cause campus to shut down and move to entirely online instruction (Question 5.2 in Appendix C), we found that 54% of

Table 5
Odds Ratios for Logistic Regression models of students' preferences for an in-person (1) course compared to an online (0) course.

Factors	Lecture Courses: **Unspecified Outbreak Risk** OR [95% CI]	Lab Courses: **Unspecified Outbreak Risk** OR [95% CI]	Lecture Courses: **50% Chance of Outbreak** OR [95% CI]	Lecture Courses: **100% Chance of Outbreak** OR [95% CI]
Perceived Risk of Infection	0.482*** [0.356, 0.655]	0.414*** [0.316, 0.544]	0.366*** [0.270, 0.500]	0.462*** [0.340, 0.628]
Current Concern Level	0.595** [0.435, 0.812]	-[a]	-	-
Current Living Suitability for Online Courses	0.665** [0.505, 0.877]	-	-	0.543*** [0.413, 0.712]
Birthyear	1.002*** [1.001, 1.003]	1.001*** [1.001, 1.002]	1.380*** [1.216, 1.567]	1.003** [1.002, 1.004]
Risk-Seeking	1.320*** [1.158, 1.505]	1.306*** [1.169, 1.460]	1.001*** [1.001, 1.002]	-
Perceived Risk of Adverse Effects if Infected	-	-	0.773* [0.606, 0.987]	0.596*** [0.464, 0.765]
Academic Year	-	-	-	0.731*** [0.585, 0.913]
Fit criteria				
Pseudo R^2	0.256	0.214	0.300	0.249
Logistic Regression Score (Accuracy)	0.78	0.78	0.80	0.72
N (Sample Size)	386	386	384	385

OR: odds ratio; CI: confidence interval.
*** $p < 0.001$; ** $p < 0.01$; *$p < 0.05$
[a] Dashes represent those factors that were not statistically significant and were accordingly removed during the recursive feature elimination process.

students preferred starting the semester in-person. However, in the scenario where there was a 100% chance of this severe outbreak (Question 5.4 in Appendix C), only 24% of respondents preferred starting the semester with in-person courses.

Student responses to *current concern level, perceived risk of infection, perceived risk of adverse effects if infected* and *current living suitability for online courses* arere summarized in Table 4. These factors together with *risk-seeking,* and *birthyear* appeared as influential to students' choice between in-person vs. online mode, as summarized in Table 5. The last two columns of Table 5 show the factors that are influential to students' choices between the in-person mode and the online mode of lecture-based courses when a probability of future severe outbreaks is given. When presented with a 50% chance of a severe outbreak, students with high *perceived risk of infection* and high *perceived risk of adverse effects if infected* (Question 7.4 in Appendix C) were more likely than others to choose the online mode of instruction. Younger and more risk-seeking students were more likely than others to choose to start the semester in-person. When presented with a 100% chance of a severe outbreak, students with a higher *perceived risk of infection* and *perceived risk of adverse effects if infected* as well as students whose *current living suitability* was conducive to online learning were more likely than others to prefer online courses. Younger students were more likely than others to prefer in-person courses in this scenario. Among those 97 students who preferred in-person courses in this scenario, the average self-reported level of *risk-seeking* was 6.96 out of 10. Only 18.6% of these students reported a "high" or "very high" *perceived risk of infection*, and only 5.2% of these students reported a "high" or "very high" *perceived risk of adverse effects if infected.*

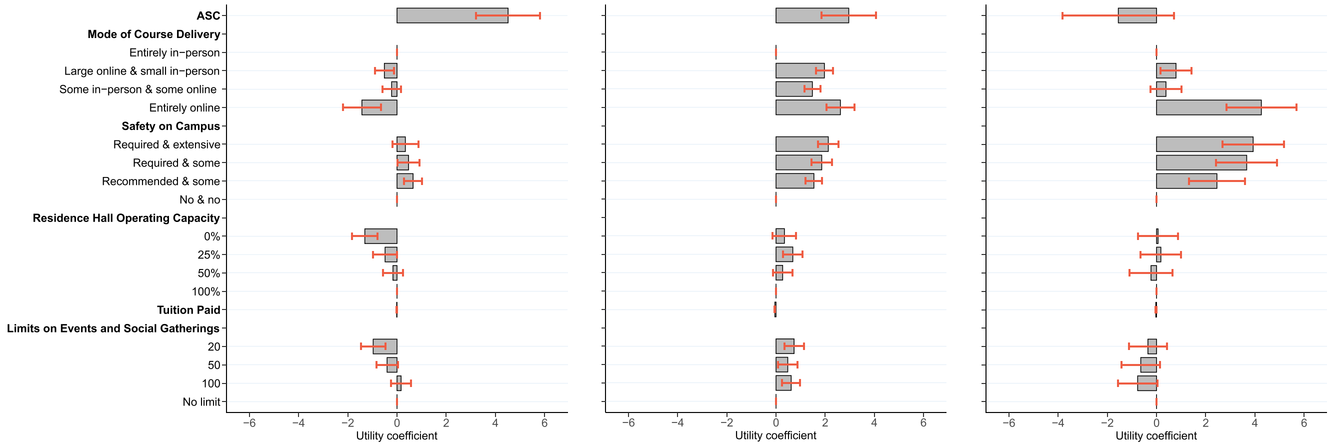
3.4. Students' preferences for enrollment and deferral influenced by course modes and safety protocols

From our analysis of the DCE, we determined the best LCM was a three-class model with variables *current concern level* and *choice of lecture-based courses* (Questions 1.1 and 5.5 in Appendix C) included in the class membership model. We accepted this model due to its fit criteria (i.e., AIC, BIC and adjusted ρ^2) and because the model offered the best interpretability and convergence among all candidate models with which we experimented. Table 6 and Fig. 1 present the final estimated model with AIC of 4616.7, BIC of 4906.4, and adjusted ρ^2 of 0.32 (equally-likely base). The fit results of LCMs with 2, 3, or 4 classes are shown in Table A2 in Appendix A. We did not investigate LCMs with 5 or more classes because the estimations of LCMs with 4 classes were poor.

Table 6
Estimated results of the final latent class model (N = 386).

Variables	**Coefficients and Standard Errors**					
	Class 1: *"Low-concern" student*		**Class 2:** *"Moderate-concern" student*		**Class 3:** *"High-concern" student*	
Class probability	0.29		0.54		0.17	
Class membership model	**Coef.**	**SE**	**Coef.**	**SE**	**Coef.**	**SE**
ASC	-[a]	-	−4.290***	0.901	−6.169***	1.367
Current concern level	-	-	4.287***	0.898	4.468***	1.337
Choice of lecture-based courses	-	-	3.724***	0.660	4.461***	0.733
Class-specific choice model	**Coef.**	**SE**	**Coef.**	**SE**	**Coef.**	**SE**
ASC	4.516***	0.664	2.959***	0.566	−1.555	1.154
Mode of Course Delivery:						
Entirely in-person[b]	-	-	-	-	-	-
Large online & small in-person	−0.514**	0.198	1.967***	0.175	0.792**	0.323
Some in-person & some online	−0.219	0.191	1.478***	0.167	0.382	0.318
Entirely online	−1.427***	0.393	2.619***	0.293	4.261***	0.728
Safety on Campus:						
Required & extensive	0.340	0.272	2.126***	0.218	3.928***	0.633
Required & some	0.467*	0.232	1.859***	0.207	3.666***	0.632
Recommended & some	0.654***	0.185	1.541***	0.174	2.455***	0.583
No & no[b]	-	-	-	-	-	-
Residence Hall Operating Capacity:						
0%	−1.308***	0.267	0.342	0.242	0.064	0.414
25%	−0.484*	0.247	0.682***	0.204	0.175	0.421
50%	−0.164	0.208	0.270	0.201	−0.225	0.448
100%[b]	-	-	-	-	-	-
Tuition Paid	−0.013*	0.006	−0.049***	0.005	−0.030**	0.01
Limits on Events and Social Gatherings:						
20	−0.967***	0.258	0.733***	0.201	−0.350	0.396
50	−0.403	0.224	0.477*	0.198	−0.641	0.397
100	0.166	0.207	0.616***	0.188	−0.768	0.409
No limit[b]	-	-	-	-	-	-
Fit criteria						
AIC = 4616.70; BIC = 4906.39; ρ^2 = 0.3337 (equally-likely base); Adjusted ρ^2 = 0.3196 (equally-likely base)						

