*Neuroergonomics and Cognitive Engineering,* Vol. 102, 2023, 192–202
https://doi.org/10.54941/ahfe1003019

# Do Increased Engagement Effects in Lecture Videos Improve Comprehension?

**Jessica M.-S. Mar and Kim-Phuong L. Vu**

California State University Long Beach, Long Beach, CA 90815, USA

## ABSTRACT

Students are choosing more and more to enroll in online courses due to convenience or acclimation from distance learning during the COVID-19 pandemic. However, instructors must learn to utilize principles of cognitive load and student engagement when designing online courses, especially when creating asynchronous lecture videos. This study examined the effects of content difficulty (Easy vs. Hard) and percentage level of engagement effects in videos (10%, 25%, 50%, 75%) on comprehension of course material. Participants were asked to watch one easy content and one hard content video and answer questions on the video topic after each video. Perceived usability, mental effort, and engagement behavior tendencies while watching instructional videos were also measured. Results showed a significant interaction between content difficulty and subject pool, with student participants performing better than Amazon MTurk participants, specifically on hard content. Participants rated lower levels of engagement effects as more usable, and participants overall rated easy content requiring less mental effort to understand than hard content. Implications and further research topics based on these findings are discussed.

**Keywords:** Instructional design, Student engagement, Asynchronous learning, Cognitive load

## INTRODUCTION

During the COVID-19 pandemic, instructors rushed to transition from synchronous, in-person courses to online courses (Gillis & Krull, 2020). In working to get course material available for students online, some instructors sacrificed good online instructional design for the sake of time or because of a lack of expertise (Gillis & Krull, 2020; Hollister et al., 2022). Some courses continued to be synchronous with the assistance of video-conferencing platforms while other courses became asynchronous with lecture recordings or videos (Gillis & Krull, 2020; Merkt et al., 2022). Now, more students than ever are choosing to enroll in online asynchronous and/or synchronous courses (Faulconer et al., 2022), either for preference or convenience. However, the growing number of online courses and course material often do not utilize established instructional design strategies (Bawa, 2016). Recorded lecture videos are uploaded for students to view in their own time, but instructors do not realize additional edits can be made to ensure greater comprehension of course material and increased student engagement in the course itself. This study examined the effect of edits to lecture videos based on Brame's (2016) recommended practices as well as how many effects in proportion to video length would be effective, usable and preferred by students.

## Asynchronous Learning and Instructional Design

Online, asynchronous learning in higher education has been available since the 1990s and instructional design research grew in response to support effective online learning (Power, 2007). It has increasingly grown in scope over the decades and the asynchronous courses of today look almost unrecognizable in comparison to the 1990s. Yet, improvements can always be implemented, and the changing landscape of new educational practices and technologies continues to push the limits of online, asynchronous learning. Research has shown that learning online can be just as effective as in-person classroom environments (Stachel et al., 2013), but the recent COVID-19 pandemic has highlighted the importance of instructional design of asynchronous courses, and it will only continue to grow as researchers study the resulting effects of learning during the pandemic.

Course materials in asynchronous learning may include lecture recordings, individual student activities, and online collaboration between classmates (Noetel et al., 2021; Faulconer et al., 2022). While certain course materials may be utilized in both online and in-person modalities, the method in distribution and learning with those materials differs dependent on the modality (Chen, 2016).

### Cognitive Load

Cognitive load is a term for the capacity of working memory, or the temporary storage in our memory containing information for a limited amount of time (Sweller et al., 1998). Working memory is not the same thing as short-term memory and its capacity influences cognitive performance. The cognitive load theory in instructional design states that learning with a lighter cognitive load is ideal and should be reflected in teaching styles and course material (Sweller et al., 1998), especially for learning in an environment where course material is taught and built upon to explain greater, more complex concepts. In a learning experience, the student has three separate components to process the material. The first component is known as intrinsic load, which is how easily the student can connect ideas within a topic (Brame, 2016).

The second component is germane load, referred to as the level of cognition required to learn and reach any educational goals. Germane cognitive load is unique in that it is associated with constructing knowledge schemas as the process naturally requires some effort (Kalyuga, 2011). As such, germane cognitive load can be considered to enhance learning. And finally, extraneous cognitive load refers to unnecessary cognitive load in a learning experience, such as how information is presented in course material. Instructional design heavily focuses on reducing extraneous cognitive load; one main source is from poorly designed course materials that may include unneeded details or confusing instructions (Sweller et al., 1998; Brame, 2016). Having too much text or too many elements on a lecture slide would increase extraneous load, as well as verbal lectures without visual aids to illustrate concepts taught.

