



Challenges, collaboration, and innovation in rheumatology education during the COVID-19 pandemic: leveraging new ways to teach

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Abstract

The novel coronavirus disease (COVID-19) pandemic has significantly impacted the field of rheumatology, in both the delivery of clinical care and didactic education for our trainees. These changes have generated significant strain for program directors and clinical educators who have had to leverage technology and develop new systems to ensure continued trainee education and assessment. We aim to outline the impacts on formal education programs presented by these unprecedented disruptions, describe the development and deployment of online teaching, reflect on the challenges and opportunities for technology-enabled learning and use of social media for education, and give some international perspectives on impacts on postgraduate rheumatology training outside the USA. With the rapid dissolution of barriers in place during the pre-COVID-19 era, we have the opportunity to assess the efficacy of new methods of care and further integrate technology into teaching and assessment. We propose that a hybrid in-person and technology-enabled learning approach, so-called blended learning, is likely to remain the most desirable future model for supporting trainee learning.

Keywords COVID19 · Fellowship · Medical education · Technology-enabled education · Virtual learning

Introduction

The novel coronavirus disease (COVID-19) pandemic has significantly impacted the field of Rheumatology, in both clinical care and education. To implement the physical distancing required to prevent viral transmission—thus protecting our patients, ourselves, and our staff—practices have rapidly converted to telemedicine clinics. Likewise, most of our formal teaching activities have moved to online formats. In addition, rheumatologists have been deployed to serve in other settings to help manage the surge of COVID-19 patients. These changes have generated significant strain for program directors and clinical educators who had to quickly leverage technology and develop new systems to ensure the continued provision of excellent patient care and educational programs to support trainee learning. This challenge is compounded by the ongoing uncertainty about how long these changes to clinical practice and teaching will be required. In this manuscript we aim to outline the impacts on formal education programs presented by these COVID-related

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disruptions, describe the development and deployment of online teaching, reflect on the challenges and opportunities for technology-enabled learning, and use of social media for education, and give some international perspectives on impacts on postgraduate rheumatology training outside the USA. We propose that a hybrid in-person and technology-enabled learning approach, so-called blended learning, is likely to remain the most desirable future model for supporting trainee learning. Additional benefits include increasing equitability of access to learning as well as scalability.

Challenges and opportunities for programs and fellows due to COVID-19

The COVID-19 pandemic has created many challenges for rheumatology fellowship programs. Rheumatology practice, traditionally centered on delivering face-to-face high-volume outpatient continuity care for patients with rheumatic and musculoskeletal diseases, has been adversely affected. Physical distancing to reduce the spread of the novel coronavirus SARS CoV-2 has moved patient care to a virtual format, removing the rich environment for bedside teaching for which rheumatologists are known. In addition, collaborative conferences and patient-focused discussions have had to move out of the clinics and conference rooms. The online format requires adaptation of presentation skills and new ways of working. Major challenges include maintaining our culture of bedside teaching and focus on collaborative patient care when we are distanced from patients, learners, and colleagues. The impact of these adjustments has been immediate and we anticipate the consequences could be long term.

One immediate impact of the pandemic was the conversion of clinics almost entirely to telehealth conducted by telephone or online videoconferencing. Telehealth has demonstrated benefits in rheumatologic care, which include increased access for patients in underserved areas, with patient reported outcomes similar after telemedicine compared with usual care visits [1]. Although an in-depth analysis of a tele-rheumatology service shows this approach increases access to care and meets care needs on most occasions, it is not appropriate in the approximately 20% of clinical situations where the diagnosis is unclear or significant complexity is present [2]. The USA faces a rheumatology provider shortage over the next decade, which may negatively affect care for patients with rheumatic disease across the USA [3]. Although the more widespread use of telehealth has been promoted to address this shortage and maldistribution of rheumatologists, there are relatively few studies that assess the feasibility and effectiveness of telehealth in rheumatology [4], and the generalizability of findings remains to be tested. In addition, other challenges such as reimbursement for medical services, credentialing of physicians, and informed consent have

slowed the incorporation of telehealth into routine rheumatology practice. Despite this, the disruption of the pandemic has rapidly required those barriers to be addressed, with swift and widespread implementation of telehealth approaches in rheumatology. This urgent and unplanned expansion of telemedicine must be evaluated to enable further refinements of this remote care to ensure comparable patient outcomes with in-person care. The impact on training also needs to be considered. What training opportunities are reduced or absent in a telehealth consultation? What configuration of telehealth might optimize the platform for learning when attending and fellow are co-located while the patient is remote? What training opportunities, if any, are enhanced or novel in a telehealth environment?

