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EARLY WARNING INDICATORS OF COVID-19 PREVENTION AND PREPAREDNESS FOR USE BY INSTITUTIONS OF HIGHER EDUCATION DURING THE COVID-19 PANDEMIC

Tufts University, September 2020

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Acknowledgments

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Executive Summary

As institutions of higher education seek to reopen during the 2020 COVID-19 pandemic, there are several strategies that can reduce transmission on college campuses and the impact returning students may have on surrounding communities. Strategies may include large scale population-level surveillance for SARS-CoV-2 amongst students, faculty, and staff with the goal of identifying asymptomatic cases and removing them from the community through robust isolation, contact tracing, and quarantine protocols supported by appropriate medical and mental health services coupled with measures to mitigate food insecurity. In addition to surveillance for SARS-CoV-2, many institutions of higher education are using daily symptom screening to identify potential cases amongst students, faculty, and staff and implementing policies and procedures for access to diagnostic testing.

In addition to surveillance testing and symptom screening, major changes have been implemented at many colleges across the country including alterations to classrooms to allow for physical distancing as well as de-densification of classes by making some online only or through use of hybrid, in-person or online instruction. In response to the COVID-19 pandemic, colleges adapted facilities and operations plans to supply masks, hand sanitizer, disinfectant. Colleges also developed social compacts with students, faculty, and staff to support adherence to COVID-19 prevention guidelines and to emphasize the fact we are all our best allies by looking out for one another and supporting each other and our communities during this trying time.

This document establishes a set of Early Warning Indicators (EWI) for COVID-19 preparedness and prevention and suggests targets for optimal performance. The EWI proposed in this document not only assess campus-level prevalence and success in mitigating the transmission of COVID-19, but also take into context the surrounding host communities, recognizing that institutions of higher education are not islands unto themselves, but rather are integral to the fabric of the wider community.

Each EWI is associated with one of four strata: green, yellow, orange, red. Green anticipates a full return to normal only achieved by successful and safe mass vaccination for COVID-19 and or easy oral treatments, while red signals suboptimal performance of a specific indicator and or signals critical increases in COVID-19 prevalence demanding immediate attention and public health action. Yellow and orange are spectrums of risk across a “new normal” as the battle rages against the COVID-19 pandemic.

Stratified (color coded) EWI targets provide indicator-specific benchmarks against which to assess performance—thus facilitating identification of areas of greatest need and allocation of resources to close gaps in COVID-19 prevention preparedness and or to signal increases in campus or community prevalence of disease and or diminution of local resources to sustain safe opening and a specific residential campus status level.

These COVID-19 prevention and preparedness EWI may be used by those in leadership positions to identify possible gaps in prevention and preparedness service delivery, which can be adjusted through changes in college specific guidelines or practices or may be used to identify changes in campus or community prevalence of disease that necessitate changes in practices in order to keep the institution and community safe. In addition, indicators may support decision making regarding changing status levels on residential campuses (i.e. moving to further de-densification, restricting additional activities, or even closing a residential campus).

Definitions of epidemiological terms

Epidemiological terms

Basic reproduction number (R_0): Average number of secondary infections produced by a typical case of an infection in a population when everyone is susceptible. R_0 is a summary index suggesting both the intrinsic transmissibility of a pathogen and the infrastructure that allows the disease to spread in a specific setting. Notably, the value of $\mathbf{R_0}$ is affected by transmission probability, contact rate, and duration of infectiousness.

Effective reproductive number (R): Average number of secondary cases per infectious case in a population made up of both susceptible and non-susceptible hosts. If R>1, the number of cases will increase, such as at the start of an epidemic. Where R=1, the disease is endemic, and where R<1 there will be a decline in the number of cases. The difference between **R** and $\mathbf{R_0}$ is that the value of **R** does not depend on the assumption that the population is completely susceptible, which is often violated in later stages of an outbreak or in a situation in which the population has been exposed to the pathogen previously. Therefore, **R** aims to characterize the progression of an epidemic in a realistic scenario.

