Communication

Safe University in the Omicron Era: An Adaptable and Adjustable Protocol for the Operation of Universities during Epidemics Caused by Airborne Viruses

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Abstract: In this work we present an updated version of "Safe University", a protocol aimed to ensure the safe operation of academic institutions during the SARS-CoV-2 pandemic. The protocol is detailed, addressing all aspects of the actions that are required, ranging from controlled access to the university premises and tracking of immunity status to air quality provisions and organization of classes and teaching methods and more. A step-by-step guide and a sample timeline are included, to facilitate practical implementation. The protocol was first developed in the summer of 2021, when the Delta variant had first emerged but not yet dominated, with the aim to support the operation of Greek universities at the beginning of the 2021–2022 academic year. Since then, it has been updated to reflect the evolution of the virus and the pandemic, as well as the developments in the relevant scientific knowledge and additional monitoring, safeguarding and treatment tools that humanity now possesses. It has also been given a more generic form, making it suitable and adjustable for other countries and cultural/political environments as well as other respiratory viruses. With some additional adjustments, it can also be suitable to deal with epidemics from non-respiratory viruses that may arise in the future.

Keywords: Safe University; protocol; COVID-19; adaptability; adjustability; respiratory virus; airborne disease; epidemic

1. Introduction

As the SARS-CoV-2 pandemic continues to exert its toll after more than two and a half years, the academic community once more has to adjust its regulations in order to have universities return to in-person teaching mode. The burning question here is how to achieve an academic experience as close as possible to the pre-pandemic standards while at the same time limiting the health risk allowances for all parties involved.

The 2021–2022 academic year has been a challenging one for many academic institutions, due to the continuing burden of SARS-CoV-2 variants with different characteristics. The first half of the academic year coincided with the dominance of the Delta variant, the properties of which necessitated specific precautionary measures against infection and infection transmission. The second semester though coincided with the dominance of the Omicron variants, which possessed strikingly different characteristics in terms of transmissibility, immune evasion, and infection severity. Thus, academic institutions needed flexible plans in order to continue operating in person. There is still limited published experience with the outcomes of the different academic approaches to the pandemic. Vaccination mandates, mask mandates, and clean air techniques have been vastly different between individual institutions, and every operational schedule, including ours, "Safe University", needs to be validated repeatedly and in different settings.

It is easy to assume that these rules, especially if proven effective, can be transferred to any other university in the world. However, this assumption would be wrong. As already mentioned in the original publication of our Safe University approach [1], there are regions where political, cultural, economic, technical or even supernatural concerns prohibit the implementation of these solutions. Many EU countries show examples of this:

- Political: In many countries the political reality is that vaccination cannot be made mandatory; the government that would attempt to pass such legislation would crumble, particularly since the effect of vaccination against Omicron transmission is inferior to that against other variants.
- Cultural: Imposed rules need to take into consideration the culture of the people that will be asked to implement them. Asking Mediterranean populations to remain at distance, avoid hugs when meeting friends and keep gatherings in small numbers has proven unenforceable, at least without a prior well designed and efficiently implemented media campaign. Media campaigns though tend to lag behind viral evolution, and when the evolving nature of a pandemic has not been adequately communicated to the public, cultural parameters may overrule scientific necessities.
- Economic: Smaller numbers of students per class, i.e., more instructors and more classrooms, are among the proposed solutions. However, there are cases where it is financially impossible to implement such a solution.
- Technical: In some countries it is common that a university operates in a campus, often outside the city limits and including student dormitories. Therefore, the university can operate as an isolated area where, as long the new entry of the virus is avoided, the university can operate as a zero-COVID area. This is not the case for universities that are dispersed around the city center and where students do not live in the university but independently throughout the city.
- Supernatural: There are multiple cases of religious leaders taking a stance against vaccination, against suppression measures or even against the notion of the virus itself. In regions where religion has a greater control over the people, this is a factor that cannot be ignored.

In this work we attempt to provide an updated all-round guide towards the safe in-person operation of universities during the current phase of the pandemic, that takes into account such limitations and is adaptable to the specifics of each country and university. As such, our guide has some elements that are constant and others that can or need to be customized depending on the individual characteristics of each university and its academic population.

The protocol was first developed in the summer of 2021, when the Delta variant had first emerged but not yet dominated, with the aim to support the operation of Greek universities at the beginning of the 2021–2022 academic year. A short overview of the main elements of that version has been published elsewhere [1]. Since then, it has been updated to reflect the evolution of the virus and the pandemic, as well as the developments in relevant scientific knowledge and additional monitoring, safeguarding and treatment tools that humanity now possesses. It has also been given a more generic form, making it suitable and adjustable for other countries and cultural/political environments as well as other respiratory viruses. With some additional adjustments, it may also be suitable to deal with epidemics from non-respiratory viruses.

Compared to the earlier publication, the current work: is updated to reflect changes in the course of the SARS-CoV-2 pandemic, including Omicron variants; details the specific actions required for each area of intervention; elaborates the fixed and adjustable parameters of the protocol; provides the functionality and specifications of the information system that is at the core of the proposed protocol; contains a sample time-line of actions; has a more generic approach that makes it relevant not only for SARS-CoV-2 but also for potential future epidemics; and is presented in a goal-driven and application-oriented manner, in order to facilitate those who wish to adopt the proposed approach in their academic environments.

The remainder of the paper is organized as follows: In Section 2, we briefly review what is new in the current phase of the SARS-CoV-2 pandemic and what we have learned so far regarding the ways to monitor its progress, limit its spread and protect ourselves, individually and as a community; this forms the relevant background for our work. Based on these, in Section 3 we outline the core concepts of our proposed protocol and in Section 4 we examine each aspect of the protocol individually and in greater detail. To facilitate practical implementation, Section 5 provides guidelines for the people that need to be involved and the wide range of activities that need to be combined, including a sample timeline of actions to be taken ahead of the forthcoming academic semester. Section 6 discusses the generic and adjustable nature of the protocol, distinguishing between fixed elements and configurable parameters. Finally, in Section 7 we discuss the potential benefits of the broader implementation of the proposed protocol and in Section 8 we list our concluding remarks.

2. Relevant Background

2.1. Recent Developments

Omicron variants dominate the pandemic in 2022. Both Omicron BA.1 and Omicron BA.2, that expanded in succession worldwide, are characterized by multiple point mutations, some of which had not been observed before. These mutations induce a propensity for immune evasion: breakthrough infections in vaccinated individuals as well as re-infections were extremely common in 2022 [2]. Furthermore, Omicron variants demonstrate a weaker affinity for the lower respiratory tract and lead, on average, to milder disease. Yet, their enhanced transmission potential has resulted in massively larger numbers of cases and thus a significant burden on both severe disease risk and absolute mortality numbers [3].

The spectrum of diagnosis has not evolved much in recent months: rapid diagnostic tests are generally adequate in diagnosing Omicron variants. On the other hand, state regulations setting the end of quarantine of the infected to 5 days, has been considered inadequate by numerous scientific boards, and studies showing that, even with Omicron variants, a significant number of patients can be theoretically infectious (rapid test positive) [4] even up to 10–12 days.

Vaccination remains our key weapon against SARS-CoV-2. As already stated, Omicron variants possess a degree of immune evasion. This is not translated into significantly increased susceptibility to severe disease, but only to significantly increased susceptibility to infection. Booster doses further restore this slight decrease in protection from severe disease, and temporarily restore protection against infection in general. The latter though rapidly wanes [5]. Still, studies have shown that triple-vaccinated individuals remain less transmissible than non-vaccinated ones, even in close-contact, such as household settings [6].

The increased transmissibility of Omicron variants means that there is an enhanced need for appropriate personal protective equipment (PPE) use: superior masks (FFP2, N95) should be used, and clean air in closed spaces should be prioritized. Experimental studies have shown that Omicron variants may survive more efficiently on surfaces, but fomite transmission remains a minor form of transmission.

The emergence of the Omicron variants has rapidly altered what we hoped for in terms of treatment options. Available combinations of monoclonal antibodies that were extremely useful against Delta variant were rendered useless with the emergence of Omicron BA.1 and particularly Omicron BA.2. At present (and including novel variants on the rise as Omicron BA.4 and BA.5), only a single monoclonal antibody is active against Omicron variants (bebtelovimab), but this remains inadequately tested in fragile populations and is of questionable availability at the moment. Another monoclonal antibody combination though, that of tixagevimab and cilgavimab, has proven to be effective as a preventive approach for immunocompromised populations, with efficacy up to at least 6 months in preventing infection. This combination remains active against the currently dominant Omicron BA.2 variant [7].

In terms of antiviral therapeutics, the combination of nirmatrelvir/ritonavir has proven bulletproof and extremely successful in minimizing hospitalization risk in individuals with comorbidities and/ or advanced age, when administered early in the disease course [8]. Less practical is the intravenous administration of remdesivir early at home, and less efficient is the use of molnupiravir, another oral medication. It should be noted that all these treatments are at present suggested for vulnerable individuals, and thus may be out of the context for the predominantly young and healthy academic population.

