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REVIEWS

Scientific Life

The Invisible University Is COVID-19 Positive

Daniel S. Park [1,*]

Within the ivory tower of academia, the coronavirus disease 2019 (COVID-19) pandemic stands to disproportionately impact the invisible workforce of postdoctoral researchers (postdocs). Faced with university closures, hiring freezes, and a general lack of support and benefits, an entire generation of postdocs and their knowledge and skills may be lost to academia without intervention.

As the continuing COVID-19 crisis engulfs the globe, its inhabitants, and their livelihoods, many are facing enormous challenges. As is the rule in a society fraught with disparity, this crisis continues to hit vulnerable groups the hardest in every way, deepening the consequences of inequality [1]. The proverbial ivory tower of academia is no exception to this rule [2].

The COVID-19 pandemic stands to disproportionately impact certain members of academia, including non-tenured faculty, graduate students, and postdocs. Largely unknown to those outside the scientific community, postdocs have PhDs but they are neither faculty nor students. They often do not qualify as employees, and their specific numbers are unknown, even within academia. Referred to as the invisible university due to this elusive nature [3], postdocs nonetheless comprise a significant proportion of the academic workforce and are at the forefront of cutting-edge research. Without them, science would come to a halt, especially in biological and medical fields.

The majority of those undertaking postdoctoral research in the sciences are doing so to compete for independent academic positions [4]. However, the COVID-19 crisis has led to numerous hiring freezes across the board, and even job offers that have been made are being rescinded [5]. This has rendered an already dire tenure-track job market – which arguably never fully recovered from the 2008 recession – nonexistent for at least two hiring cycles (i.e., years). Postdocs are most often funded by research grants tied to a particular institution and/or faculty member and are generally subject to annual contracts. Thus, a lull in hiring can have disastrous consequences for these early career scientists. Postdocs are generally not as well paid as their peers outside of academia, and often lack benefits and safety nets that faculty, students, and permanent staff have access to, such as paid family leave [6,7]. This is further conflated by the fact that many postdocs are at the stage of their lives when they start families (e.g., the two-body problem) [8]. The situation is even worse for international postdocs – it has been estimated that at least half, and up to two-thirds of all postdoctoral researchers are on temporary visas in the US, and this percentage has only been increasing through time [9]. Many of these researchers are in danger of being extirpated without continued employment, while others are unable to travel to their home countries to renew their existing visas and return to their place of employment.

Even those fortunate enough to be able to weather the aftermath of this global catastrophe and remain in academia for now will be burdened with numerous handicaps competing in future academic job markets. Many will lose months or years of scientific progress as universities have shut down laboratory activities, and travel restrictions and safety concerns make fieldwork impossible [10]. Furthermore, researchers who have already worked as postdocs for several years are in real danger of being perceived as having been postdocs for too long to warrant serious consideration for faculty positions.

At the best of times, the postdoc life is still defined by its uncertainty; one is always at the end of a deadline or funding cycle with no guarantee of future employment. However, the COVID-19 crisis has all but guaranteed that there will be next to no permanent employment for many current postdocs in the coming years, at least not in academia [11]. Although science jobs exist outside of academia, they too may be similarly impacted, and graduate and postdoctoral training generally does not foster the skills industry jobs require [12]. Inevitably, many will be forced to abandon years' worth of scientific work and training and seek alternate career options, even as the role of basic research and the scientific community has become more important than ever, in light of our lack of preparation for the COVID-19 pandemic. This represents a significant loss for both the scientific community and society as a whole, not to mention individuals.

The COVID-19 pandemic did not create these problems; rather it has highlighted long-known issues with the arguably exploitive postdoctoral system in academe [13,14]. Despite numerous calls, remedying this disparity in academia has never been a priority, as institutions and laboratories benefit from the relatively low-cost, low-maintenance workforce postdocs represent [7,14,15]. More than ever before, many of our early career scientists are faced with an impossible challenge, and their loss is a loss to the global community. Even as universities scramble to implement policies to mitigate the impact of COVID-19 on students and faculties, postdocs are being overlooked by many administrations despite outnumbering faculty staff. Will academia choose to ignore the plight of the postdocs, yet again, in the face of this global crisis?

[1]Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA 02138, USA

*Correspondence:
danielpark@fas.harvard.edu (D.S. Park).

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Spotlight

Tracking the Genomic Footprints of SARS-CoV-2 Transmission

Tommy Tsan-Yuk Lam[1,*]

There is considerable public and scientific interest in the origin, spread, and evolution of SARS-CoV-2. Lu *et al.* recently conducted genomic sequencing and analysis of SARS-CoV-2 in Guangdong, revealing its early transmission out of Hubei and shedding light on the effectiveness of controlling local transmission chains.

The outbreak of SARS-CoV-2 (the cause of the disease known as COVID-19) was first reported in Wuhan city (Hubei province), China, in December 2019, and swept across the nation and then around the world within 2 months, leading to its declaration as a pandemic by the World Health Organisation (WHO) on 11 March 2020. As of 20 May 2020, the worldwide COVID-19 death toll has reached 318 789, and nearly 5 million confirmed cases have been reported across all continents [1]. The enormous health and economic impacts caused by this virus, at such an unprecedented speed, have raised considerable public interest, fueling research into its origin, spread, and evolution. Analysis of genomic data is a key tool for studying emerging pathogens [2]. The recent identification and genomic characterization of bat and pangolin coronaviruses, which are evolutionarily related to human SARS-CoV-2, have suggested that these species could act as the zoonotic origins of the human virus [3,4]. Other pressing questions for understanding the ongoing pandemic include identifying the means by which SARS-CoV-2 has spread across China and the world from its starting place, and whether disease control measures effectively suppress the introduced infections against further transmission.

Several studies using mathematical modeling of COVID-19 and other coronavirus transmission have suggested that measures such as social distancing and city lockdown may be effective methods of disease control [5,6], but these seldom assess individual transmission chains. Lu *et al.* recently sequenced SARS-CoV-2 genomes from 53 patients in Guangdong, the province of China that reported the highest number of cases (n = 1388) outside Hubei [7]. Phylogenetic analysis of these and other genomes of SARS-CoV-2 worldwide revealed that the Guangdong virus strains are scattered among strains from other Chinese provinces and other countries, consistent with the epidemiological finding that the majority of infections detected in Guangdong were imported cases. Twenty-three Guangdong virus strains formed five statistically well-supported phylogenetic clusters, and this might indicate some local transmission following the introductions of these virus lineages. Notably, the observed durations of these putative local transmission chains largely overlap with the period from mid-January to late February in which most Guangdong local infections defined by the patients' travel histories were reported. These genetic and epidemiologic findings consistently suggest that control measures successfully reduced local transmission in Guangdong after February.

Genomic information about pathogens provides valuable empirical information about their transmission histories [1], such as the identification of transmission chains through phylogenetic analysis of genome sequences, as illustrated by the work of Lu *et al.* [7]. In addition to revealing pathogen evolutionary processes and acting as a proxy of disease transmission history, phylogenetic trees also serve as versatile frameworks for comparative analysis of virus genetics and phenotypes, disease epidemiology, clinical manifestations, and population demography and environments, thus facilitating the identification of possible interplay between these various aspects of disease dynamics (Figure 1). There has been active research into methods for integrating multidimensional data related to pathogens for statistical inference, especially in a Bayesian framework [8]. It is anticipated that such integrative analysis of SARS-CoV-2, including the work by Lu *et al.* [7], as well as a more recent study by Dellicour *et al.* in Belgium [9], will greatly promote