Time-varying effective reproductive number (R_T): Defined as the population-level transmission potential at a given time **t**. In a fully susceptible population, early values of $\mathbf{R_T}$ approximate $\mathbf{R_0}$; however, $\mathbf{R_T}$ is more informative because it tracks the subsequent evolution of transmission potential during an outbreak. Changes in transmission potential are highly correlated to control measures. Therefore, **public health practitioners evaluate the effectiveness of control measures by determining the change in R_T after implementation.**

1.0 Introduction: COVID-19 prevention and preparedness

Early Warning Indicators

COVID-19 Early Warning Indicators (EWI) of Prevention and Preparedness are intended to **signal actual increased transmission** of SARS-CoV-2 on a college campus or within the larger community or to **alert local policy makers to situations that favor transmission** of the virus. Indicators are associated with targets that may be used to inform campus leadership of gaps related to COVID-19 prevention and preparedness for which focused actions may be taken to minimize the transmission of SARS-CoV-2 on college campuses and/or its broader introduction or acquisition into or from the general community. **EWI and their associated targets are guidelines for decision making. No one indicator and no change of one indicator from one status level to another changes a college campus from one Residential Status Level (Section 8.0) to another.** If, over time however, multiple indicators signal gaps in Prevention and Preparedness and or increasing college or local prevalence of disease, a decision to change Status Levels may be considered in consultation with local and state public health officials.

As students return to the residential campus, the assumption is that colleges and universities are starting in the *yellow status level* and that every effort must be made to keep the institution of higher education within the yellow classification until such time as a safe and effective SARS-CoV-2 vaccination is available and a substantial proportion of the population has been vaccinated or safe, simple, and highly effective treatments become available for those infected with SARS-CoV-2.

To maximize the use of these indicators, it is suggested that they be monitored in real time (or near real time) and displayed on a simple at-a-glance dashboard available to leadership to support policy making. Indicators should be disaggregated by key variables such as student, faculty, staff, age band, gender, residence hall, type of residential housing (single, double, triple room), frequency of an individual's COVID-19 surveillance testing, etc. Optimal variables for disaggregation are likely to vary from institution to institution and require expert input form stakeholders at all levels to maximize their utility. Moreover, careful consideration should be given to how data are disaggregated and reported to maximize their impact and prevent misinterpretation. Indicators of personal protective equipment (PPE) supply status are optimally disaggregated by central level (central supply), peripheral storage level, and the level of individual distribution points. Transparency in reporting of data to local and state public health officials is critical, and higher education institutions may choose to make some of their key indicator data available to local and state officials.

EWI targets have been established using a mixed methods approach: a combination of criterion and normative referencing. Given lack of data for most indicators and or a desire to minimize cases to the maximum extent possible, an approach using criterion referencing with aspirational targets has largely been employed. **The targets presented in this document are specific to the residential campus of Tufts University and do not apply beyond this one campus.** However, similar targets to those presented here can be developed for other institutions of higher education by leveraging local epidemiologists and public health experts.

Generally, when an indicator result does not fall within the *yellow status level*, the first suggested action after verification and validation of data is qualitative investigation (interview) with key stakeholders with an overarching aim of ascertaining contributing factors that have led to an undesirable status classification for a specific indicator (orange, red) with the goal of identifying locally inexpensive sustainable solutions. Likewise, if a college or university has multiple campus settings and a desirable outcome for a given indicator is achieved on a specific campus but not on another, this should prompt investigation of best practices and application of these principles to campuses where the desired classification has not been achieved. **Section 7.0** briefly proposes a plan-do-study-act model that can be followed to support investigation of undesirable results. **EWI results are never intended to be punitive; rather they serve to focus leadership attention on areas that need strengthening to minimize SARS-CoV-2 transmission on college campuses and within the broader community.**

Possible response actions linked to different residential status levels are presented in **Figure 3, Section 9.0**. Possible responses may include increased frequency of surveillance testing of all or a sub-group of individuals based on stratified analyses of testing data (incident cases); change from hybrid class and cocurricular activities to virtual classes and cocurricular activities while maintaining on campus living; curtailing some clinical services (e.g. non-urgent dental procedures); limiting research operations; changes to athletics; changes to supply chain and or cleaning Standard Operating Procedures (SOPs), etc.

It is suggested that EWI be monitored throughout the fall and spring semester of 2020–2021 and beyond if safe vaccines are not available. Over time as new information becomes available, indicators may be dropped or modified if they prove not to be useful and new indicators may be added. Equally, as more scientific information becomes available about COVID-19, targets may be modified.