2.2. Earlier Experiences

There is a striking absence of literature data on universities' experience during this double variant academic season (Delta, first semester and Omicron, second semester). Isolated practices may orientate towards useful approaches regarding campus entry, surveillance (both by testing individuals and wastewater sampling) and environmental interventions. However, reports on the measured efficacy or these approaches have not been published.

The most relevant works are based on earlier phases of the pandemic. Moreover, these mostly include reports from the implementation of a fixed protocol at a single institution, not examining the ability to transfer to other universities [9–12], as well as studies regarding the thoughts and behaviours of the people involved [13–15]. Ref. [16] discusses the process to model COVID-19 policy making, but stops short of actually providing policy suggestions, let alone specific protocols to implement.

3. Protocol Outline

Safeguarding the operation of universities in a pandemic environment is a fine balancing act, with complex tradeoffs between convenience and safety and with multiple factors, some of which are external to the university and hence totally beyond the academic administration control. As a result, for a protocol to have a reasonable chance of achieving safe and continued operation in such a setting, it needs to combine and coordinate multiple complementary features.

The updated "Safe University", the current form of our protocol for safe university operation during the pandemic, combines the following features, also summarized in Figure 1:

1. Accreditation. Accreditation cards are issued to all members of the academic community and are used to access university premises. The immunization status is logged (on a voluntary basis) and linked to the accreditation cards, so that it can be considered when deciding in which cases to grant access and when to refuse it.
2. Access to the university premises. Strict access control rules are defined and implemented at the entrance of the university campus; alternatively, they may be implemented at the entrance of each individual building.
3. Access to the classrooms. Access to classrooms is controlled and logged. An adjusted headcount is defined that takes into account the immunization status.
4. Ventilation and safe operation capacity. Depending on the architectural characteristics of each room, a maximum number of concurrent participants is set. The operation capacity can be augmented by enhancing the ventilation, either naturally or artificially.
5. Relief areas. Separate relief areas are identified for each classroom, so that different groups of students can take their breaks separately and not mix.
6. Personal protective equipment. Proper masks, worn properly, are a prerequisite.
7. Organization of teaching. Students are split into smaller groups that are, as much as possible, fixed. The way of teaching is altered, to reduce the standard instruction time, allowing for the same instructors to take on more courses/groups of students.
8. Infrastructure and systems. An information system is designed, that supports various aspects of the implementation of the protocol such as access control and tracking. Additional hardware infrastructure is required for ventilation, heating and to support the operation of the information system.

9. Restaurants. These are areas with an augmented potential for widespread transmission, therefore maximum care is required.
10. Student dorms. Similar to restaurants, dorms have the potential to become the epicenters of breakouts and therefore appropriate care is required.
11. Vaccination. Being our main tool against the widespread transmission of SARS-CoV-2 and its severe implications on people's health, vaccination needs to be promoted and misinformation to the contrary needs to be battled. The very definition of full vaccination is a point to consider, based on the most recent scientific data.
12. Surveillance. The need to test–trace–isolate is well documented and could not be omitted from our protocol. Wastewater surveillance is also included.
13. Graceful degradation. Considerations are in place so that the university continues to operate even as people with critical roles become infected and need to isolate. This parameter is of particular importance in the Omicron era, which has produced and continues to produce (through novel variants) major case surges.

Figure 1. Overview of the Safe University protocol features.

We elaborate further on each one of these features in Section 5.

Rigorous as it may be, the description of the protocol is not enough on its own to lead to its successful implementation. A number of well-timed and coordinated tasks are required, in order to set the grounds for the implementation of the protocol. These include:

The preparation for the implementation of the protocol:

1. Staff and roles involved. The implementation of the protocol involves a set of individuals and committees; these need to be appointed and informed or trained accordingly before they can take on their intended roles.

2. Dissemination of information. The protocol is a complex set of processes affecting every single member of the academic community. Information regarding how each individual should behave, as well as on the current situation in the university, needs to be assembled and disseminated in an organized and efficient manner.

3. Help desk. As with any complex set of procedures involving a large number of people, the operation of an efficient help desk will be crucial to support people in their roles.

4. Gradual initiation. The implementation of the protocol starts with a small portion of the academic community, so that weaknesses can be identified and addressed, before gradually extending it to include the whole of the academic community.

5. Institutional framework. For the protocol to become part of the university operation, it needs to be included in the university policies and regulations.

6. State support. Where the current legal framework and/or the available resources do not suffice for the implementation of the protocol, the state's support is required.

7. Implementation timeline. A detailed timeline needs to be designed, aligning the timing of multiple tasks that are carried out by multiple people/committees/departments.

We elaborate further on each one of these tasks in Section 6.

4. The Protocol in detail

In this section we provide further details on each of our protocol's components.

4.1. Accreditation

Each member of the academic community is registered in an online platform that supports the implementation of the protocol. The platform records, among other things, the immunization status.

The disclosure of the immunization status (e.g., vaccination status, prior infections, etc.) is voluntary and optional; all are considered unvaccinated and without immunity in principle, unless proven otherwise. The relevant record is modified for those who wish it, upon provision of proof of their immunization status.

An accreditation card bearing a QR code (or RFID, or other technology that allows automated machine processing) is issued to all members of the academic community and is necessary to access the University premises. The accreditation card does not have color coding or other discriminating characteristics that may reveal vaccination information or other sensitive personal data to third parties.

Issuing of accreditation cards is performed in advance for all members of the academic community (permanent and temporary staff, students, contractors working on campus, etc.). The cards are kept securely (for example in locked cabinets under the responsibility of the access control service) at the main entrance of the institution and are delivered to their proper holders upon their first entry into the premises of the university.

Guests are provided with temporary accreditation cards which are returned to the access control service upon leaving the University.

4.2. Access to the University Premises

The totality of university premises is considered a space of safe operation; therefore, all access to any university premises is controlled.

The access control check is conducted at the entrance point of the safe operation area, indicatively at all entrances in the case of an autonomous campus. Alternatively, access can be controlled at the entrances of the individual buildings in the case of buildings that are scattered among the urban fabric, something that is quite common among universities in Greece.

The check is performed via scanning the accreditation card. The system responds by indicating whether (a) entry is allowed (for example for a member of the academic community who is known to be immunized and not currently infected), (b) further documentation is needed (for example the provision of a recent negative test proving there is

no active infection) or (c) entry is prohibited (for example a person that has been flagged for isolation).

Once an entry is approved, the system records the entry of the specific person to the specific safe area. Additional controls inside the safe area are not necessary, but random controls may be performed ad hoc in order to verify the integrity of the process (for example to confirm that there is no alternative entrance that has been overlooked and is used to avoid the access controls).

During the pandemic, restrictions on the entry of people from outside the academic community to the premises of the institution will inevitably have to be imposed. On the other hand, some individuals may still wish or need to enter, for example to attend conferences, open lectures, project meetings or graduation ceremonies, etc. Admission rules can be customized for such cases.

Any particular rules for an outsider entering the university premises may depend on the individual characteristics of this visit, the duration of the visit, the access to specific indoor spaces, the participation in activities along with a significant number of other attendees, and so on. Proof of a recent negative test for any such outsider attendee, regardless of their immunization status, may be warranted, according to the overall intensity of community viral flows at the time of the visit. The strict use of PPE (especially masks) will certainly be required.

In order to reduce both the burden of additional checks at the University entrance and the number of people moving within the premises, it is recommended to in general make an effort to avoid such events and limit short-term entry of people outside the academic community, when possible.

On the other hand, there are some university services, such as the protocol and the financial services, that predominantly interact with individuals outside the university. Where possible, it is recommended that these services are moved to a disconnected building or location that has a separate entrance, so that frequent visitors do not enter the area of safe operation and do not mingle with the academic community. Of course, the interaction with many different individuals places these services at higher risk. For this reason, it is recommended that remote/online interactions are facilitated, promoted and preferred where possible. Furthermore, individuals employed by the university who have major comorbidities or an immunocompromised status should be shielded from such interactions with the general public and be employed elsewhere, irrespective of their vaccination status.

If at any time it is not possible for an entrance to be properly staffed for the access controls to take place, the entrance remains closed. Alternatively, the understaffed entrance can operate ad hoc. One way to achieve this is to have the door locked and equipped with a doorbell; when the bell is rung, a staff member will let the visitors in after performing the required checks.

4.3. Access to the Classrooms

For each individual room inside the University (e.g., classroom, amphitheater, conference hall, laboratory, etc.) the capacity of safe operation is defined as the maximum allowable number of people to be present at the same time. For more details on this, please see the next section.

Before the start of a utilization period, such as a lecture, there is no person in the area. Upon entering the room, each person scans the accreditation card and the system checks whether the specific person can be added without exceeding the allotted capacity and either allows or prohibits entry. In case the entry is allowed, the presence of the specific person in the specific room at the specific time of use is recorded in the system; this will facilitate contact tracing, where needed.

An adjusted headcount is used, in which each person with confirmed immunization counts as one person, while each person for whom immunization has not been confirmed counts as two people. The 2:1 ratio is based on published estimates of a two-fold reduction in the risk of viral infection in vaccinated individuals [6] and aims to balance potentially

infectious units in a given site if two vaccinated individuals have the same rough chance of one unvaccinated to show one transmitter of the disease. In this way, an automatic adaptation of the mode of operation of the university to the respective vaccination data is achieved, with head counts adjusting automatically as the percentage of immunized participants changes. It should be noted here (and is further analyzed in subsequent Section 4.11) that in the Omicron era the definition of vaccinated and non-immune has radically changed.