SE: standard error; ASC: alternative specific constant.
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$
[a] Coefficients for Class 1 in the class membership model are fixed at zero since it is the reference class.
[b] Coefficients of this level in the choice models are fixed at zero since it is the reference level.



(a) Class 1: "Low-concern" student (b) Class 2: "Moderate-concern" student (c) Class 3: "High-concern" student

Fig. 1. Estimated results of final latent class model (N = 386); (a) Class 1: "Low-concern" student (b) Class 2: "Moderate-concern" student (c) Class 3: "High-concern" student.

3.4.1. Class membership model

The class membership model differentiated three potential classes, with both *current concern level* and *choice of lecture-based courses* being significant. Among all students, those who had the most concern and the strongest preference for online lecture-based courses had the highest probabilities of belonging to Class 3. Those who were moderately concerned and preferred online lecture-based courses were more likely to belong to Class 2, while those who were not-so-concerned and did not prefer online lecture-based courses were more likely to belong to Class 1. To distinguish these classes, we refer to Class 1 as "low-concern" students, Class 2 as "moderate-concern" students, and Class 3 as "high-concern" students.

The class probabilities gave insights into the distribution of students' attitudes towards the COVID-19 pandemic. According to Table 6, 29% of students fell into Class 1, being not-so-concerned, while 17% fell into Class 3, being highly concerned. Most of the students were in the "moderate-concern" class (i.e., there was an average 54% probability of belonging to Class 2).

We suspected that students planning to live on campus in Fall 2020 had different preferences for *Residence Hall Operating Capacity* than students living off campus, so we also tested the inclusion of *living location in Fall 2020* (Question 6.7 in Appendix C) in the class membership model. The results showed that *living location in Fall 2020* was not significant in the class membership model for all three classes, as was also the case for 2-class and 4-class models. We also observed that the response date was not significant in the class membership model.

3.4.2. Choice models

We observed that the choice models differed substantially among the three latent classes, suggesting that an LCM was a reasonable choice. In particular, the fact that in several instances the same feature had a significantly positive coefficient for at least one class and a significantly negative coefficient for at least one class highlights the extent of the heterogeneity in our sample. If we had only used a single-class model, such features may not have even appeared to be significant, given the estimation of a sample-wide "average" coefficient that may have been close to 0 (e.g., comparing the coefficient for the level "20 people" of *Limits on Event and Social Gatherings* in Table 6 and Table A1).

For the LCM, we present the class membership model and class-

Table 7
Tuition percentage point equivalent (TPPE) of 3 latent classes (N = 386).

Attributes and Levels	TPPE		
	Class 1: *"Low-concern" student*	**Class 2:** *"Moderate-concern" student*	**Class 3:** *"High-concern" student*
ASC	345.54%	60.73%	−52.61%
Mode of Course Delivery:			
Large online & small in-person	−39.34%	40.36%	26.79%
Some in-person & some online	−16.76%	30.34%	12.94%
Entirely online	−109.16%	53.74%	144.20%
Safety on Campus:			
Required & extensive	26.04%	43.63%	132.92%
Required & some	35.77%	38.15%	124.06%
Recommended & some	50.05%	31.61%	83.07%
Residence Hall Operating Capacity:			
0%	−100.08%	7.02%	2.15%
25%	−37.00%	14.00%	5.91%
50%	−12.57%	5.55%	−7.60%
Limits on Events and Social Gatherings:			
20	−74.01%	15.05%	−11.86%
50	−30.86%	9.79%	−21.70%
100	12.71%	12.64%	−25.99%

TPPE: Tuition percentage point equivalent; ASC: alternative specific constant.

specific choice model in Table 6. TPPE was calculated for all non-reference levels of attributes, as a supplement to better distinguish the heterogeneous importance weights of levels in different classes (see Table 7). TPPE can be interpreted as the contribution of a given level of an attribute (relative to its reference level) to the utility of an alternative, in terms of a percentage-point change in *Tuition Paid*. For instance, for Class 1, we observe that the *Tuition Paid* coefficient is −0.013. That is, a percentage point increase in tuition reduces utility by 0.013 utils. The "Masks recommended & some COVID-19 testing" level of the *Safety on Campus* attribute has a coefficient of 0.654, meaning that if campus safety requirements change from the reference level of "No masks and no testing" to "Masks recommended & some COVID-19 testing," the utility increases by 0.654 utils for Class 1 students. The ratio of the latter to the former, which is the TPPE for level "Masks recommended & some

COVID-19 testing," is around 50 as shown in the corresponding entry of Table 7. TPPE gives the trade-off between a specific level and *Tuition Paid* and represents the (maximum) additional percentage points of tuition that a student is willing to pay for obtaining an improvement in that attribute level and not be worse off than before (or, alternatively, the minimum percentage-point reduction in tuition that a student would require if an attribute dropped to a less desirable level). Expressed in the most natural way, this result indicates that a Class 1 ("low-concern") student would require a 50 percentage-point reduction in tuition to be equally well off if the *Safety on Campus* attribute worsened from "Masks recommended & some COVID-19 testing" to "No masks and no testing." As previously stated in Section 2.3.3 since calculating TPPEs cancels out scale differences, we can use TPPEs to compare the importance of the various levels of attributes to students' preferences for enrollment and deferral across classes. For example, we note that Class 3 ("high-concern") students would require a larger (83 percentage-point) reduction in tuition than Class 1 to be equally well off under the same change to *Safety on Campus*.

The alternative specific constants (ASCs) indicate if students preferred the base alternative formed by all reference levels of all attributes to the "Defer enrollment for at least one term" alternative, whose utility to students was assumed to be 0 in this study. As indicated by Table 6, when all attributes are at their reference levels, students in Class 1 or Class 2 had stronger preferences for enrolling in the Fall 2020 semester than students in Class 3 since those two classes had positive and significant ASCs. TPPE results further illustrated that the "low-concern" students of Class 1 had the strongest preference for taking courses in the Fall 2020 semester with the base alternative since its TPPE for ASC is the largest among all three classes.

The coefficients for levels of the attribute *Mode of Course Delivery* represent the importance of course delivery modes that incorporate online portions of classes compared to the reference mode "All classes delivered entirely in-person" on the decision to enroll or not. Based on results shown in Tables 6 and 7, students in more concerned segments (i.e., Class 2 and Class 3) placed more importance on modes incorporating at least some online courses. However, students in Class 1 did not like having online courses compared to completely in-person courses. Students in the "high-concern" segment (Class 3) put much more importance on entirely online courses when deciding to enroll compared to students in the "moderate-concern" segment (Class 2), indicated by the result that the TPPE of "All courses delivered entirely online" in Class 3 was more than twice as large as the corresponding TPPE in Class 2.