While EWI monitoring alone is insufficient to safely open and sustain a COVID-19-free campus environment, their routine monitoring provides a suggested standard that can be applied across higher education institutions with residential campuses and can provide valuable information to decision makers to minimize COVID-19 transmission and acquisition, thereby maximizing the likelihood of a safe and successful return to campus life.

2.0 Campus-level epidemiological indicators

This section defines campus-level epidemiological indicators. Notably, some indicators are proposed ***without*** associated targets as they are intended to be reported as absolute counts and do not in and of themselves indicate good or unsatisfactory performance. Care should be taken when interpreting the campus R_T. Many colleges are implementing surveillance testing of returning students during an on-boarding process. It is suggested that COVID-19 cases detected during the on-boarding process not be counted when calculating the campus R_T. Rather, the R_T may be calculated and reported after a steady state has been obtained, usually after the initial on-boarding process has been completed and any student returning to campus and diagnosed with COVID-19 has been isolated and close contacts have completed quarantine.

Table 1. Campus-level epidemiological indicators

Status Level	Green	Yellow	Orange	Red
Campus time-varying effective reproduction rate (R_T); reported by campus	Vaccine / Treatment	<1.5	>1.5–2.5	>1.5
7-day weighted average (molecular test positivity); reported by campus	Vaccine / Treatment	<1–1.6%	1.6–2.5%	>2.5%
Total number testing positive for COVID-19	NA	NA	NA	NA
Total number in contact quarantine (on campus/off campus), disaggregated by campus	NA	NA	NA	NA
Total number in isolation (on campus/off campus), disaggregated by campus	NA	NA	NA	NA

NA: Not available. At any given time, the absolute numbers of positive tests, of those in contact quarantine or in isolation are important to follow; however, what is critical is to understand the impact of the case load on campus infrastructure and capacity to deliver dining and medical services. Of greater importance that absolute numbers are the quarantine and isolation rates. See **Table 3**.

Recognizing that not all students live on campus and that institutions of higher education are woven into the fabric of surrounding communities as well as the need to report detected cases and numbers in quarantine to local public health officials, it is suggested that the total number of students in quarantine due to close contact, as defined by the U.S. CDC and the total number in isolation defined by a positive molecular test for SARS-CoV-2 be disaggregated by a student's residential status: living on campus or in off-campus housing.

3.0 State- and host community-level epidemiological indicators

This section defines state-level epidemiological indicators. In addition to monitoring state-level COVID-19 prevalence indicators, colleges and university are encouraged to monitor these same indicators in the cities and towns (host communities) in which they are located. Some indicators in this section are proposed without associated targets as they are intended to be reported as absolute counts or averages and do not in and of themselves indicate good or unsatisfactory performance but rather reflect local circumstances. Data sources for indicators in this section are likely derived from state public health department reports. State-level indicators support contextualization of campus-level indicators and acknowledge the possibility of significantly different outcomes.

Table 2. State- and town(s)-level epidemiological indicators

Status Level	Green	Yellow	Orange	Red
Statewide (R_T)[1]	Vaccine / Treatment	<1.5	>1.5–2.5	>2.5
State 7-day weighted average (molecular test positivity)[2]	Vaccine / Treatment	<1-1.6%	1.6–2.5%	>2.5%
Number of COVID-19 patients in hospital (3-day state average)	NA	NA	NA	NA
Number of hospitals within in the state using surge capacity	NA	NA	NA	NA
3-day weighted average COVID-19 deaths within the state	NA	NA	NA	NA
State guidance	Phase 4	Phase 2 or 3	Phase 1	Stay at Home Advisory

NA: Not available

[1] Colleges and universities are encouraged to monitor the R_T of the cities and towns in which they are located.
[2] Colleges and universities are encouraged to monitor the seven-day weighted average (molecular test positivity) of the cities and towns in which they are located.

4.0 COVID-19 testing, quarantine, contact tracing, and isolation capacity

This section defines indicators associated with campus-level COVID-19 testing, quarantine, contact tracing, and isolation capacity. Indicators in this section stress optimal process of surveillance testing and how well contact tracing, quarantine, and isolation protocols are implemented.