The system reserves places for the registered teachers of each class, so that there is no case to reach the capacity of the room by admitting students and leaving the teachers unable to enter.

4.4. Ventilation and Safe Operation Capacity

To determine the safe operating capacity, the architectural features of the room are taken into account, such as the size, shape and volume of the room, the number, size, type and locations of windows, the doors, the adjacent detonation spaces (corridors, etc.). Specific considerations include the amount of air intake achieved by the windows, whether there are tilted windows that can only be opened partially, the existence of HVAC system and the existence or ability to install HEPA filters for air purification, the size of the entrance door and whether it is possible to keep it open during class depending on the adjacent spaces, the ventilation of any corridors (see the following subsection on relief areas for more information on this), and the acceptable levels of induced noise for the classes taking place in the adjacent rooms. An enhanced ventilation augments the safe operation capacity as more people can coexist in the room safely, whilst on the other hand poor ventilation reduces the room's operation capacity as it is less safe for many people to stay in it concurrently for extended periods of time.

A rule of thumb for adequate ventilation is estimated by most international competent authorities at six air changes per hour [17]. Each academic institution needs to evaluate its lecture halls and laboratory spaces regarding the adequacy of purely natural ventilation. This assessment can be made by the academic staff of relevant scientific fields if there are any (universities that have departments of architecture, engineering or physics should be able to perform this inhouse) or otherwise request appropriate assistance from other academic institutions. In case this approach is not possible either, the assessment can be performed by external contractors. Technical services of the university could also be charged with this task, equipped for example with CO_2 meters and based on the existing relevant literature [18].

The assessment of the adequacy of the ventilation of each room is not limited to the examination of its architectural characteristics; the type of use is another important parameter. Thus, the offices of the academic staff, as a place where rotation of visitors is limited, can be considered safe if each visitor uses increased personal protection measures (e.g., mask N95), if the visit time is limited to the minimum possible and in any case less than 15 min, and if the visit is made with open windows or with functioning portable air cleaners. Similarly, libraries are places of minimal dispersion of viral particles through speech, so the use of a mask and the limitation of the number of those present at the same time is sufficient, in addition to the appropriate natural ventilation. The opposite applies to areas of exercise or where loud voices are used, such as gyms or music teaching areas, where maximum air renewal should be sought, by maximizing natural ventilation and adding artificial purification and/or fans if necessary.

4.5. Relief Areas

Between successive uses, the rooms will need to remain open and empty for some time, for the air to be changed and the chance of virus transmission to be reduced between the members of subsequent classes. The smooth operation of the university requires the teaching periods to be synchronized and by extension the periods during which the rooms remain empty also need to be synchronized.

Of course, it does not make sense to have provisions to keep students in smaller and constant groups for classes (see Section 4.7.1 for more info on this) and then have them mixing at every break. Therefore, separate relief areas need to be allotted for each room, where possible, so that each class takes its break in a different space.

4.6. Personal Protective Equipment

4.6.1. General Population

The proper use of an appropriate mask is a prerequisite to entering and staying in the safe operating space of the university, with specific exceptions to those with their medical background soundly ascertained. Masks should always be worn properly, i.e., the nose should be inside the mask, the jaw should be inside the mask and the mask should fit well on the face with no gaps that will allow air to enter. Preferring masks with headbands instead of ear loops may assist in superior face fitting [19].

In the current pandemic environment of highly contagious strains, the use of a mask when indoors is absolutely imperative. Its use and proper application is considered as a prerequisite to attend a course, laboratory, etc., and non-compliance, in addition to any other penalty stipulated in the regulations of the institution, entails automatic expulsion from the teaching areas or from the premises of the university altogether.

The university's regulations regarding the safe operation, i.e., the regulation making the protocol an official policy of the university, also defines whether or when it is necessary to use a mask in spaces other than teaching spaces (e.g., outdoor spaces, office spaces, dorms, etc.). Non-compliance, in addition to any other penalty stipulated in the regulation, entails automatic expulsion from the specific site or from the premises of the university altogether.

The use of N95 masks is required for areas of reduced ventilation, large gathering of people or conducting special laboratory exercises that require close contact. Medical masks, previously considered adequate in well ventilated and sparsely populated areas, should be systematically replaced by N95 masks.

These requirements apply to teaching, administrative and technical staff, students and visitors.

4.6.2. Special Populations

For the people who are tasked with performing vaccinations and SARS-CoV-2 tests, managing people who are found to be positive and/or assisting those who need to isolate, there are additional requirements for enhanced protection via PPE.

These are detailed by state mandates regarding PPE requirements for medical staff handling SARS-CoV-2 cases (uniform, gloves, masks, overshoes, etc.)

4.7. Organization of Teaching

4.7.1. Assigning Students to Classes

In Greece, as in many other countries, it is customary for university degrees to consist not only of mandatory but also of optional courses. It is also possible for students to choose courses from different years of study. As such, each course does not have the exact same students as the other courses, even of the same year. Popular courses and courses that are mandatory tend to be followed by large numbers of students, which creates the need to split the students into manageable groups.

Before the pandemic, the main criteria for the placement of a student into one the different subgroups of a course were the timing of the course and the compatibility of its timing with the timing of the other courses that the student had registered for. Regarding the number of students to place in a class, either the size of the available classroom or some university specific threshold was followed. Now, during the pandemic, our protocol stipulates that the following adjustments need to be applied to this process:

- When considering the maximum number of students that can be placed in a class, instead of the number of people that can fit in a room, the safe operation capacity should be considered (see Section 4.4).
- When counting how many students have already been registered and how many more can be added in the same class, instead of the head count the adjusted count should be considered that also takes into account the student's immunization. This way it will be possible for all the students of the class to be in the classroom at the same time; otherwise, the implementation of the protocol regarding access to the classrooms might exclude some students (see Section 4.3).

For the different courses of the same year, student allocation to classes is the same as much as possible (the same students that are registered for instance A.1 of course A are registered for instance B.1 of course B, other students who are registered for class A.2 are also placed together in class B.2), in order to create subgroups of students that, to the extent that it is possible, operate as closed bubbles. Students from different years of study that wish to attend the same courses are placed, whenever possible, in a separate class. Accordingly, when creating smaller groups of students for laboratory settings, each group includes individuals from the same class, so that there is no additional mixing of populations.

The creation of such stable subgroups does not fully ensure the closed character of each subgroup; each individual will also have their own extracurricular and extra-academic activities, often within the urban fabric. However, it does allow optimal on-site tracking in the event of a case and transmission and also limits, to some extent, the potential for widespread transmission within the university.

4.7.2. Extent of Material and Way of Teaching

The proposed organization of students into classes, taking into consideration the adjusted head count will lead to a larger number of sessions that need to be taught. This fact may put a greater pressure on teaching resources, as university funding and the number of teaching staff have not increased during the pandemic; in some cases, they have even decreased due to the effects of the pandemic on the financial aspects of the universities' operation.

We propose to maintain the course material, as defined in the curriculum, but to modify the way it is taught so that the material is covered in fewer teaching hours. For example, in parallel to the in-class delivery of the content, supplementary content can be made available for students to study individually between sessions.

This reduction of teaching hours per class will enable instructors to manage the increased number of classes they will inevitably be assigned.

4.7.3. Teaching Assistants

For academic years 2020–2021 and 2021–2022, a "supportive teaching" program was in place in Greece. This program provided universities with funds to employ graduate and doctoral students as teaching assistants for undergraduate courses. It is a program that we propose is maintained and extended, as the work of the teaching assistants can compensate for the reduced teaching hours by the core instructors. Assistants would be particularly important in the Omicron era, since the possibility of multiple simultaneous cases, leading into concurrent absences of teachers, is considerable.

4.8. Infrastructure and Systems

4.8.1. Information System

A central element of the protocol for the safe operation of universities space is the electronic platform that records the relevant medical data when provided (for example vaccination status and test results), supports procedures (for example confirmation of the right to enter the university premises and monitoring of adjusted head count of people inside a room), monitors population flows and supports case tracking when needed. The

information system is independent (i.e., not developed as an extension to the system used to record student courses and grades), secure, with controlled access and logging of who/when updates records.

Most universities have the technical capacity and human resources required to design and implement such a system, customizing it further to their own particular needs, for example by assigning the design and development to a department of informatics, computer science, digital systems, engineering and so on.

The cooperation of multiple universities for the joint development of the application could distribute the overall burden, augment the know-how and experience that will contribute to the design of the application and enable faster implementation of additional features, provided that the solution being developed is open source, so that each institution is then able to adapt it to its specific needs and to support it flexibly and autonomously.

