Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

CHAPTER THIRTEEN

Impact of Covid-19 on research and training in Parkinson's disease

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Contents

Abstract

The Coronavirus Disease 2019 (Covid-19) pandemic and the consequent restrictions imposed worldwide have posed an unprecedented challenge to research and training in Parkinson's disease (PD). The pandemic has caused loss of productivity, reduced access to funding, an oft-acute switch to digital platforms, and changes in daily work protocols, or even redeployment. Frequently, clinical and research appointments were suspended or changed as a solution to limit the risk of Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) spread and infection, but since the care and research in the field of movement disorders had traditionally been performed at in-person settings, the repercussions of the pandemic have even been more keenly felt in these areas. In this chapter, we review the implications of this impact on neurological research and training, with an emphasis on PD, as well as highlight lessons that can be learnt from how the Covid-19 pandemic has been managed in terms of restrictions in these crucial aspects of the neurosciences. One of the solutions brought to the fore has

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been to replace the traditional way of performing research and training with remote, and therefore socially distanced, alternatives. However, this has introduced fresh challenges in international collaboration, contingency planning, study prioritization, safety precautions, artificial intelligence, and various forms of digital technology. Nonetheless, in the long-term, these strategies will allow us to mitigate the adverse impact on PD research and training in future crises.

1. Introduction

In response to the Coronavirus Disease 2019 (Covid-19) pandemic, not only have many hospitals canceled elective procedures, but other clinical and research appointments have been changed to limit the risk of Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) spread and infection to patients, as well as to clinical and research staff. Since medical care and research in movement disorders and Parkinson's disease (PD) have been traditionally performed face-to-face (Cohen, Busis, & Ciccarelli, 2020), a clear impact of the pandemic was felt in clinical and research settings. One of the solutions that have been brought forward was to replace the traditional way of performing research and training with remote, and therefore socially-distanced, alternatives. Although such methods had been active across some centers even before the Covid-19 pandemic, their use has not been widespread.

In this chapter, we review the impact of the Covid-19 pandemic, directly or indirectly linked to the virus itself, as well as of the associated changes effected in response on research and training in the field of neurology with a special focus on PD. Accordingly, we attempt to make recommendations for the post-pandemic world of PD research and training.

2. Research activities

2.1 Impact

The Covid-19 pandemic has transformed the way global research is approached (Lau, Lau, & Ibrahim, 2021), with research projects around the world having to face tremendous challenges at multiple levels (Fig. 1), while some have been forced to halt completely. Those that continued have had to significantly adapt to a new reality (Tan et al., 2021). The term "research resilience" is appropriate in response to a world trying to manage this research crisis (Rahman, Tuckerman, Vorley, & Gherhes, 2021; Tan et al., 2021). It is, indeed, important to proactively incorporate resilience into the research process, as well as to

Fig. 1 The impact of Covid-19 pandemic and related restrictions on Parkinson's disease research and training.

provide lessons and considerations on adaptability and flexibility in the research field to obviate challenges faced (Rahman et al., 2021) (Fig. 2).

A striking example of how research has changed in response to the pandemic was the call for Urgent Public Health (UPH) studies in the United Kingdom (UK) (National Institute for Health Research, 2021), where trials related to Covid-19 were prioritized at the expense of non-Covid-related research, such as the ones related to PD. Because of this call, 90% of non-commercial UK government funded National Institute for Healthcare Research (NIHR) studies and over 50% of the commercial studies were temporarily halted (Iacobucci, 2020). Similar actions have been taken in other countries, such as the United States of America (US) (Kardas-Nelson, 2020). Reasons, which have affected the conduct of clinical trials during the crisis, included patient hesitancy or inability to continue interventions due to self-isolation or quarantine, as well as limited access to medical institutions, such as hospitals. Interruption of supply chains and study monitoring has also caused scarcity in research resources (AlNaamani, AlSinani, & Barkun, 2020).

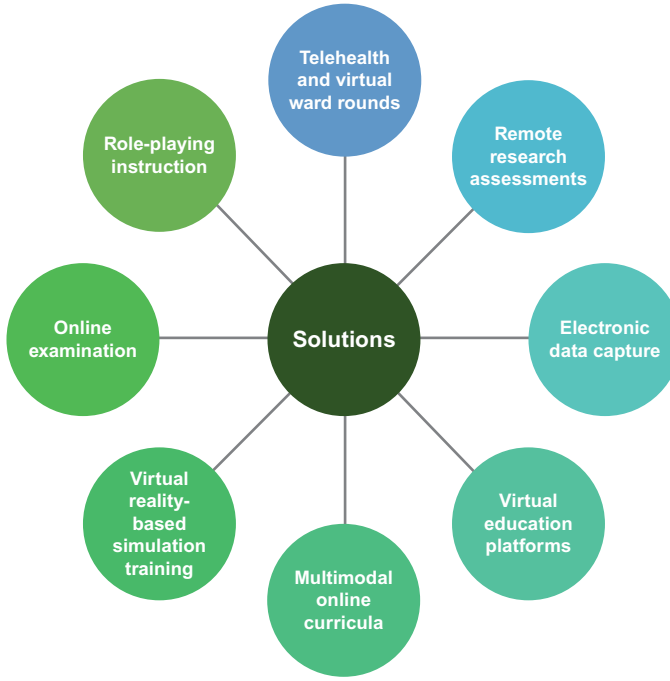

Fig. 2 The strategies effected to mitigate the impact of Covid-19 pandemic on Parkinson's Disease research and training.

As a consequence, researchers had to shift their work from a live modality to a remote one and change their priorities, focusing more on data analysis, drafting papers, and writing grant proposals (Chan & Tan, 2020). According to some authors, there have been about 6–12 months of lost productivity in research with a reduction of trial size by 30% due to patients' drop-outs (Kardas-Nelson, 2020). This has also been reflected by the drop in the number of published studies since the beginning of the pandemic (Fig. 3). Additionally, Covid-19 has caused a fundraising deficit with an average of 38% reduction in donations in medical research charities (Parkinson's UK, 2020). When looking specifically at PD research, a survey run among the Parkinson Study Group (PSG) clinician members has reported that most of the researchers stated a 75–100% reduction of their activities, while many of them had to perform protocol deviations (38.2%) or exceptions (25.5%), and some even had to change their work profile because of layoffs (16.8%) (Shivkumar et al., 2021).

Other areas where the impact of Covid-19 has been felt, were that of disease symptomatology. Data interpretation in PD clinical studies needs