Table 3. Campus-level COVID-19 testing, quarantine, contact tracing, and isolation capacity

Status Level	Green	Yellow	Orange	Red
Daily testing coverage – defined as the proportion of individuals designated for testing who are tested on a given day (disaggregated by risk category, student, faculty, and staff).	NA	>95%	90–95%	<90%
Weekly testing coverage – defined as the proportion of individuals designated for testing who are tested during a given week (disaggregated by risk category, student, faculty, and staff). Reported as a 7-day rolling average.	NA	>95%	90–95%	<90%
Proportion of COVID-19 tests returned within 24 hours from arrival of specimen in laboratory. Reported daily and as a 7-day rolling average.	NA	100%	90–95%	<90%
Proportion of people testing positive for COVID-19 who are isolated within 8 hours (disaggregated by on-campus and off-campus students).	NA	100%	NA	<100%
Proportion of COVID-19 contacts successfully traced and quarantined within 24 hours (disaggregated by on-campus and off-campus students).	NA	100%	90–95%	<90%
Percent of cases linked to known cases, reported over 7-day period.	NA	>90%	85–90%	<85%
Number of students in designated quarantine facility[3] (residence hall set aside for quarantine). *Targets based on available beds in a designated residential hall at Tufts University. Other institutions must evaluate their own capacity and set relevant targets.*	None	<30	30–60	>60
Quarantine bed availability (number of beds available in quarantine facility). *Targets based on available designated quarantine bed availability in a designated residential hall at Tufts University. Other institutions must evaluate their own capacity and set relevant targets.*	NA	>55	25–55	< 25
Quarantine rate (measured over rolling 3-day period). *Number of students placed in on-campus quarantine facility over a 3-day period, assumes 14-day total quarantine period.*	NA	≤5.5	NA	>5.5

[3] In this example, Tufts University has set aside one residence hall on its Medford/Somerville campus for quarantine. This facility will be used for quarantine of close contacts at the discretion of university Health Services. In all other cases, quarantine will occur *in situ* (i.e. in the normal bedroom of the student).

Number of students in isolation. *Targets based on 220 beds available in modular housing at Tufts University. Other institutions must evaluate their own capacity and set relevant targets.*	NA	<112	112–166	>166
Isolation bed availability (number of beds available in isolation facility). *Targets based on planned maximum isolation capacity at Tufts University. Other institutions must evaluate their own capacity and set relevant targets.*	NA	>108	54–108	<54
Isolation rate (measured over rolling 3-day period). *Target based on Tufts University's residential campus capacity and assumes 14-day isolation. Other institutions must evaluate their own capacity and set relevant targets.*	NA	≤8	NA	>8
Proportion isolated students receiving daily telehealth or in-person visits.	NA	100%	NA	<100%

When implementing indicators associated with campus-level COVID-19 testing, quarantine, contact tracing, and isolation capacity, it is important to consider local capacity as indicated in **Table 3**. Some indicators, notably the proportion of people testing positive for COVID-19 isolated within eight hours and the proportion of isolated students receiving daily telehealth or in-person visits have only yellow or red targets. This is intended to underscore their importance related to public health control measures or provision of high-quality medical care at the individual-level. The indicators quarantine rate (measured over rolling three-day period) and isolation rate (measured over rolling three-day period) have only yellow and red targets because acceleration above the established Tufts University-specific capacity rates express major impending challenges requiring immediate investigation and remedy to mitigate possible residential campus closure.

5.0 COVID-19 Personal protective equipment indicators (PPE) and adherence to PPE use and social norms in the COVID-19 era

This section describes COVID-19 campus-level personal protective equipment (PPE) indicators and related targets as well as measures of adherence to use of PPE and compliance with established social norms (often written into return to campus guidelines and/or university-wide social compacts implicating students, faculty, and staff). It is strongly suggested that PPE indicators be measured not only at the campus central supply-level but also at the level of distribution points, the latter being established through surveys conducted at random by trained individuals assessing buildings and facilities for availability of disposable masks, hand sanitizer, and disinfectant. Targets presented here are for central supply only and are based on median estimated times for supply arrival. At the level of distribution points, more stringent targets are required. Specifically, no mask distribution point should ever run out of masks as it is unknown when a member of campus may require them; thus, consideration to distribution-point buffer stocks should be considered. Likewise, hand sanitizer dispensers and disinfectant bottles (used by students, faculty, and staff before and after using a shared workspace) must never be empty.

