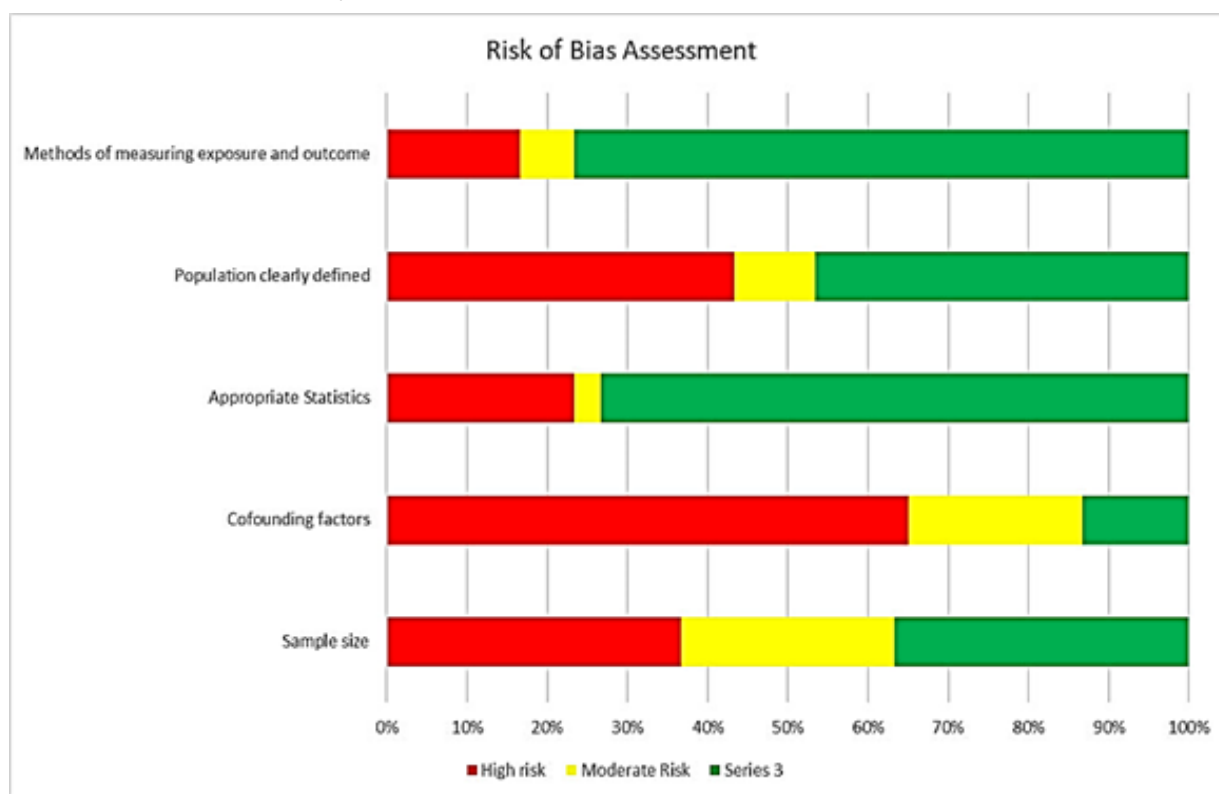


**Figure A1.** Percentages of students for various impediments to research



**Figure A2.** Visualization of risk of bias assessment results

For our main outcome which was summarizing and narratively reporting characteristics of innovative e-learning or virtual learning methods used during the COVID-19 pandemic, the study did not need quality assessment, but for reporting secondary outcomes we needed to perform the quality assessment. For assessing the risk of bias in the observational studies, we used a questionnaire consisting of five items: Adequate Sample size, Study Population clearly defined (exclusion and inclusion), Methods to Control Cofounding factors, Appropriate Statistical Analysis, and Methods of measuring exposure and outcome. Due to the special features of educational studies, we chose the mentioned questionnaire (under the supervision of an experienced medical education specialist) to achieve the best quality assessment for our study. In the case of interventional studies, because of the special quality of educational studies, most of them were conducted as pre-post-trial designs or interventions without a current control group, leading to a potentially high risk of bias. So, we used the modified questionnaire for these articles. For quality assessment of included randomized controlled trials, we used the Cochrane ROB 2.0 assessment tool