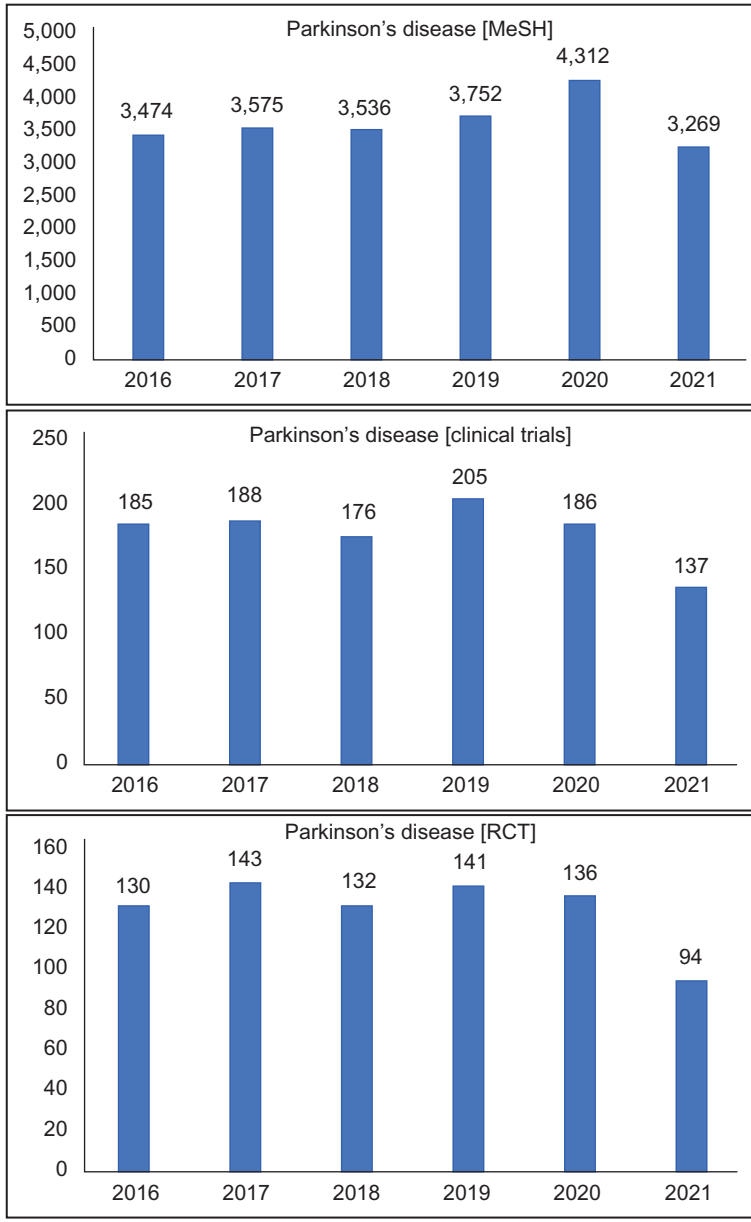

Fig. 3 The decline in the number of studies in people with Parkinson's disease over the year 2021 compared to the preceding 5 years; note the even greater decline in the number of clinical trials and randomized clinical trials (RCT). *Source: PubMed.*

to be handled cautiously, as neurological symptoms of Covid-19 may overlap with PD (and related disorders), with long-term effects on PD remaining unclear (Tan et al., 2021). Methods, which have facilitated more complete data collection during the Covid-19 pandemic, are also crucial in improving the validity of assessments, efficacy, and safety (Council., U. N. R, 2010; Fleming, 2011).

Recognizing the potential effect of pandemics as a source of bias is important to allow a balanced interpretation of results. The Covid-19 pandemic constitutes a potential source of unintentional bias and researchers should be careful not to overgeneralize the results and be more vigilant in the inspection of the data for type I/II errors (Simundic, 2013). The pandemic has also disrupted research participation among people with PD (PwP); one study has demonstrated that 40% of PwP (without Covid-19), who had been actively participating in research prior to the pandemic, had to cancel, and 35% were forced to postpone in-person research visits, although the remaining 25% were able to conduct research visits via other means (Brown et al., 2020). On the whole, while 11% felt that the pandemic has made them less likely to participate in research, 6.3% felt that the pandemic has actually made them more likely to participate (Brown et al., 2020). However, compensatory activities, such as telemedicine and digital research platforms, may exclude those lacking technological resources or competency.

Nonetheless, some of the effects of the pandemic on research seem to have been positive, providing prospects for growth for individual researchers and the scientific community. For instance, many research conferences have pivoted to a virtual format, drastically reducing the costs of registration and attendance, which has allowed for greater and more inclusive participation in global networking. Scientists have also taken greater advantage of alternative platforms for disseminating research findings, such as PsyArXiv, and of online data collection systems, which have responded by increasing research capacity. Online modalities have the capability of reaching a wider and more diverse population than traditional, center-based research, while targeted recruitment will allow future studies to clarify the extent of and plan for disparities in healthcare access during and after the pandemic (Brown et al., 2020). Strategies that have been used to reduce the impact of the Covid-19 pandemic are outlined below.

2.2 Strategies

The common limitations imposed by the pandemic which may have affected the integrity of PD (and other) clinical studies included delays in

study enrolment, staffing changes, limited clinic space, remote interactions due to social distancing measures, manpower shortages due to staff redeployment to Covid-19 frontline, lack of training to handle emergent infectious disease protocols, and inadequate financial support (Tan et al., 2021). As such, research and clinical teams have increasingly switched to telehealth modalities and the adoption of flexible research protocols and clinical trials to maintain study and data integrity (Fleming, Labriola, & Wittes, 2020; Medicines and Healthcare Products Regulatory Agency, 2020; Rose, 2020). In fact, during the pandemic, telehealth use has increased from 9.7% to 63.5%, and almost half of the patients (46%) preferred to continue using it, especially patients with a higher income and higher education, or those where technical support could be provided by a carer (Feeney et al., 2021). Nevertheless, considering the determinants of its use among patients, telehealth was able to reach only a limited, probably non-representative part of the population, a fact that could have important implications, especially in medical research.

Other crucial factors influencing trial continuation and resumption were Covid-19 disease burden and community spread (Tan et al., 2021), necessitating the prioritization of preventive, diagnostic, and interventional measures to further reduce the risk of exposure. Part of this, for all ongoing and new projects, included ranking of studies in terms of importance in the order of therapeutics and/or vaccines, diagnostics, and epidemiology, mainly impacting those studies evaluating interventions aimed at preventing or treating diseases other than Covid-19 (Tan et al., 2021). Clinical trials investigating potential disease-modifying therapies in progressive neurodegenerative diseases (such as PD), or high-impact novel symptomatic therapies were to be minimized (Papa et al., 2020). Over the course of the pandemic, clinical trials related to non-Covid-19 conditions, such as life-saving interventions for acute strokes and neurology trials for diseases with rapid progression, like amyotrophic lateral sclerosis and multiple sclerosis, resumed or continued, while other studies involving human subjects restarted gradually (Tan et al., 2020).

Additional solutions included classifying the different types of PD studies, weighing the merits of each individual study in deciding which ones to resume first. For instance, priority was given to clinical studies with no patient contact, such as telephone surveys assessing quality of life or drug-related side effects in PD, studies which could be conducted in non-clinical areas, such as an imaging study in a dedicated research scanner, and clinical trials in their passive phases (AlNaamani et al., 2020).

Potential benefits from a particular trial must be balanced against the possible risks of exposing patients and researchers to Covid-19 (Tan et al., 2020). For any study with face-to-face contact, stringent efforts should be

undertaken to comply with new safety protocols regarding social distancing, protective personal equipment, and minimizing the number of researchers physically present on-site during visits (Tan et al., 2020). To maintain physical distancing between laboratories and trial units, reopening was meant to start at reduced capacity and all staff on-site mandated to wear a mask to prevent the risk of SARS-CoV-2 transmission, with allocation of select staff to work from home. At the same time, negotiations should be done with sponsors to extend intervals for investigations, schedule study patients at the same time as regular appointments, and to defer non-essential biochemical tests. Other steps that could be taken are to sanction remote consent taking with subjects, as well as virtual investigator training, and to allow research coordinators to cross-cover different studies and work on staggered schedules (Tan et al., 2020).

An alternative was to delay initiation of enrolment in trials that had not yet started or to pause enrolment in ongoing trials, perhaps on a site-specific basis, until the SARS-CoV-2 burden in that setting is markedly reduced. In trials that were relatively near completion when severe disruption began, the study team (and not the data monitoring committee) could decide to terminate the trial, thus, sacrificing a small degree of statistical power in exchange for more interpretable inferences (Fleming et al., 2020). Valid statistical approaches should guide the presentation of results of clinical trials for which the conduct has been meaningfully influenced by the pandemic, taking into account missing data and protocol deviations (Fleming et al., 2020). Also, potential medico-legal implications must be considered in situations where trial participants may be subjected to additional risk from accidental exposure to Covid-19 while conducting clinical trials (Tan et al., 2020). Population screening (PCR and/or antigen testing) of all asymptomatic individuals, including study subjects and research staff for Covid-19, could be impractical, although testing in healthcare workers in the frontline has been frequently carried out in some places (Tan et al., 2021).