Physical distancing may be measured at the level of reported campus gatherings exceeding an established number of individuals as proposed in the Physical Distancing indicator below as well as through reports from Residential Life. These indicators should measure both on-campus and off-campus adherence given the consideration that must be paid to local communities. Adherence to social norms (physical distancing, mask wearing, and gatherings, etc.) may also be measured by weekly surveys of Residential Advisors using simple Likert scales as well as through documentation provided by anonymous observers stationed in high traffic areas of campus who document adherence over specified periods of time on random days of a week.

Those considering implementation of indicators in **Table 4** should consider local college supply chains as well as other local circumstances and stakeholder values and preferences.

Table 4. Campus-level personal protective equipment indicators

Status Level	Green	Yellow	Orange	Red
Disposable masks	NA (or per clinical policy if applicable)	> 60-day supply of masks per person	30–60-day supply of masks per person	<30-day supply of masks per person
Hand Sanitizer	Desirable but not required for COVID-19 transmission	>60-day supply	30–60-day supply	<30-day supply
Disinfectant	NA	>60-day supply of disinfection	30–60-day supply of disinfection	<30-day supply of disinfectant

Physical Distancing	NA	Indoor: < 1 gathering of 25 people per week	Indoor: < 3-5 gathering of 25 people per week	Indoor: < 3-5 gathering of 25 people per week
Mask Wearing (RA survey) (disaggregated by IN residence hall and OUTSIDE residence hall and by residence hall)	NA	>90% report students wearing masks [ALWAYS]	85–90% report students wearing masks [ALWAYS]	<85% report students wearing masks [ALWAYS]
Gatherings of 10 or more people (RA survey) (disaggregated by IN residence hall and OUTSIDE residence hall and by residence hall)	NA	>95% NEVER observe gatherings of > 10 people	85–90% NEVER observe gatherings of > 10 people	<85% NEVER observe gatherings of > 10 people
Compliance to physical distancing (RA survey) (disaggregated by IN residence hall and OUTSIDE residence hall and by residence hall)	NA	>90% report ALWAYS seeing appropriate physical distancing	85–90% report ALWAYS seeing appropriate physical distancing	<85% report ALWAYS seeing appropriate physical distancing
Report gatherings on campus per week (police reports)	NA	Outdoor: > 1 gathering of 10 people per week	Outdoor: > 3–5 gathering of 10 people per week	Outdoor: > 3–5 gathering of 10 people per week
Reported off-campus parties >10 people (as per residential life/neighbor reports)	NA	1 per 7-day period	1-3 per 7-day period	>3 per 7-day period

NA: Not available; RA: Residential Advisor

6.0 Other EWI of COVID-19 prevention and preparedness

This section defines other indicators that may be considered. They include influenza vaccination rates—this indicator is predicated upon implementation of a policy requiring or strongly encouraging influenza vaccination during the COVID-19 pandemic. Such a policy will mitigate flu-like illness and symptoms leading to a decrease in stress on campus health services as well increase specificity of case finding based on symptom screening. While specific targets have not been established for employee absenteeism, it is recognized that absenteeism may be a surrogate for illness due to COVID and if significant absenteeism occurs in critical sectors (dining, health services, police, etc.) greater restrictions on campus life, including possible campus closure must be considered. Increasing reported flu-like illness based on symptom screening may signal SARS-CoV-2 transmission, especially if highly specific indicators are used (loss of taste or smell). Finally, documenting the median/mean number of contacts per each successfully traced COVID-19 case may provide useful information especially if contextualized with Geographic Information System (GIS) or social network data, if available.