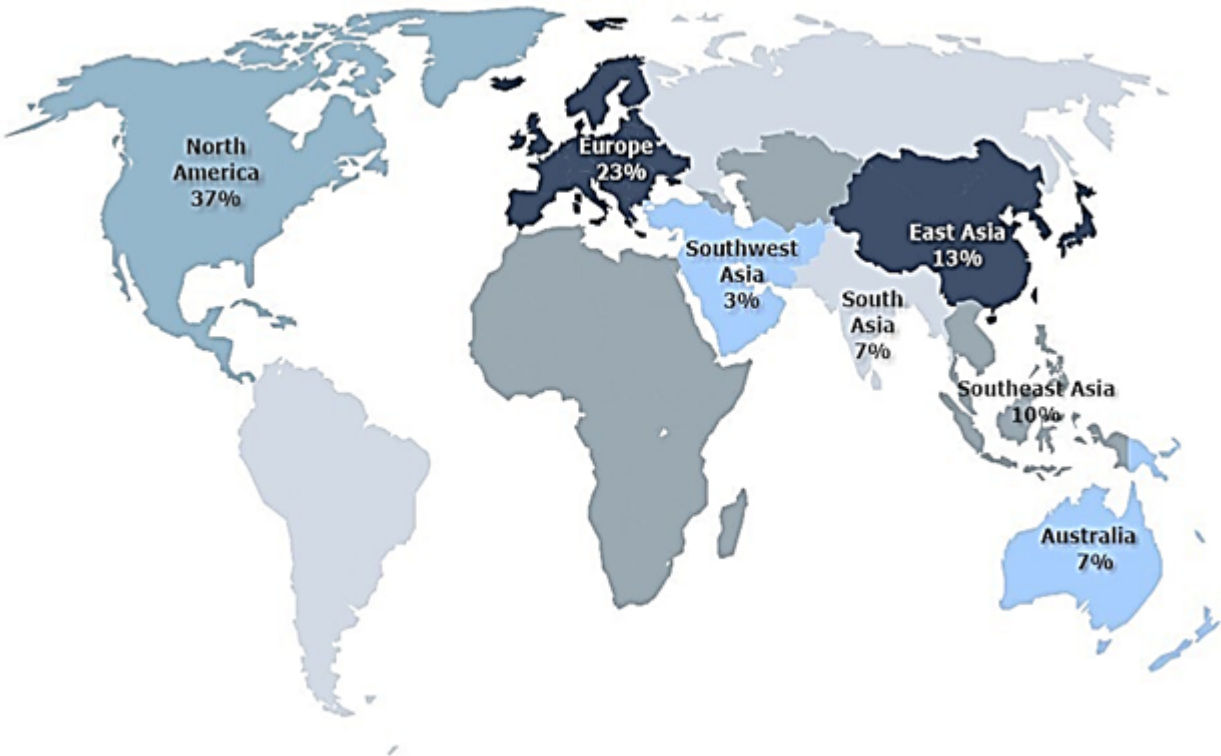


Figure A3. Geographical map of the distribution of article

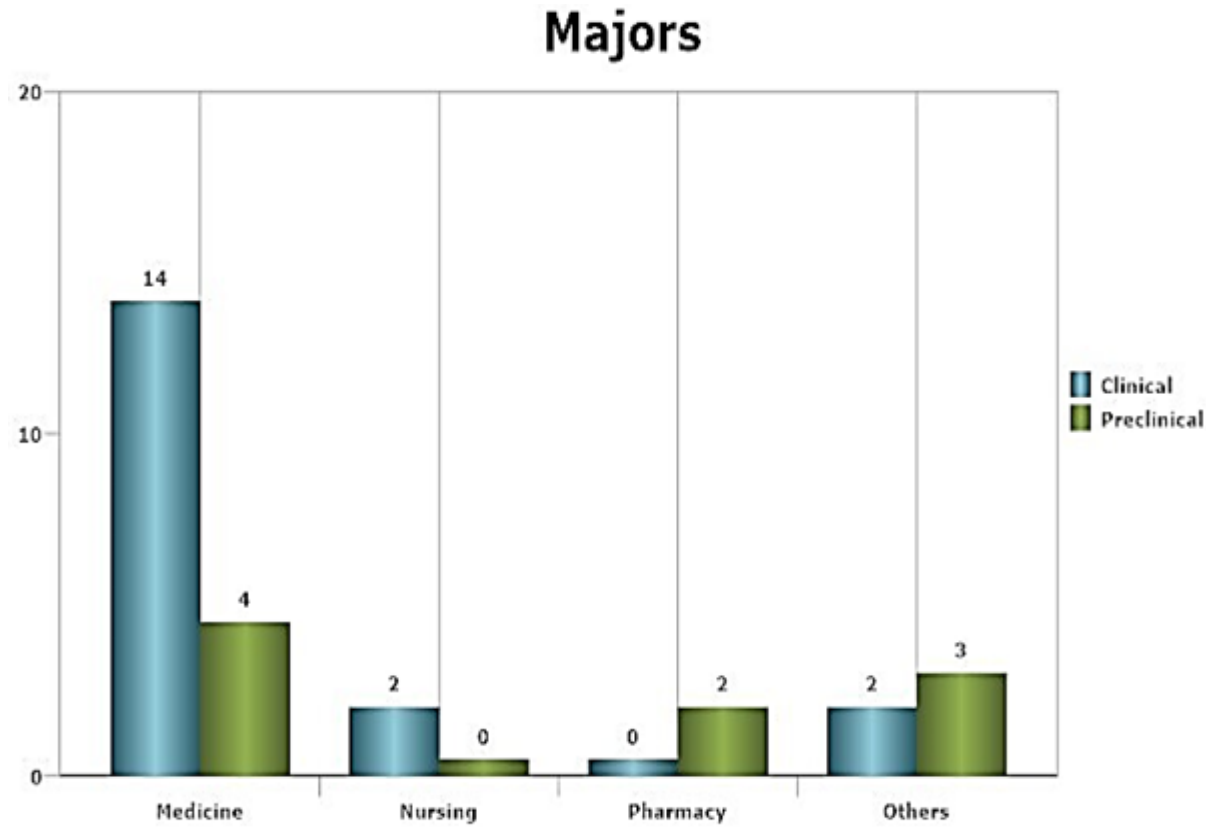


Figure A4. Distribution chart of educational fields

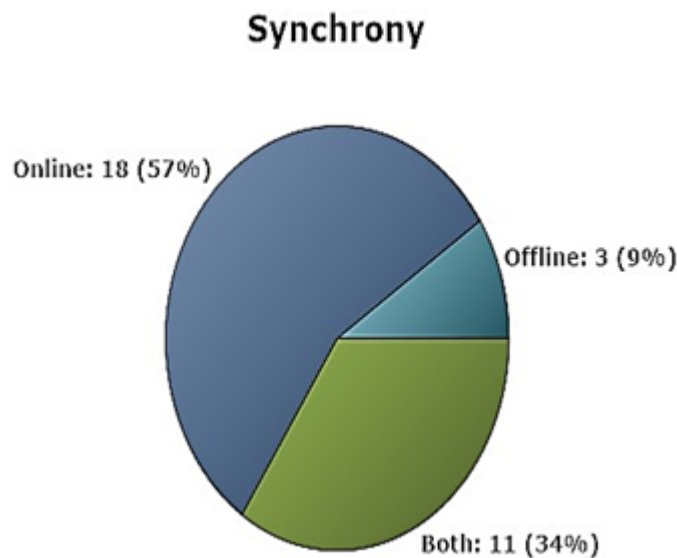


Figure A5. E-learning synchronization



Figure A6. E-learning methods prevalence visualized

Table A1. Search strategy in the PubMed database

Concept	Search Strategy
E-learning	"Distance learning" [Title/Abstract] OR "Virtual learning" [Title/Abstract] OR "Online Learning"[Title/Abstract] OR "E-Learning" [Title/Abstract] OR "education, distance"[MeSH Terms])
Health education	"Education, medical"[MeSH Terms] OR "medical education"[Title/Abstract] OR "Clinical Competence"[MeSH Terms] OR "education, medical, undergraduate"[MeSH Terms] OR "Medical Internships"[Title/Abstract] OR "Dental Internship"[Title/Abstract] OR "nursing"[MeSH Terms] OR "Midwife education"[Title/Abstract]
COVID-19	"Severe acute respiratory syndrome coronavirus 2"[Title/Abstract] OR "2019-nCoV"[Title/Abstract] OR "Wuhan coronavirus"[Title/Abstract] OR "SARS-CoV-2"[Mesh] OR " coronavirus"[ Title/Abstract]