For each class of students, placing some safety measures like requirements for masks and testing on campus was better than "No masks & no testing." The importance weight of *Safety on Campus* increased from level "Mask required & extensive COVID-19 testing" to level "Masks recommended & some COVID-19 testing" for Class 1 students. On the contrary, the more concerned students in Class 2 or Class 3 placed more importance on stricter safety measures. "High-concern" students of Class 3 placed the most importance on any level of *Safety on Campus*, as indicated in Table 7.

For attributes *Residence Hall Operating Capacity* and *Limits on Events and Social Gatherings*, having more coefficients be statistically insignificant in Table 6 suggested they were not as important as *Mode of Course Delivery* and *Safety on Campus* to influencing students' choices between enrolling or deferring. Those who were "low-concern" (Class 1) exhibited a substantial disutility when limiting the operating capacity of residence halls or the number of people for events and social gatherings, especially for the strictest limits (i.e., closing residence hall and no more than 20 people for events and social gatherings). "Moderate-concern" students (Class 2) placed the most importance on having 25% capacity of residence hall with no roommates and no shared bathrooms and placed the most importance on all limits on events and social gatherings. Class 2 students did not show a significant importance weight for having 50% capacity of residence hall with no roommates but shared bathrooms and for closing the residence hall. All coefficients of levels of *Residence Hall Operating Capacity* and *Limits on Events and Social Gatherings* were

Table 8
Class profiles (N = 386).

Variables	Class 1: *"Low-concern" student*	Class 2: *"Moderate-concern" student*	Class 3: *"High-concern" student*
Stated Concern:			
Current concern level[a]	2.78	3.93	4.02
Current concern versus concern in mid-March 2020	2.52	3.59	3.69
Risk seeking	6.53	4.56	4.29
Student's Self-Reported Intentions:			
Mask required (self)	4.70	4.86	4.86
Mask recommended (self)	4.08	4.60	4.60
Testing (self)	4.11	4.42	4.40
Safety protocol (self)	4.52	4.74	4.73
Stay home (self)	4.62	4.47	4.45
Limit size of gatherings (self)	3.50	4.18	4.22
Social distancing (self)	2.88	3.49	3.54
Expectations for Classmates' Compliance Behavior:			
Mask required (classmate)	4.27	3.95	3.89
Mask recommended (classmate)	3.35	3.13	3.08
Testing (classmate)	3.31	3.08	3.03
Safety protocol (classmate)	3.55	3.21	3.14
Stay home (classmate)	3.79	3.27	3.19
Limit size of gatherings (classmate)	2.73	2.59	2.58
Social distancing (classmate)	2.28	2.15	2.13
Choice of Course's Delivery Mode: (online = 1, in-person = 0)			
Choice of lecture-based courses[a]	0.07	0.70	0.83
Choice of lab-based courses	0.16	0.49	0.54
Living Situation in Fall 2020:			
Current Living Suitability for Online Courses	3.57	4.05	4.11
Residential location in Fall 2020 (on campus = 1, off campus = 0)	0.56	0.42	0.40
Perceived Risks:			
Perceived risk of infection	3.03	3.82	3.94
Perceived risk of adverse effects if infected	2.05	2.88	2.98
Demographic Information:			
Gender (Female)	0.52	0.51	0.50
Race (Asian/Pacific Islander)	0.25	0.43	0.45
Race (Black/African American)	0.01	0.03	0.03
Race (Hispanic/Latino)	0.10	0.12	0.12
Race (White/Caucasian)	0.64	0.43	0.40
Domestic students (yes = 1, no = 0)	0.91	0.83	0.82
Political leaning (Democrat)	0.37	0.56	0.58
Political leaning (Republican)	0.25	0.14	0.12
Political leaning (Independent)	0.33	0.27	0.26
World view (Conservative)	0.20	0.09	0.09
World view (Moderate)	0.51	0.49	0.49
World view (Liberal)	0.29	0.41	0.42
Financial aid (Yes)	0.52	0.54	0.53
Financial aid (No)	0.48	0.46	0.46
Financial aid (Did not respond)	0.00	0.01	0.01

[a] Variables included in the class membership model.

insignificant for Class 3 students.

The choice model for each class can be used to estimate the probability that students in each class would choose to enroll rather than defer under specified levels of attributes. We tested several hypothetical scenarios to check enrollment probabilities of students in our DCE. The first is a "business-as-usual" scenario in which courses are delivered entirely in-person, no requirement on mask-wearing and no testing, 100% operating capacity for residence halls, full tuition, and no limit on the size of social gatherings. Under a "business-as-usual" scenario, the low-concern class (Class 1) was predicted to enroll with 98.9% probability and the "moderate-concern" class (Class 2) was predicted to enroll with 94.8% probability. However, the "high-concern" class (Class 3) was predicted to enroll with only 17.0% probability. Weighting by the class membership probabilities, the weighted average enrollment probability is 82.8% for this "business-as-usual" scenario. In contrast, another tested scenario is a "completely online" scenario in which a 5% tuition reduction is given and has weighted average enrollment probability of 94.6% with the low-concern class enrolling with 85.4% probability, the moderate-concern class enrolling with 99.7% probability, and the high-concern class enrolling with 93.9% probability. A scenario with a higher enrollment probability is a "strict on-campus hybrid" scenario in which large courses are delivered online with small courses delivered in-person, required mask-wearing and extensive testing, residence halls are at 25% capacity (in which there are no roommates and no shared bathrooms), no tuition reduction, and a limit of 20 people at social gatherings. This "strict on-campus hybrid" scenario has a weighted average enrollment probability of 97.6% because it broadly appeals to students from the different classes: low-concern class is expected to enroll with 94.7% probability, the moderate-concern class has a near 100% probability of enrolling, and the high-concern class has a 95.1% probability of enrolling.

3.4.3. Class profiles

Table 8 presents class profiles for all three latent classes. All variables associated with *Stated Concern* and *Perceived Risks* showed the differences expected across classes. From Class 1 to Class 3, the expected values of *current concern level*, *current concern versus concern in mid-March 2020* (Question 1.2 in Appendix C), *perceived risk of infection* (Question 7.3 in Appendix C) and *perceived risk of adverse effects if infected* (Question 7.4 in Appendix C) increased while expected values of *risk seeking* (Question 1.3 in Appendix C) decreased. This phenomenon indicated that students in the two more concerned classes had more current concerns, more concern compared to mid-March 2020, and more perceived risks than students in Class 1. At the same time, "high-concern" and "moderate-concern" students were more likely to exhibit risk aversion while "low-concern" students were more likely to be risk-seeking.

The responses for *Student's Self-Reported Intentions to Comply with Health Protocols* (Section 3 in Appendix C) and *Expectations for Classmates' Compliance Behavior* (Section 4 in Appendix C) followed the same trend within each class, but the magnitude of average responses varied across classes slightly. Students in Class 2 or Class 3 were more likely to intend to comply with safety practices of requirements for masks, testing, safety protocol, and staying home if having a fever or other concerning symptoms than "low-concern" Class 1 students, even though all of them stated they were at least somewhat likely to engage in those practices. Students' stated engagements in limits on social gatherings and practicing social distancing at social gatherings were not as high as those of other practices, especially for their self-reported intentions to practice social distancing at social gatherings (*social distancing (self)*, Question 3.7 in Appendix C). For all 3 classes, the expected values of *social distancing (self)* were around 3, the value representing the middle level of each 5-level ordinal variable (see Section 3.2). "Low-concern" students were a little bit more positive about their *Expectations for Classmates' Compliance Behavior* towards those same practices used to gauge their self-reported intentions than "moderate-concern" and "high-concern" students. Similar to self-reported intentions for limits on social gatherings and for practicing social distancing at social gatherings, on average students did not think their classmates were likely to engage in these two practices.