To assist with student learning, extraneous cognitive load should be kept low to allow for more working memory resources for intrinsic and germane cognitive load.

While asynchronous courses appear popular to students, they also have higher withdrawal rates than traditional courses (Bawa, 2016), and students can fall further behind due to ineffective remote learning strategies (Hollister et al., 2022). Thus, it remains a priority to research and implement designs and practices that best facilitate learning in remote environments that take cognitive load into account (Sweller et al., 1998). Asynchronous courses often utilize online lecture videos to deliver course material to students (Brame, 2016). While seemingly impersonal and without real-time contact with instructors, previous studies have shown online videos have improved student learning (Noetel et al., 2021; Wang et al., 2022) in most online video usages in higher education. Noetel et al. (2021) specifically argues that asynchronous educational videos are beneficial for a lower cognitive load, as it allows the student to pause, replay, and fast-forward when appropriate as they process the course material. Other suggestions to keep extraneous cognitive load low for increased student comprehension in lecture videos include keeping video lengths short, using complementary audio and visual elements to assist in explaining course material, highlighting important course topics and concepts, and ensuring active learning through the usage of interactive elements (Brame, 2016). This would require active editing from instructors after recording lectures to add in effects on video-editing platforms.

**Online Learning Engagement**

Student engagement is associated positively with student learning (Northey et al., 2015). Student engagement research in instructional design has been utilized from revitalizing entire educational systems to implementing effective classroom practices (Trowler, 2010). In online learning environments, student engagement is key to effective learning and successful academics (Seo et al., 2021b). As asynchronous learning is conducted mostly online, student engagement may appear as online discussion boards within the course or the interaction of the student with the online learning management system (Seo et al., 2021b; Chen, 2016). Student interaction with online course videos has been shown to help increase student motivation and engagement in courses (Seo et al., 2021b), and improve student attitudes to achieve learning outcomes (Wang et al., 2022).

A previous in-person pilot study (Mar, 2022) was conducted utilizing Brame's (2016) recommendations, through the editing of recorded undergraduate cognitive psychology course lectures. Such editing included highlighting on key words and phrases to signal important information to reduce extraneous cognitive load, and adding in text of guiding questions stated during the lecture as well as indications on when to pause during an example given to reduce extraneous load and increase germane load (Brame, 2016). Edited and unedited video clips were presented to 8 participants obtained through convenience sampling and asked subjective questions on their level of engagement while viewing the videos. External engagement behaviors such as note-taking, rewinding and replaying, pausing, and nodding as well as any comments made were also noted. It was difficult to focus on one external measure of engagement as behaviors of engagement were subjective among individuals. Yet all participants self-reported preferring videos with effects over videos with no effects, and that the videos with effects were rated as more engaging over those without (Mar, 2022). As the effects in this study used the same effects as the previous pilot study, this variable was named "engagement effects".

### Current Research Aims

Based on the principles of cognitive load theory and recommendations for effective learning in asynchronous course videos, the present study examined the effects of lecture video content difficulty and level of engagement effects (10%, 25%, 50%, 75%) on student comprehension of course material. The first hypothesis was that participants would perform better on easy content compared to hard content, as easier content would have lower intrinsic cognitive load (Sweller et al., 1998; Brame, 2016). The second hypothesis was that higher levels of engagement effects would lead to better performance overall following Brame's (2016) recommendations for effective learning in educational videos. Finally, it was hypothesized that the addition of effects as a learning aid would help increase student comprehension in hard content by decreasing extraneous cognitive load. This mixed-design study examined interactions between two levels of content difficulty (easy, hard) and four levels of engagement effects (10%, 25%, 50%, 75%) to determine if the effects also promote increased student comprehension of lecture material. Level of effects were defined as the percentage of effects edited in the video. Effects included highlights of main points in lecture videos, zoom-ins of diagrams, and pop-up textboxes of further clarification or examples. Findings from this study were expected to have implications for future instructional design guidelines and inform a possible strategy in increasing student engagement and comprehension with asynchronous course lecture videos.

