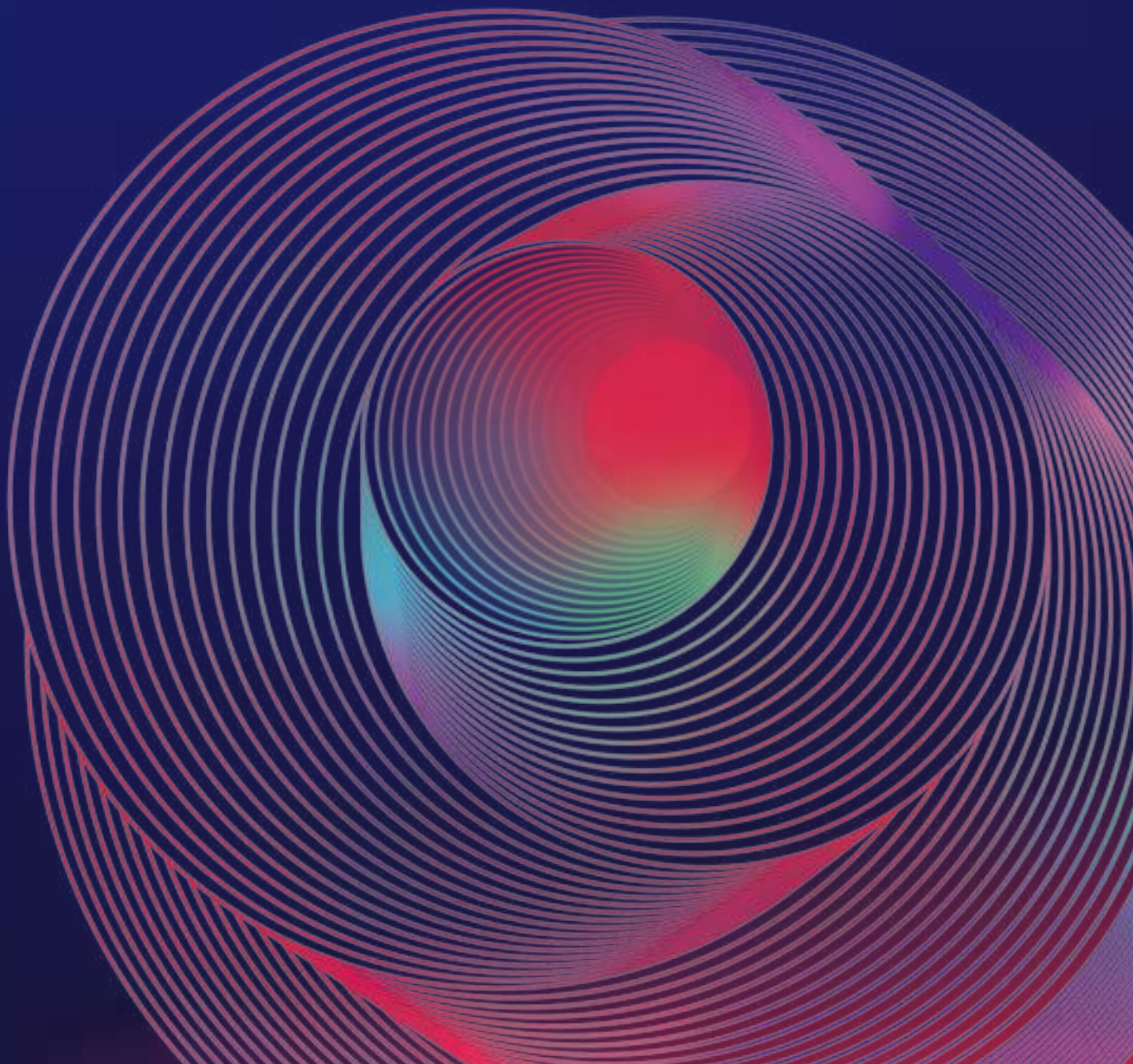
NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

NTU Report on Resilient Universities During the COVID-19 Pandemic: Differences Between East and West



NTU Report on Resilient Universities During the COVID-19 Pandemic:
Differences Between East and West

Prepared By
NTU Institute of Science and Technology for Humanity (NISTH)

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The data of this report is drawn from public information, sourced from media outlets, university websites and press releases, annual and academic reports and publications. Research performance of selected universities was analysed using SciVal.

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MESSAGE FROM THE PRESIDENT

As COVID-19, swept across the world, universities everywhere underwent dramatic recalibration. In-person education was interrupted, and technology-enabled learning rapidly adopted. Millions of students, faculty, and administrators faced cancellations of classes and examinations, travel and housing disruptions, freeze in faculty hiring, a drop in international student enrolment, restrictions and stresses of extended public safety measures, and much more.

This report chronicles the resilience of universities during the COVID-19 pandemic across the global academic landscape. Through detailed case studies, it seeks to capture the differences in the impact and responses, as well as best practices put in place, to cope with the global pandemic. This analysis incorporated in-depth case studies of eight universities, geographically separated across continents, with different local, regional and national constraints, cultures, as well as technological challenges and opportunities: Tsinghua University, China; Chinese University of Hong Kong, Hong Kong; University of Sydney, Australia; University of Rwanda, Rwanda; Monterrey Institute of Technology and Higher Education, Mexico; Stanford University, USA; Eidgenössische Technische Hochschule (ETH Zurich), Switzerland; and our own institution - Nanyang Technological University, Singapore.

The report highlights how university leaders stepped up to tackle the challenges imposed by COVID-19 through (a)round- the-clock adjustments. These actions included measures to sustain continuity of operations and mission, continue growth and momentum, and ensure the safety and wellbeing of students, faculty and staff. Additionally, they sought to deploy innovative models of online teaching and learning, make shifts in scientific research to address pressing public health needs, and forge remote collaboration with their peer universities internationally.

Inevitably, each university developed a unique and tailored response as each was impacted differently by the severity of the pandemic and the responses of its local or national government's capacity to adapt to COVID-19 and develop policies and practices. As a result, the impact on the academic, financial, and social performance of each university has varied.

This report is a reflection of the tremendous efforts undertaken individually and collectively by our peer universities to deal swiftly and innovatively with the unprecedented disruption caused by the global pandemic. The response showed a remarkable resilience on the part of faculty, students, and staff at institutions in different parts of the world.

Universities have always played an important role in shaping the future of humanity through breakthrough research and innovation and in training the workforce to better serve society. This was evidenced during the COVID-19 pandemic in the crucial contributions universities made alongside other major stakeholders in the successful development of the vaccine and in the formulation, analysis and deployment of pivotal public health policies and practices. With their collective ingenuity and commitment, universities will continue to reinvent and reshape the future of education, work, and living in the post-pandemic world.

I hope that the insights captured in this report by researchers at the NTU Institute of Science and Technology for Humanity (NISTH), led by Prof Vanessa Evers and Dr Iuna Tsyrulneva, will serve to guide the further development and adoption of global best practices for higher education institutions worldwide and to better prepare for the next crisis.

Prof Subra Suresh
President and Distinguished University Professor
Nanyang Technological University,
Singapore

ABSTRACT

This report assesses the resilience of universities worldwide during the COVID-19 pandemic. It presents general insights into the extent to which universities were able to provide educational services, engage in international collaboration, maintain research productivity, and support their nations in responding to the COVID-19 crisis. This report further offers in-depth case studies of eight universities: Nanyang Technological University, Singapore; Tsinghua University, China; Chinese University of Hong Kong, Special Administrative Region of the People's Republic of China (HKSAR); University of Sydney, Australia; University of Rwanda, Rwanda; Monterrey Institute of Technology and Higher Education, Mexico; Stanford University, United States; Eidgenössische Technische Hochschule (ETH Zurich), Switzerland. A comparison is provided on the differences and similarities in how universities have responded to and fared during the COVID-19 crisis in different parts of the world, under different circumstances and in different socio-cultural, political, and environmental contexts. The adjustments that universities made in transforming education and research environments, creating COVID-19-resilient campuses, engaging in scientific collaboration to address challenges brought by COVID-19, and protecting community wellbeing were evaluated for this report. Each university included in the analysis had a unique approach in responding to the challenges posed by the pandemic. Each approach was also influenced by national policies, fluctuations in external funding, international partnerships, technological infrastructure, research excellence, and other factors. The report offers an overview of prevailing trends, best adaptative practices and conditions needed for a swift and sound response to COVID-19 by universities worldwide.

EXECUTIVE BRIEF

The rapid advance of COVID-19 underlined the necessity for prompt, decisive action and consolidation in response to challenges faced by countries and institutes of higher education. For instance, laboratories and campuses were shut down; classes were cancelled, and examinations postponed; international student enrolment and staff hiring were frozen; scholarly conferences and exchanges were cancelled, and remote working became mandatory in some places. Even so, many universities still strived to maintain a pre-pandemic level of education and research output. The differences among various national governments' capacity to respond to emerging COVID-19 consequences unevenly affected the academic, financial, and social performances of different universities. Among the best practices identified in this report were:

- Shutdowns of campuses instantly executed by China
- Smooth deployment of safety measures and revised planning of research activities by Singapore and Australia
- Financial support provided by American and European universities to their students and staff
- Extensive leveraging of partnerships by African and South American universities.

These and other approaches taken by universities worldwide differed by the methods used and the extent to which they were implemented. Together, they accounted for a range of short- and long-term changes, such as localised education (curriculum honed by the local needs and practices), hybrid learning (combination of physical and virtual classes), and financial austerity (strict targeted economic policies).

An in-depth case-study assessment was carried out across eight universities. The universities were chosen based on the specificity of their reaction to COVID-19, a growth in academic performance over the years 2018-2021, their high number of collaborative research projects, the international standing of the university as well as the public availability of relevant data:

- Nanyang Technological University (Singapore)
- Tsinghua University (China)
- Chinese University of Hong Kong (HKSAR)
- University of Sydney (Australia)
- University of Rwanda (Rwanda)
- Monterrey Institute of Technology and Higher Education (Mexico)
- Stanford University (US)
- and Swiss Federal Institute of Technology in Zurich (Switzerland)

Data from databases curated by the Times Higher Education and Quacquarelli Symonds was analysed to estimate the dynamics of the universities' rankings. We investigated the universities' research performance using Elsevier's SciVal analytics and sourced data from consultancy and advisory agencies. Local and international media outlets as well as press releases from these universities were included to survey public dialogues relating to the performance of these universities. The findings from this analysis are aggregated in this report. Case studies and individual profiles for each university will be analysed, and analyses of their responses to the COVID-19 crisis can be found in the second section of the report.

The main objective of this report is to gain insights into the universities' COVID-19 readiness; their ability to respond to crises related to the COVID-19 pandemic. Additionally, we assessed what measures universities introduced to adapt to the fast-changing environment during the pandemic and whether these response strategies were effective in helping a university respond adequately to the pandemic. We explore the actions and policies that the selected universities put in place to create a COVID-19-resilient campus, develop a COVID-19-shaped education system, and protect the wellbeing of their staff and students. We also assessed the impact of scientific collaboration and international partnerships on the universities' ability to face crises during COVID-19.

Based on the analysis in this report, we identified the following key challenges that many universities addressed worldwide:

- There were salient fears that the sudden drop in student enrolment, plummeting international student numbers, decrease in income from tuition fees, and fall in national research funding would lead to underfinancing of both academic education and research.
- Additional research and development funding for COVID-19-related research was a trend across all

countries. However, the prioritisation of COVID-19 projects led to losses for other disciplines, especially for the social sciences and humanities.
- Major grant agencies exercised flexibility in their regulations and ensured continuation of ongoing research projects. Even so, research work was halted because of lab shutdowns and the unavailability of suppliers and service providers due to mandatory closures.
- The overnight transition to online learning was frequently accompanied by insufficient technical infrastructure, teaching staff who did not have the right technical and pedagogical training, and problems with access to laptops, a stable Internet connection or quiet places at home for attending classes virtually.
- The shift to virtual education casts doubt on the necessity of physical spaces on campus. Campuses needed fewer people in larger spaces, ways to make use of outdoor areas due to the excellent natural ventilation, touchless digitalised classrooms, and designs for spaces that allowed community safety to be easily maintained.
- Facing a decrease in national funding and in income from tuition fees, universities imposed hiring freezes that affected early-career researchers most adversely.
- Solving the issues borne by COVID-19 alone was found to be time-consuming and ineffective as each university is part of a larger, international knowledge ecosystem. Therefore, universities sought to harness the power of collaboration with multiple academic, industry, and government stakeholders to expedite the development of solutions.
- Taking charge of child- and family-care duties by female researchers deepened gender inequality and led to a decreased representation of women in COVID-19-related research projects.
- Undergraduate students had limited on-campus experiences and carried the financial burden of high tuition fees, while graduates were confronted by limited job opportunities.

Across the world, universities, people, businesses and governments responded to the challenges of COVID-19. This report sought to identify the best practices in higher education during the COVID-19 pandemic. An overview of some of the adaptative practices identified in this report are summarised in the table below. Generally, we found the following three broad trends that determined a university's ability to swiftly and adequately react to the COVID-19 pandemic:

1. **Recent investment in digital transformation:** Universities that had recently invested in upgrading their technological infrastructure, digitised their back offices and work processes, and had undergone or started a transformation towards blended or digital learning facilities were able to switch over to online learning almost overnight. This allowed these universities to focus their resources on offering training in technical and online pedagogical skills for faculty members, implement incoming mandatory measures, find ways to keep research projects going, and pay attention to the well-being of staff and students.
2. **Leveraging globalisation and international partnerships:** Universities that had strong existing international partnerships with other institutes of higher education, industry, and government were able not only to respond faster to the challenges raised by this pandemic, but they also made extraordinary progress. For instance, these universities were able to partner with counterparts in the industry to develop vaccines, treatments or tests, find external sources of funding to keep research going in light of reduced national research budgets, and innovate alternative ways of engaging international students through the networks of partner-universities, dual and joint international degrees or international branch campuses.
3. **Preparing for the worst and the best:** From previous crises such as the global financial crisis of 2008, the expectation was that during the pandemic, national funding for research would be reduced and student enrolment would increase because of bad job prospects. However, the opposite was observed during the pandemic. Governments had an urgent need to find solutions to the negative impact of COVID-19 and consequently increased funding for research. Among other factors, students who were confronted with care-tasks and the inability to travel and experience campus life dropped out or did not enrol at all, which led to lower student numbers. Universities, fearing a reduction in funding for research, acted upon initiatives to secure external funding. At the same time, income from student tuition fees dropped.

EXAMPLES OF ADAPTIVE PRACTICES

Financial support for research:

- The US CARES Act of 2020, authorised more than US$1 billion in supplemental funding for R&D, with the majority being spent on COVID-19 research.
- Argentina's Coronavirus COVID-19 Unit funded 81 initiatives with a maximum support of US$100,000 per initiative, including 17 projects in social sciences and humanities.
- France provided Đ5 billion of diversified financial support to all enterprises capable of carrying out research on COVID-19-related projects and for the construction of testing facilities.
- Poland made Đ449 million available to promote the production of vaccines, hospital and medical equipment, medicinal products, and protective equipment.
- India provided US$365 million to fund four new national virology institutes, nine new high-containment labs for studies on highly infectious pathogens and a national institution to coordinate research and surveillance on animal and human infections.
- Seventeen African countries received US$3.47 million in total from the International Development Research Centre for research on COVID-19 in Africa.
- South Korea provided US$37 million for research in infectious diseases and vaccine development.
- The National Taiwan University Hospital teamed up with the National Taiwan University to start a Research Center for Epidemic Prevention Science with a research budget of US$3 million per year. A new disease prevention centre in Taipei was additionally supported by US$144 million to focus on research, development and testing of vaccines.
- Singapore pursued a long-term strategy of excelling in research with a special focus on building health and economic resilience, supported by S$25 billion for the period of 2021-2026.
- Japan established a US$43 billion endowment fund under the Japan Science and Technology Agency which started distributing in April 2021.
- Tec de Monterrey recorded 55% growth in fundraising in 2020-2021 due to the support from donors and alumni.
- The Chinese University of Hong Kong recorded almost 40% increase in donations and gifts in 2020 as compared to 2019.

EXAMPLES OF ADAPTIVE PRACTICES

Flexibility for research grant programmes:

- The European Union's Horizon 2020 implemented amenable regulations allowing for project extension, reallocating funds to accommodate costs of working from home and helping to pay the salaries of researchers affected by lab closures.
- Many agencies like the Australian Research Council, French National Agency for Research and Singapore's NRF all facilitated late submission of grant applications and final reports due to the COVID-19 disruption.
- The US' National Science Foundation (NSF) and National Institutes of Health (NIH) enabled extensions of deadlines for project reports, and the ability to charge costs to grants that would not normally be allowed.
- The United Kingdom's Wellcome extended funding for staff salaries and PhD stipends, and also provided financial support to scientists who were unwell due to COVID-19.
- The German Research Foundation facilitated the transfer of 2020 grant money to 2021 and covered the costs of staff salaries and cancellation fees that were caused by extended projects.

Facilitating research at a distance:

- Tec de Monterrey developed and deployed virtual reality tools and remote access to computational facilities.
- Stanford University enabled experiments to be conducted online, laying the groundwork for hybrid labs with blended experimental capabilities.
- The Central European Research Infrastructure Consortium shortened regular evaluation procedures to prompt shared access to research facilities in central Europe, to accelerate research on COVID-19.
- The Oswaldo Cruz Foundation in Belo Horizonte (Brazil), University of York (UK) and German universities employed regulations to allow access to essential research facilities that could not be closed for a prolonged period of time.

EXAMPLES OF ADAPTIVE PRACTICES

Leveraging networks and partnerships:

- Collaboration between governments, educational institutions and providers of various services facilitated the development and adoption of educational platforms, which was seen in places like Hong Kong, Chile and Vietnam.
- University partnerships with industries spurred the development of essential products, such as AstraZeneca and AnGes vaccines in the UK and Japan, respectively.
- Collaboration between medical and academic institutions accelerated a robust response to the pandemic, such as the Noguchi Memorial Institute for Medical Research (Ghana), the University of Nairobi and the African Research Universities Alliance.
- Academic partnerships supported by private companies and aimed at building preparedness for the next zoonotic disease outbreak catalysed global initiatives such as the Massachusetts Institute of Technology COVID-19 Challenge and the Trinity College Challenge.
- Ohio University opened offices - Global Gateways - in China, India and Brazil to promote the enrolment of students and to host networking sessions.
- The University of Arizona offered its students a dual degree with universities, such as those in in China, India and Peru, through its micro-campus networks.
- Tsinghua University offered joint programmes with Tokyo Institute of Technology, Aachen University, HEC Paris among others.

Facilitating the shift to online learning:

- Higher satisfaction with distance learning was observed among students in countries with stricter lockdown measures and high compliance with COVID-19 measures.
- The transition to online learning was facilitated by creating free access to online educational platforms with tools and resources available for distance learning.
- Ecuador's government made investments to improve Internet connectivity.
- Vietnam made efforts to ensure the appropriate training of teachers and staff to ensure a smooth transition to online learning.
- The Federal Ministry of Education of Brazil distributed Internet connectivity kits to facilitate access to remote learning.
- The Ministry of Education of Argentina enforced free access to "edu.ar" webpages.
- In South Africa, vulnerable students received 10GB of data per month to support their participation in online classes.

EXAMPLES OF ADAPTIVE PRACTICES

Financial support for students:

- University of Bologna extended its tuition fee deadline in early 2020 to attract more students.
- Dine and Gordon Colleges (US) offered a 33-100% reduction in tuition fees.
- Tec de Monterrey offered discounts and extensions for tuition fee payments.
- Universities in the Philippines and Thailand refunded or reduced tuition fees to facilitate the financial load on students.
- The US' COVID-19 Economic Relief Bill provided relief for students with loans through payment deferment and waived interest.
- Malaysian universities distributed food and other necessities to support students locked down on campuses.
- Wales University and the University of Nebraska–Lincoln provided refunds for students' housing.
- Socially disadvantaged students in Ireland, England and France were supported by either a one-time payment or were provided with laptops.

Social and career support:

- Singapore universities participated in the SGUnited Jobs and Skills programme to help fresh graduates strengthen their competitiveness in the job market.
- ETH Zurich tested the concept of "study bubbles" – a group of students with the same curriculum allowed to hang out with each other without mingling with others – to ensure the safety of students as well as to provide real "life on campus" social experiences.
- Universities in Singapore supported young graduates by offering paid internships or traineeships at local companies or universities.
- Academic and research positions in China, Malaysia and Poland were considered relatively secure and saw an increase in demand.
- Doctoral and public institutions were least affected, seeing a small growth in full-time faculty ranks.
- Researchers, faculty and staff working on COVID-19-related research were highly sought after and their job opportunities improved significantly.
- The UK, being highly dependent on Chinese postgraduate students, managed to continue attracting prospective international students in 2020, sometimes even by organising charter flights from host countries.

THE IMPACT OF COVID-19 ON UNIVERSITIES AND HIGHER EDUCATION

As the COVID-19 pandemic swept the globe, it caused shutdowns, economic disturbances, loss of lives, civil outcry, mental health problems, and many other issues to varied severities. Educational systems were severely affected. Despite warning signals at the end of 2019 and at the start of 2020, the COVID-19 pandemic still caught the world off-guard, causing a massive-scale, multilayer challenge that was exacerbated by the state of each country's practices and socioeconomic conditions. Undoubtedly, higher education experienced a disruption of research and educational activities, faced numerous technical, financial, and safety challenges, as well as issues of physical and psychological wellbeing in students and staff. This section will show that, in general, universities that were more successful in rapidly adjusting to the new realities of COVID-19 would have had invested in digital transformation and globalisation, had strong international partnerships, and were successful in attracting external funding during the pandemic. The remainder of the section discusses best practices taken by universities around the globe to address and mitigate the effects of the pandemic. An evaluation is provided of the various economic and socio-political circumstances in the different countries that shaped the responses of the universities.

Universities dealt with financial consequences of COVID-19 by leveraging new sources of funding

CHALLENGE:
Predictions made in early 2020 forecasted reduced student enrolments, decrease of income from tuition fees, and diminished national funding for universities. This was expected to lead to underfinancing of both education and research.

Predicted COVID-19 consequences for institutes of higher education:
The way each nation responded to the COVID-19 pandemic affected national budgets and institutions of higher education in many countries. According to Moody's Analytics projections in 2020[1], finances of public universities, community colleges, and private institutions were impacted negatively due to reduced government support. Moody's investor service also warned about expected reduced overall enrolments and a subsequent drop in income from tuition fees, on-campus housing and activities, and conferences at ranked universities in the US, Canada, UK, Australia, Singapore, and Mexico that year. It was also expected that larger universities would demonstrate greater resilience and adaptability, compared to smaller ones. Enrolment to North America's community colleges was anticipated to increase, as was the case during the more recent financial recession. Due to a shrinking job market, young people were expected to be forced to acquire new skills in order to adjust to new labour demands[2]. The overall financial perspectives of universities in South Africa were generally negative during this period[3]. Next to the tremendous impact of COVID-19, South Africa's universities had been trying to balance digital transformation, decreasing state funding, student protests, socio-economic inequalities, and increasing demands for distance- and lifelong learning options[4].

1. Wood, S. (2020) Moody's Lowers Higher Education Sector's Outlook to Negative Due to Coronavirus. Retrieved from https://www.diverseeducation.com/covid-19/article/15106476/moodys-lowers-higher-education-sectors-outlook-to-negative-due-to-coronavirus
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3. Wangenge-Ouma, G., Kupe, T. (2020) Uncertain times: Re-imagining universities for new, sustainable futures. Retrieved from https://www.usaf.ac.za/wp-content/uploads/2020/09/Uncertain-Times-Paper.pdf
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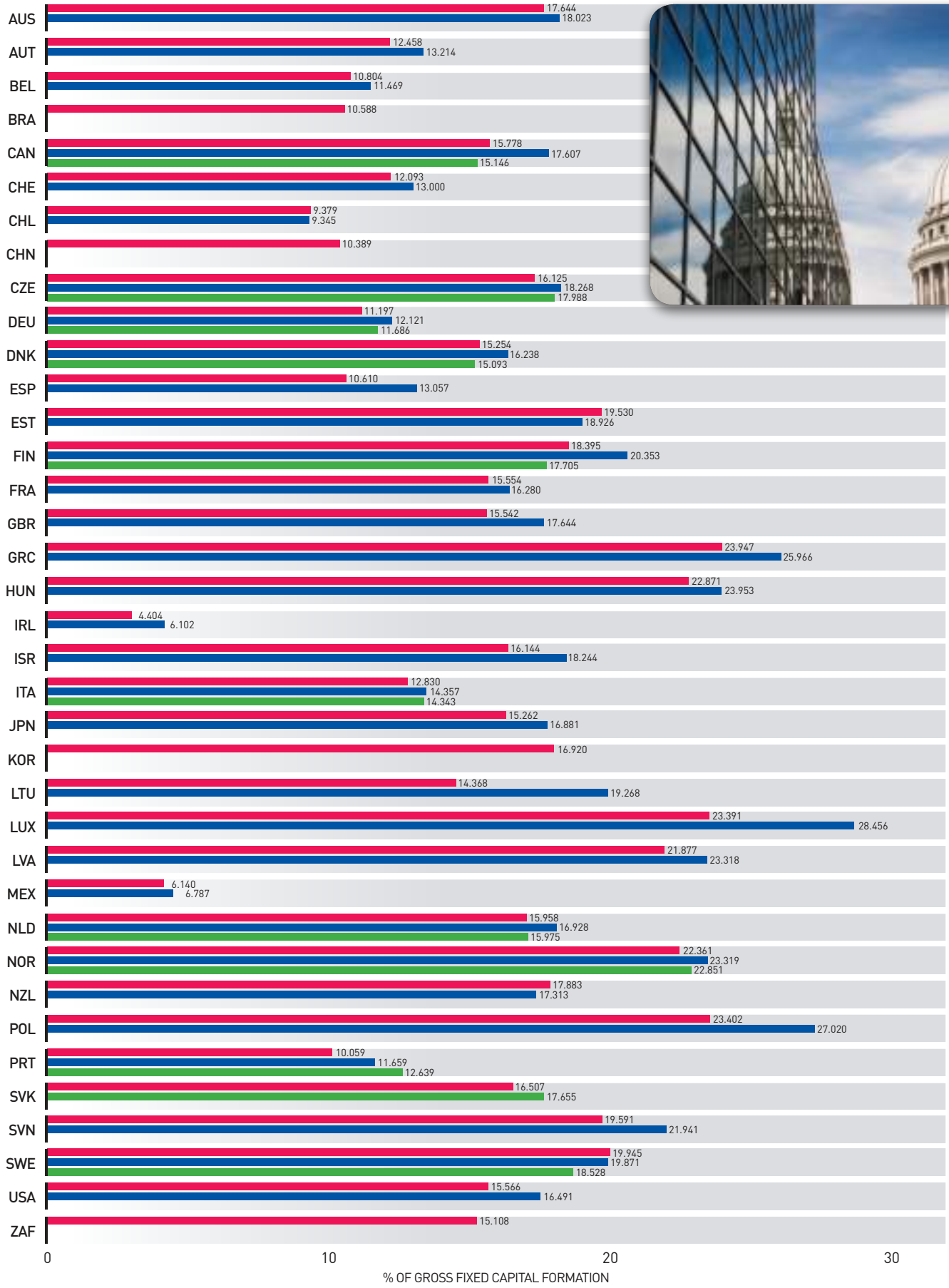
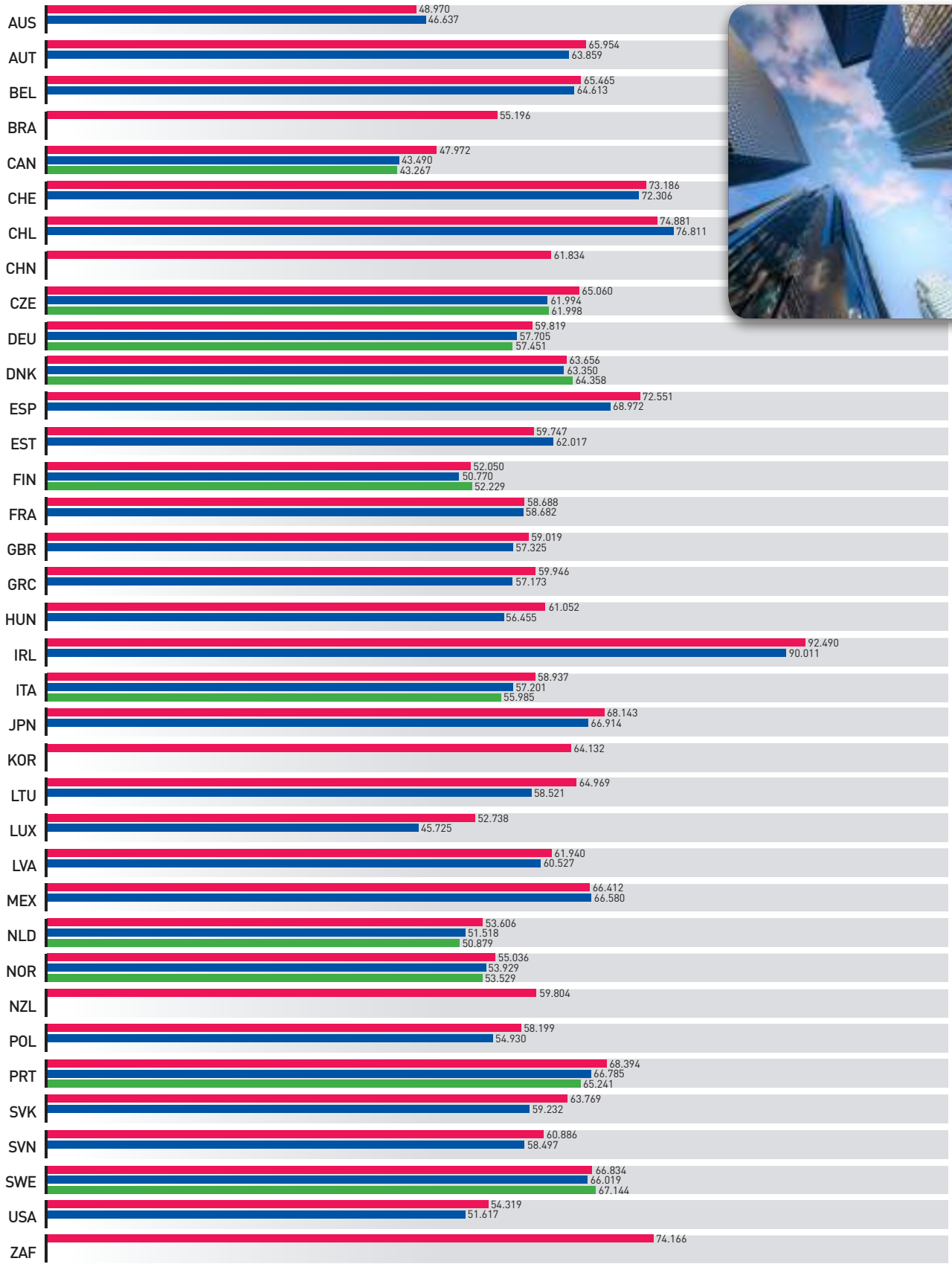
INVESTMENT BY SECTOR: GENERAL GOVERNMENT



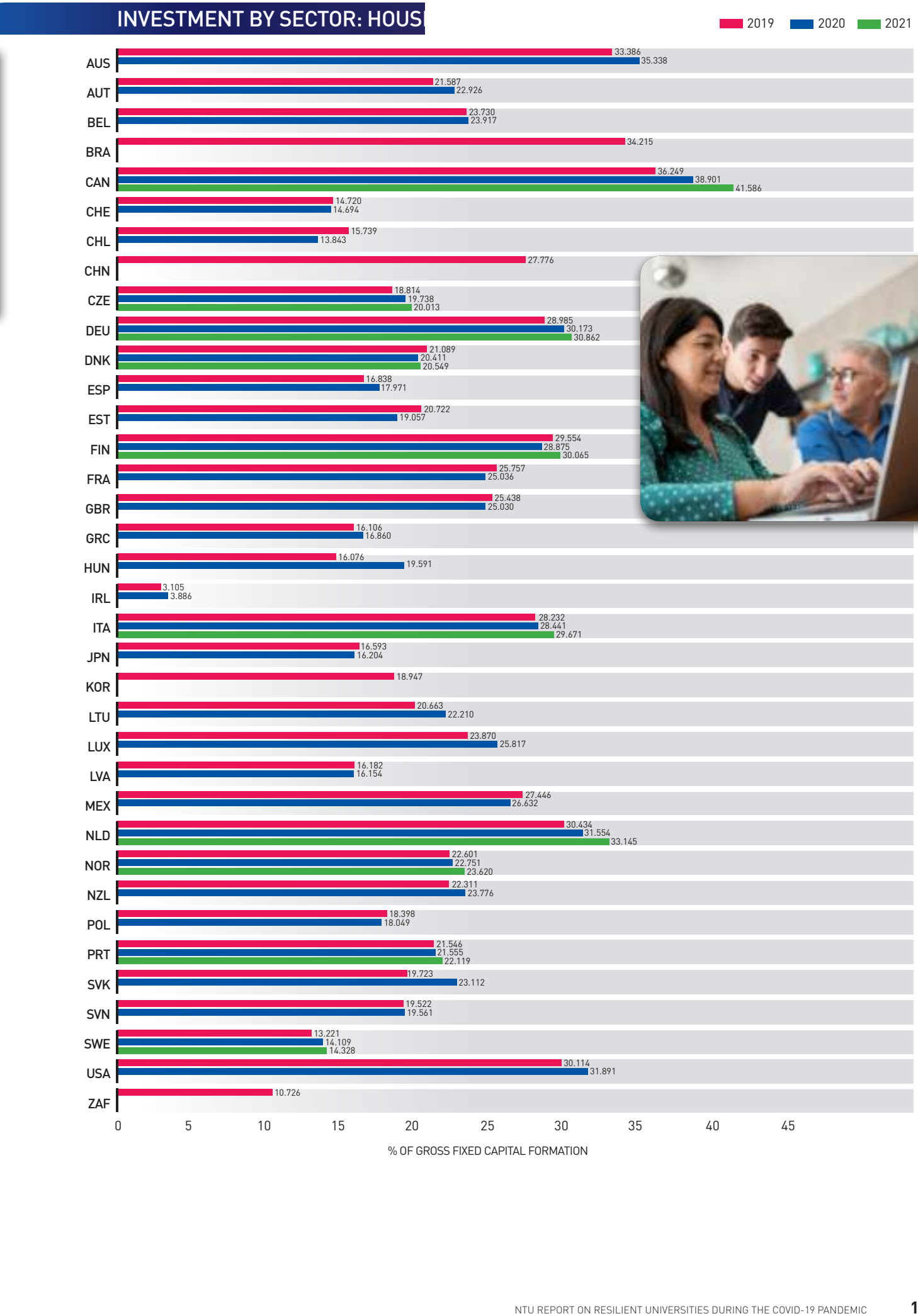
OECD (2022), Investment by sector (indicator). doi: 10.1787/abd72f11-en

INVESTMENT BY SECTOR: CORPORATE



OECD (2022), Investment by sector (indicator). doi: 10.1787/abd72f11-en

INVESTMENT BY SECTOR: HOUS



Budget cuts during the pandemic:
Several of China's universities were required to "tighten up the belt" for 2020, using 75% as the baseline for their budgets for the rest of the year, following orders from the Chinese Ministry of Education[5]. The Latin America region, which projected a 5.3% gross domestic product decline, cut expenses for public universities, calling for a redesign of the curriculum to accommodate distance learning, laying off staff, and freezing salaries[6]. Public funding of institutes of higher education in the US also declined for the first time in eight years. In 2019 and 2020 only five US states reported a fall in higher education funding, despite federal support[7]. In 2021, 21 states had registered declines. Seven mega states, (California, Florida, Georgia, Illinois, North Carolina, New York, and Texas) which collectively accounts for half of the higher education funding in the US, reported an overall funding decline of 2.1%[8].

Actions to finance academic education and research:
Despite gloomy predictions and pessimistic assessments of the market[9], many universities made efforts to rebalance their financial assets in order to respond to fast-evolving economic circumstances. For example, 55 out of 76 universities in China under the jurisdiction of the Ministry of Education recorded an increase in funding, with Tsinghua University, Zhejiang University, and Peking University being the top recipients[10] . Japan, facing the country's lack of long-term and stable funding for research which brought into attention during the pandemic, established an endowment fund (US$43 billion) under the Japan Science and Technology Agency to support science research[11]. More examples can be found in section "Eight selected universities' resilient responses to COVID-19".

Facing a decrease in federal funding and loss of income from tuition fees, universities leveraged generous support from university donors. For example, Tec de Monterrey recorded a 55% growth in fundraising in 2020-2021[12], while the Chinese University of Hong Kong observed an almost 40% increase in donations and gifts as compared to 2019[13]. More examples can be found in section "Eight selected universities' resilient responses to COVID-19". US national credit-rating agencies assessed institutional budgets as stabilising, and state support for US higher education was expected to rise in 2021 for a 10th consecutive year, according to Times Higher Education[14].

However, it was not the case for each part of the world. African universities, due to insufficient funding to build a resilient response to COVID-19, were completely closed for months. This led to severely disrupted research and educational activities[15].

CONCLUSION:
Overall, the projected negative financial consequences of the impact of COVID-19 on institutes of higher education seem to have been over-estimated. While state funding for such institutes generally decreased, many universities around the world looked for other ways to ensure funding. However, as many solutions were put in place because of the urgency of the COVID-19 crisis, longer term effects may not lead to a net-positive for academic research and education.

KEY FINDINGS
- Public funding for universities was cut along with a projected decline in national GDP.
- Despite the decrease in local funding, universities managed to leverage new endowment funds, donations and gifts from university sponsors as well as external funding from grant agencies and international organisations as additional sources of income.
- This is not universally generalisable, however, as universities in Africa were disproportionately affected by this pandemic owing to their lowered funding.

EXAMPLES OF ADAPTIVE PRACTICES
- Japan established a US$43 billion endowment fund under the Japan Science and Technology Agency that started distributing in April 2021.
- Tec de Monterrey recorded 55% growth in fundraising in 2020-2021 due to the support from donors and alumni.
- The Chinese University of Hong Kong recorded almost 40% increase in donations and gifts in 2020 as compared to 2019.