Class 2 and Class 3 students were much more inclined to choose online courses, either for lecture-based courses or for lab-based courses (Question 5.6 in Appendix C), than the "low-concern" Class 1 students. The result that the expected values of both choices are the highest for "high-concern" students was consistent with the results we generated from class-specific choice models. Since more concerned students might think delivering lab-based courses online could not guarantee acceptable quality, the expected values of this choice were less than those of the choice of lecture-based courses in Class 2 and Class 3.

Results also suggested that students in the "moderate-concern" class or "high-concern" class had slightly better *current living suitability for online courses* (Question 6.6 in Appendix C) and were more likely to live off campus in Fall 2020 (Question 6.7 in Appendix C).

We also compared the expected values of sociodemographic variables for members of each class and found differences among the classes in terms of race, political leaning and world view. Asian/Pacific Islander students were more likely to be in Class 2 or Class 3, while White/Caucasian students were more likely to be in Class 1. Our initial experiments with subgroup analysis also revealed that Asian/Pacific Islander students were generally more concerned about the COVID-19 pandemic than White/Caucasian students (see Fig. A7 in Appendix A). The differences among classes of shares of Black/African American and Hispanic/Latino students were not significant, which could be attributed to the overall low shares of respondents belonging to these two races. Students in the "moderate-concern" class or "high-concern" class tended to politically lean Democrat and had a more liberal world view. "Low-concern" students were inclined to lean Republican and had a more conservative world view. We did not observe substantial differences in the share of those on financial aid among the three classes.

4. Discussion

The purpose of this study was to examine students' willingness to comply with health protocols on campus, their choices between in-person and online learning, and the importance of course modes and safety plans to them when deciding to enroll in institutions of higher education amid the COVID-19 pandemic. In contrast to many surveys of students done at the beginning of the summer of 2020 when cases in Georgia remained under 1,000 new cases per day, students completed this survey when cases started to dramatically rise. On the first day that the survey was open, the state of Georgia reported 1,900 new cases of COVID-19 and the number of new cases grew throughout the survey period with 3,875 new cases on the final day of the survey. On June 29, 2020, the governor of Georgia signed two executive orders that extended the state's Public Health State of Emergency and its existing COVID-19 safety measures.

During the time of our survey, students were having to make their own enrollment and on-campus housing decisions without full knowledge of the mode of course delivery. Students completed the survey by July 15th, 2020 and the deadline to defer enrollment at this institution was July 24th, 2020 at the beginning of the survey. While the survey was in progress, the deadline to defer was delayed until August 3rd, 2020. Students were also weighing their housing options, because students who had previously opted for on-campus housing had until June 30th, 2020 to cancel their housing contract. Students were given the option to defer their housing deposit to a later semester if their deferral request was received by August 3rd, 2020. On July 20th, 2020 (after the survey had ended), Georgia Tech revealed the course modality to students; modes were in-person, online, or hybrid and varied by class section.

Although there have been several surveys of university students during the COVID-19 pandemic, many have focused on the influence of the transition to online learning. They have investigated students' satisfaction with the online mode, compared students' concern over financial stability, academic demands, health and well-being before and after the transition, and explored students' plans to enroll in the Fall 2020 semester [26–33]. These surveys found that students were more satisfied with the in-person mode before the transition. Even though students were more concerned about almost all aspects related to their academic lives, most of them still planned to enroll in Fall 2020. A related study on the impact of COVID-19 on students at Arizona State University found large differences in current and expected outcomes that followed existing socioeconomic divides [33]. Students from lower-income backgrounds were more likely to delay graduation than their higher-income counterparts. Other COVID-19-induced health and economic shocks also varied systematically by socioeconomic factors. Perhaps the most closely related work to ours includes two recent studies which surveyed students about their risk tolerance and willingness to enroll. One is a survey conducted among 46 Columbia University public health students [34] which used a "standard gamble" [35] exercise to measure students' risk tolerance for in-person mode and for social gatherings, and estimated the proportion of tuition they were likely to pay for entirely online courses. That study found that students would accept a 23% risk of infection to get the in-person mode, pay 48% of typical tuition for online courses, on average; and 41% of them would attend social gatherings even with some risks of infection. The other study surveyed 1,150 undergraduate students at Arizona State University and elicited the value that students assigned to in-person classes and social activities [36]. The study suggested that many students found online classes to be an acceptable substitute for in-person classes but on-campus social activities were more difficult to be replaced. Similar to our research, the study indicated that there is heterogeneity in how students value in-person instruction and campus life. In contrast to existing surveys, our research is the only one, to our knowledge, to elicit students' importance weights for different aspects of campus recovery operations with a discrete choice experiment, to evaluate features influencing students' choices between in-person and online learning, and to examine students' intentions and expectations around compliance with health protocols.

The results of our DCE indicated that there were heterogeneous importance weights for different features of campus safety measures and educational plans when deciding whether to enroll. Most students fell into a moderately concerned group. These students were strongly likely to enroll so long as courses were not delivered entirely in-person and there were sufficient safety measures in place around mask-wearing and testing and limits for social gatherings.

We found there was a latent class of students who were highly concerned, comprising about 17% of students. Students in this class placed the most importance on an entirely online mode of course delivery and for the strictest requirements for masks and COVID-19 testing. Stricter safety measures and more online courses would increase the probability that "high-concern" students enrolled in Fall 2020. Surprisingly, the importance of limits on social gatherings was not significant for this class of student, which could be attributed to the dominant importance of the entirely online mode and the design of the DCE (see details in Appendix B).

In contrast, there was another latent class of students who were not very concerned and comprised about 30% of the students. Students in this class placed importance on entirely in-person classes compared to online classes and on only modest levels of safety measures around mask-wearing and testing, and limits for residence hall and social gatherings. Stricter limits would decrease their utility of enrolling.

Our DCE analysis offered some insights for administrators when creating plans for campus operations during a pandemic. We found that scenarios that offered an on-campus experience with large classes delivered online and small classes delivered in-person, strict safety protocols in terms of mask-wearing, testing, and reduced occupancy in residence halls, and any limits on the size of social gatherings were broadly the scenarios with the highest expected enrollment. These scenarios tended to appease all "low-concern," "moderate-concern," and "high-concern" students. Based on our DCE results, recommending or requiring mask-wearing and conducting some COVID-19 testing on campus increases the probabilities of enrolling for all students. Since policies around testing and mask-wearing apply to all students, campus administrators may wish to meet preferences of as many students as possible and most students were quite sensitive to whether safety measures are put in place. Restricting the number of students in campus housing without closing residence halls was preferred by most students. In addition, modest limits on the sizes of social gatherings were also largely preferred. When deciding whether to offer courses in an entirely online format, in-person format, or a hybrid format, campus administrators should be aware of the heterogeneous preferences among students and that a one-size-fits-all approach may not satisfy large portions of the student population. Most students stated they were less likely to enroll when all classes were delivered entirely in-person while any degree of online classes was not preferred by the not very concerned students. Therefore, to properly take care of the needs of all students, administrators may better consider providing choices of different course modes to students if there are resources available to do so.

