INTRODUCTION

The Covid-19 pandemic has made a big impact in the education sector and the modes of teaching/learning have undergone a comprehensive overhaul during this period (Chandratre, 2020; Theoret & Ming, 2020). As complete/partial lockdowns were implemented in many parts of the world as an immediate response to the pandemic, ongoing in person teaching came to a sudden halt post-March 2020 (Sandhu & Wolf, 2020; Smith & Pawlina, 2021). Education pertaining to health professionals (undergraduates in particular) was significantly affected as it relied heavily on in person teaching and training (Kaul et al., 2021; Attardi et al., 2022). Being a component of the healthcare domain, anatomy education and in particular anatomy laboratory-based teaching (core element of training in anatomical sciences) essentially comprised of hands-on sessions involving human
dissection in pre-pandemic period (Attardi et al., 2022). The onset of Covid-19 pandemic and introduction of subsequent restrictions made the traditional format of anatomy teaching/learning redundant. The adoption of online synchronous and online asynchronous learning model and use of digitized resources drastically reduced the opportunity of exposure to in-person dissection-based activities as well as peer interactions integral to learning in dissection room (Bauler et al., 2022). It did not help that body donation programs were significantly hit by the pandemic as it took time for designing relevant safety guidelines thereby adversely affecting the availability of precious human tissues (Manzanares-Cespedes et al., 2021). In other words, the changes that engulfed anatomy education from the onset of the Covid-19 pandemic were colossal as well as abrupt in nature (Franchi, 2020; Ghosh, 2022). In the emerging scenario, the educators and/or policy makers had to act swiftly with an innovative outlook to ensure the continuation of the ongoing curriculum (Evans et al., 2020). It is therefore no surprise that the outlook of anatomy teaching/learning process followed by assessment methods in anatomy resembled a tectonic shift with regards to what was practiced prior to outbreak of the pandemic once the changes/modifications pertaining to medium of teaching/learning as well as adaptations in assessment methods were put in place (Brassett et al., 2020; Attardi et al., 2022).

The situation was undoubtedly challenging, but it also presented opportunities before anatomists to explore newer horizons (Woolliscroft, 2020; Iwanaga et al., 2021; Lachman & Pawlina, 2022). As mentioned earlier, the most noteworthy change involving anatomy education was that the traditional method of teaching/learning got replaced by online synchronous and online asynchronous learning model as a rational element of adaptability in the face of adversity (Evans et al., 2020; Jones, 2020; Longhurst et al., 2020; Wilcha, 2020). Online synchronous and online asynchronous learning essentially involve an information delivery mechanism wherein the academic staff and the students are separated in time and space (Billings, 2007). Embracing online synchronous and online asynchronous learning approach prevented possible wastage of precious teaching hours and allow continuation of anatomy curriculum in uninterrupted manner (Srinivasan, 2020). Incidentally, implementation of online synchronous and online asynchronous education program required altered education strategies that started evolving rapidly amidst the ongoing situation. This eventually led to the emergence of a new look anatomy education model that augured well with the “new normal” emerging in the education sector (Bay & Pawlina, 2021; Jones, 2021; Attardi et al., 2022; Lachman & Pawlina, 2022). Across geographical regions there exist remarkable variations in the factors that determine educational strategies such as accessible resources (primarily economic which reflects on use of digital tools pertaining to education), profile of stakeholders in terms of applying technology (familiarity with using online tools among the academic staff and the students), and the curricular structure (course contents, classroom hours, distribution of theory and practical classes, and student–teacher ratio) (Henderson et al., 2016; Ohr et al., 2021). Analyzing the measures adopted in anatomy teaching, learning, and assessment during Covid-19 pandemic is important to see how different countries coped with sudden imposition of lockdown and the impact it had on anatomy education.