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7. Mervis, J. (2020) As Pandemic Pounds U.S. Universities, Federal Support Helps Their Labs Stay Afloat, Science. Retrieved from https://www.science.org/content/article/pandemic-pounds-us-universities-federal-support-helps-their-labs-stay-afloat?cookieSet=1
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9. S&P Global Ratings (2020) Outlooks Revised On Certain U.S. Not-For-Profit Higher Education Institutions Due To COVID-19 Impact. Retrieved from https://www.spglobal.com/ratings/en/research/articles/200430-outlooks-revised-on-certain-u-s-not-for-profit-higher-education-institutions-due-to-covid-19-impact-11469520
10. Yang, R (2020) China's higher education during the COVID-19 pandemic: some preliminary observations, Higher Education Research & Development, 39 (7),1317-1321.
11. Kakuchi, S. (2021) Japan to set up massive fund for scientific research. Retrieved from https://www.universityworldnews.com/post.php?story=20210203130630432
12. Tec de Monterrey's Annual Report (2020). Retrieved from https://tec.mx/sites/default/files/inline-files/InformeAnual-2020.pdf
13. Chinese University of Hong Kong's Annual Report (2020). Retrieved from https://www.iso.cuhk.edu.hk/images/publication/facts-and-figures/2020/html5/english/50/
14. Basken, P. (2021) US colleges expecting hikes in state funding. Retrieved from https://timeshighereducation.us17.list-manage.com/track/click?u=8e09f1eff5b946b07c80f522d&id=5e2b9a5295&e=13d2b25547
15. Randrianalijaona, M., Salava, J., Razanakoto, T., et al. (2022). The COVID-19 Pandemic and the Higher Education Sector in Africa: A Tragedy for an Awareness of the Sector's Resilience. In: Izumi, T., Pal, I., Shaw, R. (eds) Safety and Resilience of Higher Educational Institutions. Disaster Risk Reduction. Springer, Singapore.

R&D Funding Increased for COVID-19-Related Research

CHALLENGE:
The COVID-19 health emergency required the advancement of solutions while national funding for universities was expected to be cut.

Efforts focused on COVID-19-related research:
Facing unprecedented economic and financial challenges, universities heavily relied on existing revenue streams. For example, the US endorsed the Coronavirus Aid, Relief, and Economic Security (CARES) Act on March 27, 2020, that acquired more than US$1 billion in supplemental funding for R&D. Most of this was for research on COVID-19. The act also provided funding for several R&D agencies to offset unanticipated costs arising from the pandemic. The CARES Act also established a US$14 billion Higher Education Emergency Relief Fund for colleges and universities with at least half of this total to be allocated for emergency financial aid grants to students[16]. To facilitate access to available funding opportunities both federal and private, the University of South California, among others, started a curated list to help researchers procure funds for their scientific projects[17].

A Coronavirus COVID-19 Unit created in Argentina tapped into national, regional, and international collaboration networks to generate research projects. It funded 64 initiatives designed to strengthen the country's response in terms of diagnosis, control, prevention, treatment, and monitoring of COVID-19 that received a maximum sum equivalent to US$ 100,000. It also financed 17 projects submitted by researchers in social sciences and humanities for a total sum of US$1.2 million[18].

On June 2, 2020, France endorsed an "umbrella" scheme to support research and development, testing and upscaling of infrastructures and production of COVID-19-related products. The financial support of Đ5 billion in the form of grants, repayable advances and tax advantages was provided to all enterprises capable of carrying research on COVID-19-related projects and construction of testing facilities[19]. Poland launched a scheme of approximately Đ449 million to support research and development, aiming to accelerate the manufacturing of products directly relevant to the COVID-19 outbreak, including vaccines, hospital and medical equipment, medicinal products and protective equipment[20].

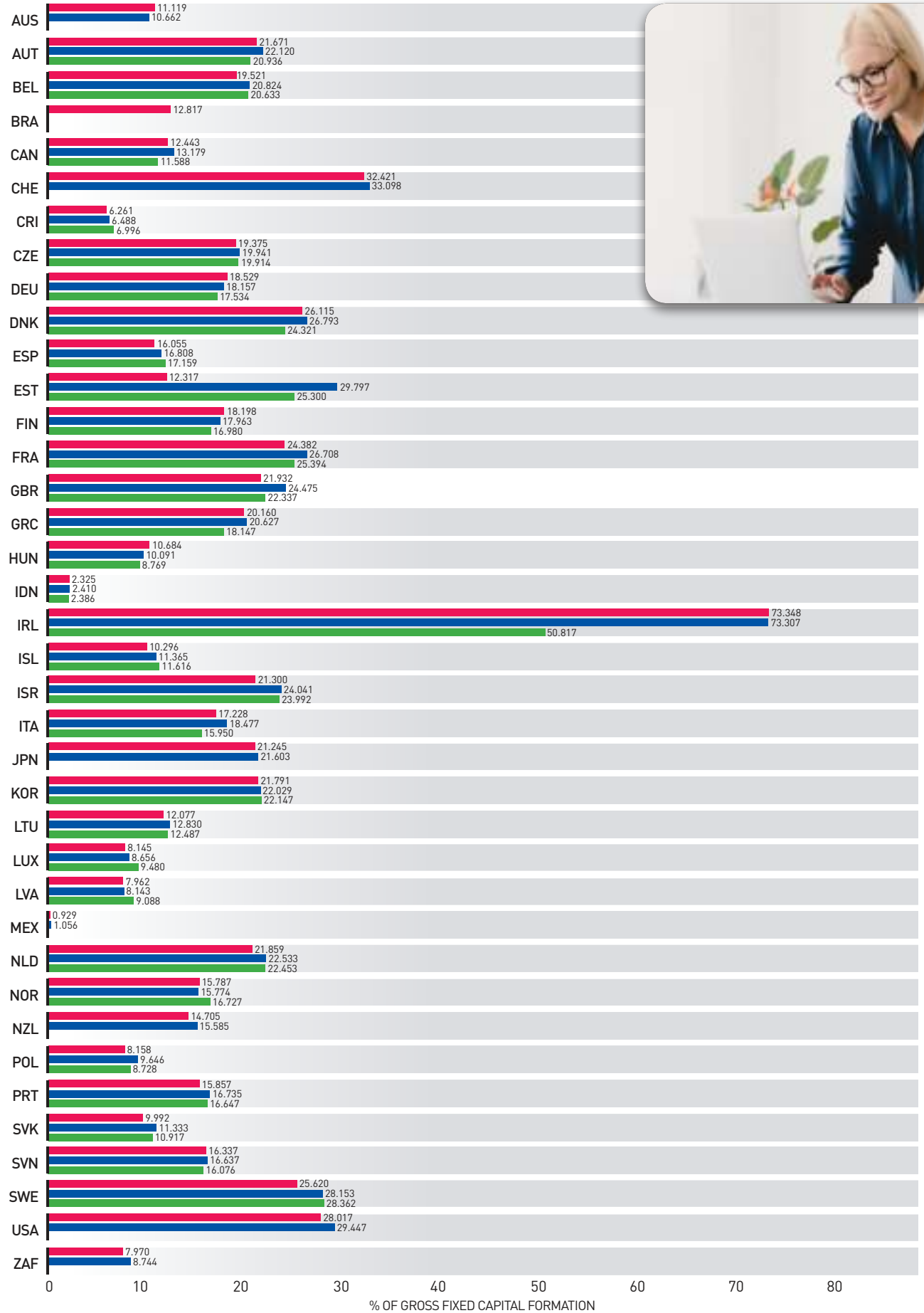
On Feb 1, 2021, the Indian government pledged to fund four new national virology institutes, nine new high-containment labs for studies on highly infectious pathogens and a national institution for "One Health" to coordinate research and surveillance on animal and human infections by providing US$365 million for the year[21].

The International Development Research Centre supported the COVID-19 Africa Rapid Grant Fund (US$3.47 million), available across 17 countries through a competitive, peer-reviewed call for research on topics related to battling the COVID-19 virus in Africa, such as prevention and control, health governance systems, socio-cultural dynamics of transmission, science engagement, the impact of COVID-19 on individual and community mental health, and vulnerability. Besides tackling problems caused by the pandemic, the fund aimed to strengthen national and regional capacity to collaborate and respond to future challenges[22].

Building a resilient knowledge eco-system to respond to crises:
In response to the unfolding pandemic, many countries had to temporarily halt or severely reduce research funding for non-COVID-19-related projects[23].

16. Congressional Research Service (2020) Effects of COVID-19 on the Federal Research and Development Enterprise https://crsreports.congress.gov/product/pdf/R/R46309
17. Grant Forward (2021). Retrieved from https://www.grantforward.com/grant-covid
18. Perrotta, D. (2021) Universities and Covid-19 in Argentina: from community engagement to regulation, Studies in Higher Education, 46(1), 30-43.
19. European Commission (2022). State aid cases: France. https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/jobs-and-economy-during-coronavirus-pandemic/state-aid-cases/france_en
20. European Commission (2022). State aid cases: Poland. https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/jobs-and-economy-during-coronavirus-pandemic/state-aid-cases/poland_en
21. Padma T. V. (2021) India budget pledges billions for virus research amid COVID pandemic. Nature.
22. International Development Research Centre (2021). COVID-19 Africa Rapid Grant Fund. https://www.idrc.ca/en/project/covid-19-africa-rapid-grant-fund
23. Ball, L. (2020) From the Antarctic to dark matter – these are the research projects halted by COVID-19. WEForum. Retrieved from https://www.weforum.org/agenda/2020/04/antarctic-exploration-primary-health-care-research-dark-matter-coronavirus/

INVESTMENT BY ASSET: INTELLECTUAL PROPERTY



OECD (2022), Investment by asset (indicator). doi: 10.1787/8e5d47e6-en

Redirection of federal funds to COVID-19 research and to enhance the national response in a short time span, reduced funding for other projects, which could ultimately lead to a decrease in research excellence in areas not directly linked to COVID-19.

To prevent this, several Asian countries budgeted for research activities in the next five years with the view to enhance their preparedness for future health and environmental emergencies[24]. For instance, the South Korean government pledged US$37 million for research in infectious diseases and vaccine development, as part of a US$5.2 billion budget for the advancement of science and information and communications technology, a 12% increase from 2020. The National Taiwan University Hospital, in collaboration with National Taiwan University, launched a Research Centre for Epidemic Prevention Science with a research budget of US$3 million a year, along with the announcement of a new disease prevention centre in Taipei to focus on research, development and testing of vaccines, supported by US$144 million.

As for Singapore, it pursued a long-term strategy by launching the Research, Innovation and Enterprise 2025 Plan with S$25 billion in funding, compared to S$19 billion for the previous five-year plan from 2016-2020, to boost the country's knowledge- and innovation-based economy and stay ahead in globally competitive advanced research, with a special focus on building health and economic resilience in the light of future emergencies[25].

CONCLUSION:

State governments that managed to secure and provide funds to support COVID-19 research inadvertently invested also into strengthening their preparedness for possible future health crises and building economic resilience. While the redirection of resources to support the most pressing research capable of solving urgent needs demonstrated good results and aided in the prompt development of COVID-19 vaccines and treatments, halting the funding of non-COVID-19 research can be expected to have long-term consequences. Other fields of research not directly related to COVID-19 may suffer from this trend of "paused research", through such negative outcomes as loss of collected data, loss of research continuity, missing grant deadlines and, ultimately, lagging behind in research advancement.

As humanity is facing multiple crises that impact our public health, environment, financial institutions, and politics, it is impossible to predict which research breakthrough or innovation can mitigate the next crisis. During the COVID-19 pandemic it has become clear that the development of vaccines is the greatest weapon to mitigate the crisis. However, vaccine hesitancy, exacerbated by misinformation and disinformation on social media as well as political influence, limit the positive impact of vaccines considerably. This highlights the importance of behavioural science, social science and communication science advancing hand in hand with vaccine development in order to truly face the pandemic effectively. Similarly, advancement of all areas of research is needed to build resilience and to holistically address future crises such as climate change.

KEY FINDINGS

- There was significant financial support for R&D in COVID-19 related projects.
- Building on national, regional and international collaborations accelerated the development of COVID-19 research capabilities by obtaining resources, manpower and the necessary facilities.
- Diverting funds to support research on viral diseases led to underfinancing of other research areas, in particular non-STEM disciplines.

EXAMPLES OF ADAPTIVE PRACTICES

- The CARES Act of 2020, developed by the US, authorised more than US$1 billion in supplemental funding for R&D, with the majority being spent on COVID-19 research.
- Argentina's Coronavirus Unit funded 81 initiatives with a maximum support of US$100,000 per initiative, including 17 projects in the social sciences and humanities.
- France provided Đ5 billion to all enterprises capable of carrying out research on COVID-19-related projects and the construction of testing facilities.
- Poland made Đ449 million available to promote the production of vaccines, hospital and medical equipment, medicinal products, and protective equipment.
- India provided US$365 million to fund four new national virology institutes, nine new high-containment labs for studies on highly infectious pathogens and a national institution to coordinate

24. Sharma, Y. (2021) New and strengthened research priorities post-pandemic. Retrieved from https://www.universityworldnews.com/post.php?story=20210304105937958
25. National Research Foundation (2020). RIE2025 Plan. https://www.nrf.gov.sg/rie2025-plan

research and surveillance on animal and human infections.
- Seventeen African countries received US$3.47 million in total from the International Development Research Centre for research on COVID-19 in Africa.
- South Korea provided US$37 million for research in infectious diseases and vaccine development.
- The National Taiwan University Hospital teamed up with the National Taiwan University to start a Research Centre for Epidemic Prevention Science, with a research budget of US$3 million per year. A new disease prevention centre in Taipei was additionally supported by US$144 million to focus on the research, development and testing of vaccines.
- Singapore pursued a long-term strategy of excelling research with a special focus on building health and economic resilience, supported by S$25 billion for the period 2021-2026.

Flexibility in Regulations Exercised by Grant Agencies Guaranteed the Continuity of Research

CHALLENGE:
The COVID-19 pandemic caused lab and campus shutdowns and imposed remote working mandates that significantly slowed down research work. It led to unmet deadlines, lack of research publications, and financially affected PhD students and early-career researchers who are reliant on grant funding.

Grant agencies offered more flexible arrangements:
Naturally, researchers who were mandated to work from home and temporarily discontinue their lab-based activities worried about delays, missed deadlines, and the inability to deliver results on time which might affect their grant funding. Big grant agencies understood the difficulties brought up by the lockdowns and made a step towards aiding researchers to preserve the results of their work[26]. The US' Council on Governmental Relations, an association of research universities and independent research institutes, consolidated the responses of the institutes to improve awareness of the easing of specific grant regulations, such as cancelled travel plans, project timeline extensions, and working from home[27]. The European Union's Horizon 2020 programme allowed "maximum flexibility", with extensions for projects by up to six months, the reallocation of funds to meet costs of working remotely, and aid to pay the salaries of researchers who were unable to continue with experiments because of lockdowns or lab closures. Projects could also be reoriented towards research on COVID-19 or other coronaviruses — requests were dealt with on a case-by-case basis[28]. The US NSF and NIH implemented an "administrative relief" to include extensions of deadlines for project reports, and the ability to charge costs to grants that would not normally be allowed[29,30,31]. Support for innovation and R&D during the COVID-19 pandemic remained essential for the UK[32]. The UK Royal Society provided "pragmatic support" to researchers who were funded through one of its fellowships or grants. However, funding programmes and calls remained open for

26. Stoye, E. (2020) How research funders are tackling coronavirus disruption. Retrieved from https://www.nature.com/articles/d41586-020-01120-2
27. Council On Governmental Relations (2022) Institutional and Agency Responses to COVID-19 and Additional Resources. https://www.cogr.edu/institutional-and-agency-responses-covid-19-and-additional-resources
28. European Research Area (ERA) corona platform (2021). https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/covid-19
29. NSF Implementation of OMB Memorandum M-20-17 (2020). https://www.nsf.gov/bfa/dias/policy/covid19/covid19_nsfombimplementation.pdf
30. NSF (2021) Impact on Existing Deadline Dates. https://www.nsf.gov/bfa/dias/policy/covid19/covid19_deadlines.pdf
31. NIH (2020) Flexibilities Available to Applicants and Recipients of Federal Financial Assistance Affected by COVID-19 https://grants.nih.gov/grants/guide/notice-files/NOT-OD-20-086.html
32. European Commission (2020) The role of research and innovation in support of Europe's recovery from the Covid-19 crisis. https://ec.europa.eu/info/sites/info/files/research_and_innovation/strategy_on_research_and_innovation/documents/ec_rtd_covid19-recovery.pdf

applications, without changes to deadlines[33]. The UK biomedical-research charity Wellcome offered its financial support to scientists who were unwell, needed to self-isolate, or had to care for someone affected by COVID-19. It also provided an extra six months of funding for staff salaries and PhD stipends[34]. Nick Hillman, the Director of the Higher Education Policy Institute, UK, had cautioned:

"...When universities have less income and face big deficits, they can opt to stem the financial losses by doing less research as research generally loses money. Less research would be terrible for the UK as it would hamper the post-pandemic recovery. So the quantity of research that institutions can afford must be a bigger part of the wider conversation about university financing."

He emphasised that the government must continue supporting universities due to the large pool of talent they provide to employers, as well as the high quality of their education and research. The Australian Research Council[35] announced that grant applications and final reports could be submitted late due to the COVID-19 disruption. The German Research Foundation[36] allowed the transfer of 2020 grant money to 2021 without paperwork. It also covered extra costs, such as staff salaries or cancellation fees, that arose from delayed projects. The French National Agency for Research[37] extended deadlines for a number of proposals and promptly awarded funding for 44 urgent new research projects related to COVID-19. Moreover, in March 2020, the French government announced that it would increase its research budget by Đ5 billion over the next 10 years, with one-fifth of the amount directed to healthcare research and the aim to prepare for future viral outbreaks. Singapore's funding agencies exercised flexibility by enabling no-cost grant extensions and allowing the start of granted projects to be delayed. In the spring of 2020, they also announced multiple grant calls for COVID-19-related research[38].

CONCLUSION:

Researchers struggled with working from home, lab shutdowns, and unexpectedly halted clinical studies and field research. They were also concerned about whether they could continue high-quality research as their work was compromised by missed grant deadlines and fewer publications. However, flexibility exercised by grant agencies that catered to the needs of researchers during lab shutdowns and state lockdowns ensured the continuation of projects. The biggest grant agencies allowed submissions to be delayed, facilitated the transfer of funding to the next year, provided financial support to staff and PhD students involved in grants, extended project timelines, and sometimes endorsed the reorientation of the project's scope towards COVID-19.

Clearly, these measures were put in place to mitigate the immediate effects of COVID-19 on existing research projects. Effects that have been observed during COVID-19 include a rise in publications concerning COVID-19[39,40] and for literature-based or meta-analysis research, leading to a changed landscape of research output. However, many researchers were not able to collect results that were lab-based or from the field or which involved human subjects or participants[41]. Dissemination of research findings and academic exchange of knowledge was hampered due to conferences being cancelled or replaced by online versions[42]. A cohort of students would also have had more distance from their instructors, peers, and university culture, profoundly altering the cohort's educational experience because of the pandemic.

Communicating research findings and science to the public has become fraught. The pandemic has laid bare a lack of trust in science and in the credibility of scientific results that inform government policy. Scientists communicating results of research and facts to people about public health matters related

33. The Royal Society (2022) Coronavirus (COVID-19): Information for applicants and award holders of Royal Society funding https://royalsociety.org/grants-schemes-awards/grants/coronavirus-covid19-grants-information/
34. Wellcome (2021) Coronavirus (Covid-19): information for grant applicants and grantholders. https://wellcome.org/grant-funding/guidance/coronavirus-covid-19-information-grant-applicants-and-grantholders?utm_source=email&utm_medium=o-wellcome&utm_campaign=1726406_COVID-19%20Grantholder%20Support&dm_i=2PXJ,1103Q,46VMBK,3WSBR,1
35. Australian Research Council (2020) ARC support for universities and researchers affected by the Coronavirus pandemic. https://www.arc.gov.au/news-publications/media/network-messages/arc-support-universities-and-researchers-affected-coronavirus-pandemic
36. Deutsche Forschungsgemeinschaft (2022) Auswirkungen der Coronavirus-Pandemie auf Arbeit der DFG. https://www.dfg.de/service/presse/berichte/2020/200318_corona_news/index.html
37. The French National Research Agency (2020) COVID-19: scheduling changes to the ANR's calls for proposalshttps://anr.fr/en/latest-news/read/news/covid-19-scheduling-changes-to-the-anrs-calls-for-proposals/?tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Baction%5D=detail&cHash=e901ed283100c9162039febd4b01c354
38. National University of Singapore (2020) Impact of Covid-19 on Research Projects. https://www.nus.edu.sg/research/research-management/notices
39. World Health Organization Global literature on coronavirus disease. https://search.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/
40. COVID-19 SARS-CoV-2 preprints from medRxiv and bioRxiv. https://connect.medrxiv.org/relate/content/181
41. Radecki, J., Schonfeld, R. C. (2020). The Impacts of COVID-19 on the Research Enterprise: A Landscape Review.
42. Vervoort, D., Ma, X., Bookholane, H., et al. (2020). Conference cancelled: The equitable flip side of the academic surgery coin. American journal of surgery, 220(6), 1539–1540. https://doi.org/10.1016/j.amjsurg.2020.07.008

to COVID-19 or about climate change may turn out to be the greatest limiting factor in how academia can positively impact humanity. Exacerbated by fake news and misinformation on social media[43], and challenges in consolidating research findings globally into one consistent message that resonates across local and regional contexts[44], the societal impact of academic research has reached a watershed moment. Over the longer term, the impact of the COVID-19 crisis on research output and advancement, the dissemination of results and informing government policies and the public will become clearer.

KEY FINDINGS

- Major grant agencies exercised flexibility: extended deadlines and delayed the start dates of granted projects, repurposed funds to ensure the continuity of research, provided financial support to PhD students affiliated to grants and to those affected by COVID-19, facilitated paperwork, paid cancellation fees and, in some cases, allowed projects to switch to COVID-19-related research.

EXAMPLES OF ADAPTIVE PRACTICES

- The European Union's Horizon 2020 allowed for projects to be extended, allowed reallocation of funds to accommodate costs of working from home and helped to pay the salaries of researchers affected by lab closures.
- The Australian Research Council, French National Agency for Research and Singapore's funding agencies facilitated late submissions of grant applications and final reports due to COVID-19 disruptions.
- The US' NSF and NIH enabled extensions of deadlines for project reports, and the ability to charge costs to grants that would not normally be allowed.
- The UK's Wellcome extended funding for staff salaries and PhD stipends and provided financial support to scientists who were unwell due to COVID-19.
- The German Research Foundation facilitated the transfer of 2020 grant money to 2021 and covered costs for staff salaries and cancellation fees caused by extended projects.

Urgent Need to Understand COVID-19 Led to a Boom in COVID-19-Related Research

CHALLENGES:

- As COVID-19-related research was being prioritised during the pandemic, the financial support for other research deemed as non-essential was temporarily held back.
- Researchers from STEM and non-STEM disciplines pivoted to broad-based investigation of COVID-19.
- It was expected that universities that were heavily reliant on STEM research with field work that required international travel or studies with human or animal subjects and that required access to physical laboratories or research sites would rebound much slower.
- Although funding from external sources remained at pre-pandemic level for running projects and because grant agencies extended deadlines, the closure of suppliers and service providers caused additional costs, increased waiting time and reduced performance.

Universities shifted focus during the pandemic: Universities possessing the relevant lab facilities and equipment shifted their research focus towards studies related to alleviating COVID-19 after disruptions caused by campus shutdowns[45]. In order to preserve the health and safety of their communities, many universities shut down non-essential research, with John Hopkins University, Michigan State University,

43. Joseph A M, Fernandez V, Kritzman S, et al. (April 29, 2022) COVID-19 Misinformation on Social Media: A Scoping Review. Cureus 14(4): e24601. doi:10.7759/cureus.24601
44. Sjölander-Lindqvist, A., Larsson, S., Fava, N. (2020) Communicating About COVID-19 in Four European Countries: Similarities and Differences in National Discourses in Germany, Italy, Spain, and Sweden. Front. Commun.
45. Sharma, Y. (2021) New and strengthened research priorities post-pandemic. https://www.universityworldnews.com/post.php?story=20210304105937958

University of Turin and Toronto University among others[46, 47, 48]. At the same time, they invested resources into exploring more urgent research domains such as those related to COVID-19.

Access to research facilities during the pandemic:
Since the start of the pandemic, scientists abruptly prioritised supporting their students and fellow academics to help them conduct research during lockdowns. The existing cooperative nature of faculties helped in the development of policies for returning to labs and fieldwork based on the research priorities. However, a lack of adequate training hindered an adequate level of support. Stanford University solved this shortcoming by establishing virtual Research Continuity Committees[49] that helped develop policies for in-person research and inform the university's priorities for the return to campus and fieldwork.

Some universities were heavily reliant on STEM research with field work that required international travel, or studies with human or animal subjects that needed constant access to physical labs or research sites. These universities were expected to rebound much slower after the pandemic. However, this was not the case as grant agencies extended deadlines and applied smoother regulations to ensure that research would not be disrupted. Resources and facilities were promptly repurposed for COVID-19-related research, sometimes followed by funding opportunities[50]. For instance, to facilitate research on COVID-19, the Central European Research Infrastructure Consortium shortened regular evaluation procedures, which enabled fast shared access to research facilities in central Europe[51].

Some institutions, like the Oswaldo Cruz Foundation in Belo Horizonte (Brazil), University of York (UK) and some German universities[52] were authorised to allow access to essential research facilities that could not be closed for a prolonged period of time. However, even in such cases, projects were significantly impacted by closure of suppliers and service providers which led to additional costs, increased waiting times and overall reduction in performance. More examples can be found in section "Eight selected universities' resilient responses to COVID-19".

Publication numbers increased rather than decreased:
Unexpectedly, the productivity of academics improved during the COVID-19 pandemic. However, this was not matched by an increase in salaries[53]. Because the work of researchers is not limited to labs, the time spent when working from home was on writing literature reviews and manuscripts, maintaining laboratory notebooks, organising data, and performing data analysis[54]. This trend was observed in the global increase in publications and preprints. Submissions to Elsevier's journals alone rose by 58% between February and May 2020 when compared with the same period in 2019. Health and medicine submissions were the largest contributing category (92%)[55].

COVID-19 revealed systemic problems across all aspects of society, and therefore spurred an increase in studies, not just with publications in medical journals, but across all disciplines. Publishers had to deal with an influx of publications and needed to recruit editors capable of managing the quality control process of new research in emerging subjects[56]. Moreover, remote working mandates prompted researchers to focus on publications based on existing results, previous research or literature reviews. 3,900 non-peer-reviewed papers were published in the bioRxiv in May 2020 alone, double the number submitted a year before. By speeding up or cutting back the long and tedious peer review process, researchers had the opportunity to publish their results faster, which led to an increased number of collaborations and a faster pace of scientific breakthroughs. These circumstances resulted in more than 125,000 COVID-19-related

46. Flaherty, S. (2020) "Nonessential" research has halted on many campuses. Inside Higher Ed. https://www.insidehighered.com/news/2020/03/30/nonessential-research-has-halted-many-campuses
47. Chen, J. (2020) Covid-19 has shuttered scientific labs. It could put a generation of researchers at risk. Stat. https://www.statnews.com/2020/05/04/coronavirus-lab-shutdowns-impact-on-scientists-research-delays/
48. Servick, K., Cho, A., Guglielmi, G., Vogel, G., et al. (2020) Updated: Labs go quiet as researchers brace for long-term coronavirus disruptions. Science. https://www.sciencemag.org/news/2020/03/updated-labs-go-quiet-researchers-brace-long-term-coronavirus-disruptions
49. Stanford University (2021) Lab life at Stanford during the COVID-19 pandemic. https://news.stanford.edu/2021/01/13/research-covid-19-pandemic/
50. NIH (2020) Coronavirus Disease 2019 (COVID-19): Information for NIH Applicants and Recipients of NIH Funding. https://grants.nih.gov/policy/natural-disasters/corona-virus.htm.
51. Central European Research Infrastructure Consortium (2020) COVID-19 Fast Track Access. https://www.ceric-eric.eu/2020/03/10/covid-19-fast-track-access/
52. Schiermeier, Q., Else, H., Mega, E.R., et al. (2020) What it's really like to do science amid COVID-19. From Germany to India, researchers are grappling with how to run labs and lessons under extraordinary restrictions. Nature 586, 486-487.
53. Flaherty, C. (2021) Faculty Salaries Dip This Year. Retrieved from https://www.insidehighered.com/news/2021/04/13/faculty-salaries-decreased-year/
54. Flaherty, C. (2020) Extraordinary Measures. Inside Higher Ed. https://www.insidehighered.com/news/2020/03/18/how-institutions-are-approaching-scientific-research-during-covid-19
55. Squazzoni, F., Bravo, G., Grimaldo, F., et al. (2020) Preprint at SSRN. http://doi.org/10.2139/ssrn.3712813
56. Palayew, A., Norgaard, O., Safreed-Harmon, K., et al. (2020) Pandemic publishing poses a new COVID-19 challenge. Nature Human Behavior, 4(4841), 666–669.

papers published in the first 10 months after the onset of the pandemic in 2020, a quarter of which were published on preprint servers[57]. This trend was observed in the worldwide increase of publications and preprints. The 58% rise in submissions to Elsevier's journals between February and May 2020 when compared with the same period in 2019 show this[58].

Being hit early by the coronavirus, China was the first to conduct studies and research that resulted in the production of publications with a citation impact of almost 17 times the world average, the largest of any major research nation. This is despite the fact that COVID-19-related publications made up only 1% of the total output, compared to the US where COVID-19-related papers constituted 2.5% of its overall research volume in 2020. Italy, one of the countries that was also hit early, managed to increase the quantity of its COVID-19-related publications, ranking 5th among all countries by June 2020[59].

CONCLUSION:

The research on COVID-19 and related topics hastened by the urgent need to understand the nature of the virus, find treatments, develop vaccines, and explore its impact on socio-economic conditions resulted in an increased number of publications worldwide. Moreover, the necessity to quickly access the data and results spurred preprint services. The availability of shared data also led to prompt academic and industry collaborations.

KEY FINDINGS

- The shift to remote work sped up the publication of results of previous research.
- The fast pivot to COVID-19-related research spurred the number of publications in the field.
- In the US, COVID-19-related papers constituted 2.5% of its overall research volume in 2020.
- COVID-19-related publications in China made up only 1% of the country's total output, but it had a citation impact of nearly 17 times the global average. This indicates that fundamental findings by China shaped global research, as well as the country's overall high research productivity.

EXAMPLES OF ADAPTIVE PRACTICES

- Stanford University established a virtual Research Continuity Committee to help faculty develop policies for returning to the labs and fieldwork.
- The Central European Research Infrastructure Consortium shortened regular evaluation procedures to allow shared access to research facilities in central Europe and accelerate research on COVID-19.
- The Oswaldo Cruz Foundation in Belo Horizonte (Brazil), University of York (UK) and German universities employed regulations to allow access to essential research facilities that could not be closed for a prolonged period of time.
- China, due to having sequenced the SARS-CoV-2 genome first, gained a citation impact of almost 17 times the world average.

57. Fraser, N., Brierley, L., Dey, G., et al. (2021) The evolving role of preprints in the dissemination of COVID-19 research and their impact on the science communication landscape. PLOS Biology, 19(4), 1–28.
58. Squazzoni, F., Bravo, G., Grimaldo, F., et al. (2020) Preprint at SSRN. http://doi.org/10.2139/ssrn.3712813
59. Aviv-Reuven, S., Rosenfeld, A. (2021). Publication Patterns' Changes due to the COVID-19 Pandemic: A longitudinal and short-term scientometric analysis. arXiv:2010.02594

Fast Transfer to Distance Learning Required Technology and Teacher Preparedness

CHALLENGE:
The capability of a university to cope with major disruptions due to COVID-19 depended on its effectiveness in adopting distance learning as well as on providing access to an advanced technological infrastructure and sufficient staff training.

Distance learning imposed across nations:
The COVID-19 pandemic struck countries disproportionately. Children in advanced economies missed the equivalent of 15 days of instruction in 2020, while those in middle income countries missed about 45 days and low-income countries up to 70, according to the Economist[60]. This large difference stems from the ability of each of the countries' education systems to repurpose existing resources for learning remotely and providing access to technology.

Different countries employed different approaches to ameliorate online learning. For example, China initiated a policy to ensure that learning was carried out properly during lockdowns[61]. The Chinese Ministry of Education developed an initiative called "Disrupted Classes, Undisrupted Learning" to provide flexible online learning to students who stayed at home[62]. The Philippines' Commission on Higher Education developed a training programme on flexible learning for staff, launched an online teaching and learning resource platform, and coordinated a space for educators to share innovative approaches[63]. In the US, more than 1,300 colleges and universities in all states cancelled in-person classes or shifted to online instruction. According to tracking from the College Crisis Initiative, by the fall of 2020, 44% of US institutions developed fully or primarily online instruction, 21% used a hybrid model, and 27% offered fully or primarily in-person instruction[64]. Taylor's University in Malaysia established virtual sites for each of its courses, facilitating online engagement, access to assessments, peer support, and communication channels between peers and lecturers[65]. China's Zhejiang University moved more than 5,000 courses online in two weeks due to a prior effort in systematic development of administrative services and academic resources[66]. A four-fold increase in digital storage capacity, performed by Nanyang Technological University (NTU) long before COVID-19 hit, prepared it to transition to online learning, with 600 courses and 624 exams that went online almost overnight.

Chile, setting an example for other Latin American countries, invested funding and resources into the development of long-term virtual learning tools and ensured access to available online tools for all institutions[67]. The Association of University Interconnection Networks of Argentina created an online collaborative platform with a catalogue of resources and tools for developing and implementing remote learning classes[68]. Other examples can be found in section "Eight selected universities' resilient responses to COVID-19".

60. Economist (2021) The prospects for developing countries are not what they once were. https://www.economist.com/briefing/2021/07/31/the-prospects-for-developing-countries-are-not-what-they-once-were
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67. Worldbank (2021) COVID-19 coronavirus response: Latin America and the Caribbean: Tertiary Education. https://thedocs.worldbank.org/en/doc/738931611934489480-0090022021/original/LACTEandCovidupdated.pdf
68. Perrotta, D. (2021) Universities and Covid-19 in Argentina: from community engagement to regulation, Stud High Educ 46(1), 30-43.

Satisfaction with online learning:
A survey conducted with 24,000 students from Germany, UK, Singapore, Thailand, Malaysia, Australia and New Zealand demonstrated that 86% of Thailand's respondents were satisfied with the institutional response to COVID-19 in the first half of 2020, followed by 85% in Germany, 79% in Singapore and Malaysia, 73% in Australia, 72% in New Zealand, and 60% in the UK[69]. 74% of the respondents among Indian students in another survey were also satisfied with online classes[70]. Higher satisfaction was generally observed in the countries with strict lockdowns and at universities compliant with the governmental policies of COVID-19 containment[71,72,73]. It is noteworthy that technological capability alone was not sufficient to provide the best online learning experience[74]. Staff training and confidence in conducting online classes, students' motivation and accessibility of technologies also played an important function in realising hybrid learning[75,76,77].

The shift to online education was not seamless. A survey launched among 3,000 Korean students pointed to unsatisfactory teaching quality, such as the lack of technical and online pedagogical skills[78]. Another survey conducted among more than 1,400 university students by the Office for Students in England[79] revealed that 72% were affected because they did not have a quiet place for receiving online instruction, 52% experienced slow and unreliable Internet connection, and 18% did not have access to a laptop or desktop computer. This situation is not unique to England. In Timor-Leste's Universidade Nacional Timor Lorosa'e, staff members mentioned an unreliable electricity supply, no free Wi-Fi on campus, and slow Internet speed, which was exacerbated by limited government funding for developing the infrastructure[80]. Indonesian students faced obstacles in switching to online learning, explained by culture shock, lack of access to devices and the Internet, and reduced interaction with peers[81].

Because of limited access to working computers and a reliable Internet connection, student performance dropped. Students generally reported a preference for a hybrid mode of instruction, which comprises in-person communal experiences connected to the "real world", online activities to allow for more flexibility, and increased accessibility for underprivileged communities[82]. To support the latter, some colleges volunteered to put enhanced safety protocols in place at university libraries to help provide access to the Internet[83]. Other universities organised laptop donation drives to distribute secondhand laptops to students without them so they could participate in online classes[84]. Ecuador's government invested in better Internet connectivity and the Federal Ministry of Education of Brazil distributed connectivity kits to facilitate access to remote learning[85], while the Ministry of Education of Argentina enforced free access to "edu.ar" web pages[86]. In South Africa, vulnerable students received 10GB of data per month to support their participation in online classes[87].

In February 2021, to tackle widespread technical difficulties and to cater to socially disadvantaged students who missed the benefits of online learning,

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73. Kaine, G., Greenhalgh, S., Wright, V. (2022) Compliance with Covid-19 measures: Evidence from New Zealand. PLOS ONE 17(2): e0263376.
74. Smith, J.A., Judd, J. (2020). COVID-19: Vulnerability and the power of privilege in a pandemic. Health Promot J Austr, 31(2), 158-160.
75. Ali, W. (2020) Online and Remote Learning in Higher Education Institutes: A Necessity in light of COVID-19 Pandemic. High Educ Stud, 10 (3).
76. UNESCO (2020). COVID-19 Educational Disruption and Response. Retrieved from https://en.unesco.org/covid19/educationresponse/
77. Pham, H.-H., Ho, T.-T.-H. (2020) Toward a 'new normal' with eLearning in Vietnamese higher education during the post COVID-19 pandemic, High Educ Res Dev, 39 (7), 1327-1331.
78. Bae, T. (2020) "Are you reading PPT again?"... Students annoyed by poor quality distance learning https://www.hankyung.com/society/article/2020090691531
79. McKie, A. (2021) Will Covid reset how universities help socially disadvantaged students? https://www.timeshighereducation.com/features/will-covid-reset-how-universities-help-socially-disadvantaged-students
80. Chen, L. (2020) Reflecting online/distance learning in higher education under Covid-19: Bitter lessons from Timor-Leste. https://shapesea.com/op-ed/covid-19/reflecting-online-distancelearning-in-higher-education-under-covid-19-bitter-lessons-from-timor-leste/
81. Susilana, R., Hutagalung, F., Sutisna, M.R. (2020) Students' perceptions toward online learning in higher education in Indonesia during COVID-19 pandemic. Elem Educ Onl, 19 (4), 9-19.
82. Eringfeld, S. (2021) Higher education and its post-coronial future: utopian hopes and dystopian fears at Cambridge University during Covid-19, Stud High Educ 46(1), 146-157.
83. Mississippi State University (2020) For students with limited access to internet services. https://www.msstate.edu/newsroom/article/2020/03/students-limited-access-internet-services
84. Nanyang Technological University (2021) A caring OneNTU community. https://www.ntu.edu.sg/alumni/alumni-stories-news/detail/a-caring-onentu-community#:~:text=Alumnus%20Mr%20Mohamed%20Abdul%20Akbar,the%20needy%20in%20the%20community.
85. Worldbank (2021) COVID-19 coronavirus response: Latin America and the Caribbean: Tertiary Education. https://thedocs.worldbank.org/en/doc/738931611934489480-0090022021/original/LACTEandCovidupdated.pdf
86. Perrotta, D. (2021) Universities and Covid-19 in Argentina: from community engagement to regulation, Stud High Educ 46(1), 30-43.
87. Universities South Africa (2020) Public universities have either embraced emergency teaching/learning, or are getting ready for the inevitable, in the COVID-19 era | universities South Africa. www.usaf.ac.za/universities-coronavirus-covid-19-updates

England's government announced an additional £50 million for support initiatives[88]. The Republic of Ireland allocated €15 million to universities to help buy laptops for low-income students[89]. France helped students in precarious situations by providing a one-time financial support of €200 in cash.