According to our analysis of students' choices between in-person and online learning, students' perceived risks of infection of COVID-19, risk-seeking level, birth year, and current living suitability with respect to online learning are the most influential factors for their decisions under most conditions with or without assumed probabilities of future outbreaks. Students who perceived themselves at higher risk of infection, were relatively more risk-averse, were older, and had better living suitability were more likely to choose online learning than others. We found that students tended to prefer in-person instruction for lab-based courses but online instruction for lecture-based courses, which suggested IHE administrators might still need to offer lab-based courses in-person but with sufficient safety measures implemented at the same time. Younger students, especially incoming freshmen, were less worried about the COVID-19 pandemic and thus consistently preferred in-person learning. This phenomenon highlighted the needs of universities to conduct awareness campaigns for information and impacts of COVID-19 among new students and at least encourage them to take some precautions when taking courses in-person. However, administrators may need to be cognizant of a potential "optimism bias" [37] which could be challenging to overcome when convincing people to take precautions. Optimism bias describes the tendency that people think that, even if there is a disaster happening to other people, the disaster will not affect them. For instance, there was a considerable group of respondents (24%) that preferred starting the semester in person even if there was 100% chance of a severe outbreak, suggesting that some students feel they would not be affected by a severe outbreak.

In terms of self-reported compliance and expectations for compliance of classmates for various health protocols, students tended to report higher likelihood of complying for themselves than expectations for their classmates. Presumably some sort of bias is indicated, or the aggregate statistics for the respondents themselves would roughly match the aggregate statistics they report to be the case for the population (of fellow students) at large. There are a few possible explanations for these discrepancies. There may be cognitive biases among respondents such as social desirability bias (respondents overreport their own compliance, but more accurately capture it in their reported perceptions of others' compliance) [38], relative superiority bias (respondents assume others are less "virtuous" than they themselves are in this respect) [39], people tend to judge their ideological opponents as being more extreme than they really are [40], and/or non-response bias (those who think the whole "pandemic thing" is overblown may be less likely to respond to the survey altogether, and therefore the disproportionately more concerned students who are responding may be accurately reflecting both their own higher level of compliance and the much lower level of compliance across the student population as a whole, including the nonrespondents as well as the respondents).

Despite these discrepancies, there are still some valuable insights that can be gained from these responses. In election forecasting, there is evidence that expectations tend to yield better estimates than intentions [41]. If the same behavior holds, students' expectations of their classmates may be a better predictor of expected compliance with those health protocols than students' self-reported compliance behavior. While students expected their classmates and themselves to be willing to comply with some safety measures (e.g., wearing masks if required and staying home from class if concerning symptoms arise), students were not optimistic about their classmates' compliance with other protocols regarding social gatherings that were suggested by the Centers for Disease Prevention and Control (i.e., limiting social gathering size to under 20 people, maintaining 6 feet of distance at gatherings [42]), which should elicit the awareness of universities. Since it was reported that students' gatherings can be blamed for campus COVID-19 outbreaks in Fall 2020 [43], universities might need to figure out an effective way to urge students to be more active in limiting the size of social gatherings and practicing social distancing.

Several limitations of our study should be kept in mind. First, our response rate was about 21%, and there was likely to be a non-response bias. We suspect that students who thought the COVID-19 pandemic was not a pressing issue would be less likely to respond than students who thought the pandemic was an important issue. Therefore, we may be seeing more representation of the "moderate-concern" and "high-concern" students than "low-concern" students. Non-response bias could lead to non-representative descriptive statistics. However, the relationships described by the models are expected to be reliable because they represent conditional relationships [44]: given a certain value of "X" (even if the occurrence of "X" in the sample is over- or under-represented), what do we expect "Y" to be? In particular, we do not expect the internet proficiency required to complete an online survey to lead to an overrepresentation of a preference for online courses, since *all* students at Georgia Tech commonly receive online communications, including surveys, and are generally internet-savvy.

Second, students surveyed in the study were all industrial engineering students at Georgia Tech. The industrial engineering major is one of the largest undergraduate majors at Georgia Tech (8.2% of the total undergraduate student body and 15.6% of the College of Engineering undergraduate student body in the 2019–2020 academic year) [45]. Students from the industrial engineering undergraduate major may not share the same distribution of preferences and opinions as those in other majors, especially since industrial engineering majors' requirements for lab-based classes (which are pedagogically better delivered in-person) are heavier than those for humanities majors and lighter than those for some other STEM majors. Further, there may be other differences that apply, such as a different political make-up of the student population. Aside from these considerations, we expect that the sample would be reasonably representative of students from peer institutions, especially public, engineering and STEM-focused schools. To the extent that there are attitudinal differences, our conditional models represent preferences conditional on attitudes, even if certain attitudes may be under- or overrepresented in our sample.

Third, Georgia Tech had announced its campus reopening plans on June 17, 2020. The plan did not require face coverings in instructional areas, motivating a petition among the students and faculty at this university to require face coverings in instructional spaces on campus. The decision to mandate masks was announced on July 6, 2020, which overlaps with the period during which the survey was open. Therefore, the responses to this survey may be a reaction to this proposed plan and the forced changes.

Fourth, during the survey, the United States Immigration and Customs Enforcement (ICE) agency announced on June 6th, 2020 that the Student and Exchange Visitor Program would modify the temporary exemption that allowed nonimmigrant students to take online classes due to the pandemic, meaning that students whose universities went completely online could have faced deportation. This may have influenced the responses around preferences for online vs. in-person classes. On June 14th, 2020, ICE announced that it was reversing that decision.

Finally, these stated preferences were gathered before the Fall 2020 semester. Preferences of students for Fall 2021 and beyond may have changed after their experience during Fall 2020 and Spring 2021 after which they would have a better sense of what the course delivery modes mean in practice and what the safety measures on campus look like in their daily life. Students may also now have different perceptions of their risk of infection and risk of adverse effects if infected due to vaccines being widely available at this institution and due to the threats from the Delta variant of coronavirus. In summary, the existence of heterogeneous preferences makes designing a one-size-fits-all plan for reopening campuses difficult. Campus administrators should try to offer flexibility in their campus recovery policies, especially for those aspects largely influencing students' decisions, like the mode of delivery for courses. For instance, providing a choice between an online offering and an in-person offering of courses or having an instructor record live lectures for remote viewing could be good ways to appeal to more students but these approaches would undoubtedly require instructors or resources for delivering both formats. There are other options that also satisfy heterogeneous preferences of many students, such as offering large courses online and optional small group activities in-person in which masks and COVID-19 surveillance tests are required. At the same time, universities should be aware that students may not comply with health protocols around social gatherings and therefore better prepare some safety precautions for emergencies in advance.

All these findings suggest that surveying students about their perceived importance of course delivery and comfort with the proposed safety plans may help inform whether students plan to enroll at their institutions of higher education during a pandemic. Further, surveying students about the trade-offs between different educational and safety aspects of reopening campuses can help campus administrators design plans that balance the needs of their students and at the same time improve the overall likelihood of student enrollment.

Ethics approval

This study was approved by the Georgia Institute of Technology's Institutional Review Board as an exempt study under Protocol H20234.

Consent to participate

Participants provided informed consent to participate.

Code availability

Upon request.

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Role of the funder/sponsor

The sponsor did not influence the design or analysis of this study.

Additional contributions

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Author credit statement

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Declaration of competing interest

None.