**Table A2.** General characteristics of the included studies

Reference	Country	University	N	Major	Grade	Course	Int <sup>1</sup> 1	Int 2	Int 3	Int 4
Alkhowailed-2020 (1)	Saudi Arabia	Qassim University	19050	Medicine	- <sup>2</sup>	-	PBL <sup>3</sup>			
Bhandari-2021 (2)	India	SMS Medical College	680	Medicine	Four-year MBBS <sup>4</sup> program	For all medical lectures in pandemic	Regular live tele-teaching			
De Ponti-2020 (3)	Italy	University of Insubria	12	Medicine	6 <sup>th</sup> year	Clinical skills and scenarios	Simulations with HFS (body interact)			
Eusuf-2020 (4)	UK	The North West School of Anesthesia	-	Anesthesia trainee	-	-	Self-isolating Virtual Education (SAVED)			
Fatani-2020 (5)	Saudi Arabia	King Abdul-Aziz University	162	Medicine	5 <sup>th</sup> year	Pediatric rotation	Web video conferencing (WVC)			
Gomez-2020 (6)	USA	University School of Medicine, Baltimore	116	Medicine	4 <sup>th</sup> year	Radiology	Remote diagnostic radiology elective			
Gulati-2020 (7)	UK	Queen's University Belfast	257	Medicine	-	-	Short clinical scenario questions (MCQs) On Instagram			
Henderson-2020 (8)	UK	Royal Free London NHS Foundation Trust	278	Medicine, Nursing	Diverse	-	Microsoft Teams	Control group; survey		
Krawiec-2020 (9)	USA	Pennsylvania State College of Medicine	33	Medicine	3 <sup>rd</sup> year	Pediatric	Video-recorded oral presentation assignment			
Michener-2020 (10)	USA	University of Pennsylvania	34	Medicine	-	Care for older adults in COVID-19, Geriatric 5Ms <sup>5</sup>	multimodal, virtual geriatrics elective			
Prasad-2020 (11)	Australia	Monash University	71	Medicine, Midwifery	4 <sup>th</sup> year medical students & 5 <sup>th</sup> year midwifery students	-	Workshop was run virtually using "Zoom"			
Singh-2020 (12)	India	All India Institute of Medical Sciences	398	Medicine	second to eighth semester	-	Online classes and adopted G Suite for Education using Google Classroom coupled with Google Meet for Video-conferencing			
Keylen-2020 (13)	Germany	Friedrich-Alexander Universität Erlangen-Nürnberg (FAU)	170	Medicine	-	Smart Decision-making in Clinical Practice	Adapted inverted-classroom concept	Asynchronous learning module		