CONCLUSION:

The road to recovery for universities around the world is not expected to return to pre-COVID-19 conditions. Instead, a re-invention of educational methods and campus design could be spurred, along with advancements in collaborative approaches to deliver high quality education, and a reimagining of the university as a partner for lifelong adaptable learning. While it remains to be seen if post-COVID-19 conditions would be preferable to pre-COVID-19 conditions, key components of this transition towards remote learning have been identified: (1) Close interaction with students and staff, (2) collecting and embedding their feedback, and (3) providing technological tools and support.

KEY FINDINGS

- Universities worldwide cancelled in-person tuition and implemented initiatives to ensure availability of distance learning.
- Prior investments in online learning infrastructure helped make the transition to such learning faster during the pandemic, as demonstrated by universities in China and Singapore.
- Students reported limited access to the Internet and laptops, a lack of dedicated areas for online learning and even cultural shock as driving factors of low satisfaction.
- Students in South Korea, England, and Timor-Leste mentioned not having a quiet place for receiving online instruction, slow and unreliable Internet connection, limited access to a computer and unsatisfactory quality of teaching, caused by a lack of technical and online pedagogical skills.

EXAMPLES OF ADAPTIVE PRACTICES

- Higher satisfaction with distance learning was observed among students in countries with stricter lockdown measures and high compliance with COVID-19 measures.
- Transition to online learning was facilitated by creating free access to online educational platforms with tools and resources available for distance learning.
- Socially disadvantaged students in Ireland, England and France were supported by either a one-time payment or by being provided with laptops.
- Ecuador's government invested in better Internet connectivity.
- Vietnam made efforts to ensure the appropriate training of teachers and staff to ensure a smooth transfer to online learning.
- The Federal Ministry of Education of Brazil distributed connectivity kits to facilitate access to remote learning.
- The Ministry of Education of Argentina enforced free access to "edu.ar" webpages.
- In South Africa, vulnerable students received 10GB of data per month to support their participation in online classes.

88. Gov.uk (2020) Government support package for higher education providers and students. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/882884/Government_support_package_for_higher_education_providers_and_students.pdf
89. Gov.ie (2020) Minister Harris announces 17,000 laptops ordered to assist students with online and blended learning https://www.gov.ie/en/press-release/7143d-minister-harris-announces-17000-laptops-ordered-to-assist-students-with-online-and-blended-learning/

Remote Education Called for Campus Redesign

CHALLENGE:
Rapid adoption of digital tools, transfer to distance learning and work-from-home mandates changed the demand for physical spaces on campus. It called for a repurposing of spaces to cater to the emerging need for flexibility in the face of a crisis.

Changing requirements for university campuses and buildings during COVID-19:
The sudden and ubiquitous introduction of online and hybrid learning brought into question the suitability of physical spaces on campuses. Campus life is not limited to only providing education and research facilities; it also involves socialising, sports and shared experiences to build the university community. The crisis has shown that existing spaces will need to be redesigned to allow flexibility of use, while at the same time remaining safe for face-to-face learning[90]. During the pandemic, safe distancing measures were put in place, requiring the need to severely restrict or limit access to lecture halls and labs and ensure safe distancing and mask wearing. When classes continued, lessons had to be held online, done in a hybrid style or with fewer people spaced far apart in large halls with sufficient ventilation. ETH Zurich, for a short while, introduced "study bubbles" for students, in which a specific group of people with the same curriculum were allowed to study together without mingling with other groups. It was a clear example of preserving the safety of students and providing real life experiences "on campus" with possibilities to network and socialise within groups of people[91]. The activity was suspended after tightened restrictions that followed another wave of COVID-19.

The abrupt suspension of research activities on campus caused by the shutdown of labs, closed access to research sites, limited face-to-face research activities and the necessity to terminate long-running experiments that required intensive support from lab assistants ultimately led to a loss of results and had a detrimental effect on the overall research capability and output of universities. How universities adapted to this differed. Some implemented work shifts or staff rotations (such as the Singapore University of Technology and Design (SUTD)[92]); adopted virtual reality (VR) tools and remotely controlled computational facilities (Tec de Monterrey[93] in Mexico); or conducted experiments online (Stanford University[94], US). Some of these improvements to address pressing needs in the pandemic became permanent, laying the foundation for hybrid labs with blended experimental capabilities[95].

An independent study commissioned by Optus and Cisco in Australia collected opinions from administrators of 80% of the Australian higher education and TAFE institutes (government-funded registered training organisations)[96]. The majority of the respondents agreed that digitalisation would impact campus redesign. Fewer people on campus would enable more managerial and support staff to work from home. Students seeking more lively and informal interaction called for experiential and interactive spaces. An increased awareness of viral spread requires re-planning of places for the next pandemic to preserve social distancing and emphasise the importance of outdoor spaces and safe distanced social interaction for mental health. Steve Morley, Director of Space Utilisation and Planning at the University of North Carolina, called for enhancing fresh air fluctuation and

90. Goh, L. (2021) The future is now: Imagining university life in a post COVID-19 world. https://www.aurecongroup.com/thinking/thinking-papers/covid-19-reshaping-education-asia
91. ETH Zurich Annual Report (2020) https://ethz.ch/en/news-and-events/eth-news/news/2021/04/annual-report-2020.html
92. Singapore University of Technology and Design (2022) Updates on COVID-19. https://www.sutd.edu.sg/advisory
93. Tec de Monterrey's Annual Report (2020). Retrieved from https://tec.mx/sites/default/files/inline-files/InformeAnual-2020.pdf
94. Kubota, T. (2021) Lab life at Stanford during the COVID-19 pandemic. Retrieved from https://news.stanford.edu/2021/01/13/research-covid-19-pandemic/
95. Kubota, T. (2021) Lab life at Stanford during the COVID-19 pandemic. Retrieved from https://news.stanford.edu/2021/01/13/research-covid-19-pandemic/
96. Vector Consulting (2020) A new era in the digitisation of education campuses https://www.optus.com.au/enterprise/accelerate/communications/a-new-era-in-the-digitisation-of-education-campuses

focusing on the importance of socially distanced green areas and plants on campus[97]. Universities globally are exploring collaborations with industries that require repurposing existing areas to turn them into innovation hubs. Finally, in the light of increasing efforts to address the impact of climate change, campuses will become more CO^2 neutral and equipped with sensors and systems to automate and regulate energy efficiency.

The future of spaces on campuses is predesignated by the necessity for social distancing leading to lower density classrooms, according to May Lim, Director of the Centre for Learning Environment and Assessment Development of Singapore's Institute of Technology[98].

"The availability of flexible and convertible furniture would facilitate transformation of room design and create multi-purpose spaces. The pandemic revealed that students prefer small collaborative group learning over attending large lectures, which can be addressed by an increase in the number of smaller learning classrooms. Digital skills of students and faculty are required for a faster move to automated, hands-free and online collaborative technology. Increased awareness of safety regulations would lead to a roll-out of touchless lighting, motion-sensor activated doors, voice-activated elevators and other technologies."

KEY FINDINGS

- Campus areas need redesigning to account for safe distancing, digitalisation and availability of open-air spaces.
- Large lecture classrooms might become obsolete and replaced by small group interactions.
- Students seek hybrid collaborative experiences in smaller groups which could increase demand for transformative and interactive classrooms.

EXAMPLES OF ADAPTIVE PRACTICES

- ETH Zurich tested the concept of "study bubbles" – a group of students with the same curriculum who study together without mingling with others – to ensure the safety of students as well as to provide real "life on campus" experience.
- To reduce the number of students on campus at any given time, Stanford University allowed students to choose any of the three quarters (out of four) in an academic year to enrol.
- NTU and Stanford University limited undergraduate housing in shared rooms to reduce the size of the university community on campus. A preference was given to freshmen, students with special circumstances and international students.
- To continue research activities during limited access to the facilities, Tec de Monterrey adopted VR tools and remotely controlled computational facilities, while Stanford University looked into conducting experiments online.

Universities Adopted Safety Measures to Protect the Wellbeing of Their Communities

CHALLENGES:

- University campuses with residential, academic, research, and sports buildings, as well as entertainment and dining venues, required streamlined measures to ensure the safety of the campus community.
- The general template of maintaining campus safety during the COVID-19 pandemic included a full shutdown with prohibited access to the campus, followed by a reopening in stages and allowing staff and students with negative polymerase chain reaction (PCR) test results to use university facilities. With a widespread adoption of vaccines, fully vaccinated individuals were allowed on campus and were required to wear face masks indoors.

97. Drawdy, R. (2020) The New Design Future of Campus Planning Post-COVID. https://www.helixeducation.com/resources/blog/the-new-design-future-of-campus-planning-post-covid/
98. Goh, L. (2021) The future is now: Imagining university life in a post COVID-19 world. https://www.aurecongroup.com/thinking/thinking-papers/covid-19-reshaping-education-asia

- Lab shutdowns had a negative impact on careers of early-career scientists who usually have temporary contracts and whose careers are dependent on the number of publications they have.

On-campus safety measures:

University campuses play a significant role in maintaining and preserving the health and safety of their communities, especially those of their students, a vast majority of whom are young adults. Evidence shows that US counties with large colleges or universities that had implemented remote learning experienced a 17.9% decrease in COVID-19 infections, whereas counties returning back to in-person tuition experienced a 56% increase. This comparison was done over a 21-day period before and after classes started in July/August 2020. Counties without large colleges or universities experienced a 6% decrease in infections during a similar time period[99]. During 2021, at least 50 US colleges reported more than 1,000 cases, and 260,000 COVID-19 cases were linked to American colleges and universities. In total, there were up to 700,000 cases reported since the beginning of the pandemic[100]. In US counties where every tenth citizen is a student, the number of cases swelled. However, the majority of universities with high infection rates were located in the Southern states, where mandates to wear face coverings or submitting negative tests before returning to campus were not exercised[101]. Moreover, the majority of infections were detected at institutions that proceeded with the football season amid the pandemic[102]. This data supports the importance of implementing safety measures on campuses and the risks involved when having mass gatherings. Prior incorporation of disaster risk considerations into higher education enabled faster and more coherent response to emergencies. For example, New Zealand's response to the COVID-19 pandemic was grounded on the national risk context of past measles outbreaks, volcanic eruptions, Australian bushfires, and earthquakes[103]. However, the survey conducted by APRU Multi-Hazards team with the aim to review preparedness capacity unveiled the fact that not so many universities conducted a general risk assessment on campus prior to COVID-19[104]. It impeded the promptness of reaction to COVID-19 pandemic.

Amid shifting messages from national public health authorities, university campuses also exercised agile responses to preserve the safety of their communities. Universities implemented safety measures endorsed by the government and paid for them with their own finances. Some general steps many campus universities took included full shutdowns with prohibited access to the campus for members of the community to buy some time for a university to put safety protocols in place. This was followed by a gradual reopening in stages to allow the community to use university facilities upon receiving negative PCR results. After a wide roll-out of vaccines, the next step was a full reopening for fully vaccinated individuals with or without the mandated use of face masks indoors[105].

Universities as living labs to test COVID-19 measures and interventions:

Some campuses collaborated intensively with government agencies and were used as testbeds for new technologies related to tracking and tracing the spread of the virus. For example, NTU (Singapore) adopted different surveillance technologies (such as taking photos of the seating arrangement in classrooms and performing QR-code check-ins through an internal university system) to complement the social distancing measures across the university's campus that were in place by August 2020. After safety testing at NTU, digital biometric surveillance technologies to measure fever and contact tracing technology such as the "TraceTogether" mobile app were deployed across Singapore. The University of Illinois Urbana-Champaign, in contrast, had planned to fully reopen its campus by August 2020. Equipped with in-house developed rapid saliva test kits and the "Safer Illinois" smartphone app that tracks users' test results and offers exposure-related push notifications, a safe return of students and staff back to campus was facilitated. While technological interventions to protect the community from COVID-19 posed risks such as those related to privacy and the safety of personal data, a spirit of community and unity was

99. Leidner, A.J., Barry, V, Bowen, V.B., et al. (2021) Opening of Large Institutions of Higher Education and County-Level COVID-19 Incidence - United States, July 6-September 17, 2020. MMWR Morb Mortal Wkly Rep, 70(1), 14-19.
100. The New York Times (2021) Tracking Coronavirus Cases at U.S. Colleges and Universities. https://www.nytimes.com/interactive/2021/us/college-covid-tracker.html
101. The New York Times (2020) Tracking the Coronavirus at U.S. Colleges and Universities. https://www.nytimes.com/interactive/2020/us/covid-college-cases-tracker.html
102. Thomas, L. (2020) Is College Football Making the Pandemic Worse? The New Yorker. https://www.newyorker.com/sports/sporting-scene/is-college-football-making-the-pandemic-worse
103. Holloway, A. (2022). Vigorous, Vital, Vulnerable: Universities and COVID-19, Aotearoa New Zealand. In: Izumi, T., Pal, I., Shaw, R. (eds) Safety and Resilience of Higher Educational Institutions. Disaster Risk Reduction. Springer, Singapore.
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105. Ladyzhets, B. (2021) How 5 universities tried to handle COVID-19 on campus. https://www.sciencenews.org/article/coronavirus-covid-19-college-university-campus-cases-testing

encouraged in order to spark change in socially responsible behaviour and to engage the university community in controlling the spread of the virus on campus together[106]. National Taiwan University created an automated temperature-measuring device enhanced with a contact tracing system to accommodate more than 80,000 daily scans of ID cards. It allowed for conducting face-to-face classes without forming COVID-19 clusters[107].

University hospitals switched to first line support: Some of the universities had academic hospitals that were part of the first line of response, opening their doors to those infected with COVID-19, as well as recruiting medical staff from a pool of eligible medical students. Stanford University, for example, having ample capacity, managed to convert one of its four intensive care units into a 20-bed COVID-19 unit, staffed by clinicians experienced in handling personal protective equipment and using ventilators to manage lung problems. It also repurposed one of the adjacent parking garages into a drive-through testing and screening site in just 12 hours, expanding its capabilities to treat patients from the San Francisco Bay Area[108]. University Malaya Medical Centre (Malaysia) adopted similar measures, from rescheduling clinic appointments and elective operations to deploying more healthcare workers to its Emergency Department and allocating more designated COVID-19 wards to manage infected cases[109]. Odense University Hospital (Denmark) arranged COVID-19-dedicated wards and trained healthcare personnel with multidisciplinary skills[110].

Having to suspend routine operations while dealing with the influx of COVID-19 patients, many university hospitals suffered substantial income losses. For example, the initial phases of lockdowns caused a total shutdown of all elective procedures in ophthalmology, otolaryngology, and dermatology in Mahatma Gandhi Medical College and Research Institute (India), which experienced a 50-60% loss in patients during the pandemic and conversely negatively affected its revenue[111]. Total surgical activity in Innsbruck Medical University Hospital (Austria) was also reduced by 65.4% compared with the same period during the previous five years[112].

Students who were unable to work in the labs were concerned about the ongoing payment of their salaries, the care for lab animals and other living organisms, and lost potential career opportunities[113]. One of the probable outcomes of lab shutdowns was the unplanned costs of restarting R&D projects as well as the impact on career prospects of graduating doctoral students, postdoctoral researchers, and early-career faculty whose research was largely interrupted[114]. The closure of labs pushed back the careers of early-career scientists whose opportunities are usually more transient, limited to temporary contracts and highly dependent on the amount of research and publications they produce[115]. Universities and senior researchers tried to mitigate the effects of such circumstances for young researchers. For example, Brown University[116] retained graduated doctoral students by offering them visiting assistant professorship positions.

CONCLUSION:

It is evident that campus safety plays a key role in containing the spread of the virus among the university community, so it needed to be reconsidered. Many campuses followed similar scenarios in lockdowns. The temporary shutdown of laboratories and suspension of research work affected progress and called for the development of new approaches of distance access to equipment. Some campuses created or acquired cutting-edge technologies to preserve the safety of the community.

KEY FINDINGS

- Universities became testbeds for the roll out of safety measures and technologies.

106. Mak, B., Stevens, H. (2021) The Campus After COVID-19. https://publicseminar.substack.com/p/the-campus-after-covid-19
107. Pan, T.Y., Tsai, H.M., Chen C.H., et al. (2022). New Role of Universities: Experiences from Taiwan. In: Izumi, T., Pal, I., Shaw, R. (eds) Safety and Resilience of Higher Educational Institutions. Disaster Risk Reduction. Springer, Singapore.
108. Stanford Annual Financial Report (2020). https://bondholder-information.stanford.edu/sites/g/files/sbiybj21416/files/media/file/fy21-stanford-annual-financial-report.pdf
109. Lim, W.H., Teoh, L.Y., Seevalingam, K.K., et al. (2020) COVID-19 Pandemic in University Hospital: Is There an Effect on The Medical Interns? medRxiv 10.01.20205112.
110. Madsen, L.W., Lindvig, S.O., Rasmussen, L.D., et al. (2021) Low mortality of hospitalised patients with COVID-19 in a tertiary Danish hospital setting. IntJ Inf Dis 102, 212-219.
111. Coumare, V.N., Pawar, S.J., Manoharan, P.S., et al. (2021) COVID-19 Pandemic—Frontline Experiences and Lessons Learned From a Tertiary Care Teaching Hospital at a Suburban Location of Southeastern India. Front Public Health.
112. Abram, J., Gasteiger, L., Putzer, G., et al (2021). Impact of COVID-19 Related Lockdown on the Frequency of Acute and Oncological Surgeries-Lessons Learned From an Austrian University Hospital. Front Publ Health 9, 625582.
113. Flaherty, C. (2020) Extraordinary Measures. Inside Higher Ed. Retrieved from https://www.insidehighered.com/news/2020/03/18/how-institutions-are-approaching-scientific-research-during-covid-19
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115. Chen, J. (2020) Covid-19 has shuttered scientific labs. It could put a generation of researchers at risk. Stat. Retrieved from https://www.statnews.com/2020/05/04/coronavirus-lab-shutdowns-impact-on-scientists-research-delays/
116. Ansari, K. (2021) Graduate students face bleak job market among nationwide university hiring freezes. https://www.browndailyherald.com/article/2021/03/graduate-students-face-bleak-job-market-among-nationwide-university-hiring-freezes

- Suspending operations and pivoting towards dealing with COVID-19 patients negatively impacted the income of academic teaching hospitals

EXAMPLES OF ADAPTIVE PRACTICES

- NTU's campus acted as a testbed for digital biometric surveillance technologies to measure fever and contact tracing technology such as the "TraceTogether" app that were subsequently deployed in Singapore.
- The University of Illinois Urbana-Champaign developed rapid saliva test kits and the "Safer Illinois" smartphone app that tracks users' test results and pushes exposure notifications. This facilitated a safe return of students and staff back to campus.
- Universities that owned hospitals (such as Stanford University, University Malaya Medical Centre and Odense University Hospital) converted their facilities to satisfy the influx of COVID-19 patients as well as trained medical staff.
- To support doctoral students, Brown University offered them visiting assistant professorship positions.

Hiring Continued for Researchers Who Worked on Externally Funded COVID-19 Projects and Halted for Others

CHALLENGES:

- Decreased student enrolment and income from tuition fees, coupled with reduced national R&D funding was expected to impede recruitment of new research staff and faculty as well as extending existing contracts.
- There is a concern that early-career researchers may leave their academic careers because of insecure employment options and a lack of opportunities. This could lead to a failure to attract and retain young talent who will carry out important research work.

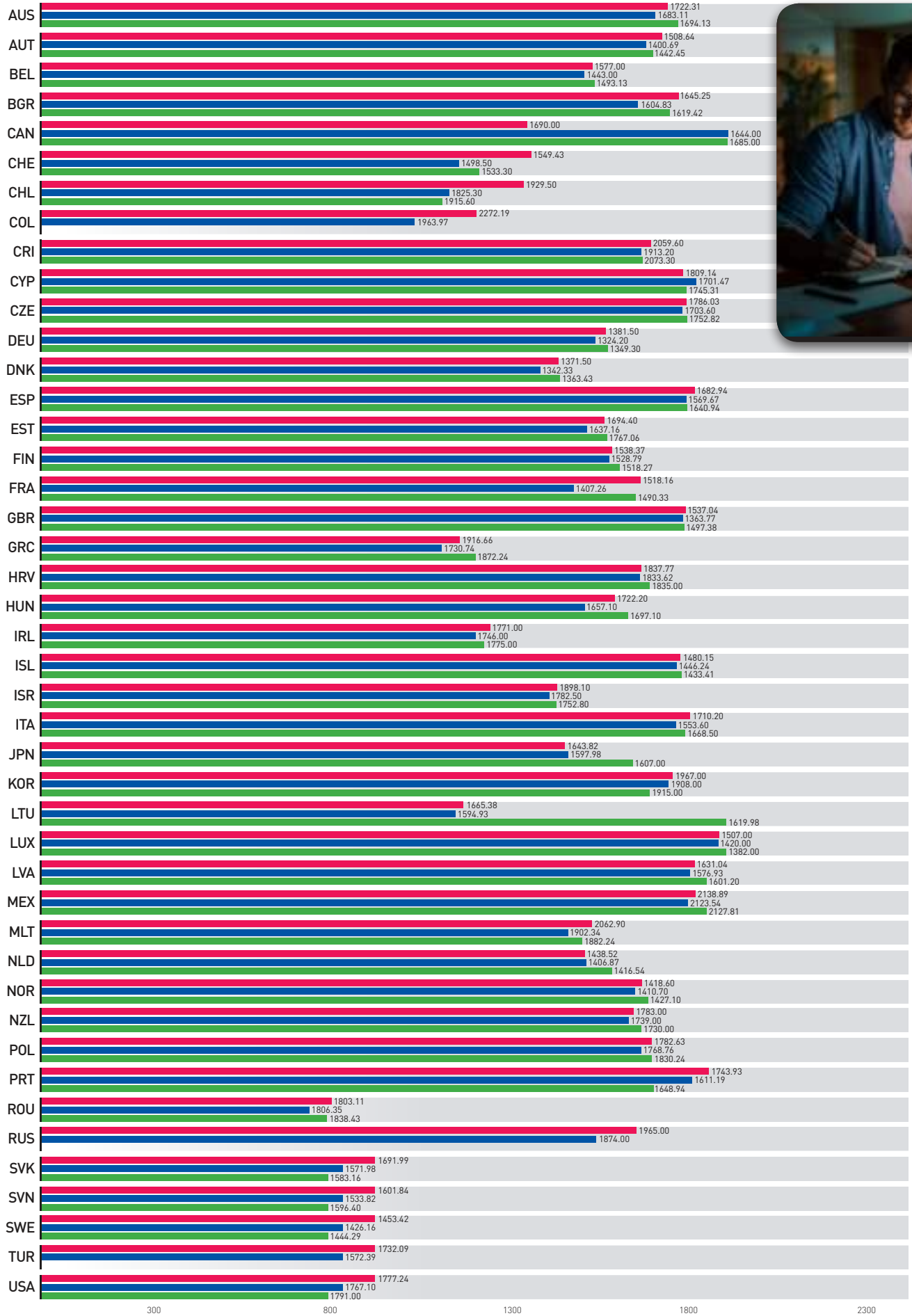
The COVID-19 crisis led to hiring freezes and job losses in higher education:

The COVID-19 pandemic and the financial uncertainty it brought nudged universities to cut back on their recruitment processes, which eventually hurt early-career researchers. Even solid financial support for universities did not reduce the number of new recruits that were cut: wealthy institutions and those with fewer resources halted or reduced recruitment procedures because candidates could not travel, the future of research programmes or units had become uncertain, or resources were focused on dealing with immediate crises. In light of economic constraints, some institutes of higher education eliminated entire departments due to budget cuts, and faculty and staff were on the brink of losing their jobs[117] (examples include the University of Vermont and Salem State University). Other universities offered short-term adjunct contracts to their faculty in an attempt to both keep staff and cut salary expenses[118].

Universities that mainly depended on tuition fees from students ceased recruitment of faculty as they were projecting or facing plummeting numbers for student enrolment. For example, the estimated decline of enrolment to UK universities (approximately 16% of local and 47% of international students) forced them to cut expenditures and halt recruitment of new staff. Many American universities imposed hiring freezes in the spring of 2020[119], gradually opening recruitment of new staff in the spring of 2021[120,121]. They also largely fell back to staff furlough . Australian universities that together employ more than 130,000 staff at 200 campus locations reported that at least 17,300 jobs had already been lost by February 2021[123]. At the same time, European principal investigators who were financed mostly through external agency

117. Dilawar, A. (2021) Universities Are Slashing Faculties and Blaming Covid. https://www.thenation.com/article/economy/universities-budget-cuts-covid/
118. Greenfield, N. (2021) American professors report declining salaries, rising university debt. https://www.universityworldnews.com/post.php?story=20210813112321174
119. The New York Times (2021) Colleges Get Billions in Coronavirus Relief, but Say Deal Falls Short of Needs. https://www.nytimes.com/2020/03/25/us/politics/colleges-universities-coronavirus.html
120. Brown University (2020) Changes to Hiring and Performance Evaluations. https://healthy.brown.edu/updates/changes-hiring-and-performance-evaluations
121. University of Michigan (2020) https://hr.umich.edu/working-u-m/my-employment/covid-19-information-employees/hiring-freeze-faculty-staff-positions
122. Nietzel, M. (2020) College Furloughs Have Begun. Forbes. https://www.forbes.com/sites/michaeltnietzel/2020/04/19/college-furloughs-have-begun/?sh=5c9646b723cd
123. Universities Australia (2021)17,000 Uni jobs lost to COVID-19 https://www.universitiesaustralia.edu.au/media-item/17000-uni-jobs-lost-to-covid-19/

TOTAL HOURS WORKED



OECD (2022), Hours worked (indicator). doi: 10.1787/47be1c78-en

funding did not experience severe reduction of job positions[124].

The career consulting website 'The Professor Is In'[125] curated an unofficial crowdsourced list[126] of American institutions with hiring freezes and contained more than 400 entries, regularly updated with furloughs or recruitment pauses for the US universities.

In the midst of the pandemic, US colleges and universities observed a salary pay decline as well as a drop in the number of full-time faculty. At 26% of the institutions, the number of full-time faculty members fell by 5%. Notably, it increased slightly at public institutions and dropped elsewhere, most of all by 2.4% at private, religiously affiliated colleges and universities. Institutions that award doctoral degree were least affected, seeing a small growth in full-time faculty ranks. Professor salaries decreased at 65% of colleges and universities. Average faculty salaries decreased at 42% of colleges and universities surveyed[127]. However, the recruitment carried on for the researchers and faculty whose research area was related to COVID-19 concerned an essential research direction or whose positions were funded by external grants and endowments.

The longer-term effects of hiring freezes:
The halt in recruitment, even if temporary, will have a long-term effect on the excellence of research and education, resulting for instance in the inability to offer complete academic programmes, reduced progress for non-essential but fundamental research directions and missed opportunities to hire talented early career researchers[128]. Moreover, loss in young talent could be irreversible: instigated by a lack of opportunities in academia, they turn to other jobs and abandon the academic career track[129]. However, the situation is not equal across countries. For example, in China, Malaysia and Poland, a university job is considered relatively secure, whereas France and the UK showed disturbing trends of researchers quitting[130]. At the same time, some Singapore universities developed ways to support their graduates through paid internships or traineeships at local companies or providing work opportunities at universities, spanning roles in central administration and across faculties, schools and research institutes[131].

The upside of this turmoil for fresh graduates was a pervasive sense of social cohesion and solidarity that endorsed the formation of student unions and all-encompassing support, peppered with the enhanced ability of universities to cut the red tape in helping students get jobs[132]. Young researchers provided support to their peers by curating the list of job openings in various research areas[133]. However, as reported by the chemjobber[134] and neurorumblr[135] blogs that oversee the availability of academic jobs in chemistry and neuroscience in the US, there was a decline in research and teaching positions listed in 2020 compared to the previous year.

Quality of teaching took a hit during COVID-19:
To understand the views of university administrators concerning the impact of the COVID-19 pandemic on higher education, Hanover Research and Inside Higher Ed conducted the "2021 Survey of College and University Chief Academic Officers" with results published in April 2021[136]. The survey included responses from 183 provosts from public, private, non-profit, and for-profit institutions in the US. Although they remained optimistic, Provosts were critical of certain measures implemented during the pandemic. When asked how the fall 2020 semester compared to previous semesters, 42% of Provosts reported deteriorated quality of courses, 51% reported underperforming faculty research, and 78% noted a decrease in student engagement. It is no surprise to

124. Woolston, C. (2020) Junior researchers hit by coronavirus-triggered hiring freezes. Nature 582, 449-450
125. Professor Is In. https://theprofessorisin.com/
126. Professor Is In. https://docs.google.com/document/d/1KohP4xZdN8BZy1OMeXCAGagswvU0WpOws72eDKpBhI4/edit
127. Flaherty, C. (2020) Faculty Salaries Dip This Year. Inside Higher Ed. https://www.insidehighered.com/news/2021/04/13/faculty-salaries-decreased-year/
128. Flaherty, C. (2020) Frozen Searches. Inside Higher Ed. https://www.insidehighered.com/news/2020/04/01/scores-colleges-announce-faculty-hiring-freezes-response-coronavirus
129. Greenfield, N. (2021) American professors report declining salaries, rising university debt. https://www.universityworldnews.com/post.php?story=20210813112321174
130. University of Tennessee Knoxville (2021) Harbingers-2: taking the pulse one year on. http://ciber-research.com/download/20211204-Harbingers2_Taking%20the%20pulse%20one%20year%20on.pdf
131. Ang, H.M. (2020) Local universities announce initiatives for financial aid, jobs for graduating students. https://www.channelnewsasia.com/singapore/covid-19-coronavirus-universities-aid-jobs-nus-ntu-graduates-766856
132. Flaherty, C. (2020) Frozen Searches. Inside Higher Ed. https://www.insidehighered.com/news/2020/04/01/scores-colleges-announce-faculty-hiring-freezes-response-coronavirus
133. Olena, A. (2020) The Pandemic Continues to Put a Damper on Faculty Hiring. The Scientist. https://www.the-scientist.com/news-opinion/the-pandemic-continues-to-put-a-damper-on-faculty-hiring-68020
134. Chemjobber. http://chemjobber.blogspot.com/2020/09/the-2021-faculty-jobs-list-99.html
135. Neurotumblr. http://neurorumblr.com/
136. Jaschik, S. (2021) Provosts Face the Pandemic. Times Higher Ed. https://www.insidehighered.com/news/survey/survey-shows-how-provosts-faced-pandemic

see that the majority of Provosts reported a decline in quality of courses, since most courses moved online, and staff and students required more time to get adjusted to the new learning environment and process. The pandemic had a detrimental effect on faculty. 24% of provosts said that they had cut faculty positions because of the pandemic. Moreover, 14% said that faculty cuts disproportionately affected the humanities departments, with the split being between 4% at public institutions and 33% at private institutions.

It is surprising that some Provosts expected a decrease in online learning after the pandemic, probably because of the negative reviews of online courses, whereas more than 73% of respondents agreed that the amount of hybrid and online courses would continue to grow post-pandemic.

CONCLUSION:
The pandemic revealed the already existing lack of job security for non-tenured faculty and young researchers which has significantly worsened since 2020. The data is available mainly for the universities based in the US, Australia and Europe, and the understanding of how Asian, Arab, South American or African universities dealt with job insecurity for early career scientists is unsure. Moreover, termination of academic programmes (entire minors, majors or master's as was the case for the University of Vermont[137]) due to reduced finances can have long standing impact on the quality of education.

KEY FINDINGS:
- Both wealthy and less-resourced universities faced problems due to hiring freezes.
- The number of full-time faculty at public and doctoral institutions increased slightly but fell at private and religiously affiliated colleges and universities.
- European researchers who were financed by external grants managed to avoid the massive reduction in job positions, compared to their American and Australian colleagues.
- Hiring freezes disproportionately affected humanities departments.
- Paused recruitment can have a long-term impact on advancing research and education caused by the inability to offer complete academic programmes, reduced progress for fundamental research directions and missed opportunities to hire talented early career researchers.

EXAMPLES OF ADAPTIVE PRACTICES
- Universities in Singapore supported young graduates by offering paid internships or traineeships at local companies or universities.
- Academic and research positions in China, Malaysia, and Poland were considered relatively secure and saw an increase in demand.
- Doctoral and public institutions were least affected, seeing a small growth in full-time faculty ranks.
- Researchers, faculty and staff working on COVID-19-related research were highly sought after and their job opportunities improved significantly.

A Multi-Stakeholder Approach Toward Solving Problems Posed by the Pandemic Expedited the Development of Solutions

CHALLENGE:
The search for viable solutions to challenges in higher education and research triggered by the COVID-19 pandemic should not be done without tight collaboration with multiple stakeholders.

The pandemic led to new and stronger collaborations:
Public-private partnerships between primary, secondary, and tertiary education with technology providers, governments, and network operators rapidly expanded due to the new realities brought by the pandemic. Their collaboration led to the development of new digital educational platforms to cater to all demographics of learners and to include those who had minimal access to technological devices. A nation's readiness to provide educational materials through internet technology has far-reaching consequences and the potential to transform the future of education. For example, the Hong Kong-based "Read Together" initiative which comprises 60 educational organisations, publishers, media, and entertainment industry professionals, supplies more than 900 educational assets and materials to learners free-of-charge. This includes videos, book chapters, assessment tools, and counselling services. They plan to maintain the platform even after the end of the COVID-19

137. University of Vermont And State Agricultural College Board Of Trustees (2021). Retrieved from https://www.uvm.edu/sites/default/files/UVM-Board-of-Trustees/committees/epir/materials_2021-06-04.pdf

pandemic[138]. In Vietnam, the government effort to provide subsidised access to infrastructure or digital and educational platforms was supported by national businesses[139]. In Chile, an alliance was established among all institutes of higher education to facilitate adaptation to the crisis by sharing best educational practices[140].

University-Industry collaborations for education:
Collaboration with government agencies to realise access to educational technology was not the only strategy adopted, as the funding for education and research stretched beyond government support. One of the observed trends for universities was the evaluation of possible educational partnerships with industries[141]. Besides mitigating financial constraints, joint courses with industries were deemed attractive for students due to the possibility of highly valued hands-on experience – online or otherwise – and applicable skillsets. Industrial giants such as Alibaba, Rolls Royce, Tencent, Microsoft and Google engaged in strategic research collaborations with universities that typically offer a pool of talented experts and a high level of science and engineering expertise, exchanging it for financial support, internships and graduate employment[142]. Revisiting the partnerships with industries in the light of pandemic accelerated the development of products, led to sharing of data and boosted awareness about science-industry collaborations which in turn can contribute to enhancing a university's preparedness for future emergencies[143,144].

Alliances across the globe stepped up:
As the pandemic unfolded across each continent, it revealed the preparedness of hospitals, universities, businesses, supply chains and governments to rally together in search of critical solutions to a life-threatening condition. For example, Association of Pacific Rim Universities (APRU) developed a report to demonstrate the importance of early preparation to future health emergencies and to highlight the value of international networks and collaboration to accelerate an effective response to pandemics[145]. APRU's efforts included a database with biomedical technologies available through APRU member universities, strategies to educate society via science and media literacy courses and assembling a handbook of health crisis management tools and lessons that can be implemented during future emergencies. In doing so, the APRU battles the infodemic of COVID-19 related misinformation.

Universities serving the community:
The pandemic turned attention towards the importance of a university's service toward the community. For example, Oxbridge universities harnessed long-standing industry collaborations in the field of biotechnology and combined it with their research excellence to drive the development of the AstraZeneca vaccine[146]. Collaborative research led to the development of innovative technology for testing and vaccination and its translation into viable products, the implementation of which was greatly facilitated by a well-organised supply chain and fast

138. Tam, G., El-Azar, D. (2020) 3 ways the coronavirus pandemic could reshape education. World Economic Forum. https://www.weforum.org/agenda/2020/03/3-ways-coronavirus-is-reshaping-education-and-what-changes-might-be-here-to-stay/
139. Le, D., Giang, T., Ho, D. (2021). The impact of covid-19 pandemic on online learning in higher education: a Vietnamese case. Eur J Educ Res 10(4), 1683-1695.
140. Worldbank (2021) COVID-19 coronavirus response: Latin America and the Caribbean: Tertiary Education. https://thedocs.worldbank.org/en/doc/738931611934489480-0090022021/original/LACTEandCovidupdated.pdf
141. Azman, N., Sirat, M. (2021) University-industry collaboration: clash of two cultures. Retrieved from https://www.universityworldnews.com/post.php?story=2021102214425747
142. Goh, L. (2021) The future is now: Imagining university life in a post COVID-19 world. Retrieved from https://www.aurecongroup.com/thinking/thinking-papers/covid-19-reshaping-education-asia
143. COVID-19 validates science–industry collaboration (2021) Nature, 594. Retrieved from https://media.nature.com/original/magazine-assets/d41586-021-01580-0/d41586-021-01580-0.pdf
144. Ulrichsen, T. (2021) Innovating during a crisis: lessons for university-industry partnerships in a post-COVID world. University of Cambridge. Retrieved from https://www.cam.ac.uk/business-and-enterprise/innovating-during-a-crisis-lessons-for-university-industry-partnerships-in-a-post-covid-world
145. Sharma, Y. (2022) Preparing for pandemics: A region's universities step up. Retrieved from https://www.universityworldnews.com/post.php?story=20220427151622812
146. Astra Zeneca. https://www.astrazeneca.com/

feedback provided by hospitals and clinicians. The University of Cambridge, working closely with industry and community partners, developed rapid diagnostic tools, sharable ventilators, non-invasive breathing aids, and affordable ventilators to improve healthcare in their own country as well as in low-income countries[147]. Japan's medical research funding agency partnered with prominent Japanese universities, calling for combinations of interdisciplinary expertise from infectious diseases, virology, molecular genetics, genomic medicine, computational science, and the private sector to develop COVID-19 vaccine AnGes[148]. The global funding drive led by the Coalition for Epidemic Preparedness Innovations and GAVI, that consists of academics, senior executives of businesses, industries, philanthropic organisations and governments established in 2017, jointly worked on the COVAX initiative aimed at transparent procurement and distribution of COVID-19 vaccines[149].

Exchanging knowledge across boundaries:
The pandemic, despite its negative impact on the academic research agenda, prompted researchers to discuss their ideas online and boosted the participation rates of virtual conferences while limiting expenses for physical travel, arguably making academic conferences more inclusive. Collaborative challenge-teams among academic and medical institutions, governmental bodies, and industries aimed at addressing problems created by COVID-19 and building preparedness for the next zoonotic disease outbreak was announced and supported by top universities in the world. Among them, MIT launched the MIT COVID-19 Challenge in March 2020, comprising hackathons, discussions and challenges and creating meaningful connections among participating agencies[150]. Trinity Challenge[151] launched by the University of Cambridge in coalition with influential leaders from business, academia, and the social sector in September 2020, aimed to prepare the world to future health emergencies and to facilitate unique collaborations to improve outcomes.