It is quite understandable that the measures (education strategies) adopted in terms of learning in the face of the pandemic were primarily focused to ensure that the education process does not come to a standstill (Al Samaraee, 2020). Moreover, they were incorporated into the ongoing curriculum during a crisis situation with minimum possible time to deliberate upon them. It was not possible to validate or evaluate these education strategies for effectiveness prior to their incorporation within the anatomy curriculum as pedagogical evidence was limited and data available at institutional level was rudimentary (Longhurst et al., 2020; Prigoff et al., 2021). Considering this scenario, the sharing of information based on personal experiences by researchers/educators across the globe through published literature emerged as a valuable channel for knowledge dissemination (Byrnes, 2021). Although this is a common practice even under normal circumstances, more so emerged as a critical interface during the pandemic because of limited scope for scientific meetings (Valenti et al., 2021). It also helped that the scientific community which include scientific societies, journal editors, research groups, and individual authors realized the urgency of the situation, prioritized this area of research and responded effectively so as to support anatomy education at the time of crisis (Evans et al., 2020; Roberts, 2020; Boscolo-Berto et al., 2021; Evans & Pawlina, 2021; Iwanaga et al., 2021).

It was perceived that an overview of education strategies adopted for delivery of online anatomy classes across different geographical regions of the world, would be useful to anatomists amidst the prevailing situation. Hence this narrative review was undertaken to collate the observations documented from different parts of the world in published literature pertaining to education strategies adopted for delivering anatomy curriculum during the Covid-19 pandemic.

MATERIALS AND METHODS

For the present study, narrative review was the selected method as it was deemed that realistically this approach is ideal to address the topic in terms main concepts, theories, sources, and knowledge gaps (Gregory & Denniss, 2018). Moreover, narrative review was found to be suitable in view of divergent methodologies followed and essentially descriptive nature of selected studies (El-Haddad et al., 2022). The literature search undertaken for this study was based on inclusion and exclusion criteria that were set after deciding the topic but before conducting literature search (Table 1). It is pertinent to mention here that for the present review, research data pertaining to education strategies for teaching/learning component of anatomy education during Covid-19 pandemic were
considered. The assessment component was excluded from the study as research data were very limited at the time of conducting literature search.

The study was conducted in the Department of Anatomy at All India Institute of Medical Sciences, Patna, India. An extensive literature search was undertaken for this study from the following indexed databases: (1) Medline and PubMed (United States National Library of Medicine, Bethesda, MD); (2) Scopus (Elsevier, Amsterdam, The Netherlands); (3) Embase (Ovid Technologies, Inc., New York, NY); (4) CINAHL Plus (EBSCO Information Services, Ipswich, MA); (5) Web of Science (Clarivate Analytics, Philadelphia, PA); and (6) Google Scholar (Google, Inc., Mountain View, CA). The above databases were explored as they are multi-disciplinary databases and provide access to large volume of peer-reviewed scholarly research.

The literature search was based on key terms relevant to the topic of the present study. These key terms were essentially key words from individual studies and mentioned when they were indexed. The key terms used for the present study were finalized during the course of literature search for finding articles pertinent to the topic of present study. Accordingly, the following terms were used during literature search: "online anatomy during Covid-19"; "anatomy education during Covid-19"; "anatomy curriculum during Covid-19"; "anatomy education strategies during Covid-19"; "Covid-19 and anatomy teaching"; and "impact of Covid-19 on anatomy education". It is noteworthy that "SARS-CoV-2" is widely used as a synonym for "Covid-19" in published research. Hence to avoid missing any relevant literature the word "Covid-19" was replaced with "SARS-CoV-2" in all the search terms (as mentioned above) and a repeat round of literature search was undertaken. Although the present study is a narrative review, but in order to mitigate the risk of bias in inclusion process, methodological rigor of a systematic review was incorporated in the literature search process. This was undertaken in accordance with the best practice recommendations for the preparation of a narrative review in clinical research (Ferrari, 2015). A total of 12 published articles were identified as appropriate with regards to the topic of the present study (Figure 1).