Table 5. Other EWI of COVID-19 Prevention and Preparedness

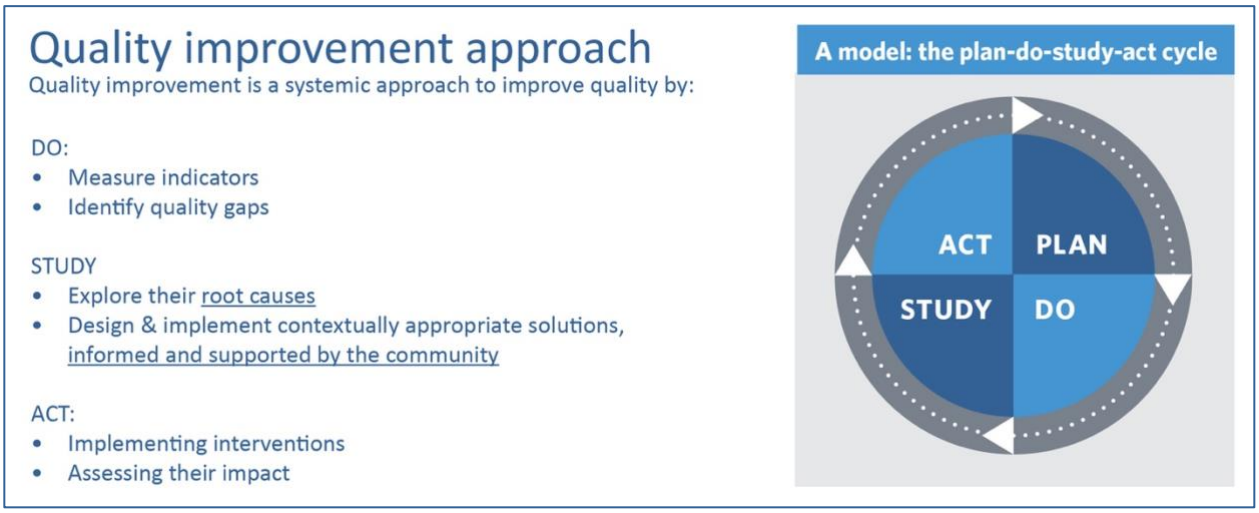
Status Level	Green	Yellow	Orange	Red
Influenza vaccination rate (fall 2020); by student, faculty, staff; by campus	>90%	>90%	75–85%	<75%
Employee absenteeism (informs capacity: dining, police, health services, environmental services, etc.)	NA	NA	NA	NA
App-based indicators (flu-like illness) by 3-,7–14-day intervals	NA	NA	NA	NA
Median/mean number of contacts per each COVID-19 case traced; disaggregated by campus, on campus, off campus; report by day; weekly average	NA	NA	NA	NA

NA: Not available.

7.0 Using indicator results for quality improvement

When faced with less than desirable indicator results, especially those related to process, it is suggested that the plan-do-study-act model or other similar approach to quality improvement be followed.

Figure 1. Plan-do-study-act cycle



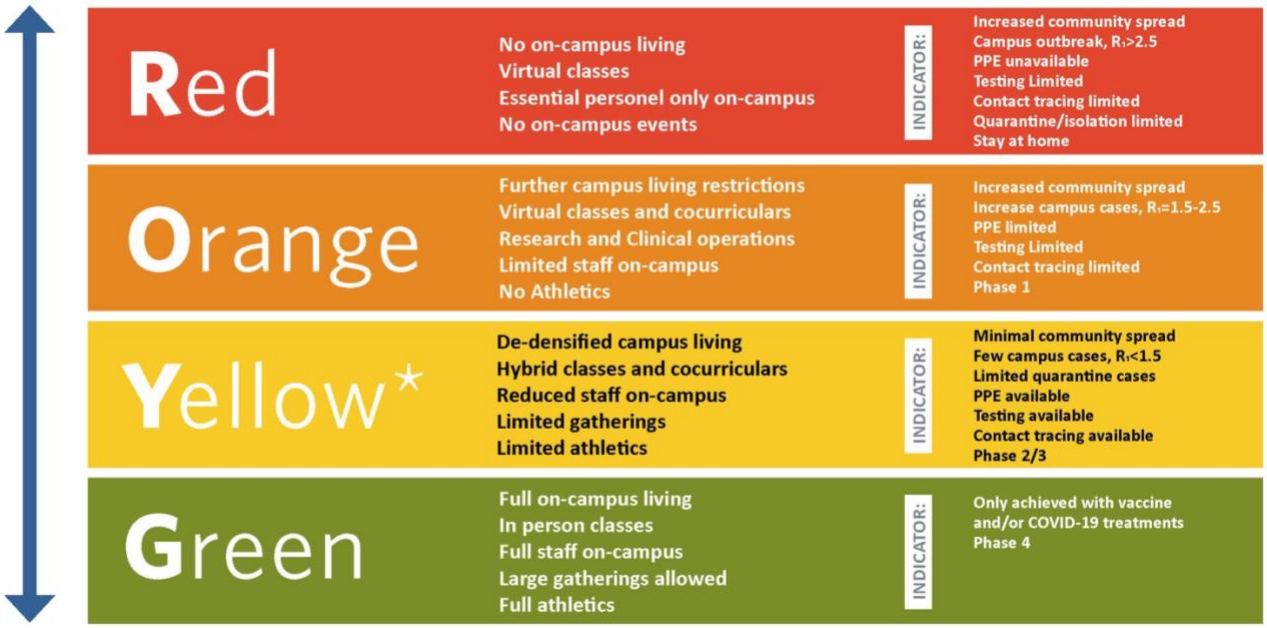
Through engagement and dialogue with local stakeholders, simple plans to optimize performance of process indicators related to testing turnaround time, contact tracing and quarantine success, etc., can be developed. In addition, when surveys of compliance to social norms show undesirable performance, this approach or that of Positive Deviance, an approach to behavioral and social change based on the observation that in any community there are people whose uncommon but successful behaviors or strategies enable them to find better solutions than their peers, in this case optimal adherence to social norms, despite facing similar challenges and having no extra resources or additional knowledge than their peers, may be consider to alter behavior[4].