Leveraging existing partnerships:
It is fair to say that universities which had already established partnerships with the industry, agencies, social organisations, and communities managed to face the new challenges with better resilience. For example, despite the scarcity of resources in Africa's Universities, the members of the African Research Universities Alliance (ARUA) demonstrated a strong scientific stance throughout the pandemic, leveraging local and international connections. Besides research on virus genome sequencing and contributions toward vaccine development, Noguchi Memorial Institute for Medical Research (Ghana) was the primary testing facility for COVID-19, accounting for over 80% of tests nationally. It has been joined by the University of Nairobi which, along with Kenya, was selected by the World Health Organisation as a testing site for vaccine trials. Virologists also consulted for national governments. ARUA Universities actively participated in tracking, modelling, and testing for the virus, provided voluntary medical support, and developed low-cost hand sanitisers, protective equipment, ventilators and treatment support while also contributing to community education and advocacy and promoting mental health[152]. The Chinese University of Hong Kong, jointly with the Collaborating Centre for Oxford University, launched the global web-based course "Public Health Principles in Disaster and Medical Humanitarian Response" in 2014 to build disaster resilience to health emergencies[153]. It allowed university administrators and more than 7,000 students from 150 countries to learn about building resilient experience, largely benefitting participants from developing countries.

More examples of collaborating universities can be found in section "Eight selected universities' resilient responses to COVID-19".

CONCLUSION:
Many universities worldwide took prompt action to explore resources for COVID-19-related research activities and partnered with governments and industries to identify optimal approaches to contain the pandemic. Interdisciplinary academic expertise nurtured at universities combined with financial and production facilities provided by industrial partners, and supporting policies from lawmakers, brought the science innovation to greater heights.

147. Ulrichsen, T. (2021) Put universities at the heart of an innovation-led recovery. Retrieved from https://www.cam.ac.uk/stories/BeyondThePandemic_innovation
148. Kakuchi, S. (2020) Vaccine research deepens university-industry collaboration. Retrieved from https://www.universityworldnews.com/post.php?story=20200915101722192
149. Gavi. The vaccine alliance. https://www.gavi.org/covax-facility
150. The MIT COVID-19 Challenge (2020). https://covid19challenge.mit.edu/
151. The Trinity Challenge (2020). https://thetrinitychallenge.org/
152. Abbey, E., Adu-Danso, E., Aryeetey, E. (2020) Research universities' multiple responses to COVID-19. https://www.universityworldnews.com/post.php?story=20200420091917110
153. Chan, E.Y.Y., Wong, C.S., Lo, E.S.K., Huang, Z. (2022). Applying New Technologies and Innovation in Hong Kong: Teaching Health Emergency and Disaster Risk Management (Health–EDRM) Using Massive Open Online Course to Enhance Resilience in Higher Educational Institutions. In: Izumi, T., Pal, I., Shaw, R. (eds) Safety and Resilience of Higher Educational Institutions. Disaster Risk Reduction. Springer, Singapore.

KEY FINDINGS

- nvolving multiple stakeholders such as government agencies, education providers, technology and service suppliers, network operators, non-governmental and public organisations, publishers and industries into finding viable solutions to the COVID-19 threats brought a multi-perspective and accelerated the development and implementation.
- Because of travel restrictions, conferences and meetings moved to virtual platforms, which increased the participation rate.
- Joint courses between academic institutions and industries gained momentum, offering the ability to merge hands-on experience and applicable skillsets, both in physical and virtual set-ups.

EXAMPLES OF ADAPTIVE PRACTICES

- Collaboration between governments, educational institutions and providers of various services facilitated the development and adoption of educational platforms, such as in Hong Kong, Chile and Vietnam.
- University partnerships with industries spurred the development of essential products, e.g., AstraZeneca and AnGes vaccines in the UK and Japan, respectively.
- Collaboration of medical and academic institutions accelerated building a robust response to the pandemic, e.g., Noguchi Memorial Institute for Medical Research (Ghana), University of Nairobi, and African Research Universities Alliance.
- Academic partnership enhanced by support of private companies and aimed at building preparedness for a next zoonotic disease outbreak catalysed global initiatives as MIT COVID-19 Challenge and Trinity Challenge.

Female Students, Researchers and Faculty Were Disproportionally Burdened

CHALLENGE:

The move to mandate remote work introduced additional challenges to academic staff with family-care responsibilities.

An increase in gender disparity:

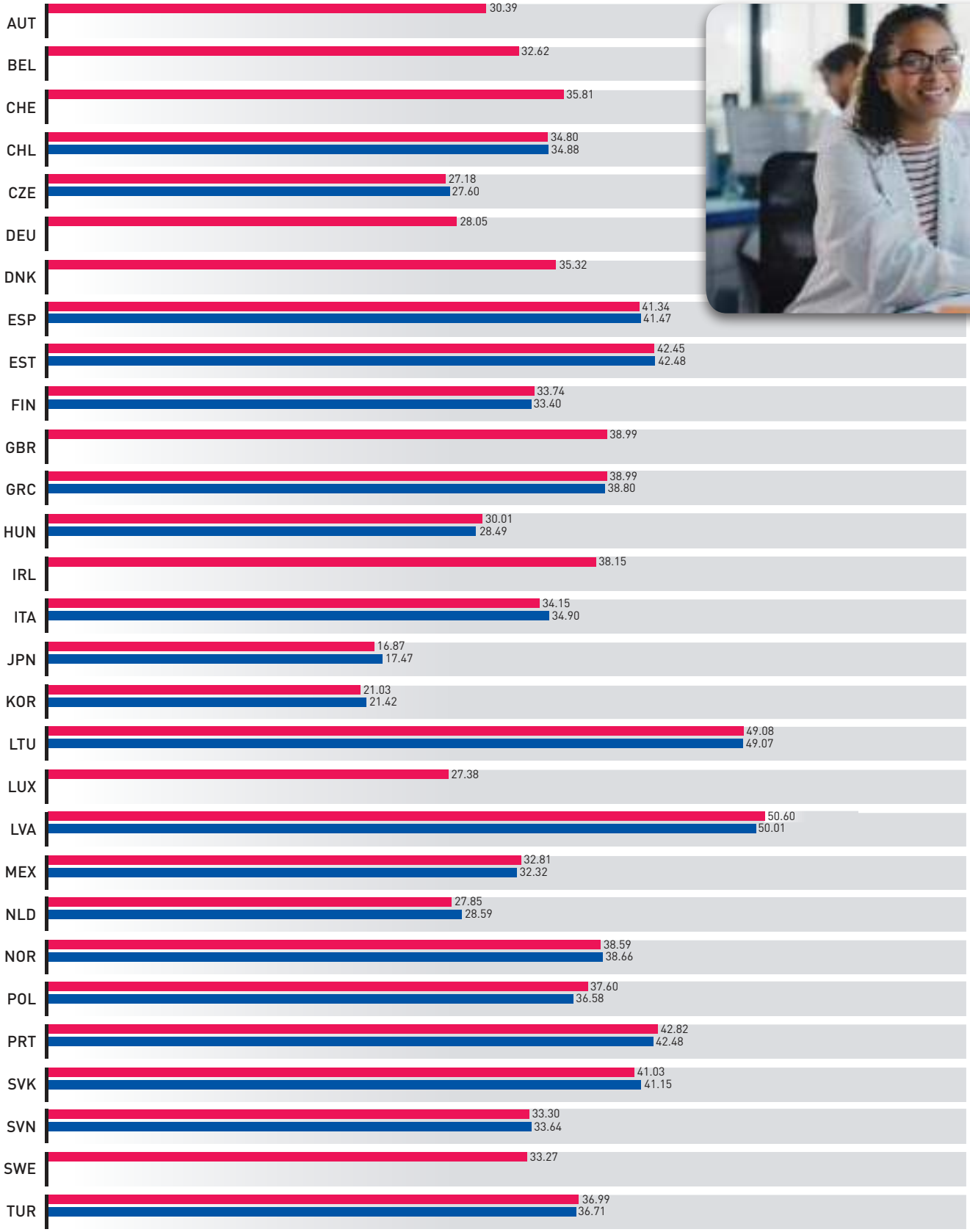
While COVID-19 caused disparities within the research enterprise[154], it has also exacerbated pre-existing inequalities. International undergraduate and graduate students had difficulties obtaining visas, graduate students had trouble finding and locking down post-doctorate positions and funding, and women still faced gender inequality in STEM research. COVID-19 deepened gender disparities for researchers with caregiver or childcare responsibilities. Female academics, disproportionally taking up caring responsibilities, fell behind their male peers at work[155].

Remote working nudged researchers to participate in writing manuscripts and reports which lead to an atypical surge in journal submissions. Data indicates that male researchers submitted more manuscripts than their female counterparts. The necessity of home schooling and eldercare required major adaptations to schedules, traditionally expected from women, which ultimately reinforced traditional gender roles across the world[156,157]. Myers et al.[158] conducted a survey of more than 4,500 Principal Investigators (PIs) in Europe and the US, and found that female scientists with laboratory-based research faced a significant decrease in research time.

Data analysis of publications on the preprint server arXiv demonstrated that while the number

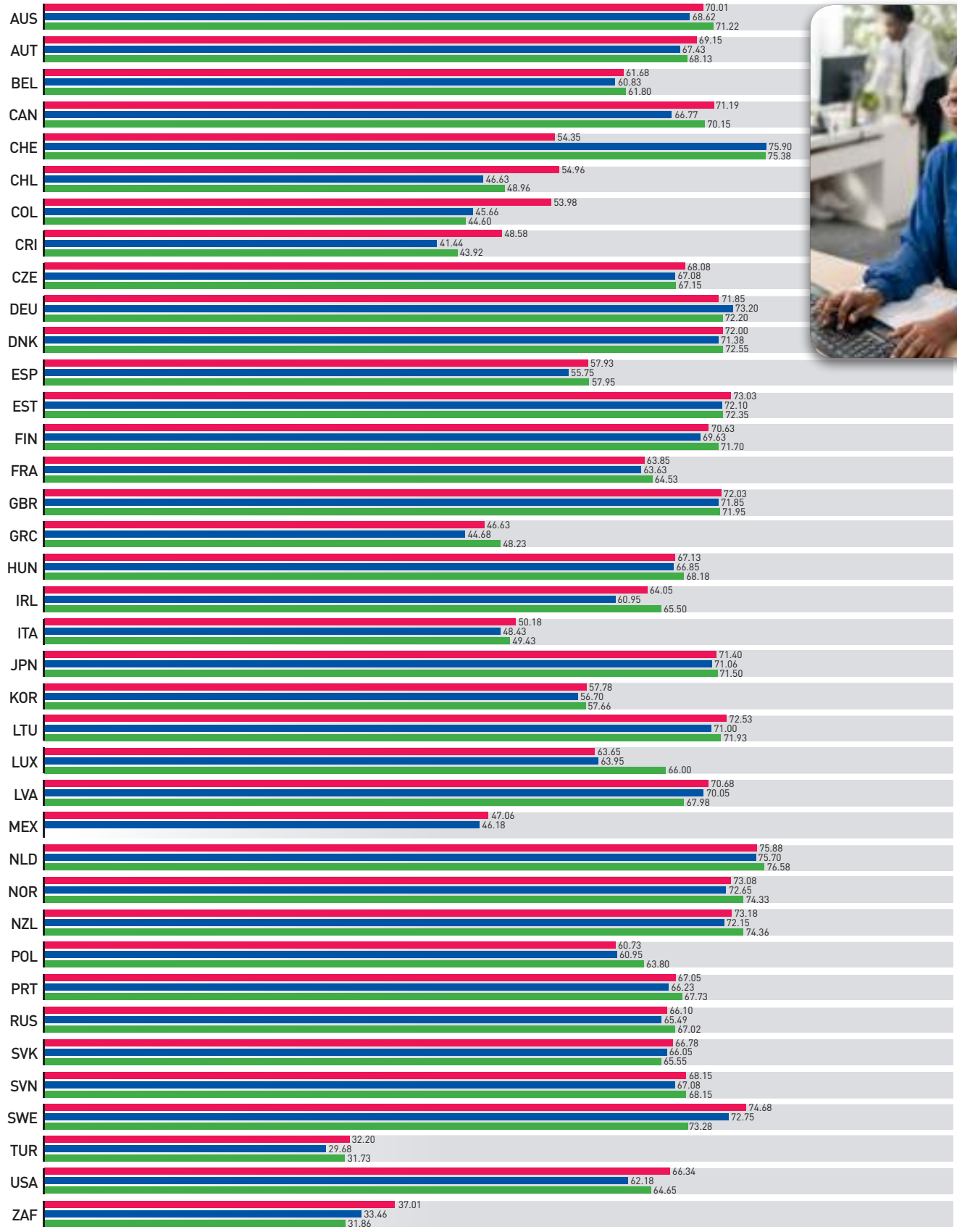
154. Radecki, J., Schonfeld, R. C. (2020). The Impacts of COVID-19 on the Research Enterprise: A Landscape Review.
155. Frederickson, M, (2020) COVID-19's gendered impact on academic productivity. Retrieved from https://github.com/drfreder/pandemic-pub-bias/blob/master/README.md
156. Collins, C. (2020) Productivity in a pandemic. Science, 369(6504), 603–603
157. Wenham, C., Smith, J., Davies, S., et al. (2020) Women are most affected by pandemics—Lessons from past outbreaks. Nature, 583, 194–198.
158. Myers, K. R., Tham, W. Y., Yin, Y., et al. (2020) Unequal effects of the COVID-19 pandemic on scientists. Nature Human Behaviour

WOMEN AMONG RESEARCHERS



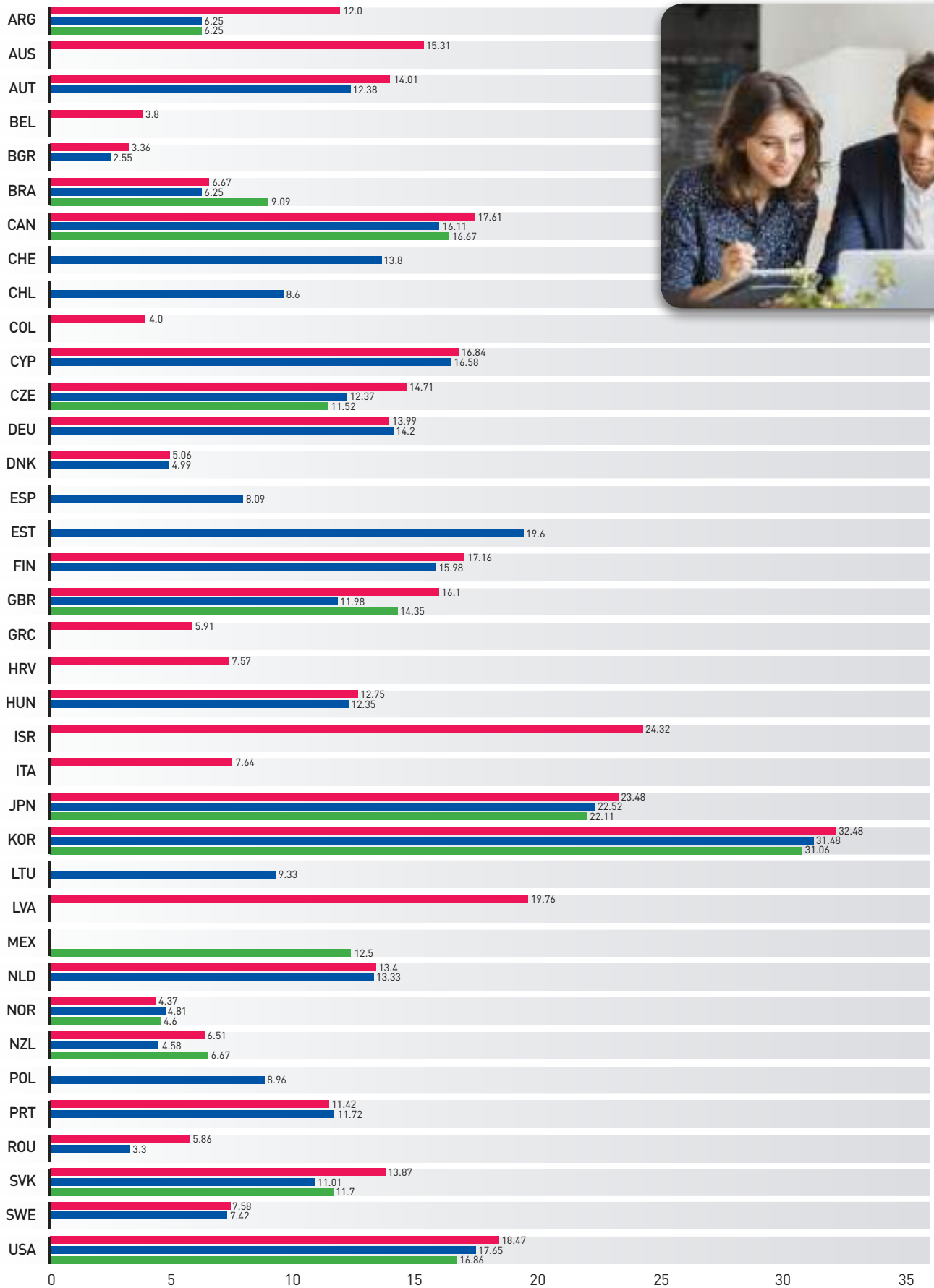
OECD (2022), Researchers (indicator). doi: 10.1787/20ddfb0f-en

EMPLOYMENT RATE WOMEN



OECD (2022), Employment rate (indicator). doi: 10.1787/1de68a9b-en

GENDER WAGE GAP



OECD (2022), Gender wage gap (indicator). doi: 10.1787/7cee77aa-en

of submissions was generally up for both males and females (compared to the same time period of March-April 2019), males published at a faster pace (2.7% increase for female authors vs 6.4% for male authors)[159]. However, it may be the consequence of the imposed remote work mandate that required more adaptations by female researchers during the early period of pandemic. The number of single authored papers increased 3.7% for females compared to 9.6% for males. Despite the recognised disadvantages of the methods applied to differentiate between male and female names, the results demonstrate a credible trend. Another analysis[160] confirmed the conclusions through a different methodology. It revealed that there was an overall decrease in publications of research projects led by female PI's. The largest dip was observed in medRxiv, which dropped from 35.9% women as first authors in December to 20.2% in April, 32.6% to 26.9% for women as middle authors, and 26.1% to 19.3% for women as last authors. Based on the analysis of publications in all Elsevier journals[161], it is also evident that females in first author positions (usually early career researchers) experienced a greater reduction in publications as compared to last authors who are typically the most senior researchers on a project. This observation suggests that the pandemic disproportionately affected younger female researchers at the beginning of their academic careers.

Women were also found more risk averse when jumping into new fields of study[162]. Female economists who worked on pandemic-related research made up only 12% of the authors despite their constant share of 20% publications in non-COVID-19-related research. Similar trends could be observed in the field of microbiology[163]. Compared to the total percentage of female PIs working in the areas of breast cancer (54.9%) and type 2 diabetes clinical trials (42.1%), only 27.8% of PI's led COVID-19-related projects worldwide. This indicates an underrepresentation of female researchers in COVID-19-related studies that could be caused by burden of care responsibilities that were imposed by lockdown.

Besides pandemic-induced care responsibilities that were taken up by women disproportionally, female faculty tended to carry out more teaching duties. Teaching was complicated by the sudden shift to online learning and required additional training and curriculum adjustments[164]. Findings also point towards disproportionality in women's access to research facilities and funding during health emergencies[165]. This inequality could have long standing consequences for universities, unless they adopt programmes to support female academics and provide COVID-19-resilient childcare as well as new ways to track, remunerate and appreciate academic performance decreasing the pressure to publish.

CONCLUSION:

Despite increased research output which resulted in more publications, the pandemic has deepened gender inequality in academia. The impact of the pandemic was worsened by family, child, or other care duties and responsibilities disproportionately taken up by and affecting young female researchers. Female researchers published at lower rates, were less eager to switch to COVID-19-related studies and faced the substantial drop in publications in Health Sciences (as confirmed by analysis of medRxiv).

KEY FINDINGS

- While the number of paper submissions increased for both male and female researchers during the COVID-19 pandemic, male authors published at a faster rate as compared for the period of March-April 2019 to March-April 2020.
- Early career, female researchers published less than their senior female counterparts.
- Compared to other research areas (as breast cancer and diabetes 2 type) where women comprised up to 55% of research project leaders, only 27.8% of project PIs were women for COVID-19-related projects.
- Female researchers were also less likely to shift their focus toward COVID-19-related research.

159. Viglione. G. (2020) Are women publishing less during the pandemic? Nature 581, 365-366
160. Vincent-Lamarre, P., et al. (2020) The decline of women's research production during the coronavirus pandemic. Retrieved from https://www.natureindex.com/news-blog/decline-women-scientist-research-publishing-production-coronavirus-pandemic
161. Squazzoni, F., Bravo, G., Grimaldo, F., et al. (2021) Only Second-Class Tickets for Women in the COVID-19 Race. A Study on Manuscript Submissions and Reviews in 2329 Elsevier Journals. PLoS ONE 16(10), e0257919.
162. Amano-Patiño, N., Faraglia, E., Giannitsarou, C., et al. (2020) Who is doing new research in the time of COVID-19? Not the female economists. https://voxeu.org/article/who-doing-new-research-time-covid-19-not-female-economists
163. Cevik, M., Haque, S. A., Manne-Goehler, J., et al. (2021) Gender disparities in coronavirus disease 2019 clinical trial leadership. Clinical Microbiology and Infection, 27(7), 1007-1010.
164. UNESCO (2020). COVID-19 Educational Disruption and Response. Retrieved from https://en.unesco.org/covid19/educationresponse/
165. Viglione, G. (2020) Are women publishing less during the pandemic? Nature 581, 365-366

Universities Countered Low Student Enrolment and Employment Rates by Reducing Tuition Fee and Offering Courses for Upskilling

CHALLENGES:

- Overall enrolment to American universities unexpectedly decreased during the pandemic, which is atypical during a recession. Black, Hispanic, Native American and female students were affected the most.
- The contracting job market complicated the recruitment of fresh graduates. Fewer entry level positions and limited support from academic institutions forced graduates to take jobs below their qualification, to agree to lower pay or to a part-time position.

Student enrolment decreased:

The number of students enrolled in the US' post-secondary institutions fell 2.7% in 2021, a figure greater than the previous year's decline of 2.5%. Compared with 2019, there were almost one million fewer students in the US colleges and universities[166]. While private institutions and colleges in the US observed a boost in admission rates by almost 4% in the spring of 2021, community colleges recorded an approximately 9% decrease, compared to previous year, as reported by National Student Clearinghouse Research Center[167]. Reduced enrolment in undergraduate studies is not typical for a recession period. During a job market contraction, people tend to pursue further education because of worsened job prospects. Instead, US colleges and universities observed a significant dip in freshman enrolment in the 2020 fall semester (21%), which was almost 3 times lower than the drop in enrolment for public colleges (8.1%)[168]. The intake of new international students dropped by a record of 43%[169] in the Fall 2020 semester but reversed to a 68% increase the first semester of the 2021-2022 academic year[170].

The enrolment of graduate students also suffered a big cut, with many doctoral programmes put on pause. For example, in the US alone, 108 doctoral programmes in the humanities and social sciences did not admit new students[171]. However, programmes in STEM continued to admit new students for the fall of 2021 supported by external research grants[172].

The enrolment rate of Black, Hispanic, Native American and female students plummeted even further, especially at community colleges, potentially widening future earning gaps. In contrast, the enrolment for graduate studies increased by approximately 5% in the period of 2019-2021 both for men and women[173].

Relief for students through reduced fees, loans and refunds:

In the fall semester of 2020, most students enrolled into distant or hybrid models of instruction. Therefore, it was anticipated that universities would reduce tuition fees as they were unable to provide an on-campus experience. However, most US universities[174,175] did not reduce their tuition fees.

166. Greenfield, N. (2022) One million fewer students enrolled since pandemic began. Retrieved from https://www.universityworldnews.com/post.php?story=20220117095802124
167. Fall 2021 Enrollment (As of October 21) (2021) National Student Clearinghouse Research Center. Retrieved from https://nscresearchcenter.org/stay-informed/
168. Term Enrollment Estimates (Fall 2020) (2020) National Student Clearinghouse Research Center. Retrieved from https://nscresearchcenter.org/wp-content/uploads/CTEE_Report_Fall_2020.pdf
169. Fall 2020 International Student Enrollment Snapshot (2020). Institute of International Education. Retrieved from https://opendoorsdata.org/wp-content/uploads/2020/11/Fall-2020-Snapshot-Report-Key-Findings.pdf.
170. Fall 2021 International Student Enrollment Snapshot (2021) Institute of International Education. Retrieved from https://www.iie.org/Research-and-Insights/Publications/Fall-2021-International-Student-Enrollment-Snapshot
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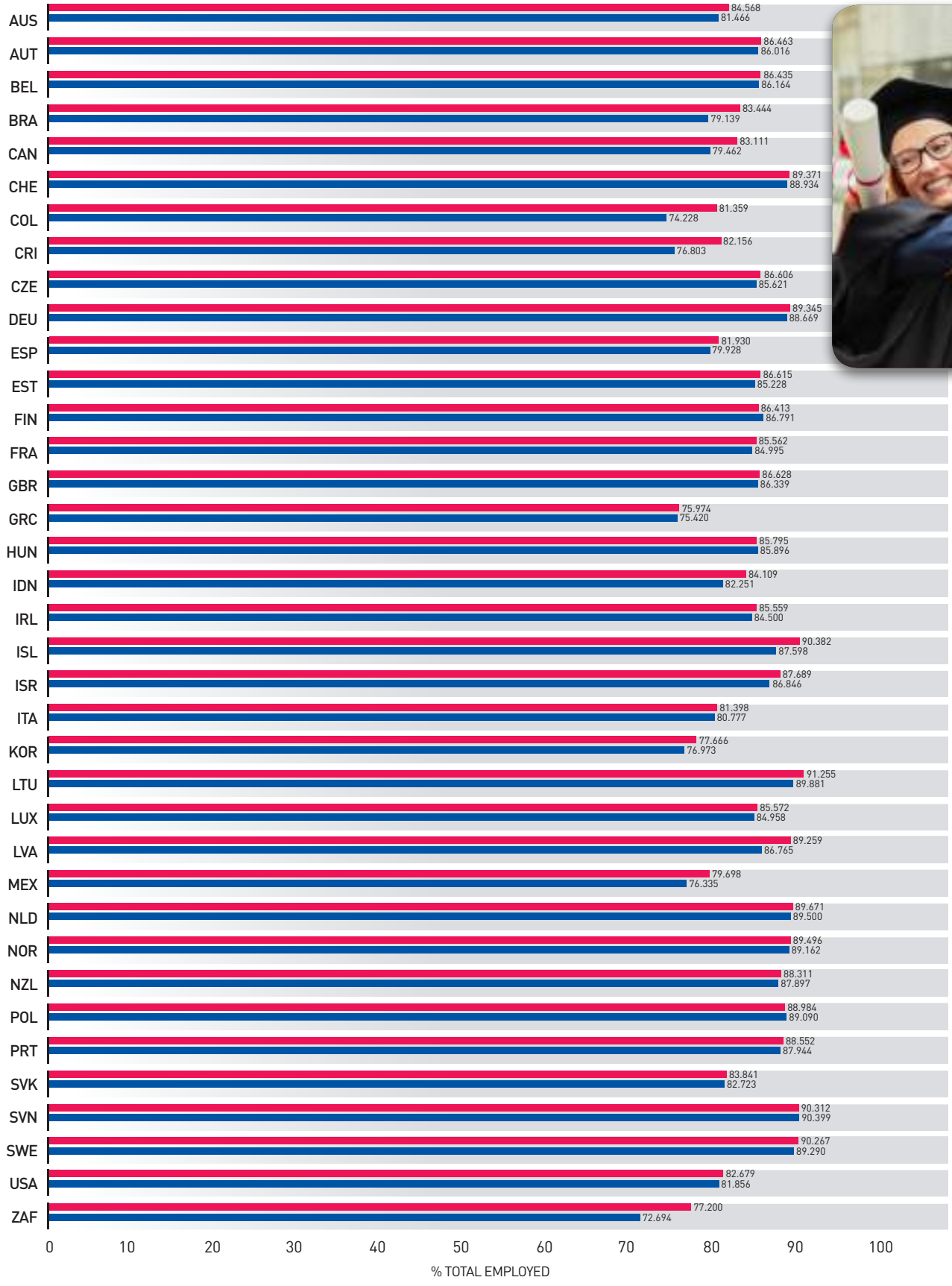
173. Fall 2021 Enrollment (As of October 21) (2021) National Student Clearinghouse Research Center. Retrieved from https://nscresearchcenter.org/stay-informed/
174. Keshner, J. (2020) Harvard and other major universities still charging full tuition as classes go online amid coronavirus outbreak. Retrieved from https://www.marketwatch.com/story/a-lot-of-colleges-simply-cant-afford-to-give-refunds-major-universities-holding-online-classes-due-to-coronavirus-are-still-charging-full-tuition-2020-03-13
175. Dickler, J. (2021) These colleges went to remote learning but hiked tuition anyway. CNBC. https://www.cnbc.com/2021/01/22/these-colleges-went-remote-but-raised-tuition-during-covid-pandemic.html

UNEMPLOYMENT RATE

EMPLOYMENT BY EDUCATION LEVEL: TERTIARY



Some universities faced low enrolment rates for the 2020 fall semester and offered a reduction in tuition fees of up to 20% in order to promote enrolment for 2021. For example, the University of Bologna extended its tuition fee deadline in early 2020[176]. Some of the US Colleges (like Dine and Gordon) offered reduction of tuition fees from 32% to 100%[177]. Tec de Monterrey supported 25,000 students with discounts and extensions for payment of tuition fees[178]. Some universities in the Philippines[179] and Thailand[180] offered refunding or reduction of tuition fees to ease the financial burden on students. These actions helped low-income students and students in need to continue their education and not drop out of university.

In the US, a strategic approach was taken to support universities during the COVID-19 pandemic that included rolling out the Coronavirus Aid, Relief and Economic Security (CARES) Act[181] and the COVID-19 Economic Relief Bill[182] which provided relief for students with loans or payment deferment and waived interest. Australia' Federal Education Ministry launched a $18 billion higher education relief package to support Australian students. It was partially used to provide short courses in nursing, teaching, health, information technology, and science for fresh graduates unable to secure job positions with the aim of retraining and equipping them with skills relevant to present market demands. This relief package helped balance the financial losses universities faced because of decreased enrolment of international students[183]. In Malaysia, universities tapped into national disaster relief funds to support students locked down on campus by distributing food and other necessities[184].

Sudden campus shutdowns led to unexpected consequences for many students with regard to their living arrangements. Some universities provided refunds for students' housing (as in Wales[185] and University of Nebraska–Lincoln[186]). More examples of financial relief provided by the universities can be found in section "Eight selected universities' resilient responses to COVID-19".

Diminished job prospects for graduates:
Fresh graduates have been impacted by a shrinking job market triggered by the pandemic and its related economic instability[187]. With fewer entry level academic positions being offered and in the absence of sufficient support from academic institutions, graduates were forced to take jobs below their qualification, to agree to lower pay or to get a part-time position[188]. This was aggravated by less social mobility and strict migration policies, which may ultimately impact the economy because it excluded young professionals from the international job market, according to a report launched by Institute for Fiscal Studies, UK, in April 2020[189] . A similar situation was observed for graduates in Australia[190], Europe[191] and the Asia-Pacific[192]. Only 18% of UK students graduating in 2020 reported to have secured jobs[193]. While recruitment of young

176. Zubascu, F. (2020) Mass closure of universities to prevent spread of COVID-19 in Europe. Retrieved from https://sciencebusiness.net/covid-19/news/mass-closure-universities-prevent-spread-covid-19-europe
177. Kerr, E., Wood, S. (2020) Colleges Giving Tuition Discounts. Retrieved from https://www.usnews.com/education/best-colleges/paying-for-college/articles/these-colleges-are-giving-tuition-discounts-this-fall
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182. National Conference of State Legislatures (2021) COVID-19 Economic Relief Bill. Retrieved from https://www.ncsl.org/ncsl-in-dc/publications-and-resources/covid-19-economic-relief-bill-stimulus.aspx
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185. Morgan, D. (2021) Covid: Students call for university accommodation refunds. Retrieved from https://www.bbc.com/news/uk-wales-55611637
186. University of Nebraska-Lincoln (2021) Housing to offer room, board refund to students. Retrieved from https://news.unl.edu/newsrooms/today/article/housing-to-offer-room-board-refund-to-students/
187. Institute of Student Employers (2020) Covid-19: Global impacts on graduate recruitment. Retrieved from https://cdn.ymaws.com/ise.org.uk/resource/collection/78C3D824-D17B-4316-8E69-15A054E40F1E/Covid-19-international_final.pdf
188. Today (2020) Covid-19: Surge in fresh grads in part-time, temporary jobs as full-time roles fall, but overall employment is up. Retrieved from https://www.todayonline.com/singapore/surge-fresh-grads-part-time-temporary-jobs-during-covid-19-their-overall-employment
189. Johnson, P. (2020) A bad time to graduate. Institute of Fiscal Studies. Retrieved from https://ifs.org.uk/publications/14816#:~:text=There%20is%20particularly%20robust%20evidence,ten%20years%20for%20unlucky%20graduates.
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192. Tan, M. (2021) 45% of Asia-Pacific undergrads, fresh grads rethinking career paths due to Covid-19: Poll. Retrieved from https://www.straitstimes.com/business/economy/nearly-half-of-asia-pac-undergrads-recent-grads-polled-rethinking-career-paths-in
193. Milkround team (2020) Coronavirus impact on Graduates securing jobs – just 18% of 2020 Graduates securing jobs compared to 60% in previous years. Retrieved from https://www.fenews.co.uk/employability/coronavirus-impact-on-graduates-securing-jobs-just-18-of-2020-graduates-securing-jobs-compared-to-60-in-previous-years/

graduates in the majority of wealthy countries is generally supported by governmental policies and universities, students in India, Afghanistan and Sri Lanka faced cancelled recruitment drives, layoffs and suspension of retraining programmes[194]. At the same time, 58% of Asia-Pacific respondents to a survey conducted by the CFA Institute[195] mentioned that despite the turmoil caused by COVID-19, they remain confident in their job prospects. Higher confidence was especially observed in the sectors of science, medicine, education and healthcare. The graduates who observed a lack of jobs in their preferred sector or who felt underqualified, considered upskilling and retraining. For example, 22% of Singapore's young graduates signed up for additional courses to strengthen their competitiveness and to explore interdisciplinary directions[196]. However, the introduction of upskilling programmes requires great efforts in coordination which slowed their fast enrolment rates in Latin America and some Caribbean countries[197].

CONCLUSION:

Help with tuition fees, reimbursement of on-campus accommodation and other forms of relief provided by institutions during the pandemic have a long-term impact on students who were able to continue their studies. Countries and universities that provided career support, retraining and upskilling opportunities for young graduates may have more access to a highly qualified and multi-skilled cohort of graduates.

KEY FINDINGS

- The enrolment to doctoral programmes in the humanities and social sciences in the US has significantly decreased due to suspended admissions.
- STEM degrees kept admitting new graduate students as they were supported mostly by external grants programmes.
- Some US universities, such as Harvard, Yale, Amherst, Brown and Tufts Universities did not reduce tuition fees, despite adopting virtual or hybrid modes of education.
- UK, Australia, Europe and some South Asian countries reported low employment rates for fresh graduates. Wealthier countries developed governmental initiatives to boost the employability of graduates.
- Students in India, Afghanistan and Sri Lanka faced cancelled recruitment drives, layoffs and suspension of retraining programmes.
- Fresh graduates in Australia and Singapore were confident about their job prospects, due to a wide offering of short courses for upskilling and retraining.
- Science, medicine, education and healthcare were reported as the most reliable industries with secure employment.

EXAMPLES OF ADAPTIVE PRACTICES

- The University of Bologna extended its tuition fee deadline in early 2020 to attract more students.
- Dine and Gordon Colleges (US) offered a reduction of tuition fees.
- Tec de Monterrey offered discounts and extensions for payment of tuition fees.
- Universities in the Philippines and Thailand refunded or reduced tuition fees to reduce the financial pressure on students.
- The COVID-19 Economic Relief Bill (US) provided relief for students with loans through payment deferment and waived interest.
- Malaysian universities distributed food and other necessities to support students locked down on their campus.
- The University of Wales and the University of Nebraska–Lincoln provided refunds for students' housing.
- Singapore universities participated in the SGUnited Jobs and Skills programme to help fresh graduates strengthen their competitiveness in the job market.

194. Niazi, S., De Alwis, D., Saif, S. K. (2020) COVID-19: South Asia graduates face bleak job prospects. Retrieved from https://www.universityworldnews.com/post.php?story=20200528155113136
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196. Ang, J. (2020) Institutes of higher learning will offer courses to graduates to boost employability during Covid-19 pandemic. Retrieved from https://www.straitstimes.com/singapore/education/institutes-of-higher-learning-will-offer-courses-to-graduates-to-boost
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Universities Highly Dependent on International Student Tuition Fees Faced Substantial Financial Losses

CHALLENGE:

Travel restrictions and national and state border closures affected the mobility of students and staff, constrained the admission of international students and consequently led to financial loss.

Closed borders:

Border closures and travel restrictions limited knowledge exchange, peer feedback, scientific collaboration, the conceptualisation of new research and technology transfer among academics globally due to interruption and suspension of international scholarly, scientific and technical conferences. While many conferences switched to hybrid or online means of execution, this is expected to have detrimental consequences for the rate of innovation and advancement of knowledge[198]. Many universities are reconsidering their current policies after realising they rely strongly on income from international students, suffered a loss of academic output because of border closures, had issues hiring talent because of visa restrictions, and are being confronted with the desire of their students to have the on-campus experience rather than distance learning alone[199].

Loss of international student tuition fees:

The example of closed borders in Australia demonstrated the loss of revenue that comes with losing international students. An AUD32 billion in revenue from students out of China, India and Malaysia in Australia alone, makes higher education the country's third largest export category[200]. Around 32% of total enrolments to Australian universities are international students (with more than 55% coming from the abovementioned countries). The number of foreign students increased by 77% in 2014-2019, making up 24% of all university revenue. Border closure contributed a lot to an overall drop in annual revenue (4.9% in 2020) and a projected drop in 5.5% in 2021[201]. However, in August 2021, it was reported that overall operating surplus for a sector was about 2%[202]. For example, the University of Sydney is dependent on international students for 39% of its income, placing it second in Australia after the Federation University Australia. While the shrink in international student enrolled at Australian universities was quite small in 2020 (5.1% compared to the 2019 peak), the enrolment of new international students fell by 23%. A similar trend was observed in New Zealand, with a 30% drop in international students compared to pre-pandemic 2019, where international student education comprised of the largest source of export earnings for New Zealand (US$3.5 billion per year)[203].

It was expected that universities with a strong reliance on international students would be hit the most by COVID-19 as their flexibility to switch to attracting more local students is limited. For example, if one in five international students don't enrol during COVID-19, Australian universities that fuel jobs, local industry and research risk losing their income[204]. Australian universities also expect their revenue to decrease by A$16 billion in 2023 (compared to the peak revenue of A$40 billion).