For those studies where virtual assessments could be an option, other factors need to be taken into consideration. Virtual consent-taking, remote prescription with delivery during enforced quarantine, and possibly institution-backed legal recourse have been among the available options (Tan et al., 2021). These measures have enabled research staff to work effectively from home by telecommunications (Tan et al., 2020). Also, supplemental approaches, such as electronic data capture implemented at home by the patient or caregiver, telemedicine, or telephone interviews (McDermott & Newman, 2020) have proven to be effective.

Further developments in telemedicine could take the form of artificial intelligence with an integrated-omics approach, aiding in better defining disease models and discovering new therapeutic targets in the field of PD (Adly, Adly, & Adly, 2020; Welton & Tan, 2021). However, despite the positive emergence of telemedicine (Bloem, Dorsey, & Okun, 2020) and the ingenious use of virtual reality for certain types of PD therapy (Chen, Gao, He, & Bian, 2020), compliance will be difficult to implement fully on the ground (Tan et al., 2021). Furthermore, validated clinical scales to assess PD and related complications through remote evaluations are currently not available and, hence, require further investigations (Tan et al., 2021).

The repercussions on research funding and policies during this pandemic also depend significantly on the resources available in that specific jurisdiction and the prevalence of SARS-CoV-2 infection of the study locality. Complications, such as unfunded extensions of grants, can lead to unfinished research or delayed initiation of studies. For instance, research funded by existing grants that had been halted, recommenced during transition period between lockdown and re-opening in the UK, whereas overall research funding has not been much affected in Singapore, with surplus funds provided for Covid-19 research (Tan et al., 2020). In Japan, telemedicine has been included in universal insurance systems since 2018, but reimbursement for it has not proven sufficient during the pandemic (Suzuki et al., 2021).

Taking all the above into consideration, the ultimate goal for researchers in a priori research planning should be to incorporate more reflection and flexibility into their research preparation, and contemplate integrating alternative data collection methods (Rahman et al., 2021). In the case of grant-funded projects, such considerations can be applied into research contingency plans (Rahman et al., 2021). There is also an extensive arsenal of studies which explore the topic of digital research ethics, encompassing issues such as informed consent, confidentiality, data security, privacy, anonymity, data storage and processing, and ethical decision making while using digital methods (Rahman et al., 2021). By applying a critical reflection framework to research practices, we have been able to provide empirical insights and lessons into research continuity in the current global pandemic context (White, Fook, & Gardner, 2006). This will allow research output obtained during the Covid-19 pandemic into making crucial contributions to the literature (Rahman et al., 2021).

Due to the limited time available to enroll large patient cohorts required for many high-quality clinical trials, as well as the resources required during such a crisis, an early coordinated effort is imperative to assimilate data and

produce research findings with more meaningful scientific rigor (AlNaamani et al., 2020). International research collaborations would be particularly essential in this regard (Fearon & Fasano, 2021), preferably to the ends of developing consensus guidelines in the conduct of PD research (AlNaamani et al., 2020).

Collaborative work with multi-center participation from different countries will enable more cohesive diverse participation and allow sufficient support of those with limited resources, permitting enrolment of larger sample sizes (Adly et al., 2020) toward favoring the broad generalizability of results, as well as adequately powered subgroup analyses.

Planning for future emergencies is a coordinated global effort in establishing worldwide protocols for the rapid implementation of strategic research prioritization and redeployment of research infrastructure and capacity (Wyatt, Faulkner-Gurstein, Cowan, & Wolfe, 2021). Dedicated databases of PD cohorts with and without Covid-19 should be assembled for future studies (Fearon & Fasano, 2021).

3. Medical and specialty training

3.1 Impact

The Covid-19 pandemic has not only directly impacted patient care, where many hospitals had to upscale their capacity and care delivery, but has also effected an unprecedented influence over healthcare professional education (Fig. 1), including the training of nursing staff and medical students (Tan et al., 2020; van der Meulen, Kleineberg, Schreier, Garcia-Azorin, & Di Lorenzo, 2020). This is exemplified by a study from Italy, showing that across 36 Medical Schools, all lessons, seminars, and conferences had been suspended, with 92% of centers rescheduling these on virtual platforms and seminars in the other centers (Di Lorenzo et al., 2021).

The above has been supported by another study showing similar rates of disruption (Abati & Costamagna, 2020). The impact has also been felt in teaching hospitals where traditional bedside clinical teaching often had to be suspended, affecting higher grade training, such as for speciality registrars and residents. Overall, the majority of those affected by the restrictions have been feeling that these would have major repercussions on their training. In fact, 79% of respondents in a European Academy of Neurology survey have indicated that the pandemic will probably have a serious impact on their training and career (Cuffaro et al., 2021). In this section, we have tried to limit ourselves to evidence in relation to the impact of the Covid-19

pandemic and related restrictions on neurological (specifically movement disorders) training, as well as stipulate some of the solutions to overcome these problems.

Clinical instructional experiences and exposure to real patients have traditionally been considered the cornerstones of nursing and medical education, an indispensable part of the healthcare professionals' development (AlThiga, Mohidin, Park, & Tekian, 2017; Mandan, Sidhu, & Mahmood, 2016). As a result of the Covid-19 pandemic, concerns have arisen that interruption of the clinical practicum could lead to a reduced quality of medical education. Thus, faculty had to urgently address this matter and ensure the quality of care delivered by future healthcare workers.

3.2 Strategies

As a learning experience for medical and nursing students, some medical schools have encouraged their students to work on the frontline during the Covid-19 pandemic (Lee, Park, & Seo, 2020; Leigh et al., 2020). However, shortage of personal protective equipment (PPE), restricted availability of Covid-19 testing, and infection control schemes have been some of the limiting factors (Wang, Deng, & Tsui, 2020). Therefore, digital education without the risks associated with in-person education could drive the way forward (Park, Park, Lim, Rhim, & Lee, 2020), and, indeed, have been applied by many Medical Schools with the adoption of virtual platforms for remotely delivered lectures or digital banks of resources, especially in the pre-clinical years. However, some concerns have been raised regarding the impact of online teaching during the clinical years, with arguments regarding the ability of students to develop clinical competence (Dost, Hossain, Shehab, Abdelwahed, & Al-Nusair, 2020; Huddart et al., 2020).

As such, these developments should ideally be standardized, by evaluating teaching methods and telemedicine, reinforcing wellbeing, and promoting international educational collaborations, which have been suggested to improve neurology training during and after the pandemic (Sandrone et al., 2021).

A large part of the available knowledge regarding the repercussion of the Covid-19 pandemic on medical healthcare professional training has recently been summarized by Hao and colleagues, who performed a systematic review of studies on this topic available up to April 2021 (Hao et al., 2022). They were able to identify 16 studies, spanning the world (United States ($n = 7$), China ($n = 3$), UK ($n = 1$), Japan ($n = 1$), Korea ($n = 1$), Italy ($n = 1$), Saudi Arabia

(n = 1), and Israel (n = 1)) and a total of 1174 participants (457 were undergraduate nursing students and 717 medical students), looking at the effect of the Covid-19 pandemic on nursing and medical training. Based on their results, it seems that universities and colleges resorted to four different types of education replacing classical training:

(1) virtual reality-based simulation training;
(2) teleconsultation and virtual rounds;
(3) web-based specialized skills learning; and.
(4) multimodal online curricula.