## METHODS

### Participants

Fifty-eight individuals participated in this study. Data from 4 participants were excluded from analysis, two due to failing both attention checks while taking the study and two for being over 55 years of age for which potential age-related on-set of cognitive decline can occur (Statsenko et al., 2021). Thus, the analytical sample was composed of 54 participants [16 undergraduate students from California State University, Long Beach's Psychology Subject Pool and 38 from Amazon Mechanical Turk (MTurk)]. MTurk qualifications for participants required to be located in the United States and to have an approval rate above 95%. The students received 0.5 credits for their participation and MTurk participants received $4.

#### Demographics

Participants ranged from 18 to 52 years of age, ($M = 30.07$, $SD = 8.83$), with twenty-six male and twenty-eight female participants. Thirty-five identified as Caucasian (64.8%), 8 as Latino or Hispanic (14.8%), 6 as Asian (11.1%), and 3 as African or African American (5.6%). One participant identified as

"Other", and one participant preferred not to share their ethnicity. Eleven participants had a high school diploma or equivalent (20.4%), 6 were currently enrolled in college and/or had an Associate's degree (11.1%), 29 had a Bachelor's degree (53.7%), and 6 had completed a graduate-level degree (11.1%).

### Materials

This study was reviewed and approved by the university's Institutional Review Board (IRB). The study was conducted with the Qualtrics platform as an online survey. The survey included the instructional videos, comprehension questions, and several questionnaires. As the videos were hosted on YouTube and embedded into Qualtrics, standard YouTube functions including video speed and seeking were available. For the questionnaires, a 1-item Paas Scale for Mental Effort was used to assess mental effort in viewing and understanding video material (Paas, 1992). A 10-item System Usability Scale (SUS) was employed to measure usability of the lecture videos (Lewis, 2018). A 7-item, modified Video-Based Learning Activity Engagement Measure was used to measure engagement goals of students while watching educational videos (Seo et al., 2021a). Two quality control questions were also inserted in the survey.

The easy content video was an 8-minute clip of a lecture on applications of cognitive psychology, specifically on the field of human factors. The hard content video was a 14-minute clip of a lecture on working memory and long-term memory, with details on primacy and recency effects. Engagement effects were edited in with the use of Camtasia, a video-editing software for educational uses, and were previously shown to decrease extraneous cognitive load (Brame, 2016). The edited video effects include highlights of important information, zoom-in animations on large diagrams, and the addition of supplemental text.

### Design

The study utilized a 4 (Effect Level: 10, 25, 50, and 75 percent) x 2 (Content Difficulty: Easy/Hard) mixed-design, with effect level as the between-subject variables and content difficulty serving as the within-subject variable. Levels of effects refer to the number of effects taking up the total time of the lecture video. Video content difficulty was determined through the levels of detail in the concepts taught. Participants viewed both easy and hard videos, with the order counterbalanced across participants. An additional between-subjects variable of Subject Pool (PSY 100 vs. MTurk) was included for the analyses. The main dependent measure was accuracy on comprehension questions. Other dependent measures included perceived usability scores (SUS), subjective ratings of mental effort (Paas Scale for Mental Effort), and engagement tendencies of educational videos (Video-Based Learning Activity Engagement Measure.

### Procedure

CSULB undergraduate participants accessed the survey through an online research management interface system known as SONA, which compiled current research studies that required student participation. MTurk participants were shown available tasks within their qualifications. A link to the full survey on Qualtrics was provided to the participants either through SONA or MTurk.

## RESULTS

The minimum time to finish the study was projected to be 25 minutes, but due to the nature of the study being an online survey with no time restraints, participants took anywhere from 4 to 9,615 minutes ($M = 293.40$, $SD = 1367.74$).

### Comprehension

Comprehension was calculated as the percentage of correct responses from both the easy and hard videos. A 4 (Effect Level: 10 percent/25 percent/50 percent/75 percent) x 2(Subject Pool: MTurk/CSULB) x 2 (Content Difficulty: Easy/Hard) mixed-design AONA was performed to evaluate the effects of difficulty, subject pool, and effect level on comprehension. Effect Level and Subject Pool were between-subjects factors and Content Difficulty was a within-subjects factor.