198. Ha, E. S., Hong, J.Y., Lim, S., et al. (2021). The Impact of SARS-CoV-2 (COVID-19) Pandemic on International Dermatology Conferences in 2020. Front Med.
199. Basken, P. (2021) Canadian colleges seek to reduce reliance on China and India. Retrieved from https://timeshighereducation.us17.list-manage.com/track/click?u=8e09f1eff5b946b07c80f522d&id=2e53e9b389&e=13d2b25547
200. Goh, L. (2021) The future is now: Imagining university life in a post COVID-19 world. Retrieved from https://www.aurecongroup.com/thinking/thinking-papers/covid-19-reshaping-education-asia
201. Yezdani, O. (2021) Which universities are best placed financially to weather COVID? Retrieved from https://theconversation.com/which-universities-are-best-placed-financially-to-weather-covid-154079
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204. Department of Education, Skills and Employment, Australian Government (2020)2019 Higher Education Providers Finance Tables. Retrieved from https://www.dese.gov.au/higher-education-publications/resources/2019-higher-education-providers-finance-tables

Strict border rules in the US led to a dramatic decrease in international student enrolment, which numbered over one million still in 2019-2020. This number fell by 16% at the beginning of the 2020-2021 academic year, when new international student enrolments dropping by 43%[205]. Moreover in 2020, nearly 40,000 students deferred enrolment to a future term[206]. With 5.5% of international students enrolled in American Institutes of Higher Education in 2019[207], they remain a key revenue source for universities. Preventing the mobility of international students might result in a $3 billion loss of revenue for the US, according to NAFSA 2020 Financial Impact Survey[208]. Furthermore, universities also had to temporarily cease study abroad programmes and international internships. The UK faced similar problems being highly dependent on Chinese postgraduate students (38% of the non-EU postgraduate cohort as of 2018), but it managed to continue attracting prospective international students in 2020, sometimes even by organising charter flights from host countries[210]. However, the visa restrictions started to gradually be lifted in most countries for those commencing studies in the Fall of 2021. The effect of restricted mobility, imposed by COVID-19, is not so pronounced for countries that are less reliant on inbound international students, such as Vietnam, Sri Lanka, China, India, and others[211].

A fresh look at student exchange programmes:
Apart from universities facing the consequences of losing international students in the short-term and long-term, other international organisations which support students' mobility and exchanges as well as auxiliary services (apartment rentals, hospitality industry) may experience financial losses[212]. Joint initiatives by a network of universities such as the International Student Exchange Programme, University Mobility in Asia and the Pacific, and Europe's Erasmus+ have a long-standing tradition in building connections and providing funding to promote students' mobility and exchange. The APRU Virtual Student Exchange Program offered knowledge and experience exchange for students working on multiple projects, varying from investigating the Galapagos to depicting Hong Kong via historical paintings and photos[213]. They enable access to educational materials without the oversight of a single university and support building networks between universities. These efforts could become an underlying stone in expediting new types of academic cooperation that ensure affordability, high quality and worldwide access to programmes. For example, Ohio University arranged overseas offices - global gateways - with China, India and Brazil to promote the enrolment of local students and to host networking sessions[214]. The University of Arizona offers its students a dual degree with universities in China, India, Peru etc. via its micro-campus networks[215]. Tsinghua University offered joint programmes with Tokyo Institute of Technology, Aachen University, and HEC Paris among others[216].

CONCLUSION:
Institutes of Higher Education with a large share of international students faced a decrease in enrolment and financial loss, because of closed borders and visa restrictions during the pandemic. Promoting multilateral collaborative programmes to expand the network of partnering institutions and countries (via global gateway campuses, international branch campuses, joint programmes and colleges[217] and overseas liaison offices[218]) enables universities to continue recruitment of prospective international students and expanding the boundaries of affordable international education.

205. Institute of International Education (2021) Fall International Enrollments Snapshot Reports. Retrieved from https://www.iie.org/Research-and-Insights/Open-Doors/Fall-International-Enrollments-Snapshot-Reports
206. Times Higher Education (2021) Covid-19 travel update: US to allow international students to return in autumn. Retrieved from https://www.timeshighereducation.com/student/advice/covid-19-travel-update-us-allow-international-students-return-autumn
207. Institute of International Education (2019) Number of International Students in the United States Hits All-Time High. Retrieved from https://www.iie.org/Why-IIE/Announcements/2019/11/Number-of-International-Students-in-the-United-States-Hits-All-Time-High
208. NAFSA (2020) Financial Impact Survey. Retrieved from https://www.nafsa.org/sites/default/files/media/document/2020-financial-impact-survey.pdf
209. Higher Education Policy Institute (2020) Landmark report on the last decade of UK postgraduate education provides an indication of what is to come after Covid-19. Retrieved from https://www.hepi.ac.uk/2020/05/14/landmark-report-on-the-last-decade-of-uk-postgraduate-education-provides-an-indication-of-what-is-to-come-after-covid-19/
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215. The University of Arizona Microcampus. Retrieved from https://microcampus.arizona.edu/
216. Tsinghua University Joint Programmes. Retrieved from https://www.tsinghua.edu.cn/en/Admissions/Graduate1/Joint_Programs.htm
217. The Duke-NUS Medical School. Retrieved from https://www.duke-nus.edu.sg/about/about-duke-nus/the-duke-nus-story
218. Tec de Monterrey Internationalization. Retrieved from https://tec.mx/en/internationalization

KEY FINDINGS

- Enrolment of new international students to universities in the US, Australia, and New Zealand dropped during COVID-19.
- Universities highly dependent on international students faced financial losses. Reduced influx of international students also led to less demand for room rental, food and beverage as well as social and entertainment facilities in the campus vicinity.
- Organisations that support students' mobility and exchanges also recorded financial losses.

EXAMPLES OF BEST PRACTICES

- The UK, being highly dependent on postgraduate students from China, managed to continue attracting prospective international students in 2020, sometimes even by organising charter flights from other countries.
- Ohio University organised a virtual global gateway with China, India and Brazil to promote the students' enrolment and to host networking sessions.
- The University of Arizona offered its students a dual degree with universities such as in China, India and Peru via its micro-campus networks[219].
- Tsinghua University offered joint programmes with Tokyo Institute of Technology, Aachen University and HEC Paris, among others.

CONCLUSION

The abrupt emergence of COVID-19 and its spread across the continents called for fast transformative action. Institutes of Higher Education as large independent bodies of research and education with diverse communities and a variety of research and educational programmes encountered their own unique problems during the pandemic.

Fearing reduced national funding and facing a decrease in students' enrolment and tuition fees, universities managed to diversify their income by leveraging support from donors and industry and establishing additional endowment funds. With the aim to support ongoing research, a majority of grant agencies eased their regulations, extended the deadlines, and provided financial support for PhD students and researchers who were affected by imposed lockdowns. Governmental agencies worldwide coordinated the provision of R&D funding for research on COVID-19-related topics, in order to expedite search for solutions to the problems brought by pandemic. At the same time, financial support for other research projects was cut back.

With campuses and academic buildings shut down, classes had to move online almost overnight. Prior investments in creating infrastructure and online education platforms paid off in this transition as universities with the platforms and systems in place could more or less 'flip the switch' to online education. Universities that had fallen behind in transforming their education suffered from insufficient pedagogical and technical training of staff, limited access to laptops and Internet connectivity, and students' low satisfaction. Online learning questioned the necessity and fit-for-purpose of spaces on campus. Students preferred to interact in small groups which points towards creating more spaces for collaborative interactive learning experiences. Besides, raised awareness about health and safety requirements beg reconsideration of the buildings' designs, with preference given to better ventilation, safe distancing and open-air spaces.

The lack of income encountered by Institutes of Higher Education brought about hiring freezes which were often combined with decreases in faculty salary. Limited job opportunities for early career researchers could have a long-term impact on research excellence as it can divert them from academic career paths. However, the recruitment continued for projects related to COVID-19. Researchers reprofiled their projects to cater to the challenges posed by the pandemic. It led to a significant increase in publications, specifically in open data repositories. The availability of data facilitated knowledge exchange, spurred collaborative research, and expedited solutioning. Specifically, partnerships developed among academics, industry representatives, start-ups, governmental agencies,

219. The University of Arizona Microcampus. Retrieved from https://microcampus.arizona.edu/

and other stakeholders empowered a well-rounded and resourceful approach to challenges posed by the pandemic. The en masse switch to videoconferencing tools facilitated discussions and allowed for wider and more inclusive international participation.

The pandemic also generated and deepened social disparities. Female researchers (and early career researchers in particular) had lower publication rates, triggered by the necessity of child- and family-care during worldwide lockdowns. In light of the worsening global economic situation, universities considered tuition fee reductions after students had questioned the appropriateness of full tuition fees in the absence of physical on-campus experiences. These fee reductions also served to aid students from low-income families. Graduated students were confronted with a lack of opportunities on the job market. In response, universities put in effort to assist them with employment opportunities by arranging upskilling and training courses, internships at partnering industries or short-term university fellowships.

In general, whilst the majority of universities experienced similar threats to research and the delivery of education imposed by COVID-19, each took different steps to shape a unique response. These steps were grounded in the context-specific features of a country's national government's response to COVID-19, the university's financial regulations, localised needs for adapting the educational system and delivery platforms, campus safety measures, and support available for the wellbeing of the community.

Universities therefore had unique approaches to mitigating the challenges posed by the pandemic because of their unique expertise, the local context and government, and financial regulations. The overview of findings concerning university resilience in light of COVID-19 in this report suggests that there are three broad trends of the conditions that needed to be in place for universities to bounce back swiftly during the pandemic:

1. **Recent investment in digital transformation:** Universities that had recently invested in upgrading their technological infrastructure, digitised their back office and work-processes, and had undergone or started a transformation toward blended or digital learning facilities were able to switch over to online learning almost overnight. This allowed these universities to focus their resources on offering training in technical and online pedagogical skills for faculty, implementing incoming mandatory measures, finding ways to keep research projects going and paying attention to the well-being of staff and students.

2. **Leveraging globalisation and international partnerships:** Universities that had strong existing international partnerships with other institutes of higher education, industry and government, were able to not only react more quickly but made extraordinary progress for instance in partnering with industry to develop vaccines, treatments or tests, finding external sources of funding to keep research going in light of reduced income, and creating alternative ways to engage international students through networks of partner-universities, dual and joint international degrees or international branch campuses.

3. **Preparing for the worst and the best:** From previous crises such as the financial crisis of 2008, the expectation was that during the pandemic, national funding for research would be reduced, and student enrolment would increase because of bad job prospects. However, during the pandemic, the opposite trend happened. Governments felt the urgency to find solutions to mitigate the negative impact of COVID-19, thereby increasing research funding. Students confronted with care-tasks and the inability to travel and experience campus life displayed a greater disposition than initially expected to terminate their studies or decide not to enrol altogether, leading to reduced student numbers. Universities, fearing a reduction in funding for research, undertook means to secure external funding. At the same time, income from student tuition fees dropped.

While this is a first analysis based on data that has been made available during the pandemic, more research is needed to build a detailed picture of how universities worldwide fared during the pandemic. There is little information publicly available on universities in Africa, the Middle East, the Caucasus, the Balkan states, and South and Central America to create a comprehensive picture of universities' resilience globally during COVID-19. As such, this report is centred around North America, Europe, and Southeast Asia. In the following section, we offer profiles of 8 universities worldwide and give insight into how each fared during the pandemic, detailing their unique approaches, best adaptative practices and the impact on their research and educational performance.

EIGHT SELECTED UNIVERSITIES' RESILIENT RESPONSES TO COVID-19

The COVID-19 pandemic swept across the globe, testing economic, political, and social systems and institutions on their resilience. The ability to withstand shocks, quickly rebalance available resources and transform ideas to action defines a resilient system. Based on the analysis of literature from the previous section of this report, we may identify the prevailing practices among universities. For example, China, which faced the first shock wave of the pandemic, managed to react robustly and roll out strict shutdowns of campuses swiftly, limiting exposure to the virus. Australia and Singapore smoothly deployed safety measures and thoughtfully planned alternative research activities. The US and European universities provided solid financial support for students and staff. South American and African universities extensively leveraged existing and proactively created new partnerships to accelerate solving the challenges caused by pandemic. Besides, universities around the world remained active in generating research output, especially for studies related to COVID-19.

In this section, we aim to assess the approaches that eight selected universities from all continents took to counter threats brought by the pandemic and to adjust to the fast-evolving situation. For this purpose, Nanyang Technological University (Singapore), Tsinghua University (China), Chinese University of Hong Kong (Hong Kong), University of Sydney (Australia), University of Rwanda (Rwanda), Monterrey Institute of Technology and Higher Education (Mexico), Stanford University (US), and Swiss Federal Institute of Technology in Zurich (Switzerland) were selected for case-study analysis. These universities demonstrated a growth in academic performance over the years 2018-2021 and demonstrated a high number of collaborative research and education projects. To gain insight into practices and strategies that the selected universities deployed, we have analysed publicly available annual and financial reports of the universities, as well as databases curated by the Times Higher Education and Quacquarelli Symonds to assess the dynamics of universities' rankings and their underlying causes. We have investigated universities' research performance using Elsevier's SciVal analytics as well as sourced data through consultancy and advisory agencies, local and international media outlets as well as universities' press releases to survey public opinion on the performance of universities.

To draw a detailed picture of each university's performance during the pandemic and its preparedness for the crisis, we looked into the measures that universities employed to mitigate the impact of COVID-19, specifically to create a COVID-19-resistant campus, ensure continuity of research, develop a COVID-19-shaped education system, and protect the wellbeing of their staff and students. We also assessed the impact of scientific collaboration and international partnerships on the universities' ability to adjust to the changing circumstances brought about by COVID-19.

UNIVERSITY OF SYDNEY

The University of Sydney is a public research university founded in 1850 on the principle of giving everyone the opportunity to realise their potential through education and still holds that belief just as strongly today. It is Australia's first university and is regarded as one of the world's leading universities. Currently ranked 4th in the world, and 1st in Australia, for graduate employability, the University of Sydney is also consistently placed among the top 50 universities in the world[220].

With a constantly evolving undergraduate curriculum, state-of-the-art facilities, world-class teaching and learning and a vibrant campus life, it is a place where students can attain widely recognised and respected qualifications. The University offers Australia's broadest range of disciplines, and its research focuses on finding solutions to society's biggest challenges. With more than 400 areas of study to choose from, students have the flexibility to follow their interests, broaden their skills, and pursue internship and global exchange opportunities.

The University has invested more than $1.5 billion in multidisciplinary initiatives in the last decade to enable academic staff to improve the lives of people in Australia and around the world. Research, supported by more than 90 research centres, is driven by the big picture. From combating the world's deadliest diseases to inventing tiny devices that make a super-sized difference to computing, the University of Sydney excels in innovative collaboration.

Photo by Ethan Shi on Unsplash

220. QS World University Rankings 2020. https://www.topuniversities.com/university-rankings/world-university-rankings/2020

Developing a COVID-19-Shaped Education and Research Environment[221]

The University's response to anticipated challenges caused by the COVID-19 pandemic included implementing a programme of austerity measures to ensure financial viability and security. A reduction in Commonwealth financial support has continued to intensify financial pressure on the University and has made it necessary for the University to broaden alternate revenue sources, such as full fee-paying students. The Commonwealth operating support for the University of Sydney increased by $11.2 million in 2020 while research revenue decreased by $14.6 million, largely due to a reduction in spending on government research projects. Grants provided by the New South Wales (NSW) Government increased by 0.3% to $33.1 million in 2020. Investment income decreased in 2020 by $145 million, mainly due to decreased returns in the global markets.

- A $46 million decrease in operating expenses was driven by a $41.6 million decrease in travel and related staff development and training.
- A $33.2 million decrease was noticed in the use of externally sourced service providers.
- A $3.3 million decrease in teaching and research grants and scholarships, resulting from decreased funding for specific research projects, was observed.
- A $74.4 million increase in salaries (3.8% compared to 2019) and payroll on-costs (9.4%) could be partially explained by imposed freeze on HR recruitment, voluntary redundancy offered to eligible staff and a significant reduction in Senior Management's salary (equivalent of 20% of their annual base salary).

The 2020 operating revenue of $2,644.4 million was $95.9 million less than in 2019. Despite the uncertainty of the global pandemic, enrolment numbers for overseas full fee-paying students remained strong in 2020, and this cohort represented 74.7% of total student income, which increased 1.7% in 2020. The total enrolment of students at the University of Sydney in 2020 decreased 4.3% as compared to 2019, while the admission of international students decreased 8.4%. The enrolment of international and local students into postgraduate studies in 2020 was almost equal, while the same distribution within the undergraduate student population was 69% local undergraduate students vs 31% international students. Combined totals of academic and general staff positions increased 2.5% in 2020 as compared in 2019.

Philanthropic gifts from donors and University's friends had a significant impact on advancing research and supporting students during the pandemic. Overall, philanthropic income increased 51% to $120.2 million in 2020 from 2019.

- $20 million from the ClearBridge Foundation to fund a new Professorial Chair, a laboratory, and vital supporting resources to drive immunotherapy research.
- $12.9 million from the BHP Foundation to support the Brain and Mind Centre's suicide prevention work that followed an earlier gift from the Foundation of $1.08 million to establish a COVID-19 Mental Health Response Independent Think Tank.
- $12.5 million from Aligning Science Across Parkinson's initiative for new research into the genetic basis of Parkinson's disease.
- $3.9 million from the Lang Walker Family Foundation to establish Australia's first Professorial Chair in head and neck cancer surgery.
- $1 million raised by WIRES from the general public, in response to the 2020 bushfires, to support the Koala Health Hub over three years.
- More than $350,000 in smaller donations for student bursary fund.
- $35 million from the Wakil family foundation were donated to launch The Susan Wakil Building, which brings multiple health disciplines to work out of the same location.

The University of Sydney acted efficiently in responding to the emergence of COVID-19 as a global issue and formed a Crisis Management Committee consisting of the Academic Response Team and the Operational Response Team (management of ongoing business operations ensuring maintenance, cleanliness and safety of buildings).

- In March 2020, University teaching and learning

221. 2020 Annual Report (2020) The University of Sydney. https://www.sydney.edu.au/about-us/vision-and-values/annual-report.html

went mostly online, and the campus was largely closed, with only limited staff continuing to work on campus. Critical research activities continued, and some teaching activities continued face to face.

- Addressing the needs of international students who were located outside Australia, the University of Australia established necessary ICT capabilities including fast network access from China and allowing students abroad to continue accessing University resources and to study remotely.
- Students reported high level of satisfaction, according to an internal survey, in efficient delivery of online courses, as of Semester 1, 2020.
- Instead of completely shutting down the campus and delaying the start of Semester 2, 2020, the University of Sydney offered small group classes back on campus which led to higher-than-expected student enrolments.

The university invested in the development of postgraduate education and micro-credentials, to maintain revenue from postgraduate students. In 2020, the Industry and Community Project Units (ICPUs) attracted more than 1,000 additional student enrolments in comparison to 2019, with 1,829 students completing 45 projects. ICPUs were introduced into the curriculum of Bachelor of Advanced Studies to support a high level of skills' transferability to industry.

The university continued to have the largest outbound student mobility programme in Australia. The university's mobility percentage was 36% in 2020 (a 35% increase from 2019). Outbound mobility has been significantly impacted by COVID-19 and the border closures. However, the university recommitted to reach the goal for 50% of students to have a global mobility experience as part of their award course once international travel resumes, with an enhanced focus on increasing participation of underrepresented cohorts.

A total of $48 million was awarded by the Australian Research Council (ARC) for 98 grants and fellowships in 2020, including:

- 7 Future Fellowships – $6.6 million
- 1 Australian Laureate Fellowship – $3.4 million
- 24 Discovery Early Career Researcher Awards, the highest success rate in the Group of Eight universities – $10.1 million
- 49 Discovery Projects – $21 million
- 5 Linkage Projects – $1.4 million
- 6 Special Research Initiative for Australian Society, History and Culture grants, the highest number of awards for any university – $1.3 million
- 6 Linkage Infrastructure, Equipment and Facilities grants – $4.2 million

A total of $92.1 million was awarded by the National Health and Medical Research Council (NHMRC) for 77 grants and scholarships in 2020, including:

- 41 Investigator Grants
- 21 Ideas Grants – $19 million
- 3 NHMRC Centres of Research Excellence (Better Outcomes in Coronary Artery Disease; Prevention of Fall-related Injuries; Integrated Community Care for People with Complex Multi-morbidities) – $7.5 million
- 3 Partnership Projects – $3.4 million
- 1 NHMRC-EU Joint Programme on Neurodegenerative Disease Research Grant – $0.5 million
- 7 Postgraduate Scholarships – $0.7 million
- 1 NHMRC-NIHR Collaborative Research Grant – $0.2 million

Between September 2019 and October 2020 more than $52 million was awarded by the Medical Research Future Fund (MRFF) for 26 projects, including:

- $3 million for a clinical trial to test the safety and effectiveness of a novel DNA-based COVID-19 vaccine that can be delivered needle free.
- $5 million for brain cancer rehabilitation, assessment and intervention.
- $4 million towards eliminating antibiotic resistant tuberculosis in the Pacific region.
- $7 million for applied AI research to support clinical excellence in neurological diseases and youth mental health care.
- $9.5 million for multiple congenital heart disease research projects, including a heart fitness intervention trial.

Experts at the University of Sydney were at the forefront of COVID-19 research in 2020, from understanding its genetic origins to assisting recovery efforts.

- Evolutionary virologist Professor Edward Holmes was named 2020 NSW Scientist of the Year for fundamental insights into the origin and spread of SARS-CoV-2.
- Sydney start-up DetectED-X developed a world-first online image-based tool for healthcare workers to improve COVID-19 diagnosis.
- The Snow Medical Research Foundation gifted $5.5 million to a national consortium of Australia's two NHMRC Centres of Research Excellence focused on emerging infectious diseases and pandemic response: the Centre of Research Excellence in Emerging Infectious Diseases (University of Sydney) and the Australian Partnership for Preparedness Research on Infectious Diseases Emergencies (University of Melbourne) to fund COVID-19 projects.
- The University led a Department of Foreign Affairs and Trade-funded programme to prevent the spread of zoonotic diseases in Southeast Asia and the Pacific.

Throughout 2020, 31 commercial deals closed, and another 52 prospects remained in the commercial pipeline of the University of Sydney. 151 invention disclosures were submitted during 2020. 7 University spin-off companies were created, of which the University continues to hold equity in 5. Sydney Knowledge Hub continued to grow, attracting 17 start-up and early-stage companies to its premises – half of which are led by University of Sydney researchers. The hub helped attract more than $3 million of additional research income from member collaborations. Despite the pandemic, the University of Sydney developed and launched its Sustainability Strategy in August 2020. It was marked by rolling out solar-powered benches embedded with revolutionary battery technology developed at the University of Sydney. Besides, in early 2020 more than 100 researchers came together and worked closely with the New South Wales and Commonwealth governments and community partners to help Australians understand the scale of the devastation of the 2019-20 bushfire season, and to elaborate a roadmap for building a more climate-resilient future. Moreover, the University of Sydney demonstrated commitment to developing sustainable solutions by supporting the translation of fundamental science to commercialisation in fields that address environmental problems: plastic-waste recycling and safe, scalable storage for renewable energy.

Creating a COVID-19-Resilient Campus[222]

The university re-aligned its priorities to immediately cater to the needs of staff moving from campus to remote work and to assess consequences for available resources and staff. The Flexible Working Arrangements Policy was updated and communicated to staff. Immediate support for those requiring workplace adjustments at home, particularly for those living with disability, was provided. From March to July 2020 a three-stage roadmap was developed to execute gradual relaxation of physical distancing restrictions and a return to safe face-to-face activities.

Semester 2, 2020 was delayed for three weeks to allow staff more time to make necessary preparations (including preparing courses for on-campus and remote delivery) and to give students time to enrol in courses and units of study, which resulted in recruiting of additional students. Face-to-face teaching resumed in small groups for selected courses and marked a gradual relaxation of safety restrictions.

Pursuing Scientific Collaboration Amidst Closed Borders

The Office of Global Engagement hosted almost 50 virtual events in 2020, with more than 28,000 attendees from leading universities across North America, Europe and Asia. The key focus of the University of Sydney's strategic vision was developing partnerships with universities in China and India. The research and education efforts were chiefly driven by the Suzhou Centre in China and the China Studies Centre. The university launched a new Industry and Community Project with the Tata Group in India to explore renewable energy; signed a Memorandum of Understanding with the Chinese Agricultural University and a Strategic Partnership Agreement with Sun Yat-Sen University; Sydney Law School and Jindal Global Law School in India entered into a dual degree pathway agreement.

31 University of Sydney scientists were on Clarivate Analytics' 2021 list of Highly Cited Researchers (an increase from 24 in 2020), ranking among the top

222. 2020 Annual Report (2020) The University of Sydney. https://www.sydney.edu.au/about-us/vision-and-values/annual-report.html

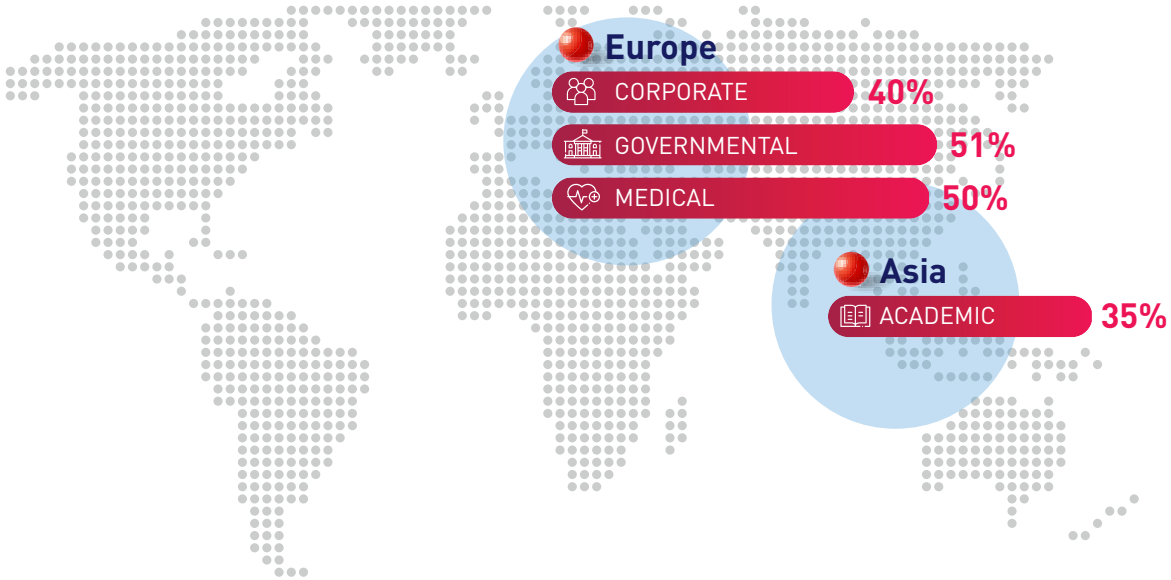
1% of global scientists in their field by citations. The following analysis of research performance of the University of Sydney was conducted in SciVal, for the publications during 2018-2021 period. It is accurate as of January 2022.

- The overall number of publications was 51,618 over the period of 2018-2021 (an 8% increase since 2018). A total of 18% of publications were in the top 10% most cited publications worldwide (the Australia average was 17%); 40% of publications were in the top 10% journals (the Australia average was 38%); 5.7% of publications were in the top 1% journals.
- 54.8% of University of Sydney's research collaboration measured by the number of joint publications was international (the Australia average was 57.7%); 30.3% was national collaboration, 8% was only institutional, and 7% of publications had single authorship. Academic-Corporate collaboration of University of Sydney was 3.6% (the Australia average was 3.3%).
- The number of joint publications with institutions worldwide was 38,061 (4,280 collaborating institutions, 35% in Asia); the biggest collaborators measured by the number of joint publications were University of New South Wales, Australia (a 12% increase in joint publications since 2018); University of Melbourne, Australia (a 17% increase); Macquarie University, Australia (a 2% increase); University of Queensland, Australia (a 28% increase); University of Western Australia, Australia (a 8% drop). In terms of number of joint publications with academic institutions, Australian institutes of higher education remained main partners of the University of Sydney.
- The number of joint publications with corporates worldwide was 1,802 (540 institutions, 40% in Europe); the biggest collaborators measured by the number of joint publications were Johnson & Johnson, US (a 75% increase in joint publications since 2018); AstraZeneca, UK (a 70% increase); Merck, US (a 25% increase); Novartis, Switzerland (a 8% drop); Novo Nordisk A/S, Denmark (a 7% increase). During the pandemic, the University of

Location of the Majority of Collaborating Institutions

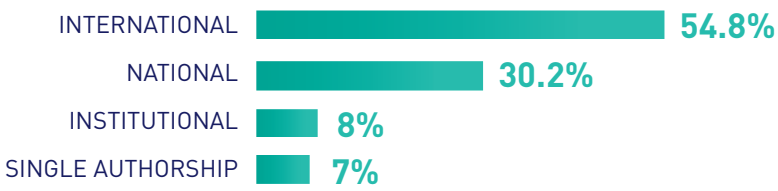
Measured by the Number of Collaborating Institutions

PERCENTAGE OF THE COLLABORATING INSTITUTIONS LOCATED IN CERTAIN CONTINENT



Type of Collaboration

Measured by the Number of Joint Publications



Sydney significantly increased collaboration with vaccine developers and manufacturers.

- The number of joint publications with government agencies worldwide was 8,486 (1,037 institutions, 51% in Europe); the biggest collaborators measured by the number of joint publications were CNRS, France (a 1% drop in joint publications since 2018); Chinese Academy of Sciences, China (a 4% drop); CSIRO, Australia (a 3% drop); Institut National de la Santé et de la Recherche Médicale, France (a 37% increase); New South Wales Ministry of Health, Australia (a 70% increase). During the pandemic, the University of Sydney significantly increased its collaboration with the Ministry of Health, which indicates University's active participation in enhancing national healthcare.
- The number of joint publications with medical entities worldwide was 13,674 (1,176 institutions, 50% in Europe); the biggest collaborators were Royal Prince Alfred Hospital (a 25% increase in joint publications since 2018); Royal North Shore Hospital (a 18% increase), Westmead Hospital (a 41% increase), Concord Repatriation General Hospital (a 33% drop), and St. Vincent's Hospital Sydney (a 17% increase), all from Australia. The University of Sydney strengthened partnerships with national hospitals, suggesting its active involvement in improving national healthcare.
- 500 publications were on COVID-19-related topics (0.46% of total number of University of Sydney's publications over the 2018-2021 period).

Protecting the Wellbeing of the University of Sydney Community in the COVID-19 Pandemic[223]

The University rescoped its student experience programme in 2020 due to the imposed temporary cut in funds undertaken as part of a university-wide COVID-19 response and supported:

- An orientation framework that articulates a university-wide vision for and coordinated approach to orientation,
- A 'China Connect' initiative to provide pre-arrival programmes, modules, welcome webinars and a WeChat mini programme online for students unable to join at the Australian campus,
- Development of a virtual clubs and societies portal, vSydney, to allow students to connect and engage with student clubs and societies in the absence of the traditional in-person Welcome Week activities,
- A pilot for a social connectivity project, UsydMates, to help students make meaningful connections with their peers and develop a sense of belonging to the University in a digital space.

Supporting students' wellbeing, social and mental health has been a critical focus for the entirety of the University's COVID-19 response.

- A digital online orientation and Welcome Week for Semester 2, 2020 accommodated the needs of students located interstate and overseas.
- A new peer support programme was launched in March 2020 to offer online consultation to students with a team of 17 trained peer support advisors fluent in English and Mandarin.
- The University partnered with Batyr programmes in May 2020 to support mental health and promote help-seeking and offered five online programmes for students experiencing stress during the exam period.
- A new partnership was also formalised in October with TalkCampus, a 24/7 global mental health online support service that provides students with a global network of peer support.

The University of Sydney introduced legal changes to its rules to accommodate the needs of the community.

- Iterations of the Retail and Other Commercial Leases (COVID-19) Regulation 2020 were introduced which gave a number of the University's tenants the right to negotiate rent relief and prevented the University from taking certain prescribed action, including terminating occupancy arrangements on the basis of non-payment of rent.
- The Higher Education Support Act 2003 was amended in October 2020 to reflect changes to university funding announced by the Australian Government in June through its Job-ready Graduates Package. These changes provide additional Commonwealth-supported places for Australian students and targeted support to increase the numbers of students from Aboriginal backgrounds.

223. 2020 Annual Report (2020) The University of Sydney. https://www.sydney.edu.au/about-us/vision-and-values/annual-report.html

- From 1 January 2021 students will pay less tuition in fields where the Government expects strong future employment growth but up to 113% more payment in disciplines considered less likely to prepare students for the future labour market.

Available wellbeing resources were quickly adapted to meet the context of the pandemic response. There was a high level of engagement – 1,552 staff participated in 16 webinars triggered by pandemic anxiety and uncertainty.
In 2020, the Student Affairs Unit received a total of 1,282 complaints – approximately double the number of complaints in 2019, spanning across 3 themes: inadequate guidance and/or support following the switch to the remote learning environment; technical malfunctions relating to online invigilation and/or examinations; eligibility for the University's financial relief packages, particularly the Travel Ban Hardship Fund. There was a total of 130 complaints during 2020, which was a 6% decrease compared to 2019.

Conclusion

The University of Sydney acted swiftly to respond to the emergence of the COVID-19 virus, forming its pandemic response team in January 2020 and moving towards remote work and study by sending staff and students to home from March 2020, in accordance with instructions from Australia's health authorities. To prepare for the anticipated financial fallout followed by a significant decline in student enrolment due to border closures, a long-standing financial shock recovery plan was developed that required major savings in infrastructure spending, repairs and maintenance, research equipment, travel and recruitment of new staff. However, the University's financial position improved due to higher than projected enrolments, especially at its overseas China-based campus. The pandemic hadn't disrupted continuing work on the Sydney Operating Model (intranet). The University was able to improve the student experience and take a leading role in promoting freedom of speech and academic freedom. The University acquired a visionary approach to planning the future, by launching the University's first sustainability strategy, developing a post-Bachelor and micro-credential education programmes to cater to the needs for lifelong learning in a changing marketplace. The University of Sydney continued to progress in research excellence, deepening the collaboration with vaccine manufacturers (J&J and AstraZeneca) as well as extending partnerships with medical and academic partners in Australia. Despite the pandemic, the University of Sydney advanced the launch of the Sydney Biomedical Accelerator and improved its campus infrastructure by opening the Susan Wakil Health Building, which houses multiple health disciplines.

TSINGHUA UNIVERSITY

Since China opened up to the world in 1978, Tsinghua University has developed at a breath-taking pace into a comprehensive research university. At present, the university has 21 schools and 59 departments with faculties in science, engineering, humanities, law, medicine, history, philosophy, economics, management, education, and art. International students can choose from more than 60 undergraduate programmes, 100 master's programmes, and 90 doctoral programmes, among which 21 master's programmes and 8 doctoral programmes are delivered fully in English.

With the motto of "Self-discipline and Social Commitment" and the spirit of "Actions Speak Louder Than Words", Tsinghua University is committed to cultivating global citizens who will thrive in today's world and become tomorrow's leaders. Through the pursuit of education and research at the highest level of excellence, Tsinghua is developing innovative solutions that will help solve pressing problems in China and the world. Tsinghua has partnerships with over 290 universities and institutes worldwide and has established over 100 exchange programmes and 50 dual and double degree programmes with world-renowned institutions.

Through the Center for Global Competency Development, Tsinghua prepares its students with 'global competence' – the capability to learn, work and live with others from different cultural backgrounds to embrace opportunities and challenges in the future. Tsinghua has a focus on creating programmes that blend global leadership development with a strong foundation in interdisciplinary thinking, including the renowned Schwarzman Scholars programme, the Global Innovation eXchange programme, and programmes at the Tsinghua Shenzhen International Graduate School. With an emphasis on entrepreneurship and innovation, on-campus platforms such as the x-lab, iCenter, and Future Laboratory help the students gain valuable skills across disciplines.

By the end of 2020, there were 53,302 registered students (31% undergraduate, 37% postgraduate, 32% doctoral candidates, among whom 6% were international students).

Photo by Vincent Lin on Unsplash

Developing a COVID-19-Shaped Education and Research Environment[224, 225]

Tsinghua University had 610 projects approved by the National Natural Science Foundation of China, 30 projects of National Key Research and Development Projects, 6 National Science and Technology Major Projects, and 197 projects approved by the National Development and Reform Commission, the Ministry of Industry and Information Technology, the Ministry of Construction, or the Ministry of Environmental Protection, as well as 102 projects supported by a wide range of Beijing's Science and Technology plans and funds, with the total contract value exceeding 2.3 billion RMB in 2020. Additionally, the faculty in the Humanities departments received 969 new topics with a total funding of 300 million RMB, including 10 National Social Science key projects. As of April 2021, there were 450 university-level scientific research institutions running at Tsinghua University.

- University established two new entities, the Department of Astronomy and the School of Vehicle and Mobility, during the pandemic.
- Tsinghua launched the Institute for Intelligent Society Governance that will provide theoretical support for research into AI's impact on social governance.
- Tsinghua opened the International Innovation Center of Tsinghua University in Shanghai to support China's national strategy of integrated development of the Yangtze River Delta.

The level of scientific pursuit by Tsinghua researchers remained high during the pandemic. The University launched a pilot research programme for virus prevention, and 70 research project applications have been received by the end of 2020, with some of the projects mentioned below:

- Neutralising antibodies from convalescent patients were isolated, developing safe and effective treatments for COVID-19, that also led to better understanding of human adaptive immunity to SARS-CoV-2.
- The crystal structure of COVID-19 RBD in complex with receptor ACE2 was resolved, providing structural insight, and identifying the precise target for vaccine design.
- COVID-19 replication transcription machinery was discovered.
- Respiratory virus nucleic acid kit for the detection of six types of respiratory virus simultaneously within 1.5 hours was developed.
- Robotic Systems for unmanned rapid temperature detection, a medical robot to patrol isolation wards, and nanofiber materials for reusable masks were designed to contain the spread of SARS-CoV-2.
- COVID-19 intelligent medical systems, big data, Internet of Things, and AI technology were employed to create an integrated solution for community network monitoring for virus control. From this, intelligent medical technologies and post-hospital patient monitoring were designed. Tsinghua donated developed systems to the Wuhan Municipal Government and medical institutions, which was put into use at 8 COVID-19 hospitals, 1 cabin hospital, and 72 quarantine zones.

For Spring semester 2020, Tsinghua made a full transition from traditional classes to real-time online interactive courses, and a total of 4,471 courses were delivered online. Since Fall Semester 2020, Tsinghua implemented hybrid teaching and learning mode. It offered a total of 4,353 courses, involving 2,784 teachers and 176,912 students.