Appendix A. Supplemental Materials

Among the following options, which one do you prefer?

	Enroll in Option 1	Enroll in Option 2	Option 3 (Defer)
Mode of course delivery	All classes entirely online	All classes deliver large lectures online & small group activities in-person	Defer enrollment for at least one term
Safety on Campus	No masks & no COVID-19 testing	Masks required & some COVID-19 testing	
Residence Hall Operating Capacity	Closed, 0% capacity	Open, 100% capacity	
Tuition Reduction	10%	30%	
Limits on Events and Social Gatherings	No limit	20 people	

	Enroll in Option 1	Enroll in Option 2	Defer Enrollment (Option 3)
Your choice:	◉	○	○

Fig. A1. Sample discrete choice experiment question.

Fig. A2. Estimated results of conditional logit model for subgroup analysis of current concern level; (a) "Not at all concerned" and "Slightly concerned" (N = 52); (b) "Moderately concerned" (N = 118); (c) "Very concerned" (N = 133); (d) "Extremely concerned" (N = 83)

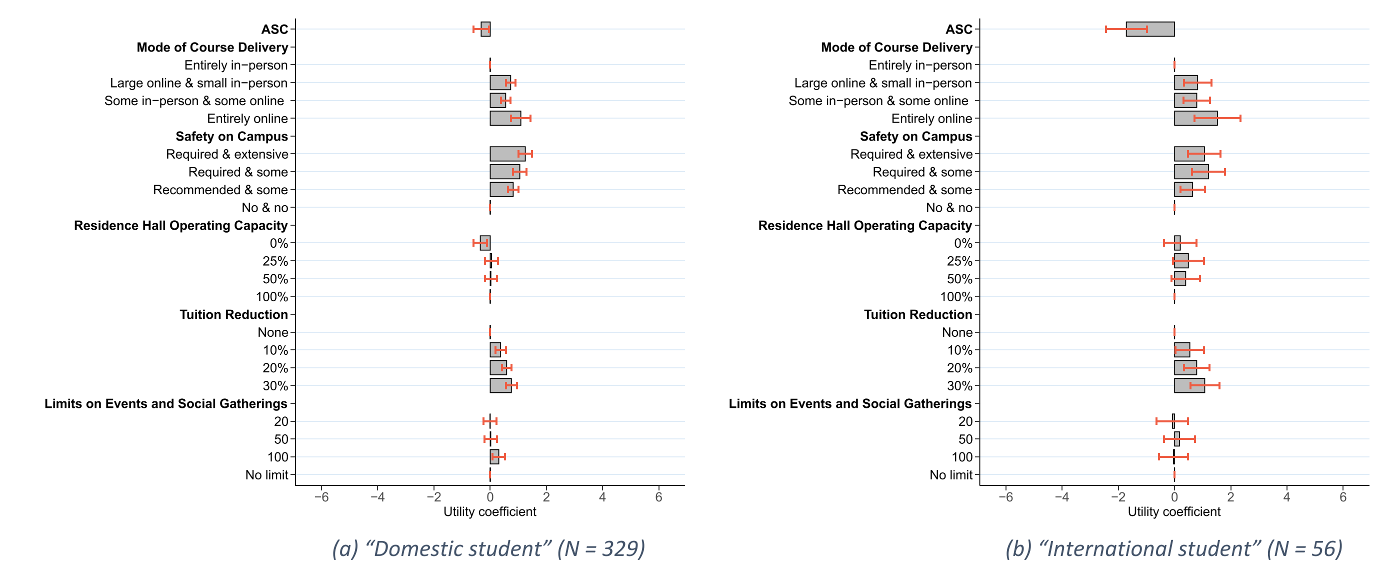
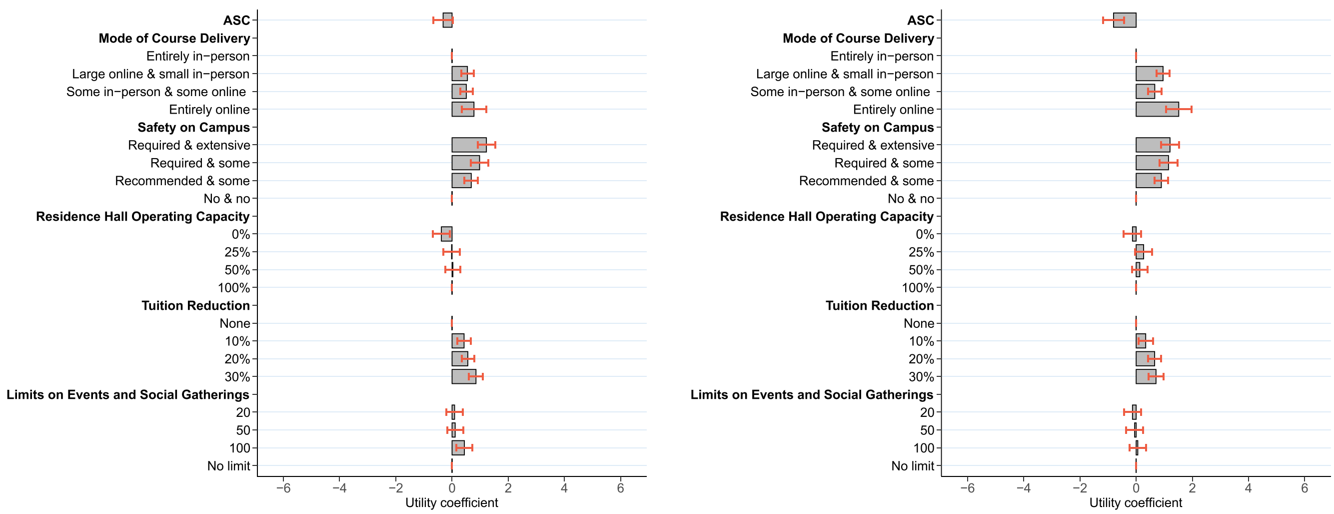
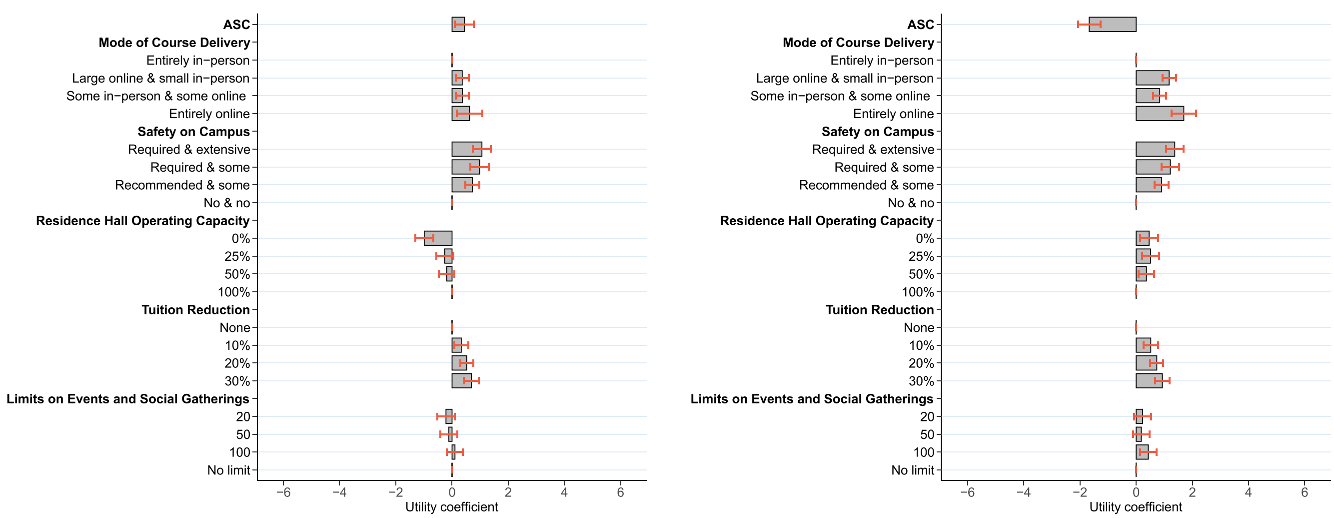