Both the main effects of Subject Pool, $F(1, 46) = 8.61$, $p = .005$, $\eta 2 = .158$, and Content Difficulty, $F(1, 46) = 8.24$, $p = .006$, $\eta 2 = .152$, on comprehension were found to be significant. CSULB participants ($M = 67.86$) performed better than MTurk participants ($M = 54.21$), and participants in general performed better on easy content ($M = 61.85$) than on hard content ($M = 55.74$). However, the main effects of Subject Pool and Content Difficulty were qualified by the interaction between the two factors, $F(1, 46) = 6.69$, $p = .013$, $\eta 2 = .127$. The main effect of level of engagement effects was found to be not significant, $F(3, 46) = .781$, $p = .511$, $\eta 2 = .048$. Bonferroni-adjusted comparisons indicated that CSULB participants performed better when the content was easy ($MD = 16.88$ points) than when it was hard ($p = .003$, 95% $CI = 6.00$ to 27.75). In contrast, performance of MTurk participants in did not differ by content difficulty ($MD = 1.58$; $p = .655$).

### Subjective Ratings

The analyses of the Paas rating and SUS scores showed no significant effects. Patterns of engagement tendencies in asynchronous course videos reported by participants using the Video-Based Learning Activity Engagement Measure are discussed in the next section.

## DISCUSSION

### Levels of Effects on Comprehension

The present study examined whether engagement effects improved students' comprehension in the instructional videos, where it was predicted that participants would have greater comprehension on easy content than on hard content. The prediction was supported with the finding that participants scored higher on the comprehension quizzes when the content was easy, which may suggest that there was less intrinsic cognitive load when they watched the easy content videos. The results are consistent with past research where easier course content have lower intrinsic load due to having less levels of understanding required to grasp the content (Sweller et al., 1998; Bai & Vu, 2023).

It was also predicted that student comprehension would increase more with higher levels of effects. However, the study found no differences between the levels of effects on comprehension, which was not what previous research has found where adding effects can decrease extraneous cognitive load to assist in student learning (Brame, 2016). While Brame's (2016) suggestions for educational videos were supported for student engagement by the previous pilot study conducted by Mar (2022), these results suggest that the impact of the video effects on comprehension may vary. Although participants were assigned videos in one level of engagement effects to watch, there may have been too many visual cues within the video and possibly increased the extraneous load instead of the intended decrease. Participants may have found the higher level of effects to be more distracting, which could have also impacted cognitive load. These factors may have contributed to increasing cognitive load and resulted in why participants performed worse in the higher effect levels (e.g., 75%) than in the lower effect levels (e.g., 10%).

Although it was anticipated that the higher level of video effects would decrease the gap in student comprehension between content difficulties, the present results did not support this hypothesis. Participants did not perform better on difficult material when more effects were added. However, when an additional factor of subject pool was analyzed, it was found that CSULB participants scored higher than MTurk participants, specifically on the hard content material. This difference may be due to CSULB students being enrolled in an undergraduate psychology course and may have more recent experience with online lectures and online quizzes compared to the MTurk participants.

## Mental Effort

While there were no significant differences across the four Effect Level conditions, participants generally devoted more mental effort to understanding hard content than they did in easy content. These results align with previous research showing that easy content requires less depth and breadth of knowledge to process and learn, and thus has a lower cognitive load than hard content (Sweller et al., 1998, Brame, 2016). Additionally, as the percentage of effects increased, participants reported expending more mental effort in hard content videos. Therefore, increasing the level of effects may not have been effective for increasing comprehension. As extraneous load refers to any unnecessary mental effort in a learning experience, it can be diminished by a simpler presentation of information through lower levels of effects (Sweller et al., 1998; Brame, 2016). The implication of the results suggest that lower levels of effects may be more desirable for less mental effort needed to understanding course material.

### Perceived Usability of Effects

As pilot study participants have shown preference for lecture videos with effects over the same lecture videos without effects (Mar, 2022), it was expected that participants in this study would also rate the perceived usability of their videos to an acceptable level, but this was not the case. Future research could examine how and when to add effects to the videos. For example, the addition of the effects should also be more standardized across the videos to ensure that the effects that were used were consistent with their meanings across each condition.