The impact on the teaching and learning opportunities for fellows in training has been dramatic. In many programs, didactic teaching, journal clubs, research conferences, and projects were suspended and in-person teaching of physical exam techniques and ultrasound came to an abrupt halt. Furthermore, consult services became remote through phone or video calls with patients and their family members. Many faculty and fellows were being redeployed to care for the influx of COVID-19 patients, outside their rheumatology capacities. Immediate tasks for Program Directors included adjusting trainee schedules, addressing trainees' very legitimate anxiety around the interruption of training, and protection of their own health. An article on the impact of COVID-19 on medical trainees described "a sense of hopelessness, helplessness, and nervous anticipation at what may yet come to pass" [5]. Promoting resilience and avoiding social and psychological isolation in our trainees is paramount, while still maintaining the physical distancing required to protect physical health.

Medium- and long-term impacts include how the adaptations made in response to COVID-19 will shift future healthcare delivery and education moving forward. Programs have used multiple platforms including Zoom, Microsoft Teams, Doximity, Webex, and Ringcentral for clinical care, and teaching. In addition to delivering didactic programs, we should also commit to providing feedback on trainees' ability to achieve milestones in the virtual setting [6]. Although virtual platforms present challenges to providing feedback on subtlety of clinical signs, they preserve opportunities to provide feedback on clinical reasoning, care planning, and patient and team communication. Clinical educators will be faced with the challenge of giving constructive verbal feedback without the benefit of using non-verbal communication. By focusing on the continued education and evaluation of our trainees while remaining flexible and innovative, the global rheumatology community will come out of this pandemic with new skills and with more versatility and resiliency than before. One example of rapid innovation which has left a repository for future learning is the Virtual Rheumatology Learning (ViRL) Collaborative.

The ViRL Collaborative

The ViRL Collaborative was developed to address the need for continued fellow didactic teaching during the pandemic. The concept was introduced by a program director (AD) who quickly assembled 24 rheumatology programs with interest in participating. Expert speakers were recruited by the program directors of these institutions to give synchronous online lectures three times weekly. The American College of Rheumatology (ACR) joined the effort by providing online registration mechanisms, logistical and technical support, and a virtual platform (RingCentral) to host the series. With this support, access to the series was expanded with content made available for live viewing at no cost to registrants and each session recorded and posted to an accessible website (<https://www.rheumatology.org/I-Am-A/Fellow-in-Training/Virtual-Rheumatology-Program/Learning-Collaborative>) for asynchronous viewing by the next day. One faculty and one fellow moderated each lecture, gathering questions during the session via the chat function to initiate discussion after the presentation. The first lecture was delivered on April 6, 2020, only 1 week after the initial email gauging program interest.

Robust interest in participating in online learning was demonstrated not only by fellow trainees but also by faculty and community rheumatologists, physician extenders, medical residents, and students, and it quickly expanded internationally. The support of the ACR enabled access to all interested learners, with 1982 registrants from 55 countries. On average 435 learners participated in each “live” virtual session. Recorded videos are hosted through the ACR website and are available to all learners. Given competing demands during work hours in the USA and international interest from learners around the globe, having the ability to access this information at their convenience—and at any future date—is a strength of this online delivery and repository. We were able to leverage the expertise of national thought leaders to rapidly build a high quality, broadly appealing lecture series on some of the most relevant topics to rheumatology trainees. Fellow participation in co-moderating sessions has increased visibility of fellow trainees and allowed increased interaction between fellows and world-renowned experts, which is not always feasible in face-to-face presentations.