4.8.2. Equipment

The utilization of the information system described in the previous paragraph requires the procurement, installation and subsequent technical support of the operation of a number of new equipment systems and their accompanying consumables. These include, but are not limited to:

- the printing equipment for the creation of the accreditation cards;
- the peripheral equipment for the operation of the entrance stations, such as scanners for the accreditation cards and networked working stations or internet enabled mobile devices;
- ventilation systems and air purification systems for rooms and laboratories;
- digital and analog displays for announcements and updates on current status and procedures;
- heating elements (for classrooms, laboratories, dining areas, etc., to enable operation with open doors/windows or even outdoors during the winter).

During the first steps of the implementation of this protocol, each university will define the exact equipment elements, their quantities and specifications, and corresponding costs.

4.8.3. Infrastructure

For each room with inadequate ventilation (see Section 4.4), additional air purifiers need to be made available so that the desired ventilation level is reached. Depending on the type of air purifier, and also on the characteristics of the room, the position in which it will be installed and its operating rate is configured, also taking into account the induced noise and its impact on the functionality of the room.

We recommend avoiding placement of plexiglass separators between student seats, and to remove them where they have been installed in earlier phases of the pandemic, as they may restrict and perplex the flow and redistribution of air.

4.9. Restaurants

Dining areas are areas of increased risk for the transmission of any respiratory virus, as they are areas of mass concentration of a large and alternating population, which remains for a sufficient period of time indoors without the use of masks. Therefore, additional care needs to be taken to limit this risk.

Based on this need, and also on the experience of the previous academic year where the measure was applied successfully and smoothly in Greece, we recommend that food is distributed in the form of individual pre-packaged meals that are picked up by the students and consumed outdoors.

Alternatively, when for example the architecture of the premises and/or the weather do not allow for this, the safety of conventional in-door operation of university restaurants can be further supported by:

- restriction of the number of people concurrently in the restaurant, combined with an extension of the functioning hours so that everyone can be served;
- taking action to ensuring the maximum ventilation of the area (as mentioned above for areas of intense exercise), for example with a combination of open windows and effective fans;
- extending the total area and volume of the restaurants by repurposing adjacent rooms, in order to maximize distance between tables and minimize the concentration of people eating at the same time.

Full vaccination of workers in food services, and especially those involved in the distribution of meals, needs to be a prerequisite for employment.

4.10. Student Dorms

Similar to restaurants, student dorms are areas in which students from different groups (even from completely different academic departments and faculties) mingle, the duration of indoor stay is extended and the use of masks at all times is unreasonable to request and impossible to impose. Therefore, they are areas of augmented risk for transmission and special care needs to be taken to reduce this risk.

Increased epidemiological surveillance is recommended, with random tests, for example per floor or group of apartments. In the case that one of these random tests returns of a positive result, then every resident in the whole floor or apartment group is tested (surveillance-based informative testing [11]).

Quarantine apartments are prepared in isolated (as far as possible) areas for the safe isolation should a positive test result occur. For dorms that use shared toilets, the exclusive use of a toilet by the residents in isolation is a requirement.

Wastewater is tested at least twice per week. It should be underlined, as this is different to earlier practice, that in the case of dorm wastewater surveillance there is no threshold under which viral load is acceptable; any viral load points to potential existence of the virus in the dorm and requires immediate and decisive action to avoid the development of a cluster that might expand, spill out and contaminate the entire university.

4.11. Vaccination

Novel modeling data for highly transmissible pathogens, similar to Omicron, and their circulation in closed domains such as universities, have emerged: The Austrian model (which may apply to many regional/peripheral academic institutions in Europe) [20] estimates that even if the number of attendees at each classroom is minimized by 75%, even with concurrent mask use, significant surges are unavoidable, if vaccine effectiveness against symptomatic infection is as low as 50%. In this model, in order to avoid surges, it would take a vaccine with >90% effectiveness against infection and 95% vaccination coverage, in order to achieve in-person sessions with 50% of the attendees, masks mandatory. A similar model from Colorado [21] estimated that for a pathogen as transmissible as Omicron, an academic institution would need vaccination coverage >93% and mandatory masks in order to continue in-person teaching with no population mitigations.

As academic institutions that promote science, universities need to be pioneers in promoting vaccination, as a proven effective weapon in reducing the severity of any disease-induced illness, but also in limiting, to some degree, the continued transmission of the virus. In this context, the university authorities collect (via the aforementioned information system) and announce the overall immunization levels of the university population (ensuring that any information that is made public is properly anonymized so that there are no concerns of mishandling of sensitive personal information).

Of course, the very definition of vaccination has become a point to consider. With newer variants requiring more shots of the vaccine to achieve adequate immunization levels, immunization waning after a few months, vaccines of different technologies or of different manufacturers achieving different efficacy, combination of vaccination and infection affecting immunization levels, etc., setting a hard threshold of who can be considered

fully vaccinated is an open question. However, universities will have to come to a decision on this. Our recommendation is that for an individual to be considered as vaccinated (in terms of resistance to infection and transmission), one has to be triple-vaccinated (or have an additional dose after the single J&J regimen), with the last dose administered during the previous 4 months (since immunity to infection wanes afterwards) [22]. Similarly, an individual who is unvaccinated and has been infected during the Omicron period, should not be considered immune for any period of time, since numerous studies have shown that the Omicron-elicited immunity wanes, in the absence of previous vaccination [23]. A vaccinated individual with at least two doses though, who has been infected during the Omicron era, could be considered temporarily (the 4-month period) adequately boosted according to multiple relevant studies. Clearly, as more scientific information becomes available on this, the definition could very well change.

It should be noted that the members of the teaching staff are most likely the super transmitters within the institution, as their work entails prolonged mixing with alternating groups of students during which time the staff, as they teach, disperse greater viral loads through speech. They are also, due to their standing, the members of the academic community with the greater potential to affect others' behavior through their own example. For these reasons it is strongly recommended that vaccination is introduced as a prerequisite for employment in a teaching role, for both permanent and adjunct teaching staff.

Considering the university professors' role in the dissemination of scientific information in both the academic and the broader community, academic authorities need to hold their members accountable (for example reprimand, call for an apology, demand a public retraction, etc.) when they make public statements that reproduce lies or misinformation regarding the safety and utility of vaccines.

As has already been mentioned in Section 4.9, the requirement for vaccination should also be established for staff engaged in catering and especially in the distribution of meals.

4.11.1. Promoting Vaccination

In universities with departments of health sciences, an information group is created that organizes online educational sessions for students and staff about the benefits of vaccination. In institutions that do not have relevant schools, such seminars can be organized via the cooperation with other universities or with relevant public services. Attendance to a minimum number of such seminars can be made mandatory, with possible differences according to the vaccination status (for example vaccinated individuals should be updated on the potential need of booster doses, and the need for further personal protective equipment use).

In accordance with its role in promoting science, the university organizes similar seminars and vaccination promotion events for the broader public, informing the community in general. It cannot be overlooked that a university is often closely embedded in the urban fabric; therefore, the promotion of vaccination in the broader public is not only the proper thing to do ethically and philosophically, but it can also have a direct impact on the safe operation of the university itself by reducing the circulation of the virus in the community.

4.11.2. Vaccination Centers

In universities that have schools of health sciences, a vaccination team is created, in consultation with the relevant public authorities. The vaccination team is given its own space, which is organized and equipped accordingly. This space needs to be at a central and visible location within the university premises.

In the case of universities that do not have a school of health sciences, or in the case of universities with campuses distributed over several cities (which is quite common for example in Greece), vaccination teams from the relevant public services can be invited to be present on the campus on certain days/hours every week, so that a vaccination center may operate.

4.12. Surveillance

4.12.1. Testing

In Greece, the current requirement is for university staff who have not completed their vaccinations to have one test per week, whilst all testing requirements for students have been alleviated. Other countries have followed different approaches, with a similar trend of reducing requirements for testing. We find this incompatible with what we know about the contribution of testing in the control of the circulation of the virus in a community, and instead propose that a more rigorous testing approach is followed.

The transmission potential of a vaccinated individual, compared to an unvaccinated one, is roughly half. A relevant model form the Universities of Virginia and Alabama estimated that everyone should be periodically tested, regardless of immune status, in order to minimize the absolute count of infections during the Omicron waves [24]. However, if one considers that such a high toll of infections is unavoidable, diagnostic testing might focus more on non-immune individuals as well as high-risk individuals or potential super-transmitters, in order to minimize the magnitude of daily cases peaks. Based on such models, we propose that adequately immune (vaccinated) individuals should nevertheless be subjected to one weekly rapid test, whereas the non-immune students, faculty and personnel should be tested twice weekly.

Our recommendation is to have testing performed in-house, by a service of the university and at the university premises. Having the university in charge of the testing has benefits, including:

- the reduction of the cost per test kit, due to the procurement in bulk
- the reduction—or total elimination, depending on policy—of the relevant costs for each individual member of the academic community;
- the university's ability to define its own specifications for the technology and characteristics of the acceptable tests; and
- the integrity of the procedure—cases of forged test certificates have already been documented in Greece and Cyprus, perhaps in other countries as well.

In the case that results of tests performed outside the university are deemed as acceptable, it is recommended that random tests are also performed at the premises of the university, to (statistically) ensure that external test certificates are not counterfeit. This random testing should be mandatory for those selected (it can be a requirement to enter the premises that one accepts to be subjected to a test, should they be randomly selected for it) and free of cost.