Vielsmeier-2020 (14)	Germany	Universität Regensburg	138	Medicine	-	ENT	HTML 5 learning package with the authoring program Exelearning 2.5			
Williams-2020 (15)	USA	Perelman School of Medicine (University of Pennsylvania)	-	Medicine	Senior medical students/ sub-internship	Urology	Asynchronous Material	Synchronous material		
Zhang-2020 (16)	China	Zhejiang University	84	Medicine	Preclinical student	Traditional Chinese Medicine (TCM)	ZJU platform <sup>6</sup>	Ding Talk platform		
Alpert-2020 (17)	USA	New York University Langone Health	83	Medicine	-	Clinical radiology	Virtual Read-Out (VRO)			
Chin-2020 (18)	USA	University of Texas	85	Medicine	-	Anatomic pathology	Hybrid On-Site			
Kan-2021 (19)	Singapore	Duke-NUS Medical School	56	Medicine	Final year	Internal medicine	Online workshop “hot seat” format			
Kang-2020 (20)	South Korea	Three different Universities	192	Nursing	-	Nursing care Learning topic for children with asthma	Virtual Reality Simulation (vSim)	High-Fidelity Simulation (HFS)	vSim with HFS	
Naidoo-2020 (21)	UAE	Mohammed Bin Rashid University of Medicine and Health Sciences	-	Medicine	-	Anatomy	Gagne’s 9 events of instruction with Peyton’s 4-step approach. Through Social media application (SMA)–integrated “interactome” strategy			
Parker-2020 (22)	USA	University of Washington	70	Medicine	3 <sup>rd</sup> and 4th year	Anatomic pathology	Remote-learning course encompassing lectures,	Virtual slides	Discussion groups	Unique case-based activities (HFS)
Zhou-2020 (23)	China	Tongji Medical College, Huazhong University of Science and Technology	60	Nursing	Internship	Emergency nursing practice	Experimental group: combined mode of MOOC micro-video	Control group: Traditional theory teaching combined with clinical practice		
Shin-2020 (24)	USA	Cleveland Clinic Lerner College of Medicine	16	Medicine	3 <sup>rd</sup> year	General Surgery	Case-based virtual surgery clerkship curriculum			
Shih-2020 (25)	USA	-	-	Medicine	2 <sup>nd</sup> year	Ophthalmology	Written information about technique, common mistakes and clinical relevance	Recorded video of techniques	ZOOM tutorial	

Costabile-2020 (26)	Australia	University of South Australia	96	Medicine, Nutrition and Food Science, Pharmacy	2 <sup>nd</sup> year, undergraduate	Biochemistry laboratory	Online simulations			
Jiang-2021(27)	China	Xi'an Jiao tong University	42	pharmacy	-	Molecular biology	Online course with electronic resources at Siyuanxuetang-XJTU			
Mobasher-2020 (28)	Iran	Kerman University of Medical Sciences	-	Medicine and Dentistry	-	Medical ethics courses	Online course and assessment of reasoning skills			
Murdock-2020 (29)	USA	Different Universities	100	Medicine	-	-	Virtual morning report (VMR)			
Suppan-2020 (30)	Switzerland	University of Geneva	90	Medicine	-	PPE <sup>7</sup>	Gamified E-learning module			

1. Int= Intervention, 2. - = Not Reported, 3. PBL= Problem-based learning, 4. MBBS = Bachelor of Medicine, Bachelor of Surgery, 5. 5Ms = medications, mind, mobility, multi-complexity, and what matters most, 6. ZJU (Information Technology Center of Zhejiang University) is a learning platform where numerous online courses can be established and accessed by all teachers and students of Zhejiang University. 7. PPE= personal protective equipment