Tsinghua University invested in development of online education platforms during past decade:

- Having deployed the online MOOC platform XuetangX in 2013, in 2020 Tsinghua launched its international version to continue promoting the quality and inclusiveness of education during the outbreak of COVID-19.
- Online lectures were broadcasted live on various media platforms, both in Chinese and English, including Tsinghua's own online teaching platform "Rain Classroom", a smart learning tool for live broadcast lessons, recorded videos, interactions, and to collect learning data, implemented in 2016.
- In 2021, Tsinghua launched 'Global Hybrid Classroom', within which students from both Tsinghua and leading overseas universities will have the opportunity to take online courses provided by different universities and obtain credits.

224. Tsinghua University (2020) Online Education Weekly Newsletters. https://www.tsinghua.edu.cn/kyzten/Information/2.htm
225. Tsinghua University. Research Feature. https://www.tsinghua.edu.cn/en/Research/Research_Feature.htm

In 2021, Tsinghua launched seven Global Open Courses, including "Carbon Neutrality: Why and How the World is Addressing Climate Change", "China's Approach to Poverty Eradication", "Future Automobiles" etc., to equip students with skills to solve society's most pressing needs.

To ensure the teaching excellency that meets Tsinghua's standards during the COVID-19 control and prevention period, Tsinghua has also expanded its social engagement by offering over 1,600 courses free of charge to the public and has provided 147 "Clone Classes" to several universities in Wuhan and other areas through XuetangX.

In June 2021, Tsinghua University held a virtual exhibition for graduating art students to cater to 282 undergraduates and 167 postgraduates from the Academy of Arts and Design[226].

In 2020, there were 7,700 Tsinghua graduates, with 3,800 entering the job market, including 400 undergraduates and 3,400 postgraduates. With support from Tsinghua Career Development Centre, more than half of job market entrants are already employed. Career fairs for job seeking students were arranged by Tsinghua University:

- In 2020, Tsinghua held online career fair in collaboration with universities in Hubei province, to support graduates in the epidemic-stricken area.
- In 2021 hybrid career fair was accompanied by more than 300 companies from 22 provinces and cities across China, including the China Aerospace Science & Industry Corporation, the China North Industries Group Corporation Limited, the China Electronics Technology Group Corporation Limited, Meituan, ZTE Corporation and SenseTime.

Pursuing Scientific Collaboration Amidst Closed Borders[227, 228]

In 2021, Tsinghua University hosted the Global Forum of University Presidents bringing together university leaders from all around the world to discuss the future development of higher education and the evolving mission of universities during periods of rapid change; and the 9th World Peace Forum with the theme "International Security Cooperation in the Post-Pandemic Era—Upholding and Practicing Multilateralism", among the biggest events.

Tsinghua University continued the pursuit of excellence in international collaboration.

- In March 2020, the establishment of the Chunfeng Foundation - International Scientific Research Support Programme to promote international joint scientific research collaboration on COVID-19, was announced.
- China Vanke Co. Ltd. Jointly with Tsinghua University established the Vanke School of Public Health to enhance China's capabilities in preventative medicine, comprehensive healthcare, big data in healthcare, and public health policy and management.
- Tsinghua University and Bosch announced a five-year research collaboration agreement in the field of artificial intelligence by establishing a Tsinghua-Bosch Joint Research Center for Machine Learning on 6th March 2020.

53 Tsinghua University scientists were on Clarivate Analytics' 2021 list of Highly Cited Researchers (same as in 2020), ranking among the top 1% of global scientists in their field by citations. The following analysis of Tsinghua University's research performance was conducted in SciVal, for the publications during the 2018-2021 period. It is accurate as of January 2022.

- The overall number of publications was 69,984 over the 2018-2021 period (a 7.6% increase since 2018). A total of 16.7% of publications were in the top 10% most cited publications worldwide (the China average was 10.9%); 47% of publications were in the top 10% journals (the China average was 28.5%); 6.5% of publications were in the top 1% journals.

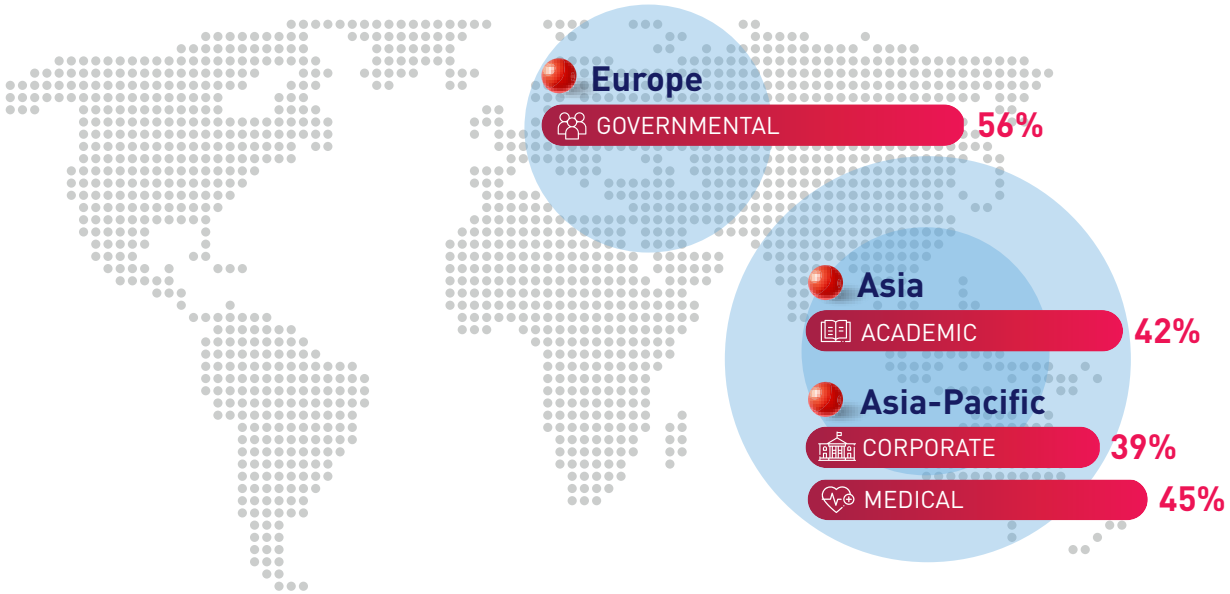
226. Tsinghua University. Tsinghua launches virtual exhibition for graduating art students. https://www.tsinghua.edu.cn/en/info/1245/5335.htm
227. Tsinghua University (2020) Online Education Weekly Newsletters. https://www.tsinghua.edu.cn/kyzten/Information/2.htm
228. Tsinghua University. Research Feature. https://www.tsinghua.edu.cn/en/Research/Research_Feature.htm

- 33.3% of Tsinghua University's research collaboration measured by the number of joint publications was international (the China average was 23%); 48.9% was only national collaboration, 16.2% was only institutional; and 1.5% had single authorship. Academic-corporate collaboration of Tsinghua University was 7.4% (the China average was 2.7%).
- The number of joint publications with institutions worldwide was 47,832 (3,712 institutions, 42% in Asia); the biggest collaborators measured by the number of joint publications were Peking University, China (a 31% increase in joint publications since 2018); University of Chinese Academy of Sciences, China (a 21% increase); Beijing Institute of Technology, China (a 7% increase); Beihang University, China (a 25% drop); Tianjin University, China (a 9% increase). In terms of the number of joint publications with academic institutions, China's institutes of higher education remained main partners of the Tsinghua University.
- The number of joint publications with corporates worldwide was 4,496 (446 partners, 39% in the Asia Pacific); the biggest collaborators measured by the number of joint publications were Collaborative Innovation Center of Geospatial Technology, China (a 55% drop in joint publications); State Grid Corporation of China, China (an 8% increase); Microsoft, US (a 55% increase); China Electric Power Research Institute, China (a 5% increase); Huawei Technologies Co., Ltd., China (a 24% increase). Main corporate collaborators of the Tsinghua University were China-based companies. At the same time, more joint publications were produced in collaboration with Microsoft.
- The number of joint publications with government agencies worldwide was 19,333 (820 partners, 56% in Europe); the biggest collaborators measured by the number of joint publications were Chinese Academy of Sciences, China (a 4% increase in joint publications since 2018); Ministry of Education, China (a 5% drop); National Climate Center, China

Location of the Majority of Collaborating Institutions

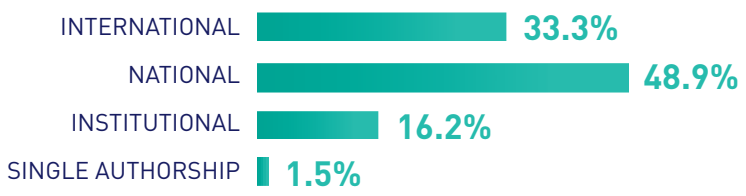
Measured by the Number of Collaborating Institutions

PERCENTAGE OF THE COLLABORATING INSTITUTIONS LOCATED IN CERTAIN CONTINENT



Type of Collaboration

Measured by the Number of Joint Publications



(a 147% increase); CNRS, France (a 12% drop); National Institute for Nuclear Physics, Italy (a 15% drop). Remarkably, the Tsinghua University significantly increased its research on climate in collaboration with National Climate Center.

- The number of joint publications with medical institutions worldwide was 1,379 (361 partners, 45% in Asia Pacific); the biggest collaborators measured by the number of joint publications were Beijing Tsinghua Chang Gung Hospital, China (a 134% increase in joint publications since 2018); General Hospital of People's Liberation Army, China (a 98% increase); Mayo Clinic Rochester, US (an 8% increase); Nanfang Hospital, China (no change); Beijing Institute of Ophthalmology, China (a 25% drop). The COVID-19 pandemic accelerated the Tsinghua University's research collaboration with national hospitals, which indicates the University's active participation in enhancing national healthcare.
- 299 publications were on COVID-19-related topics (0.4% from total number of Tsinghua University's publications over the 2018-2021 period).

Besides being affected by COVID-19 pandemic, Tsinghua University experiences the threat of climate change, which makes it actively invest in the development of green technologies to promote environmental sustainability, well-aligned with the state course. Tsinghua is a member of a Low Carbon Energy University Alliance, together with the University of Cambridge and the Massachusetts Institute of Technology. During the pandemic, Tsinghua established the Institute for Carbon Neutrality to pioneer research of fundamental theories and key technologies connected with carbon neutrality.

Protecting the Wellbeing of the Tsinghua Community in the COVID-19 Pandemic

Tsinghua University promotes social responsibility of its graduates by providing the opportunities to explore philanthropy and volunteering.

- The fifth World Philanthropy Forum on "Developing a Sustainable Philanthropy Ecosystem", co-hosted by Tsinghua University, the University of Hong Kong and the Chinese University of Hong Kong, was held at Tsinghua University.
- Tsinghua's Department of Psychology launched the COVID-19 Psychological First Aid programme, providing professional training and guidance to 3,000 volunteers, promoting psychology basics to 720,000 frontline medical workers and citizens, and offering one-on-one counselling for almost 5,500 people.
- Thousands of Tsinghua volunteers, both online and offline, organised a diverse range of activities to promote prevention of virus spread and support hygiene education.
- Tsinghua-affiliated hospitals dispatched medical workers to hospitals and quarantine zones in Wuhan and Beijing.
- Academic support was extended to the children of frontline medical staff, and high school seniors from underprivileged backgrounds.
- Members of the Tsinghua community donated blood to support patients affected by COVID-19.

Conclusion

The Tsinghua campus was preserved from major outbreaks because restrictive policies mandated by the government in order to contain the virus were followed diligently. Despite having a high number of students, Tsinghua managed to coordinate the communication in a way that ensured strict compliance with the safety measures.

Prior investments Tsinghua University made for the development of a multilingual educational platform facilitated the overnight transition of teaching and learning to online, marking the beginning of a profound transformation of their teaching methodology. Moreover, Tsinghua has shouldered additional responsibilities by expanding its social engagement. Through XuetangX, the university's online education platform, it offered over 1,900 free-of-charge courses to the public. It also provided "Clone Classes" to several universities in Wuhan. Tsinghua University actively enhanced collaborations with China-based industry, academic, government, and medical partners resulting in an increased number of joint publications. New partnerships with international counterparts were also forged that expanded University's international outlook, not disrupted by pandemic.

The forward-thinking focus employed by Tsinghua University (implementing educational modules in environmental sustainability, establishing an Institute for Carbon Neutrality, its active representation in Low Carbon Energy University Alliance) facilitates its preparedness for the next global emergency. Tsinghua's resourcefulness enabled support, both in manpower and protective equipment, provided to local and Hubei hospitals.

However, it remains unclear if staff and students received any financial support during the pandemic, and whether there were salary cuts, hiring freezes and deductions or raises in tuition fees. It is also unclear how the University supported international students and whether there were changes in the influx of international students. Information about the way the campus and buildings were adapted to deal with the emerging situation is also unavailable. Besides, China's position in zero-tolerance approach to COVID-19 that led to its lockdown in 2022 is yet to be evaluated in terms of the long-term impact it may impose on the universities.

ETH ZURICH

ETH Zurich (Swiss Federal Institute of Technology in Zürich) is a public research university in the city of Zürich, Switzerland. Founded by the Swiss Federal Government in 1854 with the stated mission to educate engineers and scientists, the school focuses primarily on science, technology, engineering, and mathematics. It is part of the Swiss Federal Department of Economic Affairs, Education and Research. With 16 departments that conduct solid academic fundamental and interdisciplinary research in subjects ranging from architecture and biology to chemistry and physics, the university makes a notable contribution to the global science and technology industry.

The successful combination of a cosmopolitan outlook with national roots made ETH Zurich one of the driving forces behind industrialisation in Switzerland as it brought the necessary expertise into the country, trained technical specialists and helped set up ground-breaking national research infrastructures.

In more recent times, global developments such as computer-assisted data processing and the far-reaching consequences of globalisation have placed ever-increasing demands on universities. ETH Zurich reacts to these new challenges by creating flexible organisational structures: new research units and programmes have emerged and the research itself is becoming more and more integrated and interdisciplinary. The long-standing tradition of ETH Zurich, combined with its ability to constantly adapt to new requirements, has brought great success to the university.

Photo by Thimo Pedersen on Unsplash

Developing a COVID-19-Shaped Education and Research Environment[229]

Financial resilience, diversified revenue, and specific investment models facilitated the university's financial adaptation to the pandemic.

- Under the current investment strategy of ETH Zurich, the funds that come from sources other than public funding can be invested only in low-risk stocks or bonds, to ensure constant income.
- In 2020, operating revenue amounted to CHF 1835 million (Swiss francs) (an increase of 3% compared to 2019), despite a drop in federal contribution to CHF 1,293 million (a decrease of 0.5% compared to 2019). Revenue from donations and bequests was up to CHF 120 million (an increase of 86%).
- In 2020, the rise in revenue reflects the higher number of students and doctoral candidates (an increase of 5.5% as compared to 2019), moderate increase in tuition fees (increase by CHF 3 million to CHF 31 million), decrease in scholarships (particularly to bachelor's students) and decrease in grants to students and doctoral students (CHF 2 million).
- Expenses for salaries and wages increased by 4%. This was related to the rise in average full-time equivalents (FTE) (by 3%) and pay adjustments in the reporting period.
- Other operating expenses fell by 2% and reflect, amongst other factors, opposing effects of the COVID-19 pandemic: while out-of-pocket expenses dropped sharply due to restricted mobility, for example, expenses for IT equipment rose due to the transition from in-person to remote teaching, and expenses were also incurred for the necessary safety protocols and measures.

A remarkable aspect in the times of pandemic and global decrease in student admissions has been the continuing rise in student applications (increase by 6% overall) and slightly increased number of staff due to rise of FTE.

- A rise (5%) in foreign students but the drop in the number of exchange students (by 33%) was observed.
- In 2020, the number of staff grew by 2.6% compared to the previous year. ETH employs 6,400 scientific and 3,000 technical and administrative staff.
- Staff turnover rate in 2020 (5.9%) is commensurate with that in 2019 (5.6%), which is evidence of retention efforts.

In March 2020, teaching staff only had one week before campus shutdown to switch from learning onsite to learning online. Collective effort from lecturers, staff, and students resulted in successful online delivery of 1,060 courses.

- The university's Virtual Private Network (VPN) capacities had to be tripled overnight.
- The student survey carried out by the Educational Development and Technology (LET) department shortly after the university's shutdown in early to mid-April revealed students' satisfaction with remote teaching of 1,043 courses (98.4%) in its current form.
- The use of video conferencing experienced rapid growth (50 times within 1 month).

Driven by the primary aim to transfer knowledge and technologies to the marketplace, ETH Zurich led to the creation of new companies, products and jobs. ETH Zurich has not only developed internationally recognised degree programmes, courses, and other teaching formats, but also founded new departments and institutes to impart sustainability-specific knowledge to its students.

- In 2020 ETH Zurich had 34 spin-offs, 4 more than in 2019, with half of them in information and communication technology.
- In 2020, ETH Zurich launched ETH AI Center, the university's central hub for artificial intelligence, in the collaboration with European Laboratory for Learning and Intelligent Systems.
- Research on quantum technologies was boosted by a donation of CHF 40 million.
- 25 European Research Council Grants, endowed with a total of CHF 55 million, were awarded to ETH members in 2020.
- In 2020, the Department of Environmental Systems Science launched a new programme:

229. ETH Zurich (2021) Annual report 2020. https://ethz.ch/content/dam/ethz/main/eth-zurich/Informationsmaterial/GB20/ETH_gb20-EN-web_29-3.pdf

Collaborative Decision-Making under Uncertainty. Participants use methodology developed at ETH Zurich – "integrated system and design thinking" – to learn how to structure complex problems related to sustainability and climate risks.

- Tackling Environmental Problems course was introduced for Bachelor's students.

Numerous initiatives sprang into existence during the pandemic and aided the society-wide response to contain the virus, with some examples as below:

- 3D-printed protective masks for healthcare and a low-cost ventilator were developed by ETH Zurich students.
- The SwissCovid contact tracing app, developed in collaboration with EPFL, KU Leuven, TU Delft and UCL has 1.8 million daily active users.
- The HelpfulETH emergency research initiative, which aims to provide short-term engineering solutions for needs in the healthcare sector caused through the current COVID-19 epidemic situation, was launched. It sets up project teams of volunteers that aim to solve needs within days or weeks, as interim relief.
- 60 research projects related to COVID-19 were initiated at short notice. The majority of these come from disciplines such as medical technology, pharmacy, immunology and epidemiology, and many of them have a direct bearing on political decisions.
- ETH Podcast COVID-19 special series was launched. In April and May 2020, ten episodes dedicated to the topic of coronavirus were produced.

Creating a COVID-19-Resilient Campus[230]

It was also essential to ensure safety of those stayed on campus. ETH Zurich has implemented several measures. Among them:

- Given the importance of onsite teaching for students in their first semester, for Autumn Semester 2020, the university organised new students into "bubbles" – groups of around two dozen people who attend all lectures and exercises together.
- By following a strict safety protocol, students were still able to attend the summer exams in person in the break between the first and second pandemic waves. Autumn Semester 2020 started with some classroom teaching but had to switch back almost entirely to remote teaching just a few weeks later as infection rates picked up.

Due to the necessity of flexible and mobile working and gradual implementation of digital solutions since 2016, staff was well prepared to work from home when shutdowns were enforced.

Pursuing Scientific Collaboration Amidst Closed Borders[231]

During this time, ETH Zurich remained active in developing partnerships both domestically and globally.

- In 2020, university researchers and faculty established more than 11,000 contacts in universities and research institutions across the globe, more than 1,500 contacts with industry partners, with Europe as the biggest collaborator. ETH Zurich was active in establishing research partnerships with the private sector (56% of them domestically).
- The ETH for Development (ETH4D) initiative was launched. ETH joined forces with Ashesi University and industrial partners based around Accra, Ghana, to offer a new master's degree programme to promote sustainable industry.

230. ETH Zurich (2021) Annual report 2020. https://ethz.ch/content/dam/ethz/main/eth-zurich/Informationsmaterial/GB20/ETH_gb20-EN-web_29-3.pdf
231. ETH Zurich (2021) Annual report 2020. https://ethz.ch/content/dam/ethz/main/eth-zurich/Informationsmaterial/GB20/ETH_gb20-EN-web_29-3.pdf

- To better understand the virus as well as its numerous implications, and prepare for society's future, a COVID-19 Call for Project Grants to support the collective effort with Asian countries was launched.

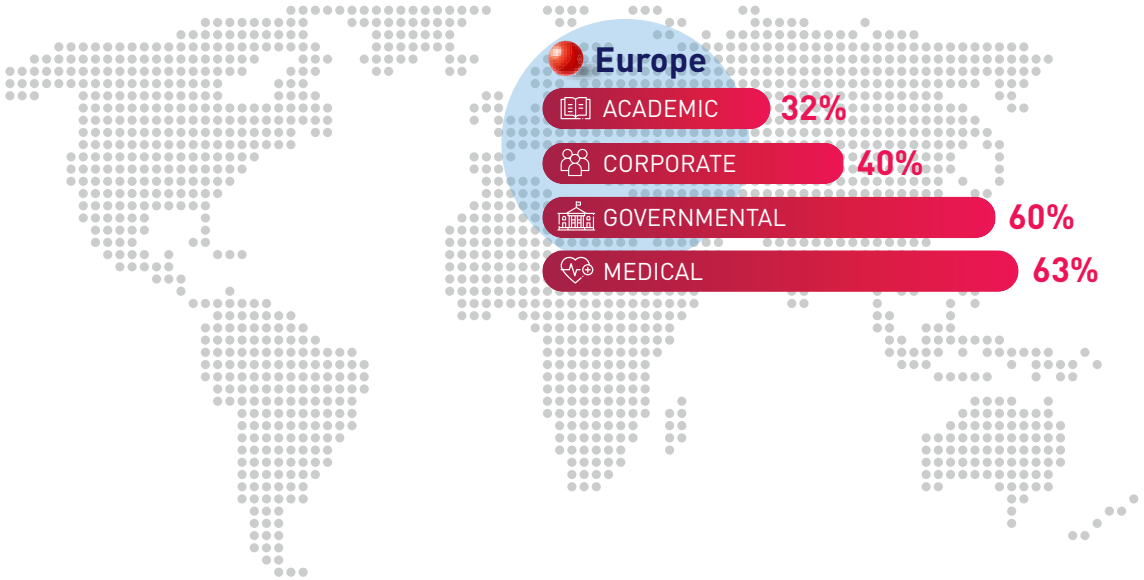
21 ETH Zurich scientists were on Clarivate Analytics' 2021 list of Highly Cited Researchers (an increase from 16 in 2020), ranking among the top 1% of global scientists in their field by citations. The following analysis of ETH Zurich's research performance was conducted in SciVal, for the publications during the 2018-2021 period. It is accurate as of January 2022.

- The overall number of publications was 32,810 over the 2018-2021 period (a 1% increase since 2018). A total of 21.7% of publications were in the top 10% most cited publications worldwide (the Switzerland average was 17.8%); 47.9% of publications were in the top 10% journals (the Switzerland average was 40.9%); 7.1% of publications were in the top 1% of journals.
- 67.9% of ETH Zurich's research collaboration measured by the number of joint publications was international (the Switzerland average was 69.9%); 13.6% was national collaboration; 14.7% was only institutional; and 3.7% of publications had single authorship. Academic-corporate collaboration at ETH Zurich was 7.3% (the Switzerland was average 8.5%).
- The number of joint publications with institutions worldwide was 23,085 (3,461 institutions, 32% in Europe); the biggest collaborators measured by the number of joint publications were University of Zurich, Switzerland (an 8% increase in joint publications since 2018); CNRS, France (a 11% drop); Paul Scherrer Institute, Switzerland (a 2% drop); MIT, US (a 17% drop); CSIC, Spain (a 29% drop). During the pandemic, ETH Zurich sightly decreased the number of publications with its well-established academic collaborators.
- The number of joint publications with corporates worldwide was 2,290 (662 institutions, 40% in Europe); the biggest collaborators measured

Location of the Majority of Collaborating Institutions

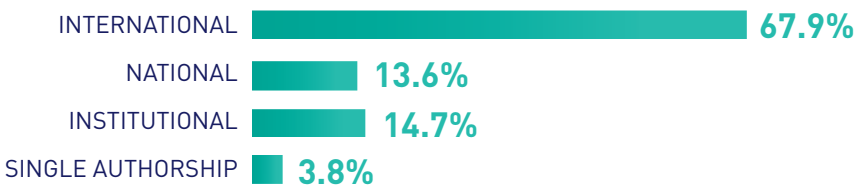
Measured by the Number of Collaborating Institutions

PERCENTAGE OF THE COLLABORATING INSTITUTIONS LOCATED IN CERTAIN CONTINENT



Type of Collaboration

Measured by the Number of Joint Publications



by the number of joint publications were IBM, US (a 4% drop in joint publications since 2018); Microsoft, US (a 19% drop); Alphabet, US (a 34% increase); Novartis, Switzerland (a 19% drop); F. Hoffmann-La Roche AG, Switzerland (a 35% increase). During the pandemic, ETH Zurich reduced the number of joint papers with the US partners.

- The number of joint publications with government agencies worldwide was 9,418 (1,060 institutions, 60% in Europe); the biggest collaborators measured by the number of joint publications were CNRS, France (a 11% drop in joint publications since 2018); Empa, Switzerland (a 9% increase); SEA, France (a 21% drop); US Department of Energy, US (25% drop); National Institute for Nuclear Physics, Italy (26% drop). During the COVID-19 pandemic, ETH Zurich also reduced the number of joint papers with international government agencies.
- The number of joint publications with medical entities worldwide was 1,093 (451 institutions, 63% in Europe); the biggest collaborators measured by the number of joint publications were Balgrist University Hospital, Switzerland (no change in joint publications since 2018); Deutsches Herzzentrum Berlin, Germany (a 471% increase); Schulthess Klinik, Switzerland (a 164% increase); Memorial Sloan-Kettering Cancer Centre, US (a 133% increase); Cantonal Hospital St Gallen, Switzerland (a 27% increase). ETH Zurich intensified its collaboration with medical entities worldwide, probably due to the change in research focus towards healthcare.
- 122 publications are on COVID-19-related topics (0.11% from total number of ETH Zurich publications over the 2018-2021 period).

Protecting the Wellbeing of the ETH Zurich Community in the COVID-19 Pandemic[232]

To find out how ETH members were coping with remote working, a staff study involving 1,700 employees was carried out. It was found that employees were less stressed compared to doctoral students and postdoctoral researchers. Online cooperation was said to function well overall. The fact that most teams knew about each other before the university went into emergency operations was certainly one reason for this. Feelings of social isolation were reported to ease slightly over the course of time that the study was run (10 weeks). Respondents claimed their work performance had not been affected by working from home.

ETH employees formed a "Corona helper" pool to provide their work colleagues with support they needed, also helping to alleviate some of the stress on academic resources.

The importance of ETH students in contributing to the wellbeing and safety of the entire Zurich community was demonstrated by the Students4Hospitals initiative, an internet platform set up by ETH students that assigned students across Switzerland to assist in hospitals.

232. ETH Zurich (2021) Annual report 2020. https://ethz.ch/content/dam/ethz/main/eth-zurich/Informationsmaterial/GB20/ETH_gb20-EN-web_29-3.pdf

Conclusion

Clear guidance from the university, reinforced by protective measures from the government, helped raise students' and staff's awareness of the infection risks, as well as to rapidly deploy campus shutdowns. An adaptive response to the reality of COVID-19 and accounting for the social needs of students allowed for a short-term campus opening in the Fall Semester of 2020. Prior arrangements for flexible working hours and locations had prepared ETH Zurich staff to work from home. In addition to being marked as satisfactory by the majority of employees, work from home was also characterised by an increase in performance. As a result of the university's modern infrastructure and highly qualified staff, ETH Zurich was able to maintain the same high level of both basic and applied research. Technology platforms and centres of excellence supported cooperation, entrepreneurship, and commercialisation that resulted in high a high number of patents, start-ups, and publications. Driven by pandemic demands, collaboration with local and international hospitals accelerated, and was reflected in increased number of joint publications.

ETH Zurich was well positioned to address the challenges presented by COVID-19. Even during lockdowns, the university was able to continue functioning and thus remained a reliable partner for its collaborators. One of the reasons could be that the network of ETH's collaborative partners is largely located in Europe and Switzerland which facilitated interaction and building of strong relationships during the pandemic, slightly limited by travel restrictions. It is also well supported by the fact that even despite a slight increase in tuition fees and reduced number of scholarships, the university witnessed an increase in both local and international students. Moreover, the readiness of ETH Zurich to support and promote research and education programmes with other countries (Asia, Ghana), as well as projects on emerging threats (COVID-19 spread, sustainable development) indicates ETH's strategic focus on collaborative approaches in responding to global crises.

NANYANG TECHNOLOGICAL UNIVERSITY, SINGAPORE (NTU SINGAPORE)

Young and research intensive, Nanyang Technological University, Singapore (NTU Singapore) has 33,000 undergraduate and postgraduate students in engineering, business, science, humanities, arts, social sciences, education and medicine. Ranked among the world's top universities, NTU is home to world-class institutes – the National Institute of Education, S Rajaratnam School of International Studies, Earth Observatory of Singapore, and Singapore Centre for Environmental Life Sciences Engineering. Besides being reputed as one of the world's most beautiful campuses, the NTU Smart Campus is a living testbed of tomorrow's technologies and a model of sustainability, with 61 Green Mark Platinum awards for its building projects. In addition to its main campus in the western part of Singapore, NTU also has a medical campus in Novena, Singapore's healthcare district.

Developing a COVID-19-Shaped Education and Research Environment[233, 234]

Previous investments in digital infrastructure, such as a four-fold increase in digital storage capacity, have prepared NTU to transition to online learning. Shortly after the start of pandemic, 600 courses and 624 exams went online, logistics and support were provided for more than 32,000 students on the NTULearn Cloud-based platform. More than 9,500 staff also worked from home, along with 5,000 students and staff who lived in housing on campus.

While government financial support decreased slightly during the pandemic, donor contributions increased.

- Specifically, more income came from tuition and other fees - S$386.7 million in 2020 as compared with S$362.4 million in 2019 - and from non-ministry funded research grants - S$124 million in 2020 versus S$107 million in 2019.
- Expenditure for manpower increased to S$955.2 million in 2020 as compared to S$952.6 million in 2019 because of salary and performance bonus increments.
- Research grants from ministries as well as awarded competitive research grants decreased to S$247 million in 2020 from S$265 million in 2019, and to S$587 million in fiscal year 2019/2020 from S$673.6 million in fiscal year 2019/2018, respectively.

NTU made investments in future-oriented skills during the pandemic. In August 2021, NTU piloted the launch of a new interdisciplinary core curriculum across all undergraduate education aimed at developing skills such as communication proficiency, ethics, digital literacy, and enterprise and innovation. The courses are designed around society's greatest challenges, such as climate change and global health. NTU is also the first university in the world to start an undergraduate course on alternative proteins "Future Foods – Introduction to Advanced Meat Alternatives". NTU students can also earn academic course credits from massive open online courses offered by some of the world's top universities.

NTU invested in enhancing graduate employability and creating a competitive workforce with a strong focus on industrial engagement.

- Paid traineeships were offered across NTU's colleges, research centres, corporate, and joint laboratories to 5,700 final-year undergraduates under the government's Workforce Singapore programme, which provides 80% of the training allowance.
- The graduates received a credit line worth S$1,600, which could be used to offset fees for NTU continuing education and training (CET) courses, which was valid until June 2021. It doubled then existing S$1,600 in credits available to alumni for CET courses.

NTU strengthened its focus on in-house innovation and commercialisation: in FY2019/2020, its total licensing revenue reached S$1.4 million; 23 spin-offs were formed; 8 mature spin-offs raised a total of S$12.7 million; and 126 patents were granted.

NTU researchers quickly pivoted to developing and working on COVID-19-related projects thanks to their access to well-equipped laboratories and available facilities for safe distance work. The most impactful research findings were those deployed in real world settings. These included COVID-19 tests such as disposable breath analyser, CRISPR-modified test suitable for identifying mutant variants and a micro-biochip for the rapid detection of SARS-CoV-2 proteins, protocols for wastewater testing, virtual SARS-CoV-2 3D models for interactive visualisation, the XDBOT for spraying disinfectant and self-disinfecting face masks coated with copper. NTU also supported fundamental research that could provide a better understanding of COVID-19 complications, such as by growing and studying mini-lungs, and the viral infection process in cells. The University also supported investigations into how the virus could be destroyed by engineered bioactive peptides.

233. NTU Annual Report 2020. https://ebook.ntu.edu.sg/ntu-annual-report-2020.html
234. NTU Annual Report 2021. https://ebook.ntu.edu.sg/ntu-annual-report-2021.html

Creating a COVID-19-Resilient Campus[235]

With the first COVID-19 case detected in Singapore in January 2020, there has been no COVID-19-cluster on the NTU campuses reported to date, due to the implementation of and rigorous compliance with safety regulations.

- Over 1,000 students and staff were recalled from overseas due to the suspension of exchange programmes.
- A community swab facility was established at one of the student residential halls to continuously test the NTU community.
- National safety checks - including temperature taking and checking into buildings, halls and rooms via the TraceTogether app - were implemented on campus.
- 50 wastewater surveillance centres to monitor viral fragments were installed in 24 student residential halls.
- 95% of the NTU community has been vaccinated from COVID-19 as of October 2021.

Pursuing Scientific Collaboration Amidst Closed Borders[236, 237]

In times of a pandemic, collaboration brings more benefits than competition. Therefore, NTU established a partnership with SUTD, adding on to the existing one with NUS. This allowed NTU PhD students to attend classes at the other two universities and vice versa.

The global focus on the importance of technology to build resilience and face natural disruptors bolstered NTU to acquire more investments from corporations. Major industry collaborations during 2020 included the following:

- In 2021, the Continental-NTU Corporate Lab was supported with S$50 million in to investigate smart mobility over the next five years.
- A collaboration with GlobalFoundries Singapore was supported with S$120 million. It aims to develop the next generation of embedded memory for smart systems.
- The SP Group-NTU Joint Lab established with S$20 million in funding from the national power grid operator to develop solutions for the energy grid of the future. SP Group also contributed S$10 million towards setting up two endowment funds at NTU.
- Singapore's first brain bank – a research repository for brain and spinal cord tissues – was launched at NTU's LKCMedicine, in partnership with the National Healthcare Group and the National Neuroscience Institute.
- The Centre for Population Health Sciences, hosted by NTU's LKCMedicine, was launched to strengthen its partnership with the World Health Organisation's first Collaborating Centre for digital health and education.
- In-principle approval was issued for the S$33 million Centre for Lifelong Learning and Individualised Cognition, a collaboration with the Cambridge Centre for Advanced Research and Education in Singapore focused on the science of learning together.

37 NTU scientists are on Clarivate Analytics' 2021 list of Highly Cited Researchers (a drop from 39 in 2020), ranking among the top 1% of global scientists in their fields by citations. The following analysis of NTU's research performance was conducted in SciVal, for publications during the 2018-2021 period. It is accurate as of January 2022.

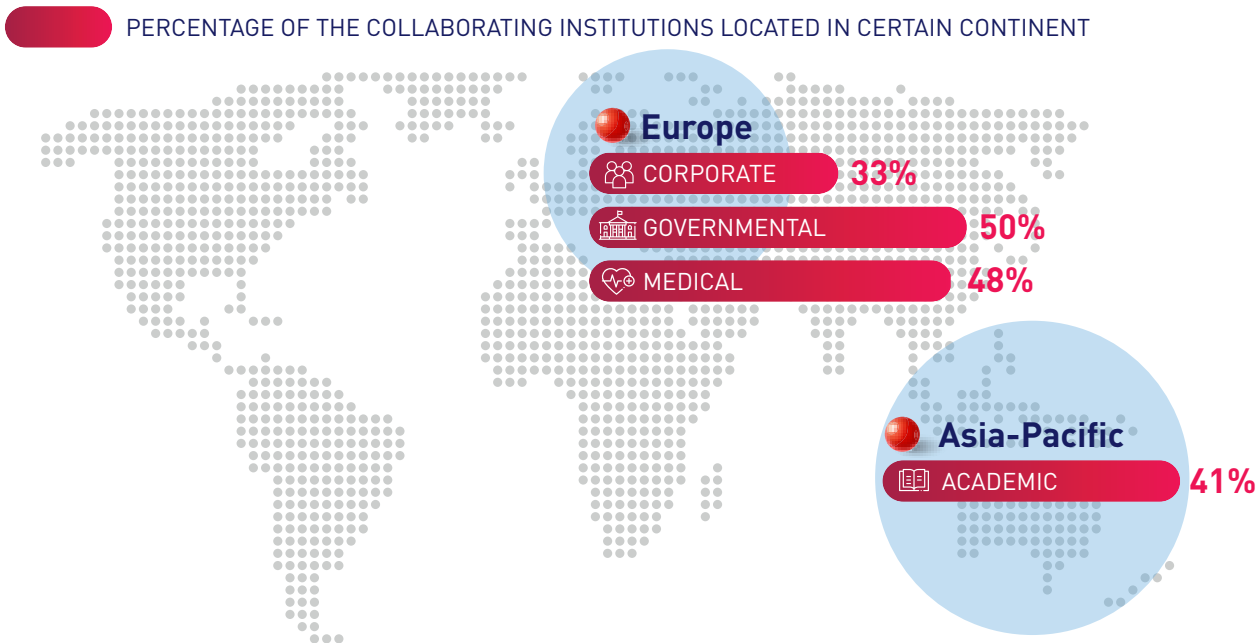
- The overall number of publications was 31,523 over the 2018-2021 period (a 2.7% increase since 2018). A total of 21.2% of publications were in the top 10% most cited publications worldwide (the Singapore average was 19.0%); 52.0% of publications were in the top 10% journals (the Singapore average was 45.4%); 10.0% of publications were in the top 1% of journals.
- 70.0% of NTU's research collaboration measured by the number of joint publications was international (the Singapore average was 67.4%); 10.1% was national collaboration; 15.7% was only institutional; and 4.6% of publications had single authorship. Academic-corporate collaboration at NTU was 6.5% (the Singapore average was 8.4%).

235. NTU Annual Report 2020. https://ebook.ntu.edu.sg/ntu-annual-report-2020.html
236. NTU Annual Report 2020. https://ebook.ntu.edu.sg/ntu-annual-report-2020.html
237. NTU Annual Report 2021. https://ebook.ntu.edu.sg/ntu-annual-report-2021.html

- The number of joint publications with institutions worldwide was 22,346 (3,461 collaborating institutions, 41% in Asia Pacific); the biggest collaborators measured by the number of joint publications were NUS, Singapore (a 17% increase in joint publications since 2018); ICL, UK (a 83% increase); Duke, US (a 70% increase); Zhejiang University, China (a 62% increase); MIT, US (a 25% decrease). Generally, NTU continued to deepen research collaboration with national and international academic institutions.
- The number of joint publications with corporations worldwide was 1,931 (338 partners equally spread across Europe, North America and Asia Pacific). The biggest collaborators measured by the number of joint publications were Thales, France (a 12% increase in joint publications since 2018); MOH Holdings Pte Ltd., Singapore (a 83% increase); Rolls-Royce, UK (a 40% drop); Alibaba Group Holding Ltd., China (a 172% increase); National Healthcare Group, Singapore (a 17% increase). NTU's academic-corporate partnership intensified during the pandemic.
- The number of joint publications with government agencies worldwide was 6,113 (713 partners, almost half of them in Europe); the biggest collaborators measured by the number of joint publications were the Agency for Science, Technology and Research, Singapore (a 9.4% drop in joint publications since 2018); Chinese Academy of Sciences, China (a 50% increase); Ministry of Education, China (a 54% increase); CNRS, France (a 6.3% increase); National Institutes of Health, US (a 136% increase). The number of joint publications NTU had with US National Institutes of Health surged, an indication of its focus on collaborative research into improving healthcare.
- The number of NTU's joint publications with medical institutions worldwide was 1,793 (481 partners, among which 48% are from Europe, 29% from the Asia Pacific); the biggest collaborators measured by the number of joint publications were Singapore hospitals with a 218% increase in joint publications since 2018. The majority of NTU's joint publications in the medical field were prepared in partnership with Singapore's healthcare providers, suggesting the University's contribution towards enhancing the national healthcare system.
- 220 publications were on COVID-19-related topics (0.7% of the total number of NTU publications over the 2018-2021 period).