We should note that not all brands of antigen tests have exactly the same performance [25]. This is also evident by, for example, the European Union frequently revising its list of approved tests, already now at its fifteenth update [26]. Moreover, in addition to the brand of tests to be used, the way to use them has also come into focus, with some recent results suggesting that saliva or throat swabs may be able to provide more reliable results now that Omicron has dominated [27]. Universities with relevant schools and faculties are urged to additionally explore the possibility to develop their own diagnostic methods, of potentially greater accuracy. These methods will need to be evaluated by third parties such as hospitals or independent labs, and upon validation transferred to immediate application.

Obviously, self-reported results of tests are not to be considered in any case if they are not also documented independently by the university of other trusted bodies.

4.12.2. Tracing

The information system described in Section 4.8.1 records, among other things, the areas that each member of the academic community has visited and, more importantly, which other members of the academic community were at the same area at the same time. The university's tracing team, which needs to be established and trained beforehand, not ad hoc when a positive case is identified, can utilize this information in order to expedite tracing, identification and further diagnostic testing or isolation (depending on individual factors as duration and proximity of exposure and immune status) of those who

are potentially exposed in a timelier manner, before they become infected and infectious. Time is of course essential, particularly in the hyper-transmissible Omicron environment, hence the need for the team to be pre-established, so that identification and isolation can take place before transmission chains are developed.

Where possible, we recommend the extension of the information system with the addition of a mobile application that can be used to automatically alert close contacts of anyone exposed, further reducing the time required to conclude the test–trace–isolate cycle.

4.12.3. Isolation

Those who return a positive SARS-CoV-2 test while they are away from the university follow governmental advice; entrance to university premises is prohibited until it is safe, the concept of safety though viewed differently between scientists and policymakers. Most official suggestions require a 5-day isolation, without need for further testing, provided there are no residual major symptoms as fever and that a quality mask is used in the following days. In practice though, as already discussed, many individuals may be positive in a rapid test (a broad surrogate for infectivity) for more days, and thus, a more prudent approach would demand the documentation of a negative rapid test before return to the campus. It should be noted here that PCR tests are not useful for evaluation post-infection, since they may detect non-infectious remnants of viral RNA for a protracted period, without this being an indication of transmission potential.

For those testing positive while within university premises, or starting to display suspicious symptoms while at the university, isolation at a pre-determined area is immediate, followed by transfer to the pre-determined isolation area for those residing at student dorms or to their homes for those living independently in the city. The team in charge of isolation can be the same as the team in charge of vaccinations, due to the overlaps in required PPE and know-how.

Isolation needs not only be immediate, it also needs to be constant throughout the determined period. For this to be realistic, arrangements need to be made for the care and support of those in confinement [28]. These include regular procurement of necessary materials (food, etc.), supplies necessary to monitor the development of the disease (thermometer, pulse oximeter), regular communication by a health professional to evaluate the general condition, psychological support hotline (staffed by relevant departments, if any). These arrangements apply to both those isolating within student dorms and those living alone.

4.12.4. Wastewater Surveillance

Wastewater surveillance has proven to be an effective way to monitor the prevalence of SARS-CoV-2 in a community [29]. We use this method to monitor the sewage of the various buildings of the university, in addition to the other, individualized, tests. Wastewater samples are taken and examined at least twice a week.

If a viral load is detected in a given wastewater flow, extensive testing of individuals using the buildings connected to that flow is required and should be repeated in specific time periods (for example on days 0, 2, 4, 6). This testing of individuals is implemented regardless of their vaccination status, it is mandatory and it is provided without cost.

4.13. Graceful Degradation

Although from a human and medical point of view, all positive SARS-CoV-2 cases carry the same weight, from the perspective of university operations some cases have a greater impact and require special handling. This applies particularly to teaching staff and to administrators in key roles. For such cases, we aim to achieve what is known in computer science as graceful degradation, a concept in which systems are designed in a way that each individual failure reduces the overall performance of the system but does not lead to its total failure.

4.13.1. Teaching Staff

In the event of a member of the teaching staff testing positive, in addition to the general provisions mentioned in the previous sections, care needs to be taken to ensure that the institution's teaching continues as smoothly as possible. In Greece, for example, a minimum of 13 weeks of teaching needs to be completed for the course to be considered taught. Other countries have other thresholds, which in any case need to be met.

The preferred and recommended approach is the completion of the course by the same member of the teaching staff that started it—and subsequently tested positive for SARS-CoV-2. This may be achieved by using alternative teaching methods (for example by remote teaching methods, if the person is otherwise feeling well and is able to perform their teaching duties online). If necessary, it is recommended to allow for partial completion of the course content and/or teaching hours.

The goal is, whenever possible, to avoid involving other instructors to fill in the void left by those testing positive. This way, courses will function as independent entities, with a positive SARS-CoV-2 test for the instructor of one course not affecting the work load of others and the time and care they can devote to their own courses.

This will allow the university to continue to function properly when there is a (limited) number of instructors who are unable to perform their teaching duties in-person or fully.

On the other hand, the university should be able to immediately initiate remote learning in cases where major clusters of cases are observed in a particular department or the campus overall.

4.13.2. Key Administrators

Universities are places of teaching, but at the same time they are also large and complex bureaucratic institutions. Their operation is governed by strict rules, which dictate which committees or individuals need to be involved in any key decision and/or operation.

The smooth operation of the university requires that some basic administrative services continue to work; examples are the financial services in charge of salaries for the staff and, at the time of the pandemic, procurement services in charge of purchasing the PPE and other materials needed.

Different universities, in different countries and under different financial and different systems obviously operate in their own ways. However, they typically share the existence of some administrative single-points-of-failure, i.e., people whose presence is essential. For example, in Greece there is for each university one specific person that needs to sign off on any payment; when that person takes a leave, payments are put on hold until their return. Other examples include the rector and vice-rectors, deans and heads of departments.

Some basic provisions are already in place to protect the university from their absence. For academic staff, sabbaticals are not allowed when they hold such a position. In addition, for truly critical roles, a deputy is often defined. However, these may not be enough during the pandemic, when it is possible for multiple individuals from the same chain of command—since they are working closely together—to become infected and in need of simultaneous isolation.

Our recommendation is to utilize digital signatures when people who need to isolate are still feeling adequately well to perform their role remotely. Additionally, exactly because in the case of a breakout things can evolve quickly, the a priori cascading appointment of multiple deputies for critical roles can offer increased resilience: as people become unavailable, the next deputy in line automatically assumes their role and duties, until they are able to return.

5. Implementation Guide

The implementation of the protocol described in the previous section presupposes the existence of well-informed trained individuals in key positions, the availability of certain equipment and the completion of various preparatory tasks. In this section we describe these needs, thus outlining the protocol's implementation guideline.

5.1. Staff and Roles Involved

5.1.1. Preparations

To prepare the university for a safe return to in-person teaching by implementing the protocol described herein, the following committees will need to be defined well ahead of time:

- Premises Committee. This committee will be charged with the inspection of the premises, the determination of the operating capacity per room and the specification of any required relevant supplies and interventions, as explained in Section 4. The committee can be staffed by members of engineering departments (preferably architects, engineers or physics specialists) or others with a relevant scientific and technical background.
- Protocol Training Committee. This committee will be charged with the critical tasks of producing the required promotional/educational material, training staff for their new roles and informing all members of the academic community on the new procedures. Members of schools of health sciences are prime candidates to be included in this committee.

Should the committees be missing a part of the know-how required to fulfil their roles, they can be supported by outsourcing parts of their work to contractors or by receiving support from other universities. In any case, it is the members of the committee that carry the responsibility and coordinate the tasks.

5.1.2. Monitoring Operation

To supervise the implementation of the protocol, identify potential areas where improvements are required and take the appropriate action, the following committees will be required:

- Access Control Committee. This committee is in charge of the organization, coordination and supervision of the access control procedures, both for the university as a whole and for the individual rooms. A person with significant administrative experience should be preferred to lead the committee. The work load for this role is expected to be significant; therefore, it is suggested that head of the committee is relieved of other teaching and administrative duties or at least that their workload is reduced.
- Vaccination and Surveillance Committee. This committee is in charge of organizing and coordinating all vaccination related actions as well as coordinating individual tests and wastewater surveillance. The management of positive cases, including the support of those in isolation, also falls within the committee's role. The head of this committee should come from the departments of health sciences. The work load for this role is expected to be significant; therefore, it is suggested that head of the committee is relieved of other teaching and administrative duties or at least that their workload is reduced.
- External Epidemiological Surveillance Committee. This committee monitors the evolution of the pandemic in the community and the relevant scientific literature. Its main goal is to update to this protocol and to the policies related to it, in case the epidemiological situation or new scientific data suggest it. Having such a committee in-house will allow the university to respond to any change rapidly, without having to wait, for example, for the relevant governmental decisions that may be taken with some delay. This committee should be staffed by an interdisciplinary group of researchers. When some relevant expertise is missing, the help of other universities may be sought.