One limitation of the lecture series includes the lack of a formalized curriculum with set goals and objectives based on a needs-assessment. As all programs were in varying stages of their didactic curriculum, and given the rapid turnaround from conception to launch, speakers were not assigned topics or asked to develop new talks. Another limitation of the online format is the lack of small group engagement and active learning. While speakers and learners adjusted to using the technology for content delivery, social aspects of learning such as discussion – which are central to andragogy—were not able to

be accommodated in the short timelines. Ideally, future virtual learning sessions will be developed around a specific curriculum, with clear goals and objectives, and include interactive processes that utilize adult learning theories.

ViRL has increased access to educational content and fostered some sense of community amongst learners, which is especially important when facing isolation from usual communities of practice. One positive and unanticipated effect of the use of virtual platforms has been enabling access for more learners to educational content provided by topic experts and expert teachers. The force of this pandemic has been met with the dedication, collaboration, and innovation amongst rheumatology programs nationally and internationally by pooling resources and optimizing structured access to didactic training for our learners. This new and exciting format for medical education may have a lasting impact on the field beyond the limits of this pandemic.

Tech-enabled medical education

While ViRL has provided a high-quality substitute for suspended in-person teaching, there has been general consensus for many years that medical education, based largely on outdated educational structures that rely heavily on didactic in-person learning experiences, has needed to change [7]. Technology-based learning offers great potential to reduce inequity in medical education worldwide, enhance learner-centered knowledge delivery, address the anticipated rheumatology workforce shortage, and prepare new providers to practice effectively in our twenty-first century health systems. The current COVID-19 pandemic, which has dramatically impaired in-person learning at all levels of medical training, may be the catalyst that galvanizes the medical education community to reassess and innovate so that teaching practices better align with the needs of contemporary healthcare learners.

Technology-based health learning platforms have the potential to mitigate inequities in medical education that include quality of accessible learning experiences, financial resources, and career development opportunities. While COVID-19 disruptions impact medical education everywhere, resource limited areas and trainees are likely to be disproportionately affected. Collaborative technology-based learning, which can be widely shared and is scalable, offers the opportunity to increase access to high-quality medical education resources and content experts worldwide while reducing the costs of medical education. This has potentially far-reaching and long-lasting benefits for growing the healthcare workforce. It also has the potential to impact the well-being of individual healthcare providers, since financial stress related to the high costs of medical education contributes to burnout in healthcare providers [8].

Technology-enabled medical education offers opportunities to integrate the science of learning into the educational framework to optimize cognitive load and increase understanding, retention, and transfer [9]. The traditional educational structure that relied heavily on one-size-fits-all didactics is mainly institutionally centered. In contrast, technology-enabled medical education offers a learner-centered approach in which technology aids and supports individualized learning and engagement. This opens doors to blended learning strategies that synergistically integrate adult learning principles to enhance and accelerate learning. Educational strategies such as personalized learning, adaptive learning, flipped classroom, just-in-time, and effective use of multimedia can all be incorporated into technology-enabled instructional design. Some strategies that have been successfully used include case discussion in virtual breakout rooms, recordings for asynchronous learning, and incorporation of polling to allow for dynamic discussion and teaching. This instruction offers opportunities to personalize education to the needs and abilities of diverse learners with variable knowledge, experiences, motivations, attitudes, and goals. Designing technology-enabled instruction guided by evidence-based principles of learning can provide medical educators with opportunities to implement effective pedagogy, develop instructional materials that facilitate efficient and effective learning, and ideally make individualization of learning affordable and available to all students. The funding, distribution, access, and support of these initiatives pose potential barriers and are considerations that will need to be addressed.

Most responses to implementing online versions of in-person learning should be seen for what they are, remote emergency teaching [10]. Designing technology-enabled learning environments is the essential next step but also poses several challenges. The first challenge for medical educators is to uphold a learner-centered approach in which technology aids and supports learning and avoid the pitfalls of slipping into a technology-centered approach. To do this effectively, medical educators should themselves be educated about evidence-based instructional design principles and technology capabilities. Second, technology-enabled learning environments should clearly specify learning objectives, be engaging and motivating for learners, and provide opportunities for real-time assessment and feedback [11]. Third, copyright laws can present barriers to widespread dissemination of educational material; support from publishing corporations to permit the use of copyrighted images and videos in widely disseminated instructional materials would greatly enhance accessibility to learners worldwide. Finally, due consideration should be made to the influences of adoption of technology by faculty and institutions, which need careful planning and adequate resourcing [12]. The COVID-19-related disruptions have made clear that there is a great and urgent need to upskill our faculty in these concepts and invest in developing fit-

for-purpose, contemporary technology enabled learning that meets the needs of our rheumatology workforce in training.