Virtual reality-based stimulation training seemed to be a good alternative to in-person training, whereby Assessment Technologies Institute (ATI) scores, the perceived quality of this training modality, has been comparable between students participating in this course compared to previous cohorts who were trained in-person (Weston & Zauche, 2021). Some results have also suggested that more than half of students preferred simulation training with virtual platforms rather than online formal teaching (De Ponti et al., 2020). This has also been confirmed by other studies showing that online teaching has been perceived as having increased convenience, enhanced quality, a sense of comfort and safety (Pokryszko-Dragan, Marschollek, Nowakowska-Kotas, & Aitken, 2021). Nonetheless, the promoting effect of simulation training on overall clinical performance was found to be slightly inferior (Kang, Kim, Lee, Kim, & Kim, 2020).

For surgical education relevant to the PD field (deep brain stimulation), most students believed new web-based surgical instruction was as difficult/easy as conventional teaching, supported by another study looking at reviewing radiology exams, which has shown that remote training has been perceived as more active and entertaining than in-person sessions (Alpert, Young, Lala, & McGuinness, 2021; Co & Chu, 2020). Similarly, telemedicine, including teleconsultation and virtual rounds, has shown benefit for students. For example, telemedicine appointments using video calls or video conferencing to interact with patients during virtual rounds have improved clinical ability and professional confidence in most of the students (Gummerson et al., 2021; Weber et al., 2021). Some studies have postulated that the overall ability to teach tele-instructors in virtual rounds has been better than even in-person rounds (Bala et al., 2021; Sukumar et al., 2021; Weber et al., 2021).

Perhaps the best studied area of remote training is that of multimodal online curricula, where Hao and colleagues were able to identify eight studies looking at this topic (Hao et al., 2022). Such curricula included online

videos, massive open online courses, discussion posts, virtual conferences, impromptu role playing and lectures, with most interested students opting for interactive discussion learning patterns and not passive teaching resources (Coffey, MacDonald, Shahrvini, Baxter, & Lander, 2020; He et al., 2021; Michener, Fessler, Gonzalez, & Miller, 2020; Weber et al., 2020). Other examples of useful resources included role-playing instruction, where a faculty member would play the role of a patient and a student acted as a physician (Kaliyadan, ElZorkany, & Al Wadani, 2020; Kasai et al., 2021). Interestingly, some programs have even allowed for students to participate in supervised remote direct patient care and support frontline healthcare workers by performing remote clinical tasks, which have been perceived as overall positive by the students (satisfaction scores 3.33–4.57 out of 5) (Safdieh et al., 2021).

For higher degree training, such as specialty registrars/residents, surprisingly less evidence is available, at least in the field of neurology and movement disorders. Perhaps the Covid-19 pandemic has caused the matter of training and research to be less pressing, and has, therefore, received less attention. This seems to be supported by the notion that for most registrars/residents, training and research have not been perceived as "most stressful" during the pandemic. Rather, safety, violence and aggression, and family matters have been perceived as the main stressors (Wu et al., 2021). Moreover, when virtual methods were used to solve some of the surrounding issues, like patient rounds on wards as an educational part of training, registrars/residents did not seem as positive. In the study by Kolikonda and colleagues, it has been shown that in "virtual rounding", consisting of patient presentation and discussion in the morning in on-line virtual team format, followed by in-person patient rounds in small groups on a stroke ward, the majority of neurology residents found telemedicine applications not useful compared to other healthcare staff providers. The authors attributed this to lack of prior exposure and preparedness (Kolikonda et al., 2022).

On the other hand, some studies have shown a more positive attitude towards virtual ward rounds (Gros et al., 2021; Zeinali, Almasi-Doghaee, & Haghi-Ashtiani, 2020) with a sharp increase in the number of hours per month spent on virtual educational meetings after the start of the pandemic (35 vs. 16 h per month) (Zeinali et al., 2020). Some services have already tried to address this by considering contingency planning, maintenance of education, sustainability of team members, and promotion of the safe delivery of neurological care, for example in the University of Toronto Adult Neurology Residency Program (Muir et al., 2021).

Similar strategies have also been deployed elsewhere in the form of a virtual intensive care unit (tele-ICU) rotation for medical students to support the care of patients diagnosed with Covid-19 in the ICU, consisting of clinical engagement, a multiple-choice pre-test, faculty-supervised, student-led case and topic presentations, faculty-led debriefing sessions, evidence-based-medicine discussion forums, a multiple-choice post-test, and a final reflection (Ho et al., 2021).

Other strategies that have been proposed to improve teaching during the pandemic, included remote supervision of neurology fellows. Suarez-Cedeno and colleagues have shown that such an approach has been considered as successful by consultants, mainly due to increased patient access and a decrease in scheduling barriers, despite some technical difficulties and lack of portions of the examination, such as tone, reflexes, and sensory testing (Suarez-Cedeno et al., 2021). In relation to practical teaching, including electroencephalogram (EEG) teaching, more evidence regarding solutions is becoming available. Yadala and colleagues have shown that virtual EEG training via zoom could be effective, with clear improvement in post-test compared to pre-test scores and high satisfaction rates among registrars/residents (100% felt more confident after the training in scoring EEGs). Moreover, when compared to traditional EEG reading, 100% have agreed that the virtual sessions were more accessible, 72.7% have agreed that they were more interactive, 81.9% have felt engaged, and 90.9% have felt they were able to attend more sessions (Yadala et al., 2020).

Finally, other obstacles in relation to teaching, such as final exams, have been the topic of a recent study. Rajan and colleagues have shown that it was possible to perform a neurology exit examination in a hybrid virtual format. They have created a case repository with history and clinical examination findings, followed by structured questions for case discussions, where external examiners would assess candidates virtually through a video conferencing platform (Rajan et al., 2020).

For postgraduate and other healthcare professional teaching, the pandemic has necessitated changes to the conventional way these used to be delivered. Examples include Continuing Medical Education (CME) programs where a general solution would be to switch to virtual webinars. Although such webinars have comprised a major avenue for education during the pandemic and initial satisfaction among physicians was high (around 75% have reported to be satisfied or very satisfied), the majority of physicians (over 75%) have felt overwhelmed with the number and frequency of webinars as the pandemic continued, resulting in increasingly lower

attendance rates, as was recently shown by Ismail, Abdelkarim, and Al-Hashel (2021). The authors have suggested that webinars should be viewed as complementing traditional in-person meetings, rather than replacing them.

Overall, although the Covid-19 pandemic and the imposed restrictions have had a major impact on teaching and training across the whole medical field, ranging from students to postgraduates, an increasing number of solutions have been recommended. After the initial cessation of in-person teaching and training sessions, many universities and hospital have now resorted to online courses, lectures, and curricula, supported by in-person sessions whenever possible. Available evidence suggests that this approach has been largely successful, achieving high rates of satisfaction with a demonstrable and adequate transfer of knowledge using virtual and other remote methods. The acquired knowledge would be important for future worldwide medical emergencies and pandemics, so that continuity in high-level quality of training and teaching can be assured.

4. Mental health in research and training

The Covid-19 pandemic has had a negative impact on the mental health of PwP. Among the PD non-motor symptoms, anxiety and depression have significantly increased during the pandemic (Dommershuijsen et al., 2021). The disruption of healthcare services, loss of usual activities and supports, and reductions in physical activity are some of the possible causes of this phenomenon (Brooks, Weston, & Greenberg, 2021). A recent study exploring the effect of the pandemic on the mental health of PwP has demonstrated a stronger association of Covid-19 stressors with mental health in women, highly educated people, individuals with advanced PD, and those prone to social distancing or seeking social support (Dommershuijsen et al., 2021).