### Engagement in Learning

Participant engagement behaviors while watching instructional videos were assessed though the Video-Based Learning Activity Engagement Measure. The question with the most responses was from the question "When watching the instructional videos, I typically navigate backwards because..." Seo et al. (2021b) intended that question to be a signifier of the student engagement for the video that was just viewed by the student. That is, the more a student rewinds a video, the more engagement with the instructional video is displayed; however, it may also mean the content being shown is too difficult for students to understand at first watch (Seo et al., 2021b). The choice with the most responses was "When watching the instructional videos, I typically pause because I need time to think and reflect on what I just watched." A previous study found that pauses during the video were correlated to points during the video where students experienced difficulties in comprehending course material, and also where students felt a break was appropriate between shifts in topics (Merkt et al, 2022), which was the second-most selected choice for the same question asking about pausing behavior. Seo et al. (2021b) connected pausing while viewing a video as reflecting on what students were watching at that moment as an engagement goal with the course material. While the measure was modified and deployed to ask about typical video viewing engagement behaviors, student's tendencies in rewinding and pausing can be used to improve designs in editing future instructional videos.

### Limitations

The lack of other significant interactions may be a result of the small sample size, and the inconsistent distribution of ages of participants. As external circumstances changed the original study's participant recruitment goals, the focus on testing college students decreased and the availability of the study allowed participants of all educational backgrounds and all ages to take the survey. As such, the diversity in education levels and age as well as potential lack of prior experience in online courses possibly had an influence in why MTurk participants performed lower in comparison to CSULB students. Participants also displayed a large range in completion time of the study, even when controlled for quality checks. While completion time was not a variable in analysis, it may also be an indicator that participants may not have been fully engaged in the videos while watching. This may have led to lower numbers of correct answers to the questions asked.

### Future Directions

While the findings of this study did not support the hypotheses, future research can continue to study how to implement engagement effects in educational videos to promote student learning in online courses. Higher levels of engagement while watching educational videos are positively correlated with higher understanding of concepts, course grades, and learning outcomes (Wang et al, 2022; Northey et al., 2015). Previous studies have been conducted on various elements of recorded lecture videos such as instructor video integration (Bai & Vu, 2023) as well as student engagement with the videos themselves (Wang et al., 2022; Seo et al., 2021b), yet not many studies have tested effects edited and integrated into the lecture videos themselves. Brame (2016) recommended learning practices for educational videos based off elements of cognitive load, student engagement, and active learning, and one takeaway from this study on their research would be to look at how and when engagement effects are edited in the instructional video. One video editor may have differing opinions on what key words to highlight compared to another video editor. Similar to how heuristic evaluations require multiple evaluators (Nielsen, 1994), it may be feasible to require multiple editors with instructional design experience to make collaborative decisions on what and where within a video requires engagement effects for student comprehension of course material. Finally, while the online modality of this study was more realistic to how students would watch asynchronous course videos, findings may be more consistent and controlled for if future studies were conducted in in-person laboratory settings.

## ACKNOWLEDGMENT

The authors would like to acknowledge the work of the research assistants and volunteers at CSULB's Center for Usability in Design and Accessibility.

## REFERENCES

Bai, X., & Vu, K.-P. L. (2023). Online learning: Does integrated videolecture help you learn more efficiently? In V. G. Duffy, M. Lehto, Y. Yih, & R. W. Proctor (Eds.), Human-Automation Interaction (Vol. 10, pp. 531–548). Springer International Publishing. https://doi.org/10.1007/978-3-031-10780-1_29

Bawa, P. (2016). Retention in online courses: Exploring issues andsolutions—A literature review. SAGE Open, 6(1), 215824401562177. https://doi.org/10.1177/2158244015621777

Brame, C. J. (2016). Effective educational videos: Principles andguidelines for maximizing student learning from video content. CBE—Life Sciences Education, 15(4), es6. https://doi.org/10.1187/cbe.16-03-0125

Chen, R. (2016). Learner perspectives of online problem-based learningand applications from cognitive load theory. Psychology Learning &Teaching, 15(2), 195–203. https://doi.org/10.1177/1475725716645961

Faulconer, E. K., Bolch, C., & Wood, B. (2022). Cognitive load inasynchronous discussions of an online undergraduate STEM course. Journalof Research in Innovative Teaching & Learning. https://doi.org/10.1108/JRIT-02-2022-0010