[4] Richard Pascale, Jerry Sternin, and Monique Sternin. *The Power of Positive Deviance: How Unlikely Innovators Solve the World's Toughest Problems*. United States of America. Harvard Business Press. 2010.

8.0 Campus status levels and example planning scenarios

Figure 2 illustrates proposed COVID-19 residential campus status levels as a continuum from full on-campus living in a situation with SARS-CoV-2 vaccination and or treatments to no on-campus living in situations of unacceptable increasing community spread, outbreaks, or major stressors on supply chains and/or prevention elements. When assessing status levels and possible change from one to another, it is important to recall that no one indicator above is sufficient to change status level, rather status levels are likely to change based on signals of increasing infection or stresses in the management of COVID-19 cases as well as changes in state or national guidelines.

Figure 2. COVID-19 residential campus status levels



*As students return to campus, the assumption is that colleges and universities are starting in the yellow status level and that every effort must be made to keep the institution within the yellow level until a safe and effective vaccine is available

Possible scenarios are proposed below for planning and education purposes.

Scenario 1: ***Increased statewide seven-day weighted average of test positivity or increase in statewide (R_T).*** Increasing incidence of COVID-19, as measured at the population-level in a state, indicates increased community spread of the virus.

Let us consider a hypothetical scenario in Massachusetts. On September 1, 2020, the seven-day weighted average of test positivity is 1% and the state R_T is 09.3 (range 0.8-1.09). Let us assume that there is an increase in community spread such that by October 15 the seven-day molecular positivity and R_T have reached 1.6% and 2.0, respectively. These increases signal a shift from Yellow to Orange (**Table 2**). The question then becomes how have statewide increases impacted a residential campus. In most scenarios, as campuses are not "closed populations," one can assume that there will be increased

transmission on campus. Sometimes an increase may be observed on a campus before it is reflected in state statistics: if a campus is a leading population (i.e. residential college students drive a statewide change); other times a statewide increase may be due to other factors (e.g. nursing home outbreaks). Thus, it is important to also have on hand local campus-specific seven-day averages and to calculate a campus-specific R_T.

For the purpose of this discussion, let us assume that an identical campus-specific increase to that observed statewide has occurred. Crossing the threshold from Yellow to Orange for these two indicators on a college campus would certainly necessitate prompt intervention such as moving all classes online for at least two weeks, limiting research (or clinical operations), and further de-densifying campus by reducing staff and faculty presence on campus. Depending on local drivers of the epidemic and available resources, a college may successfully be able to decrease the number of incident cases over the subsequent two-week period. If increases continue to be observed on campus and/or if isolation and quarantine rates are projected to exceed capacity (**Table 3**), moving to Red and closure of the campus must be considered.

Scenario 2: ***Increased citywide 7-day weighted average or increase in citywide (R_T) driven by opening of K–12 schools.*** Local school districts open K–12 schools without SARS-Co-V-2 surveillance testing in September. In this scenario, let us imagine several unlinked clusters that break out in different classrooms across all grade levels. The school district is unable to contain the outbreak and generalized community spread occurs with the citywide R_T increasing from 0.9 to 2.4. As a result, individual school buildings are closed and classes and cocurriculars move online. In this scenario, it may behoove the college or university to follow suit (i.e. move to Orange Status), even if campus-specific numbers remain in the Yellow zone in order to minimize introduction of the virus from the community into the campus setting by minimizing student interactions with members of the host community. Moreover, such an action may free up intuitional resources to assist in the local response to outbreaks in schools.