A review published in March 2020, only a year after the outbreak, reported how the Covid-19 outbreak has led to the emergence of mental health issues, such as anxiety, insomnia, and denial, both in the SARS-CoV-2 infected and non-infected individuals, with an increase of the prevalence of post-traumatic stress disorder and depression by almost 40% and 7% respectively in the general population (Torales, O'Higgins, Castaldelli-Maia, & Ventriglio, 2020). Lockdown measures and the consequent isolation have been acknowledged as some of the possible factors underlying these mental health issues, similarly to past outbreaks, such as the Middle East Respiratory Syndrome Coronavirus (MERS-CoV) in

Korea in 2015 (Kim et al., 2019). Female sex, lower socioeconomic status or frequent social media use have been shown to be possible risks factor for the development of mental health issues (Li & Wang, 2020; Mazza et al., 2020; Pierce et al., 2020).

Although it might still be early to appreciate the overall long-term impact of the Covid-19 pandemic on academia, the immediate effect on researchers' productivity and mental health are already visible. A recent survey involving more than 2000 European and American researchers has shown a decrease of 5% and 36% in the hours spent at work and in the number of new non-Covid-19-related projects initiated in the past year respectively (Gao, Yin, Myers, Lakhani, & Wang, 2021). Indeed, a search through the major database of PubMed has revealed a stark decline in the quantity of PD studies compared to the pre-pandemic era (Fig. 3).

A gender gap has been found in the reduction of time dedicated to work, with female scientists and especially mothers with young children being most affected (Myers et al., 2020). This tendency was shown to be particularly true for black female mother researchers (Staniscuaski et al., 2021). Another study conducted in the UK has shown how the Covid-19 pandemic has affected researchers' mental approach to their work, with the lowest scores observed in questions related to the energy levels and feelings of relaxation, optimism and cheerfulness, with one in four responders showing signs of burnout, such as the daily feeling of being emotionally drained from work (Wray & Kinman, 2022).

In the above context, students have been largely affected, with an increase of mental health concerns related to school closures, loss of routine, and reduced social interactions (YoungMinds, 2020). The online learning format adopted by tertiary education institutions, despite being considered a good alternative to traditional learning (Abou El-Seoud et al., 2014) and offering some major advantages, such as flexibility (Dhawan, 2020), has been viewed as another additional stressor by some authors. Obstacles, such as technical difficulties, can reduce students' motivation and put them under increased pressure to learn autonomously, leading to potentially higher rates of dropout (Coman, Țîru, Meseşan-Schmitz, Stanciu, & Bularca, 2020; Grubic, Badovinac, & Johri, 2020).

As already mentioned, several factors have limited the interaction among medical students and patients, including the reduction of in-person assessments, the possibility of being potential vectors of SARS-CoV-2, or shortages in PPE (especially during the beginning of the pandemic)

(Ahmed, Allaf, & Elghazaly, 2020; Roberts, 2020; Rose, 2020), leading to recently emerged alarming data on medical students' mental health. A study conducted at six Jordanian Medical Schools, assessing the mental wellbeing status using Kessler's psychological stress scale (K10), has demonstrated that about half of the participants had severe mental disorders with high psychological distress (Seetan et al., 2021). The negative effect of isolation on physical exercise, the lack of training, and the reduced social interactions have been noted to be among the most frequent worries. Additionally, this study has shown higher scores in younger students compared to those being at their last years of studies, a finding which has also been confirmed in a Brazilian study, reporting a high level of mental illness burden (measured with the Hospital Anxiety and Depression Scale, the Self-Reporting Questionnaire, the Interpersonal Reactivity Index, and the Mindful Attention Awareness Scale) in medical students, particularly among freshmen (Perissotto et al., 2021).

5. Conclusions

Face-to-face patient assessments, conduct of research visits, collaboration between researchers, and the redeployment of researchers to clinical care to alleviate hospitals from the clinical burden of the pandemic have been recognized as key research areas, significantly affected by the Covid-19 crisis. These modifications have resulted in new ways to conduct research, providing more resilient long-term options for future pandemics and worldwide events, including remote visits, digital data collection and electronic capture of outcomes, as well as the establishment of virtual platforms for research and education.

In general, the pandemic has created an unprecedented opportunity for researchers and healthcare professionals to show resilience and innovation and adapt to a new norm, leading to a paradigm shift in PD research and training strategies globally in the post-Covid-19 era. While much ambiguity remains, what is certain is that future neurological research and education landscape will never be the same compared to pre-pandemic times. Many institutions have now enforced this 'new normal' and productively embedded the strategies sparked by the pandemic as part of their standardized guidelines. Hopefully, the evolving changes will enhance the resilience of the medical fraternity in improving the provided services and prepare for a potential next pandemic.

References

Abati, E., & Costamagna, G. (2020). Education research: Effect of the COVID-19 pandemic on neurology trainees in Italy: A resident-driven survey. *Neurology*, *95*(23), 1061–1066. https://doi.org/10.1212/WNL.0000000000010878.

Abou El-Seoud, S., Seddiek, N., Taj-Eddin, I., Ghenghesh, P., Nosseir, A., & El-Khouly, M. (2014). E-learning and students' motivation: A research study on the effect of E-learning on higher education. *International Journal of Emerging Technologies in Learning*, *9*(4), 20–26. https://doi.org/10.3991/ijet.v9i4.3465.

Adly, A. S., Adly, A. S., & Adly, M. S. (2020). Approaches based on artificial intelligence and the internet of intelligent things to prevent the spread of COVID-19: Scoping review. *Journal of Medical Internet Research*, *22*(8), e19104. https://doi.org/10.2196/19104.

Ahmed, H., Allaf, M., & Elghazaly, H. (2020). COVID-19 and medical education. *The Lancet Infectious Diseases*, *20*(7), 777–778. https://doi.org/10.1016/S1473-3099(20)30226-7.

AlNaamani, K., AlSinani, S., & Barkun, A. N. (2020). Medical research during the COVID-19 pandemic. *World Journal of Clinical Cases*, *8*(15), 3156–3163. https://doi.org/10.12998/wjcc.v8.i15.3156.

Alpert, J. B., Young, M. G., Lala, S. V., & McGuinness, G. (2021). Medical student engagement and educational value of a remote clinical radiology learning environment: Creation of virtual read-out sessions in response to the COVID-19 pandemic. *Academic Radiology*, *28*(1), 112–118. https://doi.org/10.1016/j.acra.2020.09.011.

AlThiga, H., Mohidin, S., Park, Y. S., & Tekian, A. (2017). Preparing for practice: Nursing intern and faculty perceptions on clinical experiences. *Medical Teacher*, *39*(sup1), S55–S62. https://doi.org/10.1080/0142159X.2016.1254739.

Bala, L., Kinross, J., Martin, G., Koizia, L. J., Kooner, A. S., Shimshon, G. J., et al. (2021). A remote access mixed reality teaching ward round. *The Clinical Teacher*, *18*(4), 386–390. https://doi.org/10.1111/tct.13338.

Bloem, B. R., Dorsey, E. R., & Okun, M. S. (2020). The coronavirus disease 2019 crisis as catalyst for telemedicine for chronic neurological disorders. *JAMA Neurology*, 77(8), 927–928. https://doi.org/10.1001/jamaneurol.2020.1452.

Brooks, S. K., Weston, D., & Greenberg, N. (2021). Social and psychological impact of the COVID-19 pandemic on people with Parkinson's disease: a scoping review. *Public Health*, *199*, 77–86. https://doi.org/10.1016/j.puhe.2021.08.014.

Brown, E. G., Chahine, L. M., Goldman, S. M., Korell, M., Mann, E., Kinel, D. R., et al. (2020). The effect of the COVID-19 pandemic on people with Parkinson's disease. *Journal of Parkinson's Disease*, *10*(4), 1365–1377. https://doi.org/10.3233/JPD-202249.