Use of social media platforms to deliver knowledge and information relevant to rheumatology

Social media has become a powerful instrument for international collaboration and knowledge and information sharing that supplements traditional learning, and rheumatology medical education has been no exception. Recent years have seen increasing trends in the utilization of social media for teaching and learning in the health professions [13]. Twitter, Facebook, YouTube, WhatsApp, and Instagram provide learners and facilitators in the health professions a chance to interact, collaborate, and share perspectives and information with each other, as well as facilitate wide dissemination of educational material. The use of Twitter proved instrumental in the worldwide dissemination of the ViRL lecture series and recordings can be viewed via YouTube for asynchronous learning. Twitter was also the hub for the development of the COVID-19 Global Rheumatology Alliance, which has enabled collaboration internationally to learn and collect data about COVID-19 and rheumatic disease patients. The emerging literature on the use of social media for graduate medical education describes the use of Twitter, podcasts, and blogs for engaging learners and disseminating information [14]. These social media platforms are likely to continue to increase in uptake and further evaluation of use and impact are warranted. Limitations to the use of social media in medical education include but are not limited to concerns surrounding professionalism and risks of data protection. Medical educators and learners engaging with social media for medical education purposes should be aware of its limitations and challenges, which can be mitigated by training users on appropriate use of social media [13].

Global educational collaboration and breaking boundaries

Internationally, rheumatology services in high-income countries in Europe and Australasia have been impacted in very similar ways to the USA: a rapid, unplanned move to tele-rheumatology, disruption of usual teaching and learning opportunities, and redeployment of trainees and senior staff. Training accreditation bodies are working hard to balance competing demands: medical licensing regulators and the public deserve to be confident that sufficient rheumatology training has been available, and that the relevant learning has occurred. We are challenged with simultaneously protecting the wellbeing of our trainees as they continue to learn and provide care in unfamiliar ways, or even outside their current

expertise. Decisions about assessment progression through training should be made with careful consideration and compassion and additional learning opportunities need to be provided. In smaller countries the ability to rapidly provide online didactic content may be more limited, although the ViRL content has been made available internationally on request.

Examining physician training in Australia and New Zealand does highlight how local training requirements, and the different country-level responses to the pandemic shape education changes. Entry to rheumatology training in Australia and New Zealand requires a medical resident to pass a knowledge examination (multiple choice format), then a full day in-person clinical examination. The clinical examination includes “long-cases” (full history, examination and management planning) and “short-cases” (physical examination and synthesis) during which multiple examiners, candidates, and patients travel to examination sites and interact with each other. Although community transmission of COVID-19 has been better controlled in these countries, this examination format has been deemed too risky. Instead the examination will be split into “long cases” delivered remotely via videoconferencing, and if candidates are successful, short cases will be sat for in-person at a later date, likely at a local site. Although the change to examination may seem relatively minor, this has been a large source of anxiety and distress to physician trainees and huge efforts on the part of the training accreditor, the Royal Australasian College of Physicians. It also remains unclear what examination processes will remain on an ongoing basis. Overall, rheumatology training has been able to continue relatively uninterrupted; however, the remaining unknown is when it may become feasible again for trainees from Australia and New Zealand to travel to gain experience training at larger rheumatology centres or to attend international in-person conferences when these resume. Access to online conferences is an interim solution.

The European League Against Rheumatism (EULAR) School of Rheumatology (ESOR) may serve as a good example to illustrate new developments resulting from the pandemic in the field of rheumatology training in Europe (more detailed information available here: <https://esor.eular.org/>). The online courses such as EULAR Course on Rheumatic Diseases or the EULAR Online Course on Imaging in Rheumatic Diseases play the main role, while the ESOR formats of live courses and meetings that are also offered are currently not feasible. Driven by the educational committee, EULAR continues to make substantial efforts and investments in the further development of e-learning opportunities. Achieving a modern, attractive presentation of the teaching content covered by the individual modules is currently the main development focus. This way, EULAR aims at optimizing quality, range, and acceptance of this teaching and learning format.