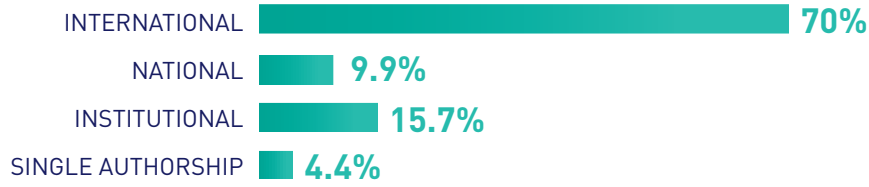
Location of the Majority of Collaborating Institutions

Measured by the Number of Collaborating Institutions



Type of Collaboration

Measured by the Number of Joint Publications



Protecting the Wellbeing of the NTU Community in the COVID-19 Pandemic[238]

With the wellbeing of the NTU community as one of its highest priorities, NTU kickstarted the University-wide OneNTU Initiative in March 2021 to promote wellbeing, diversity, and inclusivity. It also aimed to reach out to all representatives of NTU and advocates for collegiality in addressing challenges. As part of the initiative, the University Wellbeing Office was established to cater to the needs of students and staff. NTU provided financial support to affected students as well:

- A COVID-19 relief package was initiated by NTU Leadership, which has helped more than 1,000 students.
- The NTU Priorities Fund, which is driven by private philanthropy, raised S$4.6 million as of December 2020 from supporters that included faculty, staff, alumni, friends, Board members, foundations and organisations.
- Tuition fees were not raised for the academic year 2020.
- More than S$10m was raised from voluntary donations of 20,000 annual leave days from 1,800 employees.

Faculty recruitment more than halved, from 114 faculty in 2019 to 48 in 2020. This could be partly due to government policies on hiring freezes and work visas for foreign professionals. Postponements in the issuing of entry permits by the Ministry of Manpower also led to delays in recruitment.

Conclusion

Despite the fast spread of SARS-CoV-2 in Asia and the early detection of the first COVID-19 cases in Singapore in January 2020, NTU's alignment with national safety regulations and Singapore's rapid vaccination regime protected the University's community. The rapid deployment of testing systems developed in-house to track and control the spread of SARS-CoV-2 demonstrated the readiness of NTU's research facilities to pivot towards an emerging challenge. Continuous exploration of new academic and industry collaborations pursued amidst closed borders led to an increase in the university's joint publications and enhanced its quality of scholarly output.

The distribution of welfare packs to student residents on campus, donation drives, and focus group discussions with students and researchers under the OneNTU initiative promoted a sense of connectedness and peer support in the community. Greater support from donors also aided the most vulnerable students. NTU benefitted greatly from measures that were adopted to for past emergencies, such as the SARS epidemic from 2002-2004, including the implementation of online learning management systems, faculty and student training in online teaching and learning, and an increase in operational capacity. NTU also introduced new interdisciplinary educational modules to its curriculum and raised financial support for interdisciplinary projects.

The actions taken by NTU during the pandemic are indicative of the University's resilience developed and nurtured over the years, as well as its readiness for the next emergency. NTU's efforts were recognised internationally - in September 2021, the University received the COVID-19 Agility and Response runner-up award at the Duty of Care Awards organised by the International SOS Foundation. NTU is the only institute of higher learning in Singapore chosen for the Duty of Care Awards. To commemorate digital transformation and administrative reforms that aided NTU's timely COVID-19 response and solid commitment to a sustainable future, the University was awarded the Leadership and Management Team of the Year accolade in 2022, the top honour at the Times Higher Education Awards Asia.

238. NTU Annual Report 2020. https://ebook.ntu.edu.sg/ntu-annual-report-2020.html

STANFORD UNIVERSITY

Stanford University is one of the world's leading research universities. Stanford is known for its entrepreneurial character, drawn from the legacy of its founders, Jane and Leland Stanford, and its relationship with Silicon Valley. Research and teaching at Stanford both stress interdisciplinary approaches to problem solving. Areas of excellence range across all disciplines. Stanford is located in California's Bay Area, widely considered to be one of the most intellectually dynamic and culturally diverse areas of the nation.

Located midway between San Francisco and San Jose, Stanford University is in the heart of Northern California's Silicon Valley, home to Yahoo, Google, Hewlett-Packard, and many other cutting-edge tech companies that were founded by, and continue to be led by, Stanford alumni and faculty. Covering over 8,000 acres, Stanford has one of the largest university campuses in the US, with 18 interdisciplinary research institutes and seven schools. Four of Stanford University's seven schools offer undergraduate and graduate coursework, and the remaining three serve solely as graduate schools. Graduate programmes include the highly ranked School of Education, the School of Management Science and Engineering, Stanford Law School, the School of Medicine and the Graduate School of Business. The Stanford Woods Institute for the Environment oversees collaboration between environmental research, teaching and public outreach.

Developing a COVID-19-Shaped Education and Research Environment[239]

In FY2020, net assets of the university, excluding hospitals, increased by $1.8 billion USD (4.7%) to $40.3 billion. University operating revenues were $6.1 billion USD, reduced by $22 million USD or 0.4% from the prior year. This resulted in an operating surplus of $41 million USD. The surprisingly positive operating surplus resulted from increased philanthropic support including from corporations and foundations (28% higher than the previous year), a steady performance of sponsored support and investment income, and widespread cost saving measures. Stanford University reported $1.3 billion USD in philanthropic gifts during the fiscal year of 2020, reflecting the financial support from more than 51,000 donors. Stanford's $28.9 billion USD endowment (from more than 8,300 endowed university funds) increased 1.4% and was disbursed as a $1.4 billion USD payout to support academic programmes and financial aid during the fiscal year of 2020, funding 22.3% of the university's total operating expenses.

Stanford's hospitals were agile in their response, rapidly increasing COVID-19 testing and capacity to treat patients across the Bay Area and the state, using telehealth tools to reduce in-person visits, and delaying renovations to older buildings in order to address a potential surge in patients. In early FY2020, the new Stanford Hospital opened its doors which doubled the capacity for patient care.

There are more than 7,700 externally funded projects throughout the university, with the total budget for externally funded projects at $1.93 billion USD, as of 2021, including the Stanford National Accelerator Laboratory (SLAC). Of these projects, the federal government funded approximately 75%. Also, nearly $474 million USD in support came from non-federal funding sources, such as industries and endowment funds.

Stanford researchers pivoted quickly to work in a remote environment and shifted their focus to COVID-19 related research projects, collectively referred to as RISE – Respond, Innovate, Scale, Empower. The university was awarded over $30 million USD in funding aimed at understanding and preventing the spread of the virus. As a result, they developed one of the first FDA-approved diagnostic tests to identify the virus, as well as methods for 3D printing of ventilators, and a computer model to predict how COVID-19 spreads in cities by tracking population movements. Additionally, a privacy-focused coronavirus alert app was developed to send anonymous alerts to exposed individuals along with an online tool used to flag communities at risk for a surge in cases of COVID-19.

$5.9 million USD funding was provided for more than 800 undergraduate students to support a wide range of research projects, even with the restrictions on travel and on-campus activities. Among them, 26% was used for interdisciplinary student projects. Moreover, Stanford actively integrated arts into the curriculum due to financial support from an Endowment: the COVID-19 Creative Community Response grant, to promote creative expression and a sense of connection to others.

Enabling virtual learning student support called for tools and resources to deliver the academic mission virtually. Faculty and staff shifted academic education online, leveraging existing resources while expanding upon online resources and remote collaboration tools, and developed new models enabling effective remote education. The university invested in learning technology to support its faculty in their efforts to develop creative formats for online coursework and maintain a fulfilling and enriching experience for remote learners in all disciplines.

Creating a COVID-19-Resilient Campus[240]

Safety of the Stanford community as well as clear, timely and transparent communication by the University's administration remained a priority during the pandemic. The following steps in transforming education were performed to maintain safety:

- Students were allowed to choose any three quarters (out of four) from the academic year in which to enrol, in an attempt to reduce the number of students on campus at any given time.
- In response to the COVID-19 pandemic, the university limited undergraduate housing on campus during 2020–2021. In assigning undergraduate on-campus housing, preference was given to freshmen, sophomores, and students in special circumstances.

239. Stanford Annual Financial report (2020) https://bondholder-information.stanford.edu/sites/g/files/sbiybj21416/files/media/file/stanford-annual-financial-report-2020.pdf
240. Stanford University. Campus life. https://www.stanford.edu/campus-life/

- All students coming to campus during fall 2021 were required to be fully vaccinated for COVID-19.
- The Stanford Bing Overseas Studies Programme, which offers study-abroad opportunities in Australia, Berlin, Cape Town, Florence, Hong Kong, Istanbul, Kyoto, Madrid, New York, Oxford, Paris, and Santiago was suspended until the fall of 2021.

Since the onset of the COVID-19 pandemic, some programmes have been temporarily modified and enhanced cleaning and safety protocols have been implemented to continue service while keeping students and staff safe. A new tool called Health Check was developed by the Occupational Health Center's Workplace Health Innovation Lab and University IT to streamline the process for reporting health status for those working at Stanford locations.

The pandemic caused universities to consider their role in the local community more strongly, both as a major employer but also as a significant provider of medical care and science outreach. One of the examples is an outreach initiative by medical students at Stanford University where they provided answers to coronavirus related questions from homeless people. Additionally, Stanford worked to create a Black Community Council, which connects Black alumni with students, staff and faculty to provide oversight of university initiatives on racial justice[241].

Pursuing Scientific Collaboration Amidst Closed Borders[242]

Stanford University continued its well-established tradition of promoting the transfer of Stanford technology for society's use and benefit while generating income to support research and education. Between September 2019 and August 2020, Stanford received $114 million USD in gross royalty revenue from 847 different technologies. Ten of the inventions generated $1 million USD or more each. The Office of Technology Licensing (OTL) evaluated 594 new invention disclosures and finalised 121 new licenses and options. Of the 121 agreements, 42 were with Stanford start-ups and 23 of them involved equity.

121 Stanford University scientists were on Clarivate Analytics' 2021 list of Highly Cited Researchers (an increase from 114 in 2020), ranking among the top 1% of global scientists in their field by citations. The following analysis of research performance of the Stanford University was conducted in SciVal, for the publications during the 2018-2021 period. It is accurate as of January 2022.

- The overall number of publications was 59,386 over the 2018-2021 period (a 7.7% increase since 2018). A total of 22.7% of publications were in the top 10% most cited publications worldwide (the US average was 13.9%); 51.6% of publications were in the top 10% of journals (the US average was 36.8%); 9.2% of publications were in the top 1% of journals.
- 42.7% of Stanford University's research collaboration measured by the number of joint publications was international (the US average was 36.7%); 36.6% was national collaboration; 14.4 was only institutional; and 6.3% of publications had single authorship. Academic-corporate collaboration of Stanford University was 7.7% (the US average was 4.7%)
- The number of joint publications with institutions worldwide was 40,589 (4,114 institutions, 30% in Asia); the biggest collaborators measured by the number of joint publications were Harvard University, US (a 13% increase in joint publications since 2018); University of California at San Francisco, US (a 33% increase); US Department of Energy, US (a 1% drop); University of Pennsylvania, US (a 8% increase); University of Washington, US (no change). The majority of joint academic publications by Stanford University was prepared in partnership with the academic partners from the US.
- The number of joint publications with corporates worldwide was 4,407 (872 institutions, 56% in the US); the biggest collaborators measured by the number of joint publications were Alphabet, US (a 22% increase in joint publications since 2018); Microsoft (a 55% increase); Genentech Inc, US (a 10% increase); SRI International, US (a 50% increase); J&J, US (a 3% increase). The majority of joint corporate publications by Stanford University was prepared in partnership with the corporates from the US.
- The number of joint publications with government agencies worldwide was 13,338 (1,097 institutions, 55% in Europe); the biggest collaborators measured by the number of joint publications were US Department of Energy, US (a 1% drop in joint publications since 2018); Department of Veterans

241. Stanford News (2020) Stanford trustee Charles Young appointed to chair newly established Black Community Council; council members selected. https://news.stanford.edu/2020/11/09/stanford-trustee-charles-young-appointed-chair-newly-established-black-community-council-council-members-selected/
242. Stanford University Research. https://www.stanford.edu/research/

Affair, US (a 25% increase); Stanford Linear Accelerator Centre, US (a 5% drop); CNRS, France (a 2% drop); National Institutes of Health, US (a 10% drop). The majority of joint publications by Stanford University and government agencies originated from the US.

- The number of joint publications with medical entities worldwide was 9,878 (1,194 institutions, 46% in Europe); the biggest collaborators measured by the number of joint publications were the Mayo Clinic Rochester, US (a 19% increase in joint publications since 2018); VA Medical Centre, US (a 1% increase); Cleveland Clinic Foundation, US (a 164% increase); Memorial Sloan-Kettering Cancer Centre, US (a 22% increase); Dana Farber Cancer Institute, US (a 18% increase). During the pandemic, Stanford University increased the number of publications prepared in collaboration with medical entities in the US which could be evidence of the University's strong contribution into enhancement of the national healthcare system.
- 858 publications were on COVID-19-related topics (1.4% of total number of Stanford University publications over the 2018-2021 period).

In addition to the pandemic, Stanford university also felt the effects of climate change. During the past several summers, Stanford has experienced record heat waves driving the investment of $85 million USD in doubling chiller capacity to ensure adequate cooling of research and health care facilities. During the summer of 2020, California had a record number of wildfires including several surrounding the Bay Area in August 2020. The fires caused numerous employees to evacuate their homes and the intense wildfire smoke caused suspension of campus outdoor activities.

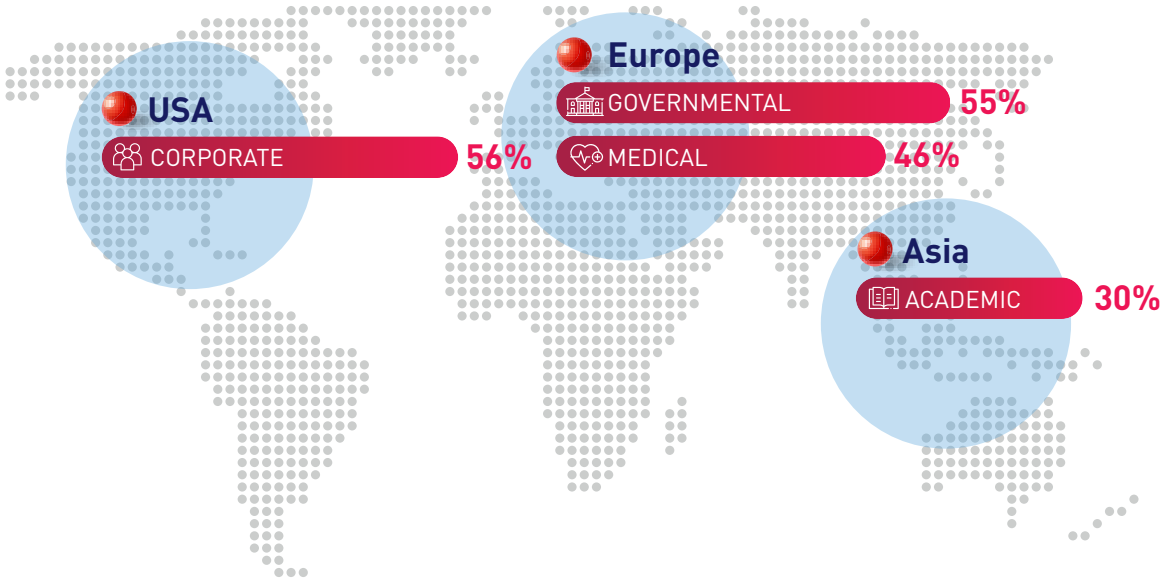
Protecting the Wellbeing of the Stanford Community in the COVID-19 Pandemic[242,244]

Stanford University was one of very few institutes of higher education who conducted a quality-of-life survey among staff to analyse the most contributing factors to their COVID-19-induced stress. The results of a survey run during October-November 2020 among 1,547 staff revealed the following:

Location of the Majority of Collaborating Institutions

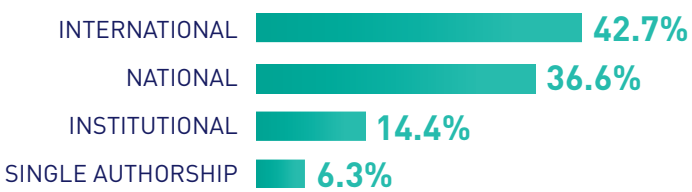
Measured by the Number of Collaborating Institutions

PERCENTAGE OF THE COLLABORATING INSTITUTIONS LOCATED IN CERTAIN CONTINENT



Type of Collaboration

Measured by the Number of Joint Publications



243. Stanford Annual Financial report (2020) https://bondholder-information.stanford.edu/sites/g/files/sbiybj21416/files/media/file/stanford-annual-financial-report-2020.pdf
244. Stanford COVID-19 announcements. https://healthalerts.stanford.edu/covid-19/latest-updates/

- Nearly 9 out of 10 respondents said that they had experienced more stress since COVID-19 began.
- More than one-third of faculty members said they were dissatisfied with Stanford's response to the pandemic. Tenured faculty reported the greatest levels of satisfaction, while pre-tenure faculty reported the least. Respondents expressed concerns about their inability to continue research, potential unfairness in performance assessment and financial struggles due to COVID-19.
- Over 74% of faculty reported having less time for research compared to before the pandemic. On the other hand, faculty members reported spending slightly more time on service, mentorship/advising and teaching.
- Faculty members who took care of children reported a significant increase in stress. Of the faculty that cared for children, 61.6% reported a lot more stress, while less than half of faculty without childcare responsibilities said the same.

It aided the university to adjust its policies and to support staff in improving work-life balance and reducing overall stress.

Stanford University increased financial aid to its students, 50% of undergraduates were awarded need-based financial aid from Stanford while 83% of graduate students received some form of financial support (over $330 million USD in financial aid). Other types of aid included assistance with travel, IT equipment and IT services, increase in minimum salary for graduate student assistantships, enabling more students to qualify for financial aid by removing the home equity component from the undergraduate financial aid calculation, creating a new grant programme for Stanford employees facing financial hardships and ensuring pay continuation for regular employees. Overall salaries and benefits increased $553 million USD as a result of a combination of continued growth in headcount and annual merit compensation increases at the beginning of FY2020. To support their faculty, Stanford University implemented additional sabbatical credits for senior faculty and prohibited the increase of childcare costs at campus childcare centers.

However, no steps towards the students' requests for a reduction of tuition fees were made. Additionally, in early April 2020, the university imposed a salary freeze, a hiring pause, a pay reduction for senior leadership, reduced discretionary spending by departments, and held off on approvals for all its projects that required new capital.

Conclusion

With the first confirmed COVID-19 case on Stanford University campus on 15 March 2020, the University executed a prompt shutdown of the campus, facilitated the return of local students to their homes, and retained a handful of international students and those with health and safety risks on campus. Stanford administration's communication to its community remained timely, transparent, and clear throughout the pandemic. However, plans were continuously revisited to adjust to the constantly changing COVID-19 conditions and to implement a phased arrival programme for freshmen, sophomores and students with special circumstances to campus, which resulted in student dissatisfaction. Strong financial support was provided for students, but at the same time, hiring freezes and salary cuts were temporarily imposed on staff. Despite a deliberate, decisive, and well-weighed roadmap of adapting to COVID-19 circumstances developed by Stanford University, at least one third of faculty and staff who participated in a quality-of-life survey (fall 2020) reported increased stress caused by additional childcare duties and unequal application of some of the policies that could be caused by the lack of communication and parity across departments.

During the pandemic, Stanford University increased its number of joint research publications with American academic, corporate, medical and governmental partners. Due to the contribution of Stanford researchers to the development of SARS-CoV-2 vaccines, collaboration with Johnson & Johnson and Pfizer intensified in 2020. Moreover, Stanford was well placed to contribute back to the community - the new Stanford hospital opened in early 2020 and the community in the Bay area benefitted greatly from the increased capacities for testing and shared facilities for isolating and treating COVID-19 cases. Addressing COVID-19 did not remain the only priority - Stanford invested in adapting the campus to the impact of climate change and has developed a long-term sustainability plan to get ready for the next natural emergency.

The actions above taken by Stanford University during the pandemic are indicative of a prompt response, resourceful planning for long-term resilience and the readiness to rebalance towards a next possible crisis. Being a university with a long history, well-established traditions and a high number of students and staff might require a longer lead time to implement preventive measures that satisfy the majority of the community.

TEC DE MONTERREY

A non-profit private university founded in 1943 in Monterrey, Mexico, the Monterrey Institute of Technology and Higher Education (Tec de Monterrey) has since grown its national presence to 31 campuses across 25 Mexican cities, with satellite offices in Asia, Canada, Europe, the US, and Latin America. Tec de Monterrey is home to a community of over 92,000 students and more than 24,000 faculty and staff. Each campus is relatively independent, but they all share a national academic curriculum. Most campuses deliver both secondary (in form of high schools) and tertiary (undergraduate) education, some offer postgraduate programmes, and only eight (Cumbres, Eugenio Garza Sada, Eugenio Garza Lagüera, Santa Catarina, Metepec, Santa Anita, Esmeralda, and Valle Alto) deliver high school courses exclusively. Tec de Monterrey also has two hospitals. All campuses are funded by non-profit organisations composed primarily of local businesspeople. The institute is the only Latin American institution that is a part of the European Consortium of Innovative Universities — an organisation committed to innovations in both teaching and learning, and a part of Universitas 21 – an international network of research-intensive universities established as an "international reference point and resource for strategic thinking on issues of global significance." It is also a member of the Association of Pacific Rim Universities, an international consortium of leading research universities including Stanford University, University of California, Berkeley, NTU Singapore, National University of Singapore, University of Sydney, and the California Institute of Technology.

Tec de Monterrey was also ranked 6th by the Princeton Review 2022 as a top 10 university for undergraduate entrepreneurship. It is the number one university in Mexico in employability and according to QS World University Rankings® 2020, Tec was ranked number 52 in the world, with 95 percent of graduates accepting job offers within 12 months.

Developing a COVID-19-Shaped Education and Research Environment[245]

The year 2020 was marked by the pandemic caused by the SARS-CoV-2 virus, which led to a limited number of grant calls, as well as by delayed or altered research focus due to the urgency to deal with the current situation. Of the 328 proposals submitted for a total of 611 million pesos, 134 million pesos were approved, representing only 16% of the resources requested from other funds. Of the amount of funding attracted, 24 million pesos came from industry, 84 million pesos from foundations; 10 million pesos from national funds, and 14 million pesos came from international funding sources.

At the same time, Tec de Monterrey saw a record year in fundraising: 629,157 million pesos were raised in 2020-2021 from 10394 donors, indicating about a 55% increase in participation. Besides, in response to the COVID-19, the Unidos Podemos initiative was launched, which raised 23,401,123 pesos thanks to more than 1,000 donors and more than 1,000 University alumni.

Tec de Monterrey has the research capacity to offer solutions to deal with COVID-19 as well as sufficient facilities to transfer to remote research and education, with some of the examples listed below:

- Virtual Laboratories, low-cost laboratory equipment platforms based on computer emulators of Programmable Controllers and Operating Panels were utilised for the simulation of manufacturing processes.
- Use of telepresence systems enabled remote access to physical laboratory resources.
- Cyber Laboratories were equipped with real control and virtual reality devices for process simulations and automation practices.
- Enabling remote access to all computer labs on campus via distributed specialised software allowed conducting technical tutorials and learning sessions.

In the face of COVID-19, Tec de Monterrey put its academic, medical, and scientific resources to the service of society, and developed various initiatives, some of which are listed below:

- Doctors-in-residence at San José Hospital and Zambrano Hellion Hospital continued to carry out their work as the pandemic started in March 2020.
- 26 primary care modules were installed in campus hospitals and medical teams were reinforced with 33 members of the medical community to provide care and support for suspected and confirmed cases.
- A molecular biology laboratory for the diagnosis of COVID-19 carried out more than 63,000 PCR diagnostic and more than 10,000 serological tests.
- The research group on Bioinformatics for Clinical Diagnosis collaborated in the "TecGenome" project, with a financing of 0.9 million pesos. They performed research in 3 directions: determination of clinical and immunological predictive factors for the development of severe SARS-CoV-2 disease; decreasing the infectivity of SARS-CoV-2 by TMPRSS2 and Furin inhibitors, their effect on the inflammatory response and the pathogenesis of severe forms of COVID-19; and identifying clinical and genetic risk factors associated with the infection and COVID-19 severity.
- Mask MADiT, a personal protective device, and 3D-printed repurposed diving masks were also developed at Tec de Monterrey to provide sufficient protection against COVID-19.

In order to withstand limitations imposed by the shift to online learning and remote work, all onsite activities were suspended. Preparation for the switch to studying online took 2 days.

- More than 10,000 academic community members were trained to deliver teaching remotely.
- New technology was acquired to provide 50,000 weekly online learning sessions to more than 32,000 classes taught by more than 8,000 professors across the country.
- Physical and technical resources were provided to faculty and employees who worked from home.

245. 2020 Informe Annual. https://tec.mx/sites/default/files/inline-files/InformeAnual-2020.pdf

- 650 educational spaces with flexible hybrid technology that combined face-to-face and virtual interaction were deployed. This allowed the gradual and voluntary return of up to 25% of people to campuses.
- Free consultations, MOOCs, workshops and laboratory practices were provided for the Tec de Monterrey community.
- Remote access to the Launching Pad platform was provided to graduates to support their transition to the work environment.

Mexico does not provide federal student loans, and only a limited number of student loans were offered by commercial banks. With the aim to financially support students and their families who faced problems during the COVID-19 crisis, a contingency fund was created since the January-June 2020 semester. More than 25,000 students have been supported with discounts and extensions for payment of tuition fees. The fund for scholarships and financial support was increased in August 2020 with its eligibility criteria revised to consider more candidates. A temporary support fund was organised for tuition discounts that were granted in addition to scholarships based on the needs of new students who applied for the August-December 2021 semester. 90.5% of students received some type of scholarship or educational support.

Although the COVID-19 pandemic was a critical factor for deployment of the different initiatives, Tec de Monterrey managed to successfully capitalise on a fast transition to virtual formats. This facilitated the connection with various audiences not targeted before and allowed building a sense of belonging for graduates at the University and supporting them along their first career steps. Employability of professional graduates during the pandemic remained high (85%). Professors and employees did not experience any salary cuts. Despite complications from the COVID-19 pandemic, the number of students enrolled in 2020 was almost at the same level as in 2019.

Creating a COVID-19-Resilient Campus[246]

With a strong emphasis on community wellbeing, Tec de Monterrey promoted the 'Conscious Return Culture' by providing reliable COVID-19-related information, enforcing safety protocols and empowering the community to act in a responsible way. A comprehensive plan, 28 protocols, 18 quick guides and 10 regulations were released to facilitate a 'Conscious Return'. To support the safe return on campus and ensure compliance with state health protocols, Tec de Monterrey deployed the following interventions:

- The SAP Fiori Conscious Return App acted as a self-reporting tool that generated a QR code to enter the campus premises and verified compliance with requirements for return.
- An app demonstrated proximity to people who were in a close contact to a confirmed positive case.
- COVID-19 boards displayed the dynamically changing indicators associated with COVID-19 to adjust safety measures on campus, according to the evolving situation.

A strategy to reduce the spread of the virus in the Tec de Monterey community was implemented and included the following:

- A community member had to provide a daily report of a self-diagnosis of symptoms prior to arrival at the campus.
- Access to the stations with temperature measurement and sanitiser was organised at every entry to the campus.
- Compliance with the protocols for health and hygiene around campus was actively monitored.

Implemented measures facilitated the return of students and staff back to 15 campuses to a 25% presence quota. Staff worked in shifts of 4 days of face-to-face work and 10 days of remote work, by December 2020.

To protect the health of the local and university community, Tec de Monterrey supported a state-wide vaccination programme by strengthening the distribution and logistics capacity of campuses and hospitals. PCR tests on alternating weeks were deployed on all campuses. Spaces and services on all campuses were

246. 2020 Informe Annual. https://tec.mx/sites/default/files/inline-files/InformeAnual-2020.pdf

reconfigured to comply with new health and hygiene protocols (mandatory use of a mask, interpersonal distance of 1.5 meters, reduced capacity in classrooms etc.). In order to reduce the risk of outbreaks, a Wastewater Monitoring programme was implemented to identify traces of the SARS-CoV-2 virus in campus wastewater. The university's capabilities to carry out and process PCR tests on all campuses were also expanded. In 2020, 219 analyses of wastewater samples and 1,060 PCR tests were carried out with an average positive test result of less than 2.3%. Flagship projects carried out by the School of Bioprocess Sciences and Engineering (the national laboratory for genomic sequencing "Tec BASE" and the wastewater monitoring laboratory) received 20 million pesos for research on SARS-COV-2 sequencing and water surveillance on Tec de Monterrey campuses.

Pursuing Scientific Collaboration Amidst Closed Borders[247]

As a private university, Tec de Monterrey largely relies on external funds to support research activities, which makes the university's availability to local and international collaborators essential. Some of the funded research collaborations are listed below:

- A collaboration project "Food for health" with the ultimate goal to contribute to legislation to combat obesity was established in collaboration with National Autonomous University of Mexico and National Institute of Medical Sciences and Nutrition Salvador Zubirán.
- The Energy and Climate Change Group received 6 grants from national and international funders: Google-ICLEI-Mexico Action Fund for 6.7 million pesos and Campus City financed by the Fomento Económico Mexicano Group for 8 million pesos with a focus on smart cities, and a research project on hybrid photovoltaic/thermal technologies for energy production financed by the Royal Society, UK, for 220,000 pounds.
- The Biomedical Engineering Group attracted 25,000 euros from the Biocodex Foundation (Mexico) for the study of the relationship between human microbiota and colorectal cancer.
- The Optimisation and Data Science group acquired projects in 2020 on Models for Preparedness for Natural Disasters in collaboration with the University of Laval, Canada; as well as a project on the Development and Optimal Allocation of Low-Cost High Throughput PCR and Immunoassay Tests for COVID-19 in Mexico and Ecuador in collaboration with the University of Edinburgh, UK (240,000 pesos).
- The "Remote Virtual Lab 4.0" project between the University of Applied Sciences Würzburg-Schweinfurt and Tec de Monterrey aimed to improve students' ability to explore and implement Industry 4.0 methods and tools.
- The Advanced Manufacturing research group attracted 2 research projects with companies from the software and automotive sectors for an amount of US$78,000. The group also received a US$150,000 fund for the development of advanced bioreactors, in partnership with The Ohio State University.
- The group working on intelligent systems attracted projects with the Tec-China Hub on the development of metaheuristic models using hyper-heuristic schemes for continuous optimisation problems; and with Tec-UTSA (the University of Texas at San Antonio) on an initiative for the development of computational vision models with automatic learning algorithms to detect suspicious behaviour.
- The Robotics group worked on "Rapidly manufactured artificial respirators" financed through INTEL for an amount of 3,358,000 pesos.

More than 30 consulting and advisory projects on COVID-19-related problems were carried out in collaboration with industrial partners (e.g., Grupo Aeroportuario del Pacífico, Cemex, Banregio and Liverpool etc). During 2020, Tec Monterrey submitted 57 patents among which 8 were granted. 1 trademark was registered.

1 Tec de Monterrey scientist was on Clarivate Analytics' 2021 list of Highly Cited Researchers, ranking among the top 1% of global scientists in their field by citations. The following analysis of research performance of the Tec Monterrey was conducted in SciVal, for the publications during the 2018-2021 period. It is accurate as of January 2022.

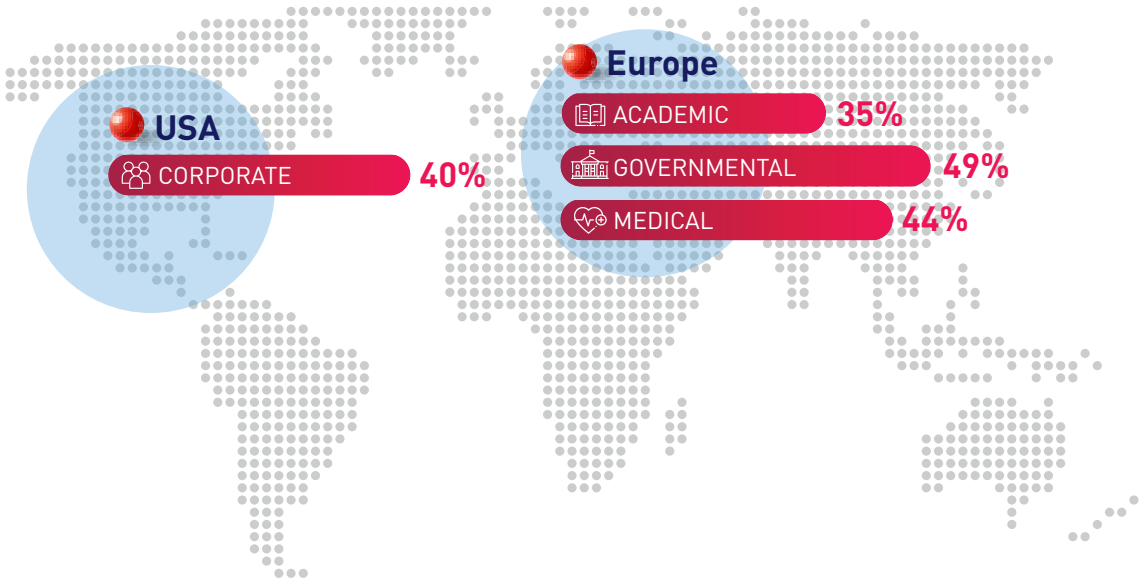
247. 2020 Informe Annual. https://tec.mx/sites/default/files/inline-files/InformeAnual-2020.pdf

- The overall number of publications was 6,653 publications over the 2018-2021 period (an 61% increase since 2018). A total of 12.7% of publications were in the top 10% most cited publications worldwide (the Mexico average was 8%); 24.1% of publications were in the top 10% of journals (the Mexico average was 19.6%); 2.9% of publications were in the top 1% of journals.
- 48.5% of Tec de Monterrey research collaboration measured by the number of joint publications was international (the Mexico average was 43%); 26% was national collaboration; 20.7% was only institutional; and 4.9% of publications had single authorship. Academic-corporate collaboration of Tec de Monterrey was 2.7% (the Mexico average was 1.8%).
- The number of joint publications with institutions worldwide was 4,151 (1,881 institutions, 35% in Europe); the biggest collaborators measured by the number of joint publications were Instituto Politécnico Nacional, Mexico (a 137% increase in joint publications since 2018); Universidad Nacional Autónoma de México, Mexico (a 108% increase); Universidad Autonoma de Nuevo Leon, Mexico (a 6.6% increase); Huaiyin Institute of Technology, China (a 550% increase); Universidad de Guadalajara, Mexico (a 90% increase). Tec de Monterrey increased the number of joint publications with Mexican universities and at the same time recorded 5-fold growth in publications with Huaiyin Institute of Technology, China.
- The number of joint publications with corporates was 170 (84 partners, 40% in the US and in Europe); the biggest collaborators measured by the number of joint publications were General Motors, US (no change in joint publications since 2018); Petróleos Mexicano, Mexico (a 300% increase); Intel, US (a 400% increase); Novo Nordisk A/S, Denmark (a 300% increase); MOH Holdings Pte Ltd., Singapore (no change). Tec de Monterrey significantly increased the number of joint publications with corporates from the US, Denmark and Mexico.
- The number of joint publications with government agencies worldwide was 1,230 (260 partners, 49% in Europe); the biggest collaborators measured by the number of joint publications were Instituto Nacional de Ciencias Medicas y Nutricion Salvador Zubiran, Mexico (a 138% increase in joint publications since

Location of the Majority of Collaborating Institutions

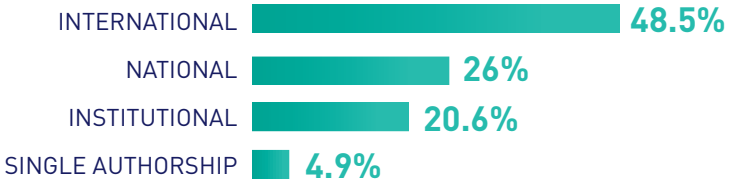
Measured by the Number of Collaborating Institutions

PERCENTAGE OF THE COLLABORATING INSTITUTIONS LOCATED IN CERTAIN CONTINENT



Type of Collaboration

Measured by the Number of Joint Publications



2018); CINVESTAV-IPN, Mexico (a 106% increase); Instituto Mexicano del Seguro Social, Mexico (a 160% increase); CNRS, France (a 50% increase); Consejo Nacional de Ciencia y Tecnologia Mexico, Mexico (a 62% increase). The majority of joint with government agencies publications originated from Mexico.

- The number of joint publications with medical entities worldwide was 436 (301 partners, 44% in Europe); the biggest collaborators measured by the number of joint publications were Instituto Nacional de Rehabilitación, Mexico (a 700% increase in joint publications since 2018); Dana-Farber Cancer Institute, US (a 1166% increase); Houston Methodist Hospital, US (a 10% increase); Hospital de Especialidades, Mexico (a 467% increase); Hospital General de Mexico, Mexico (a 120% increase). Tec de Monterrey remarkably advanced the number of joint with medical institutions publications indicating its strong stance in improving the healthcare system.
- 104 publications were on COVID-19-related topics (0.09% from total number of Tec de Monterrey publications over the 2018-2021 period).

In December 2019, right before the pandemic started, Tec de Monterrey became a signatory of the Global Climate Letter for Universities and Colleges. By signing this declaration, Tec de Monterey committed to achieve carbon neutrality by 2040, to mobilise resources for action-oriented climate change research and skills creation and to support the creation of environmental and sustainability education on the campuses, both in the classroom and in the community. It developed a Sustainability Plan 2025 that enlists necessary steps to adjust to the fast-changing climate.