Chan, C. H., & Tan, E. K. (2020). Safeguarding non-COVID-19 research: Looking up from ground zero. *Archives of Medical Research*, *51*(7), 731–732. https://doi.org/10.1016/j.arcmed.2020.05.023.

Chen, Y., Gao, Q., He, C. Q., & Bian, R. (2020). Effect of virtual reality on balance in individuals with Parkinson disease: A systematic review and Meta-analysis of randomized controlled trials. *Physical Therapy*, *100*(6), 933–945. https://doi.org/10.1093/ptj/pzaa042.

Co, M., & Chu, K. M. (2020). Distant surgical teaching during COVID-19—A pilot study on final year medical students. *Surgical Practice*. https://doi.org/10.1111/1744-1633.12436.

Coffey, C. S., MacDonald, B. V., Shahrvini, B., Baxter, S. L., & Lander, L. (2020). Student perspectives on remote medical education in clinical core clerkships during the COVID-19 pandemic. *Medical Science Educator*, 1–8. https://doi.org/10.1007/s40670-020-01114-9.

Cohen, B. H., Busis, N. A., & Ciccarelli, L. (2020). Coding in the world of COVID-19: Non-face-to-face evaluation and management care. *Continuum (Minneap Minn)*, *26*(3), 785–798. https://doi.org/10.1212/CON.0000000000000874.

Coman, C., Ţîru, L. G., Meseşan-Schmitz, L., Stanciu, C., & Bularca, M. C. (2020). Online teaching and learning in higher education during the coronavirus pandemic: Students' perspective. *Sustainability*, *12*(24), 10367. https://doi.org/10.3390/su122410367.

Council., U. N. R. (2010). The prevention and treatment of missing data in clinical trials, D. o. B. a. S. S. a. E. In *Panel on Handling Missing Data in Clinical Trials. Committee on National Statistics*, National Academies Press.

Cuffaro, L., Carvalho, V., Di Liberto, G., Klinglehoefer, L., Sauerbier, A., Garcia-Azorin, D., et al. (2021). Neurology training and research in the COVID-19 pandemic: a survey of the resident and research fellow section of the European academy of neurology. *European Journal of Neurology*, *28*(10), 3437–3442. https://doi.org/10.1111/ene.14696.

De Ponti, R., Marazzato, J., Maresca, A. M., Rovera, F., Carcano, G., & Ferrario, M. M. (2020). Pre-graduation medical training including virtual reality during COVID-19 pandemic: A report on students' perception. *BMC Medical Education*, *20*(1), 332. https://doi.org/10.1186/s12909-020-02245-8.

Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. *Journal of Educational Technology Systems*, *49*(1), 5–22. https://doi.org/10.1177/0047239520934018.

Di Lorenzo, F., Ercoli, T., Cuffaro, L., Barbato, F., Iodice, F., Tedeschi, G., et al. (2021). COVID-19 impact on neurology training program in Italy. *Neurological Sciences*, *42*(3), 817–823. https://doi.org/10.1007/s10072-020-04991-5.

Dommershuijsen, L. J., Van der Heide, A., Van den Berg, E. M., Labrecque, J. A., Ikram, M. K., Ikram, M. A., et al. (2021). Mental health in people with Parkinson's disease during the COVID-19 pandemic: Potential for targeted interventions? *NPJ Parkinsons Disease*, 7(1), 95. https://doi.org/10.1038/s41531-021-00238-y.

Dost, S., Hossain, A., Shehab, M., Abdelwahed, A., & Al-Nusair, L. (2020). Perceptions of medical students towards online teaching during the COVID-19 pandemic: A national cross-sectional survey of 2721 UK medical students. *BMJ Open*, *10*(11), e042378. https://doi.org/10.1136/bmjopen-2020-042378.

Fearon, C., & Fasano, A. (2021). Parkinson's disease and the COVID-19 pandemic. *Journal of Parkinson's Disease*, *11*(2), 431–444. https://doi.org/10.3233/JPD-202320.

Feeney, M. P., Xu, Y., Surface, M., Shah, H., Vanegas-Arroyave, N., Chan, A. K., et al. (2021). The impact of COVID-19 and social distancing on people with Parkinson's disease: A survey study. *NPJ Parkinsons Disease*, 7(1), 10. https://doi.org/10.1038/s41531-020-00153-8.

Fleming, T. R. (2011). Addressing missing data in clinical trials. *Annals of Internal Medicine*, *154*(2), 113–117. https://doi.org/10.7326/0003-4819-154-2-201101180-00010.

Fleming, T. R., Labriola, D., & Wittes, J. (2020). Conducting clinical research during the COVID-19 pandemic: Protecting scientific integrity. *JAMA*, *324*(1), 33–34. https://doi.org/10.1001/jama.2020.9286.

Gao, J., Yin, Y., Myers, K. R., Lakhani, K. R., & Wang, D. (2021). Potentially long-lasting effects of the pandemic on scientists. *Nature Communications*, *12*(1), 6188. https://doi.org/10.1038/s41467-021-26428-z.

Gros, P., Rotstein, D., Kinach, M., Chan, D. K., Montalban, X., Freedman, M., et al. (2021). Innovation in resident education—description of the neurology international residents videoconference and exchange (NIRVE) program. *Journal of the Neurological Sciences*, *420*, 117222. https://doi.org/10.1016/j.jns.2020.117222.

Grubic, N., Badovinac, S., & Johri, A. M. (2020). Student mental health in the midst of the COVID-19 pandemic: A call for further research and immediate solutions. *The International Journal of Social Psychiatry*, *66*(5), 517–518. https://doi.org/10.1177/0020764020925108.

Gummerson, C. E., Lo, B. D., Porosnicu Rodriguez, K. A., Cosner, Z. L., Hardenbergh, D., Bongiorno, D. M., et al. (2021). Broadening learning communities during COVID-19: Developing a curricular framework for telemedicine education in neurology. *BMC Medical Education*, *21*(1), 549. https://doi.org/10.1186/s12909-021-02979-z.

Hao, X., Peng, X., Ding, X., Qin, Y., Lv, M., Li, J., et al. (2022). Application of digital education in undergraduate nursing and medical interns during the COVID-19 pandemic: A systematic review. *Nurse Education Today*, *108*, 105183. https://doi.org/10.1016/j.nedt.2021.105183.

He, M., Tang, X. Q., Zhang, H. N., Luo, Y. Y., Tang, Z. C., & Gao, S. G. (2021). Remote clinical training practice in the neurology internship during the COVID-19 pandemic. *Medical Education Online*, *26*(1), 1899642. https://doi.org/10.1080/10872981.2021.1899642.

Ho, J., Susser, P., Christian, C., DeLisser, H., Scott, M. J., Pauls, L. A., et al. (2021). Developing the eMedical student (eMS)-a pilot project integrating medical students into the tele-ICU during the COVID-19 pandemic and beyond. *Healthcare (Basel)*, *9*(1). https://doi.org/10.3390/healthcare9010073.

Huddart, D., Hirniak, J., Sethi, R., Hayer, G., Dibblin, C., Meghna Rao, B., et al. (2020). #MedStudentCovid: How social media is supporting students during COVID-19. *Medical Education*, *54*(10), 951–952. https://doi.org/10.1111/medu.14215.

Iacobucci, G. (2020). Covid-19 makes the future of UK clinical research uncertain. *BMJ*, *369*, m1619. https://doi.org/10.1136/bmj.m1619.

Ismail, I. I., Abdelkarim, A., & Al-Hashel, J. Y. (2021). Physicians' attitude towards webinars and online education amid COVID-19 pandemic: When less is more. *PLoS One*, *16*(4), e0250241. https://doi.org/10.1371/journal.pone.0250241.