While we have concentrated on the most tangible aspects of postgraduate education – the visible and measurable formal

and informal teaching—our trainees are also still learning the “art” of rheumatology. The need to rapidly adapt to the COVID-19 impacts on learning, teaching and clinical care will allow ample opportunities for modeling of key characteristics of a rheumatologist: advocating for individual patients, collaborating and working effectively with an interprofessional team, demonstrating professional, compassionate, and ethical behavior and engaging in lifelong learning [15].

Post-pandemic adaptations

The COVID-19 crisis imposed challenges on our normal approach to medical education that necessitated accelerated innovation. How will this experience and our community’s response influence rheumatology education after the pandemic?

The successful implementation of telehealth to deliver rheumatologic care during the pandemic suggests that it could play an important role in routine clinical practice. However, this experience also taught us that there are challenges to delivering rheumatologic care virtually, especially for trainees and educators. An advantage of providing virtual care during the pandemic was that the learner, educator, and patient did not need to be in the same room. However, many of the foundational elements of rheumatology education, particularly the physical exam, occur at the bedside where the teacher can show a learner how to examine or aspirate a joint, for instance, and the learner can demonstrate mastery of these skills. In order for the novice trainee to develop proficiency in musculoskeletal ultrasound, hands-on demonstration and practice with the ultrasound machine at the bedside under the guidance of an experienced practitioner is critical. One path forward would be to prioritize keeping a portion of trainee clinics in-person, especially during the first year, but using arrangements in clinic that protect the learner, educator, and patient (e.g., universal masks, hand hygiene, frequent sanitizing, providing adequate space and ventilation in rooms) in consultation with infection control. Patients with stable disease or conditions that may not require a frequent physical exam could be prioritized for virtual visits.

Assuming virtual care will be a part of our routine practice moving forward, we need to consider how to train learners to obtain a history efficiently and effectively over video and by phone and perform a limited physical examination by video. There will also need to be consideration given to how we maximize the educational benefits of virtual precepting for learners and educators. Perhaps the learner and educator could conduct virtual visits together from the same clinic office space so that some of the benefits of in-person education like interviewing patients together, discussing the complexities of a case, and reviewing management strategies are retained [16].

Outside of the clinic setting, there will continue to be restrictions on gatherings for educational conferences. The

COVID-19 pandemic has demonstrated how virtual didactics (e.g., by Zoom or WebEx) can be used to maintain institution-specific curricula. However, the pandemic has also provided us opportunities to deliver educational training by experts at a larger scale for trainees across institutions, even internationally. Virtual lectures have the potential to improve the education of rheumatology fellows by providing access to the most up-to-date information delivered by global experts and by ensuring fellows have equitable access to excellent educational content on a broad range of topics regardless of where they train. Obtaining input regarding the needs and best practices from the community of learners should be used to inform evolving education initiatives. Despite the opportunities and strengths associated with virtual learning, there are also advantages to in-person didactics and opportunities to further innovate face-to-face learning, which will remain an important component of educational training. Educators are being challenged to explore new avenues in teaching by purposely mixing modern teaching formats such as interactive debates, round-table discussions, workshops and seminars. These formats allow for relationship building and networking, as well as the ability to teach new facts, theories and book-knowledge, refresh memories, and gain and improve practical skills. It would seem likely that a mixture of increased online content and discussion and co-located in-person educational activities will become our norm.

To maximize the benefits associated with virtual education and in-person learning, one way forward would be to build a hybrid model leveraging the strengths of each format. For instance, a nationwide virtual “foundations” lecture series could be delivered by experts either at the beginning of the academic year or at regular intervals throughout the first year. The lectures could be streamed in order to enable tools such as polling and question/answer but also be available in recorded form for those trainees who are not available during the streaming session given the wide variability in clinical schedules. These could be made available internationally, benefiting both high-resource countries by supplementing local education and low-resource countries by providing most of the rheumatology education in settings without local teaching infrastructure. When available, this virtual series could be supplemented by local in-person didactics that utilize small group collaborative formats and fellow-driven learning. This hybrid approach would give fellows access to a standardized, cutting-edge knowledge base while still fostering the growth that occurs in person with discussion and debate.