Scenario 3: ***On-campus or off-campus party resulting in 50 incident infections, each with multiple contacts.*** In this scenario, a group of students host or attend an off-campus party with 150 students trafficking through the party in an evening. At the party, 50 students become infected, and each has an average of seven close contact contacts. Depending on isolation and quarantine capacity, a college or university would most likely move to Orange status for at least two weeks, while determining the number of secondary infections due to close contacts. If the number of secondary infections is relatively low, moving back to Yellow status or maintaining more stringent Orange status level policies may be reasonable. However, if 25–30% of the close contacts also became infected, (i.e. up to 105 cases) leading to smaller outbreaks in residential houses and off campus, strong consideration to moving to Red status with consideration given to closing the campus would be required. In fact, in a scenario of 50 initial cases with 105 secondary cases, isolation capacity would be severely stressed, likely precipitating campus closures (See *isolation rate*, **Table 3**).

Scenario 4: Clusters of cases in a non-residential campus. Not all campuses are residential. Consider for example a graduate biomedical research campus. The total number of faculty, staff, and students on this campus is 600. Let us assume that there has been an established R_T of 0.85 (this corresponds to roughly one case per week over a prior eight-week period). On day one of the hypothetical outbreak, four people in one laboratory are identified as having SARS-CoV-2. They are isolated, and 20 close contacts are quarantined. The laboratory is closed and fully sanitized and will remain unused for one week. Three days later (day four), surveillance testing identifies six more cases, all of whom had a negative test one week prior. These six individuals have no known contact with those in the original cluster in the laboratory—all work in different parts of the building. As a result of the initial cluster and subsequent outbreak of seemingly unrelated cases, the campus-specific R_T rises to 2.7. Based on this evidence, the entire campus is moved to virtual learning for 14 days as additional contact tracing and quarantining are performed, and the entire building is disinfected. An R_T of 2.7 is in the Red zone (**Table 2**). A timeline for safe reopening of the campus will be dependent on successful contact tracing, quarantine, isolation, and will be informed by any changes in community prevalence as well as the ability to identify and mitigate any possible campus or building-specific determinants associated with infection (i.e. enforcement of universal masking, review and strengthening of sanitization protocols, etc.).

9.0 Response actions

This section presents possible actions in response to different Residential Campus Status and assumes normal pre-pandemic conditions in green and likely move to closure of the higher education institution in red. Proposed COVID-19 response actions are presented in **Table 6**.

Table 6. COVID-19 response actions

Status Level	Green	Yellow	Orange	Red
Staff	Regular	De-densified	De-densified	Essential only
Classes	In person	In person/de-densified	Online	Online
Dining	Normal	Indoor allowed with residential cohorts at preselected times & to go	To go only	To go/delivery
Library	Normal	Open/de-densified	Pick-up/drop off	Closed
Academic & Campus Life Buildings	Full access	Restricted access	Closed	Closed
Residence Halls	Normal	Open with residential cohort rules in place	Open with residential cohort rules in place	Closed[5]
Galleries/Museums	Open	By appointment only	Closed	Closed
Research and clinical operations	Allowed	Allowed	Essential only	Closed
Communication to students and parents	Normal campus operations	Return to campus guidance applies	Prepare to go home. Create travel and contingency plans.	Campus shutdown
Gatherings	Allowed	Follow state and university host-	No gatherings	No gatherings

[5] Some colleges and universities may choose to keep some residence halls open for students with no housing alternatives.

		community guidelines		
Testing frequency	Not applicable	As normal or increased testing in sub-population(s)	Increased testing frequency for all; enhanced testing in sub-population(s) based on disaggregated data	Increased testing frequency for all; enhanced testing in sub-population(s) based on disaggregated data

10. Conclusion

Since the COVID-19 pandemic hit in 2020, institutions of higher education have been working at an accelerated pace to design safe operating procedures to open campuses and have been seeking guidance on how to best interpret local and community prevalence of COVID-19, assess campus-specific readiness to open safely, assess prevention and preparedness practices, and devise frameworks for action and decision making. This document may help to fill this void.