5.1.3. Pandemic Monitoring Board

To coordinate the above committees and oversee the overall safe operation of the institution at the highest level, a Pandemic Monitoring Board is set up. It includes the leaders of the university (for example the rector, the vice-rectors and the deans), the heads of the above committees and representatives of staff and students. The board meets regularly (e.g., once every two weeks) to monitor the situation in the university. Emergency ad hoc meetings are held in the case of an outbreak.

The board pre-determines the criteria and thresholds for the safe in-person operation of the university, beyond which immediate and more drastic measures are required. For example, one threshold could be that if a (specific and pre-determined) number of concurrent cases in the university community or a specific department is surpassed, all in-person teaching will stop.

5.1.4. Access Control Service and Administrative Staff

Rigorous access control is the most critical element of this protocol. In the case that for some reason it is not possible to implement proper access control, then either no one will enter and the university stops operating, or some individuals may enter uncontrolled and no part of the university premises will be safeguarded and considered safe. Clearly, neither is acceptable.

When understaffed, it is preferable to maintain the proper operation of access control while leaving other services to under-function or not function at all. This way only some services are affected, but the rest of the university—and primarily teaching, which is its main role—can continue safely.

With this principle in mind, we propose that all administrative staff will be trained on the basic aspects of working in the access control service. This way, all staff will be available to be transferred to the access control service, should the need arise.

5.2. Dissemination of Information

The implementation of a protocol such as the one described in this text brings many and major changes in the way the university operates compared to what its members have been accustomed to, despite the >2-year experience with the pandemic, and possibly partly due to "pandemic fatigue". Therefore, timely, comprehensible, unambiguous, focused and effective dissemination of information regarding the nature and goals of the new procedures and the exact methods of their implementation is crucial for the success of the effort.

In this direction, we propose the following indicative set of actions, underlining that each university will need to examine the particular needs of its community and adjust our generic recommendation accordingly:

- Creation of a website with simple, specific and practical instructions, organized based on the different roles people hold. Possible categories are "for students", "for teaching staff", "for administrative staff", "for contractors", "for members of the access control service", "for members of the cleaning service", "for members of the catering service" and "for visitors".
- Organization of online training sessions, customized to each category of staff, with mandatory participation.
- In-person orientation sessions during the first days of the implementation of the protocol, customized for the different categories of members of the academic community. Emphasis is suggested on the training of teaching staff and students, always in small groups.

The reasoning should be included in the dissemination and educational material, i.e., not only what we do but also why, so that community members are more involved and personally committed in the overall effort for the safe operation of the university.

It is suggested that all communications from the university to its members, even when about another topic (for example announcements regarding the start of classes) also contain a reference to the protocol for safe operation during the pandemic. A standardized addition to email signatures could be used for this.

First year students, who may not yet have institutional email accounts and will certainly not yet be familiar with the way administrative information flows in the university, constitute a special target group. Care needs to be taken so that at least some of the utilized dissemination channels reach them too, in a timely and effective manner.

Finally, and in addition to the above, the placement of visual signs through the university premises is recommended. These should carry the most basic instructions, customized to each location (e.g., instructions about access requirements at the entrances, about PPE use in classrooms, about what to do if feeling unwell at the dorms, etc.).

5.3. Help Desk

The development of the digital platform described earlier is central to the proposed plan, but is not enough on its own. The existence of the digital system is complemented by the function of a support desk—help desk. The help desk will assist, among other things, with user creation, issuing of access control cards, recording of vaccination status and handling of ad hoc requests.

5.3.1. User Creation

The list of users for the information system, in other words the population that will be accredited to enter the university premises, is initialized using data from:

- the records of regular teaching staff;
- the records of the various types of adjunct teaching staff;
- the records of regular administrative staff;
- the records of regular technical staff;
- the records of temporary administrative and technical staff;
- the corresponding lists of personnel of the Research Center associated with the university, if one exists and operates within the university premises;
- the lists of staff placed within the university by various contractors (catering, cleaning, etc.); and
- the records of undergraduate, graduate, doctoral and postdoctoral students of the various university departments.

The above list has been developed with the reality of modern Greek culture in mind; universities operating in other countries and with different organizational structures can easily adapt the list to fit their own particular characteristics.

The records of accredited users can be further enriched with contact information (for example from an LDAP server for students or from their contracts for personnel), so that there is the possibility of immediate direct communication if needed.

In addition to the initial user creation in bulk for the initiation of the implementation of the protocol, new user creation will need to take place at various times ad hoc. Examples include the hiring of new teaching staff, the enrollment of new doctoral students, changes in the personnel of contractors, etc. The help desk will be in charge of both the creation of the initial user base and of any additions that may be required in the future. It is also in charge of any modifications or deletions that may be required.

5.3.2. Issuing of Accreditation Cards

It has already been mentioned (see Section 4.1) that accreditation cards are created in bulk at the start of the implementation of the "Safe University" protocol. However, as new users may be added at any time, it is necessary to also be able to issue new accreditation cards quickly at any time.

During the first few weeks of the implementation of the protocol, the main entrance of the university where access control takes place may be overwhelmed, due to the facts that (1) access control personnel will not yet have experience with the new process, (2) those who wish to enter will also not have experience with the new process and (3) time will be spent in searching for and delivering the pre-constructed accreditation cards to their intended holders.

During this period, it is recommended that any new accreditation cards are issued by the help desk. At a later time, when the access control service is no longer overwhelmed, it will be preferable to transfer the responsibility of issuing new accreditation cards to the access control service, so that the new cards can be issued without delay, as needed at the entrance. This requires that the relevant equipment (e.g., for printing) is available at the access control site. For this to be possible the access control site needs to be staffed with at least two people, so that when one works on issuing a new accreditation card the other(s) can continue admitting to the premises those who already hold valid accreditation cards.

5.3.3. Recording of Immunization Status

For the same reasons mentioned in the previous paragraph, for the first period of implementation of the safe operation protocol we recommend that updating of user records with vaccination information is assigned to the help desk. At a later time, updating this information directly by the access control service upon demonstration of the relevant documentation might also become a possibility.

Those working in the university's vaccination center need to also have access, so that they can directly update the immunization information for those who receive a vaccine shot within the university premises.

Strict criteria will need to be specified for the classification of immunization status and also for the documentation required in order for the records to be updated. For example, considering the Greek reality, it could be specified that printed certificates of vaccination will only be considered if they have a QR code which, when scanned, provides a confirmation by the corresponding service of the Ministry of Digital Governance of (a) the validity of the document and (b) of the ID of the vaccinated person; the criteria will need to be customized for universities operating in different countries, according to the methods used to record vaccination in said countries.

It should be noted here though, that state certificates of vaccination may have a different period of validity (for example an indefinite period post-third dose) and thus be at odds with the suggested "immune/vaccinated" status that the authors propose, and that does not extend beyond a period of 4-months post-booster dose (or a breakthrough infection in a previously vaccinated individual). This discrepancy is due to the fact that the state is more focused on prevention of severe disease (which is sustained for a protracted period of time post-booster dose), whereas a university guide should take into account predominantly the effect of vaccination on transmission potential, one that has been significantly affected in the Omicron variants period.

5.3.4. General Support

As with any complex protocol involving many diverse roles and individuals, it is hard to predict everything that might occur; particularly in a rapidly evolving environment. It will be the responsibility of the help desk to provide guidance for situations not already specified in the safe operation protocol and the university's established policies.

With the information system holding such a key role in the implementation of the protocol, and with it affecting so many of the university's operations, it is reasonable to expect that a number of unforeseen situations will arise, particularly over the first few weeks of utilization. With this in mind, it is recommended that the member of the development team—if the software has been developed in-house—are among the staff of the help desk. In this way the help desk, in addition to providing advice, will also have the capacity to implement ad hoc interventions to the software, as needed.

5.4. Gradual Initiation

Both the new information system and the new procedures will require some testing in a real-life setting before they are fully deployed. Towards this end, we recommend that the return to the university premises for the coming fall semester takes place gradually, giving people and systems some time to test and adjust, as and where needed.

For the smooth implementation of this protocol, we target starting the in-person operation of the university after the summer break and September examinations, on 26 September, with only administrative staff. Over a period of two weeks, systems and procedures will be tested and the necessary adjustments and improvements will take place.

On 10 October, the fourth- and fifth-year undergraduate courses can begin, together with graduate courses. Third-year undergraduate courses start on 17 October and second-year undergraduate courses start on 24 October.

On 31 October, all courses will have started, including those for the first-year students. It is important to keep this group last as (1) it is the largest in size and (2) it is comprised of people who are the least acquainted with the way the university works and would need some support figuring things out at the beginning even without the pandemic and the safe operation protocol.

As we move from one week to the next, the load on the system and procedures gradually increases with the addition of more people; any difficulties are addressed rapidly, before the load is increased again in a week's time.