Kaliyadan, F., ElZorkany, K., & Al Wadani, F. (2020). An online dermatology teaching module for undergraduate medical students amidst the COVID-19 pandemic: An experience and suggestions for the future. *Indian Dermatology Online Journal*, *11*(6), 944–947. https://doi.org/10.4103/idoj.IDOJ_654_20.

Kang, K. A., Kim, S. J., Lee, M. N., Kim, M., & Kim, S. (2020). Comparison of learning effects of virtual reality simulation on nursing students caring for children with asthma. *International Journal of Environmental Research and Public Health*, *17*(22). https://doi.org/10.3390/ijerph17228417.

Kardas-Nelson, M. (2020). Covid-19's impact on US medical research-shifting money, easing rules. *BMJ*, *369*, m1744. https://doi.org/10.1136/bmj.m1744.

Kasai, H., Shikino, K., Saito, G., Tsukamoto, T., Takahashi, Y., Kuriyama, A., et al. (2021). Alternative approaches for clinical clerkship during the COVID-19 pandemic: Online simulated clinical practice for inpatients and outpatients-a mixed method. *BMC Medical Education*, *21*(1), 149. https://doi.org/10.1186/s12909-021-02586-y.

Kim, Y. G., Moon, H., Kim, S. Y., Lee, Y. H., Jeong, D. W., Kim, K., et al. (2019). Inevitable isolation and the change of stress markers in hemodialysis patients during the 2015 MERS-CoV outbreak in Korea. *Scientific Reports*, *9*(1), 5676. https://doi.org/10.1038/s41598-019-41964-x.

Kolikonda, M. K., Blaginykh, E., Brown, P., Kovi, S., Zhang, L. Q., & Uchino, K. (2022). Virtual rounding in stroke care and neurology education during the COVID-19 pandemic—A residency program survey. *Journal of Stroke and Cerebrovascular Diseases*, *31*(1), 106177. https://doi.org/10.1016/j.jstrokecerebrovasdis.2021.106177.

Lau, Y. H., Lau, K. M., & Ibrahim, N. M. (2021). Management of Parkinson's disease in the COVID-19 pandemic and future perspectives in the era of vaccination. *Journal of Movement Disorder*, *14*(3), 177–183. https://doi.org/10.14802/jmd.21034.

Lee, Y. M., Park, K. D., & Seo, J. H. (2020). New paradigm of pediatric clinical clerkship during the epidemic of COVID-19. *Journal of Korean Medical Science*, *35*(38), e344. https://doi.org/10.3346/jkms.2020.35.e344.

Leigh, J., Bolton, M., Cain, K., Harrison, N., Bolton, N. Y., & Ratcliffe, S. (2020). Student experiences of nursing on the front line during the COVID-19 pandemic. *The British Journal of Nursing*, *29*(13), 788–789. https://doi.org/10.12968/bjon.2020.29.13.788.

Li, L. Z., & Wang, S. (2020). Prevalence and predictors of general psychiatric disorders and loneliness during COVID-19 in the United Kingdom. *Psychiatry Research*, *291*, 113267. https://doi.org/10.1016/j.psychres.2020.113267.

Mandan, J., Sidhu, H. S., & Mahmood, A. (2016). Should a clinical rotation in hematology be mandatory for undergraduate medical students? *Advances in Medical Education and Practice*, *7*, 519–521. https://doi.org/10.2147/AMEP.S112132.

Mazza, C., Ricci, E., Biondi, S., Colasanti, M., Ferracuti, S., Napoli, C., et al. (2020). A Nationwide survey of psychological distress among Italian people during the COVID-19 pandemic: Immediate psychological responses and associated factors. *International Journal of Environmental Research and Public Health*, *17*(9). https://doi.org/10.3390/ijerph17093165.

McDermott, M. M., & Newman, A. B. (2020). Preserving clinical trial integrity during the coronavirus pandemic. *JAMA*, *323*(21), 2135–2136. https://doi.org/10.1001/jama.2020.4689.

Medicines and Healthcare Products Regulatory Agency. (2020). *Guidance on minimising disruptions to the conduct and integrity of clinical trials of medicines during COVID-19*. Retrieved from https://www.gov.uk/guidance/guidance-on-minimising-disruptions-to-the-conduct-and-integrity-of-clinical-trials-of-medicines-during-covid-19.

Michener, A., Fessler, E., Gonzalez, M., & Miller, R. K. (2020). The 5 M's and more: A new geriatric medical student virtual curriculum during the COVID-19 pandemic. *Journal of the American Geriatrics Society*, *68*(11), E61–E63. https://doi.org/10.1111/jgs.16855.

Muir, R. T., Gros, P., Ure, R., Mitchell, S. B., Kassardjian, C. D., Izenberg, A., et al. (2021). Modification to neurology residency training: The Toronto neurology COVID-19 pandemic experience. *Neurology Clinical Practice*, *11*(2), e165–e169. https://doi.org/10.1212/CPJ.0000000000000894.

Myers, K. R., Tham, W. Y., Yin, Y., Cohodes, N., Thursby, J. G., Thursby, M. C., et al. (2020). Unequal effects of the COVID-19 pandemic on scientists. *Nature Human Behaviour*, *4*(9), 880–883. https://doi.org/10.1038/s41562-020-0921-y.

National Institute for Health Research. (2021). *Urgent public health COVID-19 studies*. Retrieved from https://www.nihr.ac.uk/covid-studies/.

Papa, S. M., Brundin, P., Fung, V. S. C., Kang, U. J., Burn, D. J., Colosimo, C., et al. (2020). Impact of the COVID-19 pandemic on Parkinson's disease and movement disorders. *Movement Disorder Clinical Practice*, *7*(4), 357–360. https://doi.org/10.1002/mdc3.12953.

Park, J., Park, H., Lim, J. E., Rhim, H. C., & Lee, Y. M. (2020). Medical students' perspectives on recommencing clinical rotations during coronavirus disease 2019 at one institution in South Korea. *The Korean Journal of Medical Education*, *32*(3), 223–229. https://doi.org/10.3946/kjme.2020.170.

Parkinson's UK. (2020). *Protecting the future of research after coronavirus (COVID-19)*. Retrieved from https://www.parkinsons.org.uk/news/protecting-future-research-after-coronavirus-covid-19.

Perissotto, T., Silva, T., Miskulin, F. P. C., Pereira, M. B., Neves, B. A., Almeida, B. C., et al. (2021). Mental health in medical students during COVID-19 quarantine: A comprehensive analysis across year-classes. *Clinics (São Paulo, Brazil)*, *76*, e3007. https://doi.org/10.6061/clinics/2021/e3007.

Pierce, M., Hope, H., Ford, T., Hatch, S., Hotopf, M., John, A., et al. (2020). Mental health before and during the COVID-19 pandemic: A longitudinal probability sample survey of the UK population. *Lancet Psychiatry*, *7*(10), 883–892. https://doi.org/10.1016/S2215-0366(20)30308-4.

Pokryszko-Dragan, A., Marschollek, K., Nowakowska-Kotas, M., & Aitken, G. (2021). What can we learn from the online learning experiences of medical students in Poland during the SARS-CoV-2 pandemic? *BMC Medical Education*, *21*(1), 450. https://doi.org/10.1186/s12909-021-02884-5.

Rahman, S. A., Tuckerman, L., Vorley, T., & Gherhes, C. (2021). Resilient research in the field: Insights and lessons from adapting qualitative research projects during the COVID-19 pandemic. *International Journal of Qualitative Methods*, *20*, 1–16. https://doi.org/10.1177/16094069211016106.

Rajan, R., Radhakrishnan, D. M., Srivastava, A. K., Vishnu, V. Y., Gupta, A., Shariff, A., et al. (2020). Conduct of virtual neurology DM final examination during COVID-19 pandemic. *Annals of Indian Academy of Neurology*, *23*(4), 429–432. https://doi.org/10.4103/aian.AIAN_593_20.