Conclusion

The COVID-19 pandemic has accelerated the adoption of virtual platforms for both clinical care and didactic education. With the rapid dissolution of barriers in place during the pre-

COVID-19 era, we have the opportunity to assess the efficacy of new methods of care and further integrate technology into teaching and assessment. The importance of balancing increased accessibility for patients and learners through leveraging technology with the value of hands-on engagement, teaching and assessment that is enabled through in-person contact is critical. It is important for us as a global rheumatology community to identify the strengths and limitations of the adaptations developed in response to the COVID-19 pandemic in order to preserve and integrate those features that will optimize the education of rheumatology fellows in training.

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Compliance with ethical standards

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References

1. Wood PR, Caplan L (2019) Outcomes, satisfaction, and costs of a rheumatology telemedicine program: a longitudinal evaluation. *JCR: J Clin Rheumatol* 25(1):41–44
2. Kulcsar Z, Albert D, Ercolano E, Mecchella JN (2016) Telerheumatology: a technology appropriate for virtually all. *Semin Arthritis Rheum* 46(3):380–385
3. Kilian A, Upton LA, Battafarano DF, Monrad SU (2019) Workforce trends in rheumatology. *Rheum Dis Clin N Am* 45(1):13–26
4. Piga M, Cangemi I, Mathieu A, Cauli A (2017) Telemedicine for patients with rheumatic diseases: systematic review and proposal for research agenda. *Semin Arthritis Rheum* 47(1):121–128
5. Shaw SCK (2020) Hopelessness, helplessness and resilience: the importance of safeguarding our trainees' mental wellbeing during the COVID-19 pandemic. *Nurse Educ Pract* 44:102780–102780
6. Isaza-Restrepo A, Gómez MT, Cifuentes G, Argüello A (2018) The virtual patient as a learning tool: a mixed quantitative qualitative study. *BMC Med Educ* 18(1):297
7. Frenk J, Chen L, Bhutta ZA, Cohen J, Crisp N, Evans T, Fineberg H, Garcia P, Ke Y, Kelley P, Kistnasamy B, Meleis A, Naylor D, Pablos-Mendez A, Reddy S, Scrimshaw S, Sepulveda J, Serwadda D, Zurayk H (2010) Health professionals for a new century: transforming education to strengthen health systems in an interdependent world. *Lancet* 376(9756):1923–1958
8. West CP, Shanafelt TD, Kolars JC (2011) Quality of life, burnout, educational debt, and medical knowledge among internal medicine residents. *Jama* 306(9):952–960
9. Mayer RE (2010) Applying the science of learning to medical education. *Med Educ* 44(6):543–549
10. Hodges C, M S, Lockee B, Trust T, Bond A (2020) The difference between emergency remote teaching and online learning. *Educause*

- Review. Retrieved from <https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning>
11. Kirkley SE, Kirkley JR (2005) Creating next generation blended learning environments using mixed reality. *Video Games and Simulations TechTrends* 49(3):42–53
 12. Grainger R, Liu Q, Geertshuis S. (2020) Learning technologies: a medium for the transformation of medical education? *Med Educ.* <https://doi.org/10.1111/medu.14261>
 13. Latif MZ, Hussain I, Saeed R, Qureshi MA, Maqsood U (2019) Use of smart phones and social media in medical education: trends, advantages, challenges and barriers. *Acta informatica medica : AIM : journal of the Society for Medical Informatics of Bosnia & Herzegovina : casopis Društva za medicinsku informatiku BiH* 27(2):133–138
 14. Sterling M, Leung P, Wright D, Bishop TF (2017) The use of social media in graduate medical education: a systematic review. *Acad Med* 92(7):1043–1056
 15. Brown CR Jr, Criscione-Schreiber L, O'Rourke KS, Fuchs HA, Putterman C, Tan IJ, Valeriano-Marcet J, Hsieh E, Zirkle S, Bolster MB (2016) What is a rheumatologist and how do we make one? *Arthritis Care & Research* 68(8):1166–1172
 16. Keswani A, Brooks JP, Khoury P (2020) The future of telehealth in allergy and immunology training. *The journal of allergy and clinical immunology. In practice*, p. S2213–2198(20)30481–5

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