Fig. A3. Estimated results of conditional logit model for subgroup analysis of domestic/international student; (a) "Domestic student" (N = 329); (b) "International student" (N = 56)



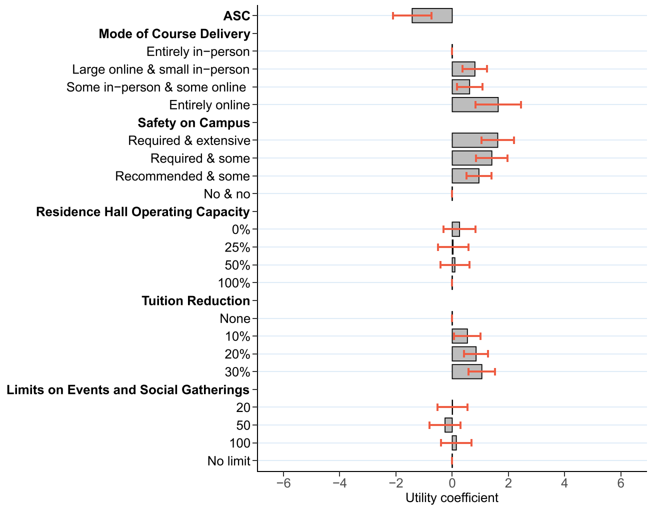
(a) "Female" (N = 196)　　(b) "Male" (N = 188)

Fig. A4. Estimated results of conditional logit model for subgroup analysis of gender; (a) "Female" (N = 196); (b) "Male" (N = 188)

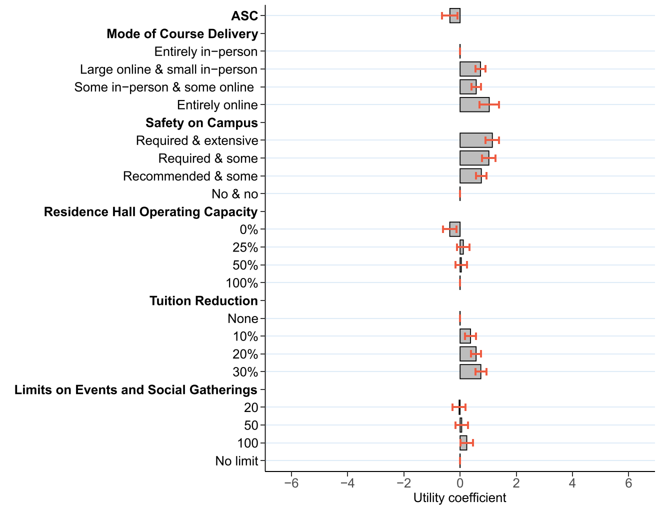


(a) "Living on campus" (N = 176)　　(b) "Living off campus" (N = 210)

Fig. A5. Estimated results of conditional logit model for subgroup analysis of living location in Fall 2020; (a) "Living on campus" (N = 176); (b) "Living off campus" (N = 210)

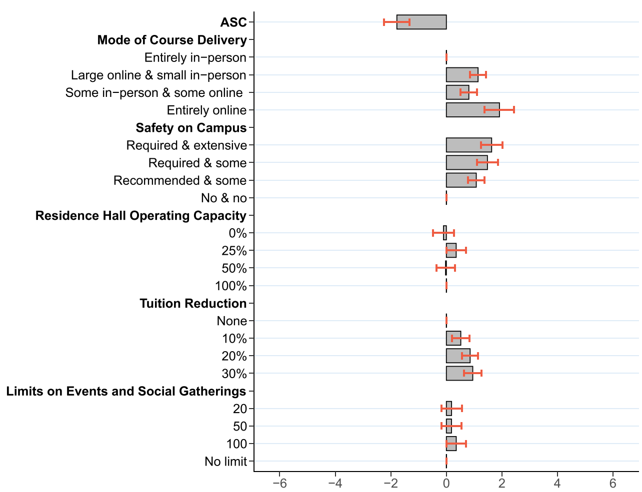


(a) "Yes" (N = 62)

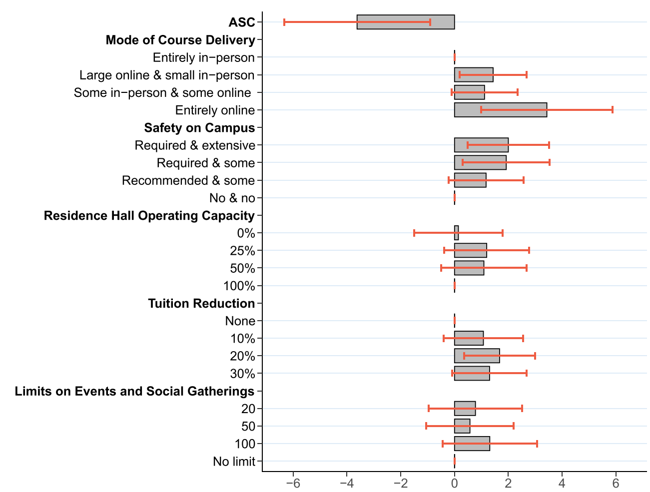


(b) "No" (N = 324)

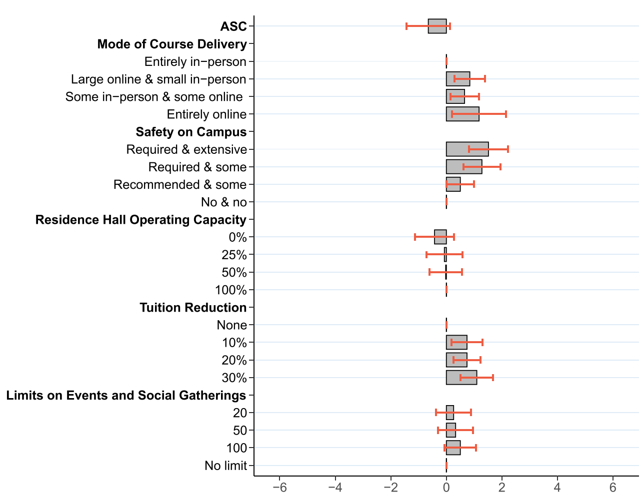
Fig. A6. Estimated results of conditional logit model for subgroup analysis of having preexisting conditions or not; (a) "Yes" (N = 62); (b) "No" (N = 324)