Roberts, M. (2020). *Coronavirus: Has the NHS got enough PPE? [Online]*. BBC News.

Rose, S. (2020). Medical student education in the time of COVID-19. *JAMA*, *323*(21), 2131–2132. https://doi.org/10.1001/jama.2020.5227.

Safdieh, J. E., Lee, J. I., Prasad, L., Mulcare, M., Eiss, B., & Kang, Y. (2021). Curricular response to COVID-19: Real-time interactive telehealth experience (RITE) program. *Medical Education Online*, *26*(1), 1918609. https://doi.org/10.1080/10872981.2021.1918609.

Sandrone, S., Albert, D. V., Dunham, S. R., Kraker, J., Noviawaty, I., Palm, M., et al. (2021). Training in neurology: How lessons learned on teaching, well-being and telemedicine during the COVID-19 pandemic can shape the future of neurology education. *Neurology*. https://doi.org/10.1212/WNL.0000000000012010.

Seetan, K., Al-Zubi, M., Rubbai, Y., Athamneh, M., Khamees, A., & Radaideh, T. (2021). Impact of COVID-19 on medical students' mental wellbeing in Jordan. *PLoS One*, *16*(6), e0253295. https://doi.org/10.1371/journal.pone.0253295.

Shivkumar, V., Subramanian, T., Agarwal, P., Mari, Z., Mestre, T. A., & Parkinson Study, G. (2021). Uptake of telehealth in Parkinson's disease clinical care and research during the COVID-19 pandemic. *Parkinsonism & Related Disorders*, *86*, 97–100. https://doi.org/10.1016/j.parkreldis.2021.03.032.

Simundic, A. M. (2013). Bias in research. *Biochemica Medica (Zagreb)*, *23*(1), 12–15. https://doi.org/10.11613/bm.2013.003.

Staniscuaski, F., Kmetzsch, L., Soletti, R. C., Reichert, F., Zandona, E., Ludwig, Z. M. C., et al. (2021). Gender, race and parenthood impact academic productivity during the COVID-19 pandemic: From survey to action. *Frontiers in Psychology*, *12*, 663252. https://doi.org/10.3389/fpsyg.2021.663252.

Suarez-Cedeno, G., Pantelyat, A., Mills, K. A., Murthy, M., Alshaikh, J. T., Rosenthal, L. S., et al. (2021). Movement disorders virtual fellowship training in times of coronavirus disease 2019: A single-center experience. *Telemedicine Journal and E-Health*, *27*(10), 1160–1165. https://doi.org/10.1089/tmj.2020.0419.

Sukumar, S., Zakaria, A., Lai, C. J., Sakumoto, M., Khanna, R., & Choi, N. (2021). Designing and implementing a novel virtual rounds curriculum for medical students' internal medicine clerkship during the COVID-19 pandemic. *MedEdPORTAL*, *17*, 11106. https://doi.org/10.15766/mep_2374-8265.11106.

Suzuki, K., Numao, A., Komagamine, T., Haruyama, Y., Kawasaki, A., Funakoshi, K., et al. (2021). Impact of the COVID-19 pandemic on the quality of life of patients with Parkinson's disease and their caregivers: A single-center survey in Tochigi prefecture. *Journal of Parkinson's Disease*, *11*(3), 1047–1056. https://doi.org/10.3233/JPD-212560.

Tan, E. K., Albanese, A., Chaudhuri, K., Lim, S. Y., Oey, N. E., Shan Chan, C. H., et al. (2021). Adapting to post-COVID19 research in Parkinson's disease: Lessons from a multinational experience. *Parkinsonism & Related Disorders*, *82*, 146–149. https://doi.org/10.1016/j.parkreldis.2020.10.009.

Tan, E. K., Albanese, A., Chaudhuri, K. R., Opal, P., Wu, Y. C., Chan, C. H., et al. (2020). Neurological research & training after the easing of lockdown in countries impacted by COVID-19. *Journal of the Neurological Sciences*, *418*, 117105. https://doi.org/10.1016/j.jns.2020.117105.

Torales, J., O'Higgins, M., Castaldelli-Maia, J. M., & Ventriglio, A. (2020). The outbreak of COVID-19 coronavirus and its impact on global mental health. *The International Journal of Social Psychiatry*, *66*(4), 317–320. https://doi.org/10.1177/0020764020915212.

van der Meulen, M., Kleineberg, N. N., Schreier, D. R., Garcia-Azorin, D., & Di Lorenzo, F. (2020). COVID-19 and neurological training in Europe: From early challenges to future perspectives. *Neurological Sciences*, *41*(12), 3377–3379. https://doi.org/10.1007/s10072-020-04723-9.

Wang, J. J., Deng, A., & Tsui, B. C. H. (2020). COVID-19: Novel pandemic, novel generation of medical students. *British Journal of Anaesthesia*, *125*(3), e328–e330. https://doi.org/10.1016/j.bja.2020.05.025.

Weber, D. J., Albert, D. V. F., Aravamuthan, B. R., Bernson-Leung, M. E., Bhatti, D., & Milligan, T. A. (2020). Training in neurology: Rapid implementation of cross-institutional neurology resident education in the time of COVID-19. *Neurology*, *95*(19), 883–886. https://doi.org/10.1212/WNL.0000000000010753.

Weber, A. M., Dua, A., Chang, K., Jupalli, H., Rizwan, F., Chouthai, A., et al. (2021). An outpatient telehealth elective for displaced clinical learners during the COVID-19 pandemic. *BMC Medical Education*, *21*(1), 174. https://doi.org/10.1186/s12909-021-02604-z.

Welton, T., & Tan, E. K. (2021). Applying artificial intelligence to multi-omic data: New functional variants in Parkinson's disease. *Movement Disorders*, *36*(2), 347. https://doi.org/10.1002/mds.28481.

Weston, J., & Zauche, L. H. (2021). Comparison of virtual simulation to clinical practice for prelicensure nursing students in pediatrics. *Nurse Educator*, *46*(5), E95–E98. https://doi.org/10.1097/NNE.0000000000000946.

White, S., Fook, J., & Gardner, F. (2006). *Critical reflection in health and social care*. Open University Press, McGraw-Hill Education.

Wray, S., & Kinman, G. (2022). The challenges of COVID-19 for the well-being of academic staff. *Occupational Medicine (London)*, *72*(1), 2–3. https://doi.org/10.1093/occmed/kqab007.

Wu, A., Parris, R. S., Scarella, T. M., Tibbles, C. D., Torous, J., & Hill, K. P. (2021). What gets resident physicians stressed and how would they prefer to be supported? A best-worst scaling study. *Postgraduate Medical Journal*. https://doi.org/10.1136/postgradmedj-2021-140719.

Wyatt, D., Faulkner-Gurstein, R., Cowan, H., & Wolfe, C. D. A. (2021). Impacts of COVID-19 on clinical research in the UK: A multi-method qualitative case study. *PLoS One*, *16*(8), e0256871. https://doi.org/10.1371/journal.pone.0256871.

Yadala, S., Nalleballe, K., Sharma, R., Lotia, M., Kapoor, N., Veerapaneni, K. D., et al. (2020). Resident education during COVID-19 pandemic: Effectiveness of virtual electroencephalogram learning. *Cureus*, *12*(10), e11094. https://doi.org/10.7759/cureus.11094.

YoungMinds. (2020). *Coronavirus: Impact on young people with mental health needs*.

Zeinali, M., Almasi-Doghaee, M., & Haghi-Ashtiani, B. (2020). Facing COVID-19, jumping from in-person training to virtual learning: A review on educational and clinical activities in a neurology department. *Basic and Clinical Neuroscience*, *11*(2), 151–154. https://doi.org/10.32598/bcn.11.covid19.910.2.