Gillis, A., & Krull, L. M. (2020). COVID-19 Remote learning transitionin spring 2020: Class structures, student perceptions, and inequality incollege courses. Teaching Sociology, 48(4), 283–299. https://doi.org/10.1177/0092055X20954263

Hollister, B., Nair, P., Hill-Lindsay, S., & Chukoskie, L. (2022). Engagement in online learning: student attitudes and behavior duringCOVID-19. Frontiers in Education, 7. https://doi.org/10.3389/feduc.2022.851019

Kalyuga, S. (2011). Cognitive load theory: How many types of load doesit really need? Educational Psychology Review, 23(1), 1–19. https://doi.org/10.1007/s10648-010-9150-7

Lewis, J. R. (2018). The system usability scale: past, present, andfuture. International Journal of Human–Computer Interaction, 34(7), 577-590.

Mar, J. M.-S. (2022). CUDA practicum project technical report: Ausability evaluation of the CSULB cognition asynchronous course lecturevideos. [Unpublished manuscript]. Department of Psychology, California State University, Long Beach.

Merkt, M., Hoppe, A., Bruns, G., Ewerth, R., & Huff, M. (2022). Pushingthe button: Why do learners pause online videos? Computers & Education, 176, 104355. https://doi.org/10.1016/j.compedu.2021.104355

Nielsen, J. (1994). Heuristic evaluation. In Nielsen, J., and Mack, R. L. (Eds.), Usability Inspection Methods. John Wiley & Sons, New York, NY.

Noetel, M., Griffith, S., Delaney, O., Sanders, T., Parker, P., del PozoCruz, B., & Lonsdale, C. (2021). Video improves learning in highereducation: A systematic review. Review of Educational Research, 91(2), 204–236. https://doi.org/10.3102/0034654321990713

Northey, G., Bucic, T., Chylinski, M., & Govind, R. (2015). IncreasingStudent Engagement Using Asynchronous Learning. Journal of MarketingEducation, 37(3), 171–180. https://doi.org/10.1177/0273475315589814

Paas, F. G. W. C. (1992). Training strategies for attaining transfer ofproblem-solving skill in statistics: A cognitive load approach. Journalof Educational Psychology, 84(4), 429–434.

Power, M. (2007). From distance education to e-learning: A multiple casestudy on instructional design problems. E-Learning and Digital Media, 4(1), 64–78. https://doi.org/10.2304/elea.2007.4.1.64

Seo, K., Dodson, S., Harandi, N. M., Roberson, N., Fels, S., & Roll, I. (2021a). Video-Based Learning Activity Engagement Measure [Databaserecord]. Retrieved from PsycTESTS. https://dx.doi.org/10.1037/t81381-000

Seo, K., Dodson, S., Harandi, N. M., Roberson, N., Fels, S., & Roll, I. (2021b). Active learning with online video: The impact of learningcontext on engagement. Computers & Education, 165, 104132. https://doi.org/10.1016/j.compedu.2021.104132

Stachel, J., Marghitu, D., Brahim, T. B., Sims, R., Reynolds, L., &Czelusniak, V. (2013). Managing cognitive load in introductoryprogramming courses: A cognitive aware scaffolding tool. Journal ofIntegrated Design and Process Science, 17(1), 37–54. https://doi.org/10.3233/jid-2013-0004

Statsenko, Y., Habuza, T., Charykova, I., Gorkom, K. N. V., Zaki, N., Almansoori, T. M.,... & Belghali, M. (2021). Predicting age frombehavioral test performance for screening early onset of cognitivedecline. Frontiers in Aging Neuroscience, 13, 661514.

Sweller, J., van Merrienboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. Educational PsychologyReview, 10(3), 251–296. https://doi.org/10.1023/A:1022193728205

Trowler, V. (2010). Student engagement literature review. The HigherEducation Academy. https://www.heacademy.ac.uk/system/files/studentengagementliteraturereview_1.pdf

Wang, J.-Y., Yang, C.-H., Liao, W.-C., Yang, K.-C., Chang, I.-W., Sheu, B.-C., & Ni, Y.-H. (2022). Highly engaged video-watching pattern inasynchronous online pharmacology course in pre-clinical 4th-year medicalstudents was associated with a good self-expectation, understanding, andperformance. Frontiers in Medicine, 8, 799412. https://doi.org/10.3389/fmed.2021.799412