5.5. Institutional Framework

For the protocol to be implemented by a bureaucratic institution such as a university, it needs to be embedded in the institution's regulations and policies. Following is a list of the most essential interventions required in the operation framework of the universities:

- The aforementioned committees need to be established, with their roles, authorities and limitations clearly defined. In order to expedite procedures, it is recommended that they are given augmented authorities, so that, for example, they can initiate procurement procedures in dealing with urgent details to fulfill their role without having to go through the time-consuming process of approvals from numerous other administrative units.
- The procedures described in this protocol need to become university policy, approved by the appropriate administrative bodies such as the university senate.
- According to the current legal framework in Greece, the heads of the departments are responsible for their smooth operation; other individuals may carry this responsibility in other countries. It is important to clarify the priority of authority and responsibility between the heads of the departments and the members of the committees coordinating the implementation of the "Safe University" protocol. It is recommended to leave the responsibility of smooth operation to the heads of the departments, who will be in charge of assuring that all members of the department follow the new guidelines, as defined by the various committees. In order to expedite the flow of information, it is

clarified that the committees' decisions are effective immediately and are communicated to all related individuals directly; the confirmation of the head of the department or other administrators is not required to start implementation.

- The code of conduct and disciplinary code needs to be updated to include procedures and address infringements related to the safe operation of the university.
- The code of conduct and disciplinary code need to address in particular, and with severity, public statements by high profile members of the university that go against the principles of science, be it "simply" misinformation, or worse, disinformation.
- The academic calendar, specifying the start and end dates of the different teaching and examination sessions, needs to be adjusted to account for the gradual start of teaching that is required for the smooth initiation of the "Safe University" protocol.
- The case isolation protocol described herein addresses health issues and has provisions for the support required for the individuals to go through the isolation period as smoothly as possible. However, it does not yet include provisions to address their inability to fulfil their obligations as students. We recommend that teaching sessions are extended by a couple of weeks, so that lost time can be made up, that allowances are provided for absences in the case of infection and that alternative methods of examination are considered; in any case, this is an issue that each university will have to address separately, in a way best fitting their own way of operation.

5.6. State Support

5.6.1. Legislation

The implementation of the protocol requires various procurements which in most cases are impossible to complete in time for the coming academic semester, due to the bureaucratic procurement legislation in place for universities run by the state. With the Greek legal framework in mind, we recommend that (a) an exemption is provided so that tender procedures can be expedited and (b) procurements related to the safe operation of the university are allowed to move forward even in the case of a legal challenge—that often takes years to conclude.

We have proposed making vaccination obligatory for certain groups. Where this is not agreeable to the standing law, the corresponding legal amendment will be required.

The information system receives, stores and handles sensitive personal information. In some cases, amendments to the legal framework are required to make the specified use of such this system possible.

5.6.2. Transfer of Authority

According to our protocol, each university monitors its internal epidemiological situation and reacts as needed, without delay. In addition, of course, it is possible that while at one university in-person teaching needs to stop due to a major cluster of cases or multiple clusters, another institution may be able to continue in-person education due to a different ability to handle multiple absences in a specific period of time.

For such timely and individualized responses to be possible, the authority to decide on their way of operation needs to lie with the universities; where this authority is currently held by the state, the corresponding changes to the legal framework will need to be implemented.

5.6.3. Teaching Assistants

The "supportive teaching" program mentioned in Section 4.7.3 was proven very effective in the previous academic years. Its continuation can contribute to the creation of smaller classes, with the same core teaching staff and without a substantial reduction in the quality of the syllabus. We believe it is necessary to continue and bravely expand this program, so that it can be applied to all courses with a large number of participants, reducing class sizes.

5.6.4. Financial Aid

Universities will need financial aid for the procurement, installation and configuration of the equipment described in the previous sections, for PPE and for materials for individual testing and wastewater surveillance. Additional personnel will also be required to effectively and efficiently staff the access control service, the help desk and the vaccination centers. The latter might initially be voluntarily staffed by students and faculty of relevant departments of health sciences, if existing, but in need for an extended, daily function of such a center, the possibility of financial compensation of the employees should be entertained.

The exact amount of financial aid required for each university may be determined by the committees described above.

5.7. Implementation Timeline

We provide an indicative action timeline, commencing this summer and aiming to have the university ready to implement the "Safe University" protocol at the start of the coming fall semester. The timeline can be modified by each institution, depending on the exact time it will choose to start the courses as well as depending on the degree of flexibility and speed of work of the administrative units and individuals involved.

The timeline has been designed to be as fail-safe as possible, in the sense that many of the actions listed are independent. Thus, should there be a delay in some actions, that will not necessarily imply a similar delay in the implementation of the overall action plan, provided that the necessary reaction speed and ability is demonstrated in the coordination of the overall effort.

The indicative timeline runs over 10 weeks, which we consider to be a reasonable minimum for a reasonably organized preparation. With more time at hand a better preparation will of course be available, with fewer risks and reduced pressure on all involved. For this reason, our recommendation to all universities is to start as soon as possible.

For the sake of clarity and space, the timeline is provided in Appendix A.

6. Adaptability and Adjustability

6.1. Adaptability

When attempting to put this generic protocol into practical application one will soon discover that one size does not fit all. There are a number of issues that require an ad hoc consideration and adaptation to fit the specific needs and peculiarities of each university. These issues include:

- Cultural and political considerations; whilst some societies will be more open to the implementation of certain measures, others may not. The degree to which the preferred measures clash with culture as well as the level of political commitment to impose what is required affects the reality of what can be implemented and to what extent (the so-called "blackbox of implementation" [30]).
- Resources available; any aspect of the protocol that is implemented will require the investment of some resources, be they manual effort, money or materials. The availability of these resources may vary from university to university, affecting the ability to implement the preferred interventions.
- Time available; any intervention will require the investment of time for detailed design, implementation, test application, fine-tuning and communication. However,

epidemics are at times fast evolving and, depending on whether a wave is predicted for the future or is already present, the time available may vary immensely.

- Physical limitations; in some buildings sufficient openings will already be available whilst in other buildings, especially in historical ones, they may not be present and architectural/structural interventions may not be permitted.

- Characteristics of the academic society; universities are not homogeneous groups and unite various people who differ in political and religious views, have different cultural backgrounds, different states of physical and mental health, etc. Any chosen solution will need to carefully balance between the needs and preferences of the academic society as a whole, considering the restrictions imposed by the various subgroups that comprise it.

For these reasons we have given our protocol an adaptable nature, with core fixed features combined with optional or adaptable parameters. For the sake of clarity and space, we list some of the adaptable features of the protocol in Appendix B. As universities achieve greater detail in their individual plans on how to implement the protocol, they will identify more areas of flexibility.

6.2. Adjustability

The "Safe University" protocol was first conceived and formulated a year ago, at a time when the Delta variant had just emerged and the majority of students—at least in Greece—had not even received a single dose of vaccination. Finding ourselves in a considerably different environment today, we have had to adjust the protocol accordingly. Still, the main concepts remain unaltered. However, we have also seen, in this time, that the pandemic sometimes evolves rapidly; hence it is possible that the protocol, as it is today, to no longer be the appropriate response for what we may be facing tomorrow.

Therefore, in addition to the adaptability—which refers to decisions that are made before the implementation—in this second iteration of the protocol, we have made sure to formulate it in a way that it is also adjustable, i.e., having the option to make changes to it while it is in application. Potential triggers for this include the changing nature of the virus as well as the varying extent of the overall threat of the virus in the community surrounding the university.

7. Discussion

Admittedly, our initial response to the pandemic, as a civilization, has not been optimal. It was also not uniform and coordinated on a global level. However, we now find ourselves in a new phase, in which there is a greater coordination of actions, at least among many developed countries. With the current trend pointing towards easing of restrictions, lifting of measures and full return to the pre-COVID-19 way of life, one needs to recognize the political reality that the implementation of the protocol proposed herein is not straightforward; not because it is scientifically unfounded or technically difficult to implement, but because we are lacking the political will to take action against a threat that we prefer to pretend is no longer eminent and crucial. Clearly, it is science that should inform policy, not the other way around.

Having seen how every time that we belatedly acted against SARS-CoV-2 in the past, we have paid a high price as humanity, our sincere hope is that this time around we will opt for more and sooner than for less and later; when unable to perfectly balance our response it is best to overreact preemptively and assure our safety than to underreact and retrospectively acknowledge our shortcomings. With this in mind, we hope that universities, being pillars of science in the community, will push through the political stagnation and achieve the implementation of the "Safe University", now.

The implementation of such a protocol can also be seen as a matter of principle for universities. "Panepistimio", the Greek word for university, roughly translates as the place of all sciences. For universities to not only have science in their title, but also show that they incorporate it in their practice, they need to demonstrate that their operation is governed by the latest scientific advice. In addition, since the current scientific advice is that the pandemic is far from over, universities need to be the first to show, in action, that they operate accordingly.

Regarding the overall response of the community towards the pandemic, the approach followed by the universities can become a beacon and leading example. Should the universities demonstrate the ability to operate safely and in-person in a pandemic environment, when a proper protocol is in place, other segments of the economy and the society are sure to follow. For this reason, it is in the state's interest to urge and assist universities in the application of the safe operation protocol.

Regarding methods of disseminating information to the community, again implementation in the university is a very effective tool. What students learn and apply at the university, they will also bring home as information to their families. Effective practical education of students on how to behave safely during the pandemic means that all of their families will also obtain this information; and with the information coming from the university and from the member of the family that follows a scientific path, it has a greater potential of being accepted and adopted.