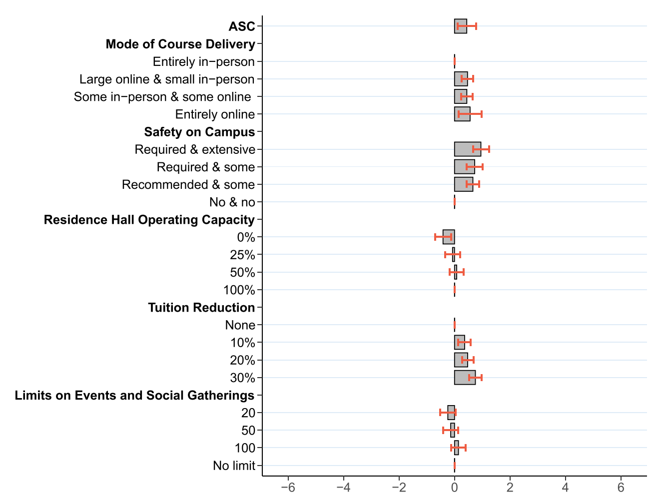
(a) "Asian / Pacific Islander" (N = 142)



(b) "Black / African American" (N = 10)



(c) "Hispanic / Latino" (N = 44)



(d) "White / Caucasian" (N = 215)

Fig. A7. Estimated results of conditional logit model for subgroup analysis of race; (a) "Asian / Pacific Islander" (N = 142); (b) "Black / African American" (N = 10); (c) "Hispanic / Latino" (N = 44); (d) "White / Caucasian" (N = 215)

Table A1
Estimated results of the conditional logit model (N = 386)

Variables	Coef.	SE	95% CI
ASC	−0.524***	0.129	[-0.777, −0.271]
Mode of Course Delivery:			
Entirely in-person [a]	–	–	–
Large online & small in-person	0.724***	0.082	[0.562, 0.885]
Some in-person & some online	0.560***	0.082	[0.399, 0.721]
Entirely online	1.116***	0.159	[0.804, 0.427]
Safety on Campus:			
Required & extensive	1.209***	0.112	[0.990, 1.429]
Required & some	1.074***	0.112	[0.855, 1.294]
Recommended & some	0.786***	0.087	[0.616, 0.956]
No & no [a]	–	–	–
Residence Hall Operating Capacity:			
0%	−0.265*	0.111	[-0.483, −0.047]
25%	0.108	0.105	[-0.098, 0.313]
50%	0.065	0.098	[-0.127, 0.256]
100% [a]	–	–	–
Tuition Reduction:			
None [a]	–	–	–
10%	0.390***	0.089	[0.215, 0.564]
20%	0.613***	0.082	[0.453, 0.773]
30%	0.790***	0.091	[0.611, 0.969]
Limits on Events and Social Gatherings:			
20	−0.029	0.109	[-0.242, 0.184]
50	0.021	0.105	[-0.186, 0.227]
100	0.238*	0.101	[0.040, 0.436]
No limit [a]	–	–	–
Fit criterion			
AIC = 5688.32; BIC = 5784.89; $\rho^2 = 0.1664$ (equally-likely base); Adjusted $\rho^2 = 0.1616$ (equally-likely base)			

SE: standard error; CI: confidence interval; ASC: alternative specific constant.
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$
[a] Coefficients of this level are fixed at zero since it is the reference level.

Table A2
Fit criteria of latent class models by number of classes (N = 386)

Number of classes	AIC	BIC	ρ^2 (equally-likely base)	Adjusted ρ^2 (equally-likely base)
2	4873.89	5060.17	0.2719	0.2626
3	4616.70	4906.39	0.3337	0.3196
4	4455.23	4823.23	0.3597	0.3417

Table A3
Comparison of demographics for survey respondents, industrial engineering undergraduate majors at Georgia Tech, and undergraduate students at Georgia Tech.

Characteristic	Survey Respondents, no. (%)	Industrial Engineering Undergraduate Majors, no. (%)	Undergraduate Students, No. (%)
N	398	1349	16073
Female	201 (51%)	621 (46%)	6415 (40%)
Race/ethnicity*			
Asian/Pacific Islander	144 (36%)	451 (33%)	5024 (31%)
Black/African American	11 (3%)	146 (11%)	1220 (8%)
Hispanic/Latino	47 (12%)	45 (3%)	1401 (9%)
Native American	1 (<1%)	0 (0%)	10 (<1%)
White/Caucasian	220 (55%)	340 (47%)	7383 (46%)
Other	5 (1%)	66 (5%)	1025 (6%)
Academic standing as of Fall 2020			
Freshman	61 (15%)	99 (7%)	2094 (13%)
Sophomore	54 (14%)	260 (19%)	3470 (22%)
Junior	92 (23%)	366 (27%)	4030 (25%)
Senior	189 (47%)	624 (46%)	6479 (40%)
Did not answer	2 (1%)	–	–
International student	59 (15%)	233 (17%)	2145 (13%)

* The classifications of race/ethnicity were different between our survey and the demographic information collected by Georgia Tech.

Appendix B. Design of Discrete Choice Experiment

In this appendix, we detail our experimental design for the discrete choice survey. The following are the attributes and levels considered for the choice sets. The corresponding labels indicate which variable corresponds to this level in the first and second choices.

Attributes & Levels

1 Mode of Course delivery: (4 levels) [“Mode”]
- All classes delivered entirely in-person; (level 1)*
- All classes deliver large lectures online & small group activities in-person (level 2)
- Some classes delivered entirely in-person or some classes delivered entirely online (level 3)
- All classes delivered entirely online (level 4)

2 Safety in Campus: (4 levels) [“Campus Safety”]
- Masks required & extensive COVID-19 testing (level 1)
- Masks required & some COVID-19 testing (level 2)
- Masks recommended & some COVID-19 testing (level 3)
- No masks & no testing (level 4)*

3 Residence Hall Operating capacity (4 levels) [“Housing”]
- Closed, 0% (level 1)
- Open at 25% capacity (No roommates & no shared bathrooms) (level 2)
- Open, 50% capacity (no roommates, but shared bathrooms) (level 3)
- Open, 100% capacity (level 4)*

4 Tuition Reduction (4 levels) [“Tuition”]
- None (level 1)*
- 10% (level 2)
- 20% (level 3)
- 30% (level 4)

5 –Limits on events and social gatherings (4 levels) [“Campus Life”]
- No more than 20 people (level 1)
- No more than 50 people (level 2)
- No more than 100 people (level 3)
- No limit (level 4)*

The following is a list of restrictions on the design in the choice set.
List of restrictions on the design:

1. If a choice includes “All courses delivered completely online,” then the level for Campus Safety must be “No Masks & No COVID-19 Testing,” the level for Housing must be “Closed, 0%," and the limits on social gatherings must be “No limit”
2. Do not allow options that are identical except for tuition, because one of the choices will be dominated.
3. If a choice requires masks, there must be limits on campus housing (cannot offer “100% capacity) and limits on events (cannot offer “No Limit”).
4. If a choice includes “All courses completely in-person,” the tuition reduction for this option must be less than or equal to the tuition for the other option.
5. If a choice includes “All courses completely online, the tuition reduction for this option must be greater than or equal to the tuition for the other option.
6. For choice sets where neither option includes “All courses completely online,” the choice sets must have a consistent ordering on the “Campus Safety,” “Housing” and “Limits on Events” attributes in terms of their “strict” to “relaxed” policies. That is Option 1 must have all attributes at least as strict as Option 2 or vice versa. We remove choice sets with “All courses” completely online because of the extreme values on the other attributes.

- **Campus safety:** 1 (Most strict) to 4 (Most Relaxed)
- **Housing:** 1 (Most strict) to 4 (Most relaxed)
- **Events:** 1 (Most strict) to 4 (Most relaxed)

When only restrictions #1 and #2 are shown, the D-efficiency was 88%. Under restrictions 1–6, the D-efficiency was 75%.

Appendix C. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.seps.2022.101266.

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