**Table A3.** The definition of each factor utilized in evaluating the quality of E-learning

Factor name	Factor Category	Description	Reference
Optimal Quality of Media Factors	Learning Environment	This factor focuses on the learning environment and facilities that are provided for both students and instructors.	(31-34)
Appropriate Evaluation Strategies	Course	Assessments and Examination.	(32, 33, 35)
Provide an appropriate assignment	Course		(32-34)
Useful, Relevant and Up-to-date content	Course	This factor focuses on the course material and objectives.	(31, 32, 34)
Optimal Interaction	Student Characteristics	This factor focuses on social interaction between Student-Student or Student-Educator and the engagement of Students.	(31, 33, 36)
Student Satisfaction	Student Characteristics	This factor focuses on the student's environment while learning.	(31, 35, 36)
Educator competence	Instructor Characteristics	It includes the instructor's attitude, flexibility, knowledge of learning technology, teaching style, and efficacy in student motivation.	(31-34, 37)
System training and clear instructions for using E-learning Components	Technology Knowledge	This factor focuses on the knowledge of using technology for both instructor and students. Use of computers, software, etc.	(31, 33, 36)
Constructive answers and feedback to students	Support	This factor focuses on answering the challenges for students.	(32, 33, 35, 37)
Availability	Information Technology	This factor focuses on the information technology system to deliver learning materials and objectives.	(31, 34, 35)
Ease of use (Technical difficulties	Information Technology	This factor focuses on the information technology system to deliver learning materials and objectives.	(31-33)

To cover the main objective, this rating consists of 11 concepts assessing the validity and quality of the teaching models of e-learning

**Table A4.** Applications and websites used in included articles

Application or Website	Applications use	Prevalence
Zoom	Zoom Cloud Meetings platform was utilized as an alternative tool. Lectures presentation.	10
Canvas learning management system	The online learning management system, Canvas hosted asynchronous readings, lectures, and discussion boards. Course administration; organizing the course and for real-time feedback throughout the course. Centralize information and documents.	6
Microsoft Teams	This is an online communication and collaboration platform which enables users to host virtual meetings, post in groups and send instant messages and is protected and monitored within the NHS Secure Boundary. Course materials are housed permanently in Microsoft Teams. Surveys were provided and submitted via Canvas using Microsoft Forms. Centralize information and documents. Delivering didactic sessions. Course-related messages communications.	4
WebEx	Using teleconferencing and screen sharing. It permits colorful screen annotation as the instructor points out relevant imaging findings. For making reflective video consultations.	4
Blackboard	Ultra-Web based videoconferencing. Established course management software at our institution, thus course materials including lecture slides, assignments, and external links were hosted on an existing Blackboard site maintained by the course directors. Learning management system as the primary tool for virtual teaching.	3
WhatsApp	Discussions with their peers in the group. Used to respond to any inquiry and obstacle. Sharing questionnaires.	3
Google Classroom	Videoconferencing. The primary purpose is to streamline the process of sharing files between teachers and students.	2
Instagram	Instagram story feature for daily MCQs	1
YouTube	Students were directed to relevant podcasts and videos available from different universities.	1



Google meet	Videoconferencing.	1
WeChat	A social media platform, used for online learning.	1
Poll Everywhere	An online dynamic polling platform, to engage students in answering questions.	1
Ding talk	Learning platform with abilities such as teachers' lectures, students' presentations, question and answer, and chapter homework.	1
ZJU website	Learning platform with abilities such as Archiving lectures, instruction materials, submitting assignments, and group discussion.	1
Vimeo	Video-making.	1
Exelearning Software	Authoring HTML 5 learning package.	1
EvaSys software	Developing survey.	1
ILIAS	A learning platform for making audio-annotated videos.	1
Google Form	Designing questionnaire.	1
Qualtrics management software	Survey administration.	1
Joomla	Creation of online platform.	1
AcyMailing	Sending Emails.	1
Community Survey Pro	Used to create the study paths.	1
Articulate Storyline 3	Creation of gamified E-learning module.	1
BlueJeans	Videoconferencing was utilized for synchronous discussions and case presentations.	1
PathPresenter.net	Virtual slides presentation.	1
Body Interact	Virtual reality platform, with a variety of clinical case-based. Scenarios of different types and complexity.	1
Siyuanxuetang-XJTU	A teaching platform.	1

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