As a final note, although the protocol presented herein has been developed during the SARS-CoV-2 pandemic, with the intention to provide an immediate solution to a pressing problem, it has deliberately been designed to be generic. This makes it potentially applicable for any future epidemic that is caused by an airborne virus. In this way, any effort put in and any costs incurred towards the implementation of the protocol are not sunk costs but rather investments in preparedness and public health safety ahead of the next respiratory epidemic or pandemic; this can also be an argument to push the political agenda and facilitate its implementation. Furthermore, one could underline the demonstrated benefit of clean classroom air in cognitive performance [31]. In addition, with proper adjustments, it can also be configured to address epidemics caused by other viruses, whether they are primarily transmitted via the air or in some other manner; the monkeypox virus making headlines at the time of writing these words, and many more with the potential to emerge as we continue to push the boundaries of wild species.

8. Conclusions

In this work, we have presented the updated version of "Safe University", a detailed protocol for the safe in-person operation of universities during the SARS-CoV-2 pandemic, taking into account the current epidemiological state of hyper-transmissible and partly immune-evasive Omicron variants, recent scientific developments and the particularities of universities as complex bureaucratic institutions and as links between science and society.

In the protocol, we have examined all aspects of the operation of the university and its interaction with the evolving nature of a pandemic/epidemic/outbreak: from procedures for the students to procedures for the staff; from defining the safe operating capacity to controlling access to the university premises; from creating roles to coordinating in-person operation to specifying thresholds to cease in-person operation; from promoting vaccination to recording immunization status; from individual tests to wastewater surveillance; from restaurant to dorm safety; and more. We have also provided guidelines to support the preparations for the smooth implementation of the protocol and constructed an indicative timeline of actions to be taken.

The protocol has the potential to allow for safer in-person operation of the universities whilst the pandemic still holds. It provides a general guidance while also allowing for customization; through its adaptable features it can match the individual needs of any particular university and through its adjustable nature it can also address future threats, from the current pandemic or from new ones.

As far as validation is concerned, although the earlier version of the protocol was developed last year, it has not yet been fully adopted by an institution. As such, we do not have to this day any quantitative data concerning the impact its implementation will have on the operation of a university. What we do have is a qualitative indication, based on how solutions that are similar to parts of our proposed approach have been used by universities across the world; these support that our approach is in the right direction.

We recognize, of course, that the protocol we have developed is not perfect. However, as far as we know, it is one of the first and to this day one of the extremely few detailed guidelines [32] for the safe operation of universities in a pandemic environment. Our hope is that it will be either a ready to implement protocol or a basis that each university will adapt and customize to its own particularities.

Above all, however, we hope that this work will demonstrate that the design and implementation of such a protocol is not only necessary but also feasible. We also hope that through the successful implementation of this protocol and others with a similar approach, universities will show the way for other sectors of society on how to successfully—and safely—operate in the pandemic environment, paving the way for a successful transition to a post-pandemic reality.

Appendix A

Table A1. Indicative Implementation Timeline.

What	When		Who
Approval of "Safe University" protocol as university protocol	Week 1	29 August to 3 September	Senate
Appointment of Premises Committee	Week 1	29 August to 3 September	Senate
Appointment of Protocol Training Committee	Week 1	29 August to 3 September	Senate
Appointment of Access Control Committee	Week 1	29 August to 3 September	Senate
Appointment of Vaccination and Surveillance Committee	Week 1	29 August to 3 September	Senate
Appointment of External Epidemiological Surveillance Committee	Week 1	29 August to 3 September	Senate
Appointment of Pandemic Monitoring Board	Week 1	29 August to 3 September	Senate
Transfer of authorities to the senate	Week 1	29 August to 3 September	State/Ministry of Education
Appointment of institution/department in charge of developing the information system	Week 2	5 September to 10 September	Senate or union of universities
Site inspection, relevant measurements, determination of operating capacity, determination of required equipment and interventions on a case-by-case basis	Week 2	5 September to 10 September	Premises Committee
Development of promotional material, development of educational material, formation of a training group.	Week 2	5 September to 10 September	Protocol Training Committee
Procurements and implementation of interventions in classrooms and other areas, as required	Week 3	12 September to 17 September	Premises Committee
Customization of "Safe University" parameters to the individual needs of the university	Week 3	12 September to 17 September	Senate
Updating of procedures and policies	Week 3	12 September to 17 September	Senate
Update of code of conduct	Week 3	12 September to 17 September	Senate
Update of disciplinary code	Week 3	12 September to 17 September	Senate
Submission of request for financial aid from the state	Week 3	12 September to 17 September	Senate
Configuration of vaccination center, including the procurement and installation of required equipment and materials	Week 4	19 September to 24 September	Vaccination and Surveillance Committee
Approval of financial aid and transfer of funds to the university	Week 4	19 September to 24 September	State/Ministry of Education/Ministry of Finance
Definition of criteria and thresholds to cease in-person teaching	Week 4	19 September to 24 September	Pandemic Monitoring Board
Receive, install and configure the alpha version of the information system	Week 4	19 September to 24 September	Access Control Committee

Table A1. *Cont.*

What	When		Who
Create users	Week 4	19 September to 24 September	Help desk
Issue accreditation cards and distribute them to staff	Week 4	19 September to 24 September	Help desk
Issue accreditation cards for students	Week 4	19 September to 24 September	Help desk
Staff training on the protocol	Week 4	19 September to 24 September	Protocol Training Committee
Start of in-person operation with application of the protocol	Week 5	26 September to 1 October	University administrative services (no teaching)
Start recording immunization status for staff	Week 5	26 September to 1 October	Help desk
Teaching staff training on the protocol	Week 5	26 September to 1 October	Protocol Training Committee
Start sewage monitoring	Week 6	3 October to 8 October	Vaccination and Surveillance Committee
Start testing	Week 6	3 October to 8 October	Vaccination and Surveillance Committee
Start operation of vaccination center	Week 6	3 October to 8 October	Vaccination and Surveillance Committee
Student training on the protocol	Week 6	3 October to 8 October	Protocol Training Committee
Start of in-person teaching for graduates and 4th, 5th year undergrads	Week 7	10 October to 15 October	Schools and Departments
Start recording immunization status for students	Week 7	10 October to 15 October	Help desk
Start of in-person teaching for 3rd year undergrads	Week 8	17 October to 22 October	Schools and Departments
Start of in-person teaching for 2nd year undergrads	Week 9	24 October to 29 October	Schools and Departments
Start of in-person teaching for 1st year undergrads	Week 10	31 October to 5 November	Schools and Departments

Appendix B

Table A2. Fixed and Adaptable Feature of the Protocol.

Fixed Features	Adaptable Parameters and Optional Features
Controlled access to the university campus	• Specific rules on when entrance is allowed • Whether guests are allowed • Whether access is controlled centrally for the whole campus or separately per building • Whether services that have frequent contact with outsiders remain within the area of safe operation or are moved to its borders
Recording of immunization status	• Voluntary or mandatory nature of recording • Criteria for adequate immunization status • Determination of accepted documents to prove immunization status
Recording of movement within the campus	• Extent of recording (only classrooms and labs or other areas too)
Gaps between uses of rooms	• Duration of gaps
Specification of safe operation capacity	• Exact criteria to set operation capacity • Analogy of "immune/ non-immune" participants
Relief areas	• Separate relief areas per room or per group of rooms • Concurrent breaks or timed differently per class
Use of PPE	• Specification of criteria for adequate PPE, per category of user • In which areas and situations the use of PPE is required

Table A2. *Cont.*

Fixed Features	Adaptable Parameters and Optional Features
Fixed groups of students	• Size of groups
Adaptations to organization of courses	• Specific adaptations that are recommended/permitted • Employment of additional teaching assistants
Information system	• Extent of personal information to be stored • Provision of full equipment at access control points or delegation of certain tasks only to the help desk
Additional infrastructure to enhance air quality	• Extent of investment to be made • Exact mix of tools (air purifiers, fans, adjustments to doors and windows, etc.)
Safer restaurants	• In-person operation or takeaway of individual meals • Restaurant schedule
Safer dorms	• Frequency of testing
Promotion of vaccination	• Whether it is optional or mandatory • For which groups of people there will be a stronger recommendation for vaccination • Tools used to promote vaccination of the academic community • Count, locations and operating schedule of vaccination centers
Use of testing to monitor current status	• Which test results documents will be accepted when tests are conducted away from the university • Frequency of testing • When to perform ad hoc tests • Whether in-house solutions will be developed
Tracing of positive cases	• Use of mobile app for immediate communication
Isolation of positive cases	• Level of support for those isolating • Provisions to prevent those in isolation from falling behind in their studies
Wastewater surveillance	• Detail of monitoring (per campus, per building, per WC station, etc.) • Frequency of monitoring (every day, twice a week, etc.)
Aim to achieve graceful degradation	• Who/how to continue teaching when an instructor needs to isolate • Balance between flexibility (cascading delegation of authority to many) and maintenance of control (keeping authority in the hands of few)
Halt of in-person teaching in case of a break out	• Exact specification of criteria to halt in-person operation
Dissemination of information	• Detail of communicated information • Communication tools to be used

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