Protecting the Wellbeing of the Tec de Monterrey Community in the COVID-19 Pandemic[248]

Wellbeing of the community plays a central role in Tec de Monterrey's agenda. In order to provide well-rounded support to faculty and students, the following measures were introduced:

- A guide to conscious return of students to campus was designed to promote responsible behaviours toward others, including observing safe distance and wearing masks.
- The training course Commitment to My Wellbeing was developed to provide tools for maintaining personal wellbeing, with more than 75% of the community having completed the course.
- A Wellness Ambassadors programme was designed to develop a new culture of self-care with more than 500 trained employees, faculty and student volunteers.
- Enabling the LiFE@Home, Cuida Tu Mente and Boost Your Skills programmes, with more than 123,000 accumulated registrants joining sessions.
- The Caring for Our Health questionnaire was rolled out to learn about habits and the state of wellbeing of Tec de Monterrey community.
- A support programme was implemented for employees who had COVID-19.
- Implementation of "Take a Break" allowed employees to take breaks in times of stress, without considering them as vacations.
- More than 600 employees were supported with Internet and telecom technology, to facilitate their remote work.

Tec de Monterrey remained at the front of the fight against COVID-19 by delivering 500,000 protection kits for first line responders and donating 3,100 ventilators through participation in the Juntos por la Salud initiative together with other universities.

248. 2020 Informe Annual. https://tec.mx/sites/default/files/inline-files/InformeAnual-2020.pdf

Conclusion

The healthcare crisis brought challenges to Tec de Monterrey, specifically because of the decrease in national funding for research. Due to prior investments in partnerships with local and international partners, the university succeeded in attracting funding from industrial and academic partners to continue pursuing research with a strong focus on green energy and food technology. International Liaison Offices located in the US, Canada, Australia China, South America and Europe continued to monitor new academic programme opportunities for students and faculty, as well as to promote Tec de Monterrey's academic programmes. Innovation Hub Tec-China, located in Hangzhou and aimed at accelerating scientific start-ups, sourced partners and advanced research ideas. Moreover, strong genetic sequencing capabilities of Tec de Monterrey's hospitals were supported by national and overseas medical institutions that led to a fourfold increase in joint publications.

Due to the international spread of COVID-19, face-to-face activities were suspended on the 17th of March 2020. Since then, the university implemented rapid changes with a focus on preserving the academic research and education agenda to high academic standard. A fast shift to distance learning and hybrid teaching, strengthened by innovative technologies such as Hologram Teacher and telepresence systems installed in laboratories, enabled continuity of high-quality teaching. Moreover, computational capabilities allowed secure and full access to cloud computing that facilitated remote research work.

Despite strong satisfaction reported by students and faculty concerning online lessons, Tec de Monterrey recognised the importance of face-to-face interaction, teamwork sessions and a comprehensive university experience for better development of professional and personal competencies. To implement this vision while protecting the health of community, Tec de Monterrey introduced multiple safety guidelines, embedded hygiene stations, mandated the use of self-reporting and tracing apps and implemented a work shift scheme to keep workplaces occupied by 25%. Moreover, despite the pandemic, graduates achieved 85% employability, making Tec de Monterrey the leader in Latin America in graduate employability for the 6th consecutive year.

Tec de Monterrey's emphasis on building a resilient community released the Conscious Return initiative, which promoted unity and connectedness among faculty and students. Timely and transparent communication through multiple channels helped the community stay informed and united during uncertain times. Financial support provided relief for students in need and flexibility in paying tuition fees allowed many students to continue their education.

Building a resilient campus and education system was not a singular goal during the COVID-19 pandemic. Tec de Monterrey published the Sustainability Plan 2025 where it committed to carbon neutrality by 2040 and has developed a plan to achieving this.

CHINESE UNIVERSITY OF HONG KONG

The Chinese University of Hong Kong is a public research university in Shatin, Hong Kong, formally established in 1963 by a charter granted by the Legislative Council of Hong Kong. CUHK is organised into nine constituent colleges and eight academic faculties and remains the only collegiate university in the territory. The university operates in both English and Chinese. CUHK is recognised as the most innovative university in Hong Kong for the fourth consecutive year and is ranked 26th in the Asia-Pacific region in Reuters' "Asia Pacific Region's Most Innovative Universities" listing from 2019. The University currently has more than 1,000 granted patents worldwide, with some of them been licensed to relevant industries that help bring these innovations to the market to benefit society.

CUHK undertakes a wide range of research programmes in many subject areas and strives to provide opportunities for all academic staff to undertake consultancy and collaborative projects with industry. The University's insistence on the highest standards of research has led to an enviable research reputation. 3 Areas of Excellence (out of 28) supported by Hong Kong's University Grants Committee in 2020 were being led by researchers from CUHK. The university houses 5 key state laboratories (Translational Oncology, Agrobiotechnology, Research of Bioactivities and Clinical Applications of Medicinal Plants, Digestive Disease, Synthetic Chemistry) which are entrusted by the Ministry of Science and Technology of China to produce research of international quality and carry out important national research tasks. CUHK also is home to the Prince Wales Hospital and the Shenzhen Research Institute, focusing on agricultural products and food safety, biotechnology, internet and information technology, and economics and social subjects.

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Developing a COVID-19-Shaped Education and Research Environment[249, 250]

Confronted with the epidemic, the university announced the deferment of the start date of Spring semester to February 24th, 2020. In order to minimise the impact on students' academic progress, online teaching and learning was arranged for students from February 17th onward. Over 1,100 e-classes had been held every day, with over 70,000 participants, reaching an attendance rate of close to 90%. With the opening of the new semester in September 2020, a curated 'hybrid' mode has been implemented.

CUHK employees who carried out their duties from home were assisted by tools such as Office 365 for sharing files and documents, VPN for remote access, and Zoom for video-conferencing.

During the year 2019-20, a total of 4,296 students (15% international students) were admitted to undergraduate programmes. 1,373 (45% international students) were admitted to postgraduate programmes. The CUHK employed new faculty members and researchers to ensure that the goal of CUHK education and research and excellence is met. The number of staff was 8,140 in 2020.

Despite the COVID-19 pandemic, the CUHK supported by the government, provided scholarships and aid to a large number of students:

- Government grants worth HK$107 million were provided to 2,551 students.
- Government loans worth HK$105 million were provided to 2,557 students.
- Government hostel subsidies worth HK$10 million were provided to 1,349 students.
- CUHK university scholarships worth HK$187 million were provided to 8,885 students.
- CUHK financial aid worth HK$32 million was provided to 4,464 students.

The largest sources of external funding in 2019-2020 included (in HK$ million) $247.56 (21%) from the University Grants Committee, $135.13 (11.5%) from the RGC Collaborative Research Fund, $194.37 (16.5%) from industry, $390.8 (33.2%) from charitable, trust and individual donations, and $238.37 (20.23%) from government departments and agencies.

Donations and endowments also increased almost 40% to HK$1.31 million as compared to 2019.

To aid CUHK members adversely affected by the pandemic, the University launched the CU Relief Fund in April 2020.

- On-campus part-time job opportunities were provided for full-time undergraduate students.
- Students of the class of 2020 and alumni of the class of 2019 were provided with more than 300 short-term job opportunities.
- Interest-free emergency loans for full-time staff members in junior posts were available to ease their families' financial difficulties.

In a major contribution to Hong Kong's innovation agenda, in November 2021 CUHK has established six InnoHK Centres covering health, biomedicine, robotics and artificial intelligence. Combining expertise available at CUHK and leveraging partners from prestigious global universities, such as Oxford, Cambridge, Karolinska Institutet, UC Berkeley, ETH Zurich, and Massachusetts Institute of Technology, the centres will position Hong Kong as a global powerhouse of innovation. Under the Health@InnoHK cluster, the University has set up the Centre for Novostics, the Microbiota I-Center and the Center for Neuromusculoskeletal Restorative Medicine; under the AIR@InnoHK cluster: the Hong Kong Centre for Logistics Robotics, the Multi-Scale Medical Robotics Center and the Center for Perceptual and Interactive Intelligence. 5 of the centres have started operations at the Hong Kong Science Park, with the 6th having started in January 2022.

249. Annual Report 2019-20 https://www.iso.cuhk.edu.hk/images/publication/annual-report/2019-2020/html5/
250. Annual Report 2020-21 https://www.iso.cuhk.edu.hk/images/publication/annual-report/2020-2021/pdf/2020-2021.pdf

Creating a COVID-19-Resilient Campus[251]

The CUHK emphasised the great importance of preventing and controlling epidemics, and promptly set up an Epidemic Prevention and Control Team, coordinated by the President's office. It integrated coordination, medical and security teams, a faculty working team, a student working team, and a public information team. Under their lead, several measures were taken, such as designating quarantine areas, disinfecting major public areas, temperature checking, tracking the situation of quarantined personnel, and properly disposing masks after use.

Access to the campus was restricted. Outside visitors were not permitted to enter, while students and staff were required to undergo temperature detection before entering. For asymptomatic students, the university provided free tests since March of 2020. By September 2020, the university conducted 2,000 COVID-19 tests per day. 3,000 persons from the community were recruited by the university with the subsequent testing of blood and saliva.

Pursuing Scientific Collaboration Amidst Closed Borders[252]

Following the onset of the COVID-19 virus, the university executed an online learning scheme that aimed to make sure that students' learning was not affected by the pandemic. For example, CUHK led a virtual student exchange programme organised by the Association of Pacific Rim Universities (APRU) where 78 online courses ranging from the culture of Hong Kong, impacts of climate change, business in Latin America, to indigenous languages, were offered, catering to the students of 14 university members from 9 countries.

CUHK and the Shanghai Artificial Intelligence Laboratory in September 2020 launched the CUHK Artificial Intelligence and Interdisciplinary Research Institute to promote the development and innovation breakthroughs in AI and related interdisciplinary areas.

10 CUHK scientists were on Clarivate Analytics' 2021 list of Highly Cited Researchers (an increase from 11 in 2020), ranking among the top 1% of global scientists in their field by citations. The following analysis of CUHK research performance was conducted in SciVal, for the publications during the 2018-2021 period. It is accurate as of January 2022.

- The overall number of publications was 24,694 publications over the 2018-2021 period (a 6.3% increase since 2018). A total of 20.3% of publications were in the top 10% most cited publications worldwide (the HKSAR average was 19.5%); 47.5% of publications were in the top 10% of journals (the HKSAR average was 47.3%); 3.7% of publications were in the top 1% of journals.
- 71.9% of CUHK research collaboration measured by the number of joint publications was international (the HKSAR average was 73.9%); 9.7% was national collaboration; 13.5% was only institutional; and 4.9% had single authorship. Academic-corporate collaboration of CUHK was 5.2% (the HKSAR average was 3.6%).
- The number of joint publications with institutions worldwide was 18,739 (3,425 institutions, 39% in Asia); the biggest collaborators measured by the number of joint publications were the University of Hong Kong, HKSAR (a 18% increase in joint

251. Annual Report 2019-20 https://www.iso.cuhk.edu.hk/images/publication/annual-report/2019-2020/html5/
252. Annual Report 2019-20 https://www.iso.cuhk.edu.hk/images/publication/annual-report/2019-2020/html5/

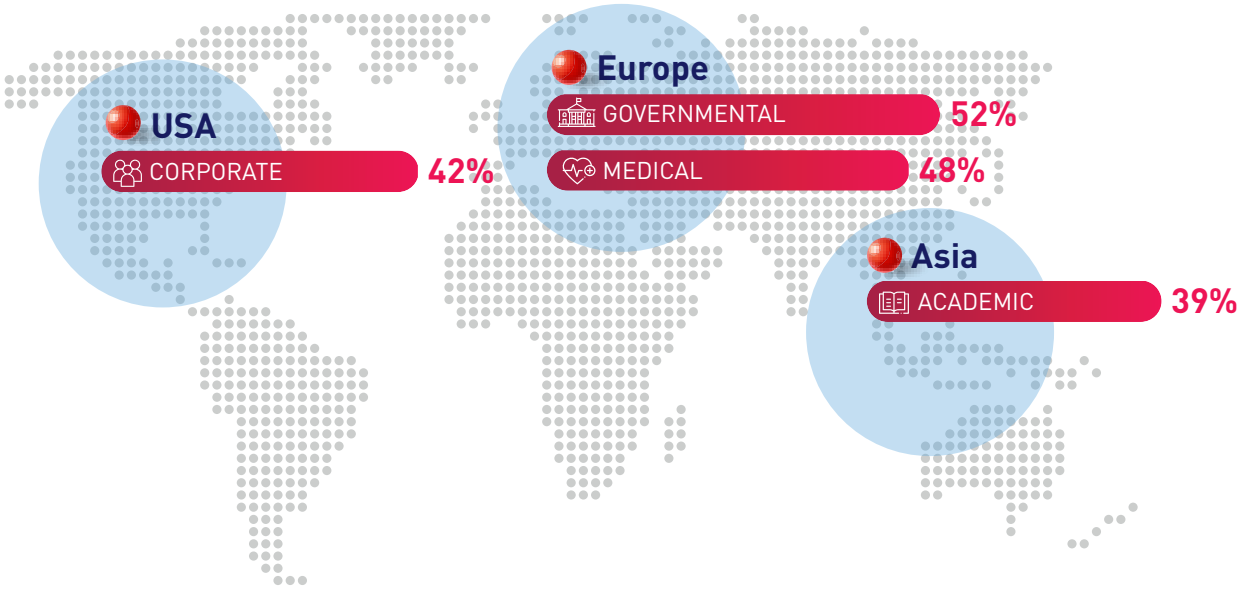
publications since 2018); Hong Kong Polytechnic University, HKSAR (a 1% increase); City University of Hong Kong, HKSAR (a 39% drop); Sun Yat-Sen University, China (a 9% drop); Shanghai Jiao Tong University, China (a 1% increase). The academic collaboration of CUHK in 2021 remained similar to 2018.

- The number of joint publications with corporates worldwide was 1,198 (269 partners, 42% in the US); the biggest collaborators measured by the number of joint publications were Tencent, China (a 6% increase in joint publications since 2018); SenseTime Group Limited, China (a 30% drop); MOH Holdings Pte Ltd., Singapore (a 4% increase); Microsoft, US (a 19% drop); Huawei Technologies Co., Ltd., China (a 42% drop). Generally, CUHK observed a decrease in joint publications with corporate partners over the 2018-2021 period.
- The number of joint publications with government agencies worldwide was 4,788 (687 partners, 52% in Europe); the biggest collaborators measured by the number of joint publications were Chinese Academy of Sciences, China (a 23% drop in joint publications since 2018); Ministry of Education, China (a 10% drop); CNRS, France (a 21% drop); National Institute for Subatomic Physics, Netherlands (a 26% drop); National Institute for Nuclear Physics, Italy (a 26% drop). Generally, CUHK observed a decrease in joint publications with established government partners over period of 2018-2021.
- The number of joint publications with medical entities worldwide was 2,920 (1,034 partners, 48% in Europe); the biggest collaborators measured by the number of joint publications since 2018 were HKSAR based hospitals. No significant change in joint publications was observed during the 2018-2021 period.
- 528 publications were on COVID-19-related topics (2.2% from total number of CUHK publications over the 2018-2021 period, with 49% decrease in publications since 2018).

Location of the Majority of Collaborating Institutions

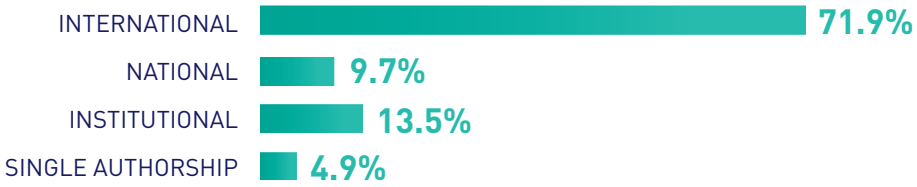
Measured by the Number of Collaborating Institutions

PERCENTAGE OF THE COLLABORATING INSTITUTIONS LOCATED IN CERTAIN CONTINENT



Type of Collaboration

Measured by the Number of Joint Publications



Protecting the Wellbeing of the CUHK Community in the COVID-19 Pandemic[253, 254]

Considering the psychological impact that the pandemic and the safety measures may have on the students, the Student Counselling and Development Service of the university's Office of Student Affairs provided online psychological counselling daily. The colleges paid special attention to the mental health of 253 students who were in the Hubei province and provided the necessary support to these students.

Technical and learning support, including laptop computers on loan were available to ensure students were provided with as much support as possible during extended work-from-home orders and for hybrid learning. CUHK ensured clear and transparent communication with students and staff by providing timely updates through public announcements.

Conclusion

The tragic emergence of the pandemic amidst the Spring Festival of 2020 required a multitude of adjustments to the daily operations of the university. However, acting quickly and creatively, Hong Kong became one of the best-managed areas in the world with CUHK at its fore, setting an example for the world. Using a hybridised methodology, the university and its affiliates managed to curb the impact of COVID-19, by pairing large-scale epidemiological methods with an individualised human touch to care for students, faculty and researchers on a human level.

Claiming its position as one of the most innovative universities in Asia, CUHK embarked on establishing new interdisciplinary research centers to meet the challenges of the future, despite financial devastation brought by the pandemic. Both by continuing regular functioning and by leveraging the crisis as an opportunity for developing new pathways in biomedical research, CUHK has managed to continue to thrive despite the COVID-19 pandemic.

CUHK was financially supported by the governments, through providing scholarships, loans, and hotel subsidies for students. It also leveraged the monetary support from charitable, trust, and individual donations.

CUHK had a record of publishing papers on coronaviruses since 2018, according to SciVal. However, an unexpected decline was observed in 2021. Besides, a decline in joint publications with the top 5 international governmental institutions, located mainly in China and Europe, was also observed. Such a drop can be partially explained by restrictions imposed by border closures that affected travels and international collaboration.

The effect of zero-tolerance approach to COVID-19 that led to HK lockdown in 2022 is yet to be evaluated.

248. Annual Report 2019-20 https://www.iso.cuhk.edu.hk/images/publication/annual-report/2019-2020/html5/
249. CUHK vs COVID-19. Announcement & Actions. https://www.cuhk.edu.hk/english/whats-on/faces/antivirus-annc.html

UNIVERSITY OF RWANDA

The University of Rwanda (UR) is Rwanda's largest higher education institution. It was formed in 2013 through a merger of the previously independent public institutions of higher education: National University of Rwanda; Kigali Institute of Science and Technology; Kigali Institute of Education; Higher Institute of Agriculture and Animal Husbandry; School of Finance and Banking; Higher Institute of Umutara Polytechnic; Kigali Health Institute. The university has a total of 14 campuses. The university has more than 30,000 students, and more than 99% of which are Rwanda nationals. The proportion of postgraduate students has increased from 2% to 5% in the past 3 years. The university employs 1,450 academics and 816 support and administrative staff.

UR is a home to 4 African Centres of Excellence: Data Science, Internet of Things, Energy for Sustainable Development, and Innovative Teaching and Learning Mathematics and Science, which are funded by the World Bank. UR earned a premier accreditation from the Data Science Council of America which allows UR to offer world class Master's and PhD programmes in Data Science. UR's African Center of Excellence in Data Science is the first in Africa to earn this accreditation.

'We move on from 'implementing projects' to 'projecting implementation' to a future version of the University' - Prof Philip Cotton, UR Vice Chancellor

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Developing a COVID-19-Shaped Education and Research Environment[255]

Facing a lack of academic staff, the university leadership plans to increase the percentage of academic staff holding doctoral degrees from 20% to 60% of UR's overall workforce by 2024.

The shift to online learning required time and preparation by its faculty. By the end of 2020, 91% of modules taught in UR were hosted on eLearning platform and delivered online. The number of platform users grew from 300 students daily pre-pandemic to 9,000 daily students during the lockdown. Moreover, the Partnership for Enhanced and Blended Learning UR extended its undergraduate online module in Introduction to Information Technology to students of the State University of Zanzibar, the Open University Tanzania, Kenyatta University, Strathmore University, and Makerere University. UR and Unicaf University launched a partnership to convert educational modules into online versions.

With help from the Department of Computer and System Sciences at Stockholm University, the ICT department at UR received technical support to establish and maintaining its e-learning platform and meet the increasing demand for distance learning. This programme was funded by the Swedish International Development Agency for the period 2019-2024, with the aim to support ICT development at UR both in terms of infrastructure and human capacity. In November 2021, the IT team from Stockholm University visited UR to identify ICT infrastructure needs and challenges at UR, establish ICT staff skills and training needs and to find solutions to existing IT challenges. The collaboration with the Department of Computer and System Sciences, Stockholm University, allowed UR to invite scientists from 8 African countries to the African Centre of Excellence in IoT for training during the pandemic.

In 2020, the African Centre of Excellence in Energy for Sustainable Development won a grant of US$ 250,000 to establish an Incubation Centre. This centre has the objective to equip graduates with real life knowledge in industrial needs and in current market demands and to bridge the gap between academia and industry.

Pursuing Scientific Collaboration Amidst Closed Borders[256, 257]

Expanding the existing international collaborations such as the joint MSc degree programme in agribusiness with Michigan State University, UR entered a partnership with the Swedish International Development Cooperation Agency in late 2019, with the aims to fund research capacity development in Rwanda and to increase research towards poverty reduction in Rwanda. In 2019, before the pandemic, it went into its third phase and included 14 research training programmes and 5 research support programmes. It targeted to enrol 80 PhD candidates who will be trained both at UR and in Swedish universities, 26 postdocs, and more than 240 Masters Students.

To promote university-industry leadership, UR embarked on a 5-year research project with Rwanda Environmental Management Authority (REMA) and Institute of Applied Sciences Ruhengeri on agro-ecology intensification, agrodiversity and biodiversity, and climate change.

There were no academics from UR recognised as Highly Cited Researchers by Clarivate Analytics among the top 1% of global scientists in their field by citations. The following analysis of research performance of the University of Rwanda was conducted in SciVal, for the publications during the 2018-2021 period. It is accurate as of January 2022.

- The overall number of publications was 1,518 over the 2018-2021 period (a 58.5% increase since 2018). A total of 8.4% of publications were in the top 10% most cited publications worldwide (the Rwanda average was 11.8%); 23.3% of publications were in the top 10% of journals (the Rwanda average was 27.5%); 1.2% of publications were in top 1% of journals.
- 87% of UR's research collaboration measured by the number of joint publications was international (the Rwanda average was 89.7%); 4.2% was national collaboration; 6% was only institutional; and 2.8% had single authorship. Academic-corporate collaboration of UR was 2% (the Rwanda average was 3.5%).
- The number of joint publications with institutions worldwide was 1,163 (1,204 institutions, 28% in Asia); the biggest collaborators measured by

255. University of Rwanda Annual Report 2020-2021. https://ur.ac.rw/IMG/pdf/signed_ur_annual_report_2020-2021.pdf
256. University of Rwanda Annual Report 2020-2021. https://ur.ac.rw/IMG/pdf/signed_ur_annual_report_2020-2021.pdf
266. UR-Sweden Programme for Research, Higher Education and Institutional Advancement. https://ursweden.ur.ac.rw/

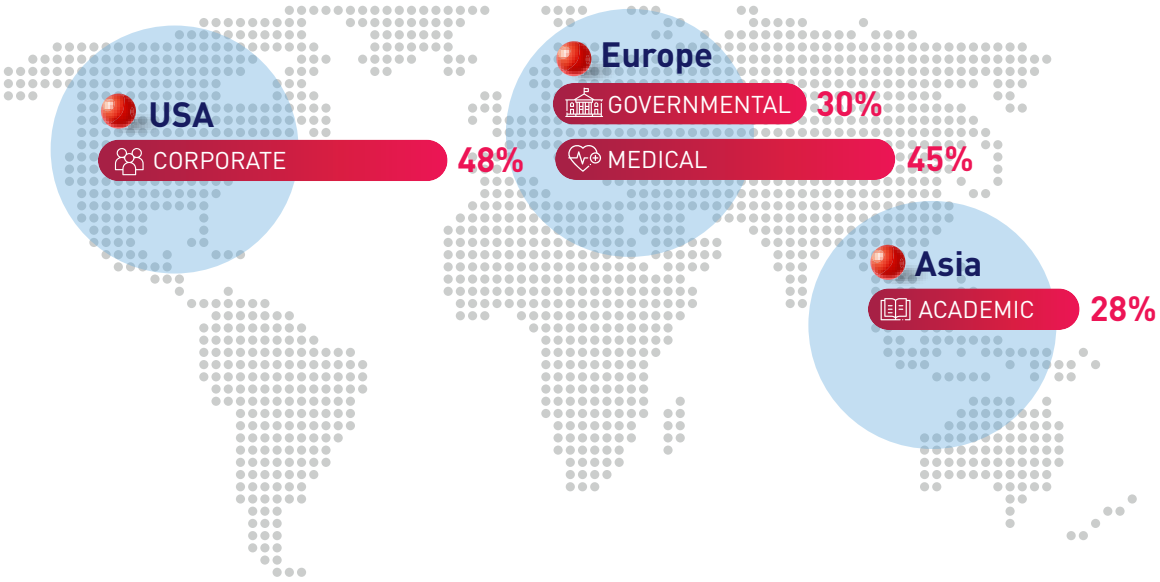
the number of joint publications were Harvard University, US (a 3% drop in joint publications since 2018); University of KwaZulu-Natal, South Africa (a 100% increase); Yale University, US (a 46% increase); University of Capetown, South Africa (a 40% increase); Makerere University, Uganda (a 86% increase). The University of Rwanda demonstrated a positive trend of increasing academic collaboration with African institutions.

- The number of joint publications with corporates worldwide was 29 (22 partners, 48% in the US); the biggest collaborators measured by the number of joint publications were UCB S.A, Belgium (a 55% increase in joint publications since 2018); Razi Vaccine and Serum Research Institute, Iran (5 publications); Ariadne Labs, US (3 publications); Clinton Health Access Initiative, US (2 publications); Creativ-Ceutical SARL, Luxembourg (2 publications). UR had active collaboration with UCB S.A, Belgium, but at the same time lagged behind other African countries in establishing academic-corporate collaborations.
- The number of joint publications with government agencies worldwide was 309 (165 institutions, 30% in Europe); the biggest collaborators measured by the number of joint publications were Rwanda Biomedical Center, Rwanda (a 29% increase in joint publications since 2018); South African Medical Research Council, South Africa (a 160% increase); Chinese Academy of Science, China (a 233% growth); Rwanda Agricultural Board, Rwanda (a 40% increase); WHO, Switzerland (a 267% increase). UR recorded a boost in joint with government agencies publications since 2018, that could be explained by active involvement in the COVID-19-related research.
- The number of joint publications with medical entities worldwide was 95 (282 institutions, 45% in Europe); the biggest collaborators measured by the number of joint publications were Hamad Medical Corporation, Qatar (a 500% increase in joint publications); International Centre for Diarrhoeal Disease Research Bangladesh, Bangladesh (a 500% increase); Oxford University Hospitals NHS Foundation Trust, UK (a 500%

Location of the Majority of Collaborating Institutions

Measured by the Number of Collaborating Institutions

PERCENTAGE OF THE COLLABORATING INSTITUTIONS LOCATED IN CERTAIN CONTINENT



Type of Collaboration

Measured by the Number of Joint Publications

increase); Azienda Ospedaliero-Universitaria di Bologna Policlinico S. Orsola – Malpighi, Italy (a 500% increase); Mayo Clinic Rochester, MN, US (a 600% increase). More than 5-fold growth in publications with international medical institutions indicated UR's expertise in the area of healthcare.

- 36 publications were on COVID-19-related topics (2.3% from total number of UR publications).

Protecting the Wellbeing of the University of Rwanda Community in the COVID-19 Pandemic[258]

UR was actively involved in community relief activities during the COVID-19 outbreak by becoming part of Rwanda's joint Task Force. Moreover, UR staff organised a donation drive and help for distant communities by providing food and other essentials during lockdown and periods of limited mobility.

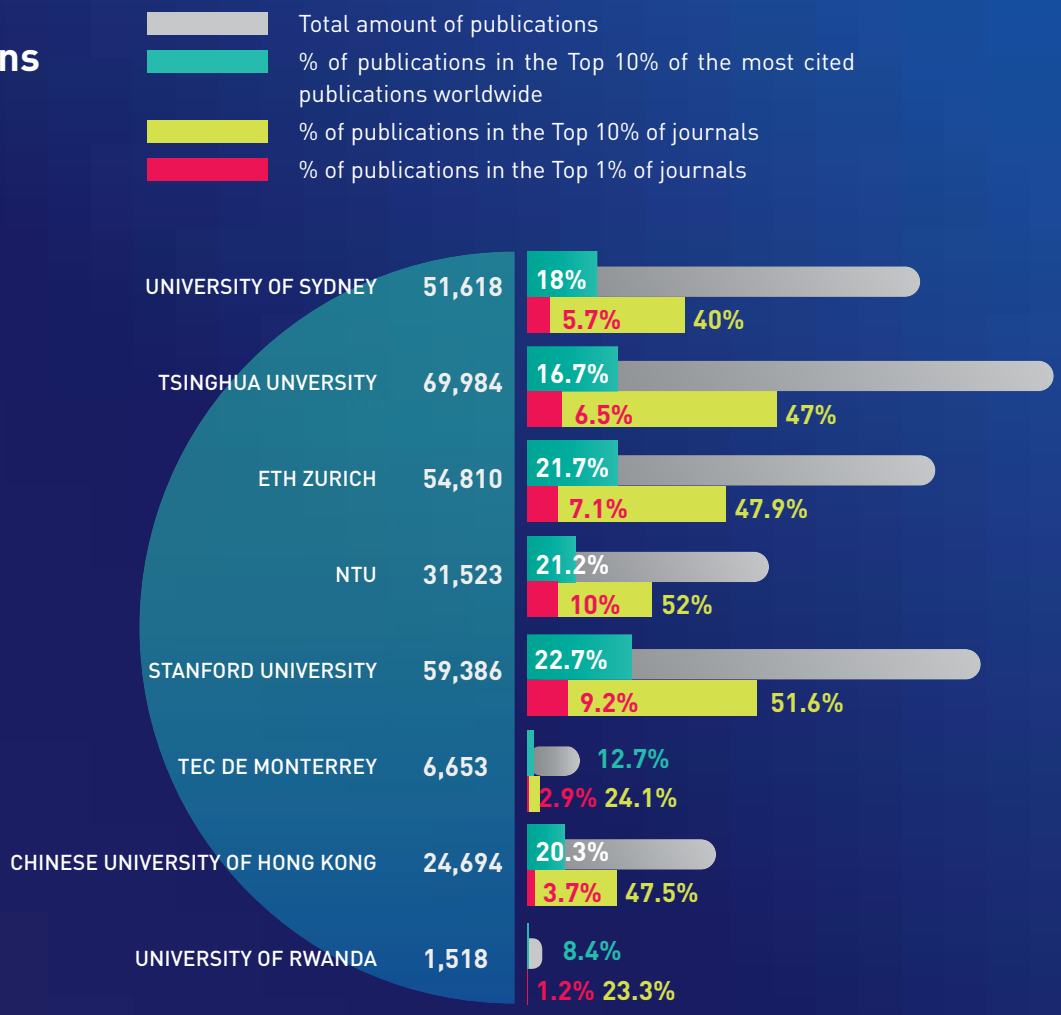
Conclusion

University of Rwanda has been steadily moving toward research excellence since its establishment in 2013. The pandemic has not disrupted this advancement significantly. Instead, it boosted the collaborative research with medical institutions worldwide. The partnerships with China's academic institutions (Harbin Institute of Technology and Chongqing Normal University) that were formed right before the pandemic resulted in an increase of joint publications. Existing partnerships (such as with the Swedish International Development Cooperation Agency) helped equip UR's IT team with necessary skills to support the transition to online education.

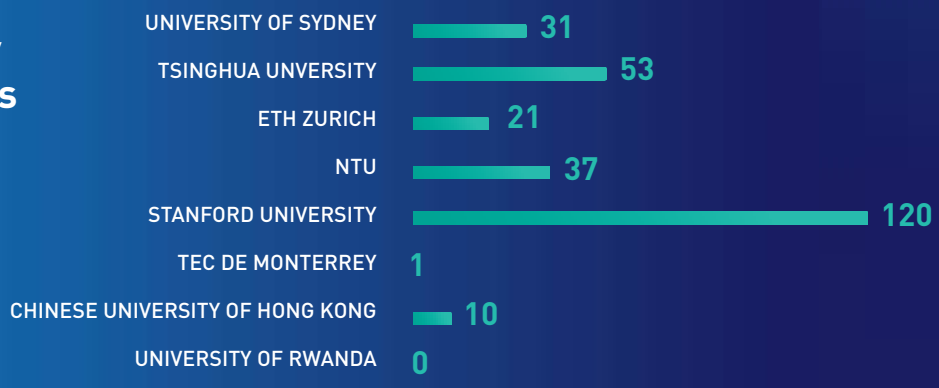
In the face of the pandemic and the global healthcare crisis, UR remained committed to research on health, agricultural technology, biodiversity and climate change.

258. University of Rwanda Annual Report 2020-2021. https://ur.ac.rw/IMG/pdf/signed_ur_annual_report_2020-2021.pdf

Publications Statistics

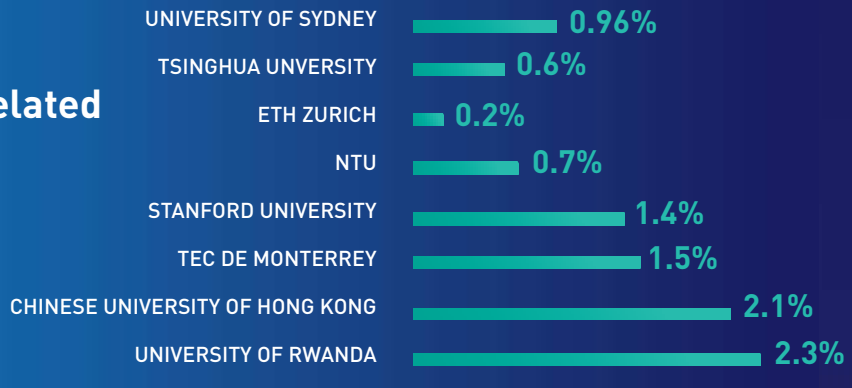


Number of Highly Cited Researchers in 2021*



* According to Clarivate Analytics

% of COVID-19-Related Publications



RECOMMENDATIONS

COVID-19 has demonstrated how integrated the world is. In order to pursue research and teaching excellence it will become more crucial to embrace global interconnectedness and to master navigation across social, academic, economic and political differences. The road to the universities' recovery is not in expecting to return to pre-COVID-19 reality, but instead in reinventing the education approach and campus design, innovating with collaborative approaches to research, reconsidering the vision, and reimagining university as a partner for lifelong adaptable learning. It is essential to look into the challenges created by the pandemic as new unchartered opportunities that would improve academic experience for students and researchers.

Supporting Lifelong Learning and Employability

The need for lifelong learning represents the common goal and poses difficulties for universities. However, it becomes of increased importance to nurture students' resilience and adaptability through teaching them creativity, communication and collaboration, emotional intelligence as well responding quickly to the changing needs of volatile job markets by introducing short-term micromodules and online courses, virtual exchange alliances, virtual internships, and digital certifications.

To assist fresh graduates with search for a job in a digitalized economy, organizations that provide virtual internships[260] evolved prior to COVID-19 and spurred their activities during the periods of restricted mobility. Besides providing internships around the globe, these services helped address the issue of unequal access to the opportunities, thus releasing students from the burden of geographical borders or physical disabilities. The adaptations in operating universities in the resilient post-pandemic future might include all-year-round students' enrolment to maintain the safe distancing.

Developing Digital Infrastructure

The ability of universities to promptly shift online allowed students to stay on track of their academic curriculum. Moreover, trained teaching personnel and previously implemented platforms for digital pedagogy cushioned the shocks of swift campus shutdowns. In the view of disrupted on-campus education, universities were obliged to explore new ways and online platforms to deliver regular on-campus experiences, as counselling, student support, and networking, opening a roadway for innovative technical solutions. Traditional educational schemes prioritizing on-campus education need to be revised and redesigned[259]. However, low income countries heavily relied on available low-tech solutions, faced with the limited access to the Internet, laptops and even electricity. There is an urgent need to consider development of adjustable low-tech improvements to existing learning systems or to expand current solutions to universities in need.

Localising Higher Education

In the face of disrupted academic and students' mobility, many students decided to pursue higher education during the pandemic, seeking for opportunities within the region. Establishing new universities and expanding international networks in the regions that were previously ignored due to lack of infrastructure and demand and attracting international students from various parts of the world can help reimagine the future of education and maintain steady performance in the face of coming emergencies. Universities that are currently highly reliant on international students may be interested in developing and offering hybrid academic programmes, whereby international students choose to undertake an initial period of study in their home country (either online or with a partner institution), before travelling to the overseas university for a shorter, more intensive, on-campus experience.

259. Quattrone, F., Borghini, A., Emdin, M., et al. (2020) Protecting higher education institutions from COVID-19: insights from an Italian experience, Journal of American College Health, DOI: 10.1080/07448481.2020.1791885
260. Virtual internships. https://www.virtualinternships.com/

Diversifying Flow of Funds

The ability of universities to navigate through financial impacts of the pandemic was largely enhanced by diversified funding that came from partnerships with private sector, industries and international organizations, as well as from endowment funds and donations. The extensive support of research activities provided to universities by national governments proved to boost research outputs.

Cultivating Partnerships

Pandemic taught the world a lesson in importance of partnerships and multilateral collaborations, be they for policy or regulation adoption, developing a research direction or employment of young graduates. Universities that expand their networks through arranging partnerships with industries will be able to analyse real world needs first-hand and adjust by developing micro-modules or shorter degrees to retrain industrial experts. The investment in joint laboratories, collaborative research initiatives and open data brought its dividends as the accelerated development of vaccines, validation of research findings and ensuring high quality of research and implementation. It is anticipated that the demand in joint with industry short courses will grow. Google, Microsoft and IBM set the bar in creating short-term and less expensive courses focused on developing of applied and hard skills.

Boosting Knowledge Sharing

Transforming the entire business of conferences from physical attendance to virtual meetups facilitated the access of scientists to the latest research findings, opened up discussions to a wider audience and promoted knowledge exchange at different levels. Although face-to-face meetings remain preferential and more effective for networking and building partnerships, virtual meetings, courses and seminars enabled equal access of diverse communities to the knowledge sharing. This had a profound impact on the inclusion of more diversified opinions into discussion and the development of collaborations that would not be possible otherwise.

Preparing for Future Emergencies

The world learnt that neglecting obvious threats as zoonotic viral diseases can lead to unprecedented economic impact, loss of lives and throwback in achieving Sustainable Development Goals (as poverty reduction, gender equality and access to education). COVID-19 revealed the blind spots that the society ignored and underlined the importance of proactive planning of research funding. Prioritization of research that focuses on increasing health and economic resilience as well as building future preparedness for pandemics and other emergencies should become a must for the nations.

The COVID-19 pandemic turned out to become a necessary nudge for higher education institutions to reflect upon the best way to self-sustainability. It augmented the importance of mental and emotional wellbeing, flexibility and digital transformation of university assets and facilities. Ultimately, the majority of universities managed to strengthen their position as key contributors to state resiliency.

Careful accounting for the gaps and strategic preparation of manpower, resources and facilities to meet future existential crises became a necessary obligation for states, and universities should be tasked to play the foundational role in developing innovative approaches.

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