### RESULTS

Among the 12 published articles identified through literature search and deemed appropriate for the present narrative review, nine of them were original research articles (Kim et al., 2020; Longhurst et al., 2020; Pather et al., 2020; Abdelkader & Barbagallo, 2021; Cheng et al., 2021; Harmon et al., 2021; Park et al., 2021; Singal et al., 2021; Yoo et al., 2021), two were review articles (Brassett et al., 2020; Nimavat et al., 2021), and one was letter to editor (Patra et al., 2021). It was noted that the articles were distributed across six geographical regions around the world: Republic of Korea (3); India (3); Australia and New Zealand (2); United Kingdom and Republic of Ireland (2); People’s Republic of China (1) and United States of America (1). Data regarding core education strategies adopted for anatomy teaching/learning during Covid-19 pandemic were extracted from nine articles (Table 2). Whereas, information regarding the use of online digital tools for implementing the strategies were available from all the 12 articles (Table 3). Since the 12 articles were distributed across different geographical regions of the world, therefore they were grouped accordingly for the convenience of presenting the observations. Furthermore, as the extracted data were identified primarily as core education strategies and online digital tools used for implementing these strategies, hence findings are presented accordingly under each group (geographical region) for easy interpretation of the conceptual flow. The observations of anatomy educators from different parts of the globe pertaining to the salient strategies adopted for delivering anatomy education during the Covid-19 pandemic are documented below:

| Inclusion criteria | Exclusion criteria |
|--------------------|-------------------|
| • Original research articles, reviews, short communications, editorials, letter to editor (peer reviewed and published) pertaining to education strategies in the domain of anatomy education during Covid-19 pandemic | • Pre-prints and non-peer-reviewed contentsa |
| • Studies reporting observational data relevant to the topic of study | • Articles with information limited to a particular institutionb |
| • Articles with information relevant to the study pertaining to a particular country or geographical region | • Articles with limited focus on education strategies |
| • Articles published any time after the onset of Covid-19 pandemic (March 2020) till conduction of literature search | • Articles not in English language where translation in English was not available |
| • Articles in English | • Articles not in English language but with available translations in English |

aThese articles were excluded as there could be possible changes in the data and the analysis thereof by the time it is published. This can have a confounding influence on data available from peer reviewed contents.

bThese articles were excluded as the topic of the present study mandates data extraction from articles with relevant information regarding medical schools across a country/geographical region.
Records identified through database searching

- Medline & PubMed (n = 557)
- Scopus (n = 335)
- Embase (n = 229)
- CINAH L Plus (n = 252)
- Web of Science (n = 383)
- Google Scholar (n = 848)

Records after duplicates removed (n = 317)

Records screened for potential inclusion (n = 229)

Additional records identified by a manual research in the reference lists from the retrieved articles (n = 25)

Records excluded as:
- Pre-prints and non peer-reviewed contents
- Articles with information limited to a particular institution
- Articles with limited focus on education strategies
- Articles not in English and translation in English not available (n = 242)

Total records included in narrative review (n = 12)
Data relevant to the present study were available from two original research articles (Pather et al., 2020; Abdelkader & Barbagallo, 2021). The study by Pather et al. (2020) was based on descriptive qualitative accounts and data were collected from 10 universities (nine from Australia and one from New Zealand). Abdelkader and Barbagallo (2021) conducted a survey-based study with data collected from three regional campuses of one university in Australia. Analysis of data from the two studies revealed that with the onset of the pandemic, anatomy education delivery was shifted to completely online mode. Education strategies were designed for both lecture as well as practical classes. Active online learning sessions were conducted to complement learning from regular sessions. Online digital tools having specific use during delivery of online sessions were incorporated with education strategies.

Online classes were organized into synchronous (students and academic staff meeting online at the same time for a class to take place) and asynchronous modes (where study materials can be conveniently accessed during different hours). Most medical schools preferred to deliver lecture sessions in asynchronous mode. This was done to ensure that more time can be devoted toward organizing the delivery of practical classes in a combination of synchronous and asynchronous modes. A unique intervention in terms of lecture delivery was to avoid large content in a single session. Educators preferred short manageable content for each session which were convenient to deliver (Pather et al., 2020) (Table 2).

The digital tool commonly used for practical classes were videos/video clips, which were either pre-pandemic ones or recorded as per requirements of online classes during pandemic. In few cases popular YouTube videos (YouTube LLC, San Bruno, CA) were also used by educators. Even proprietary digital learning resources which were purchased commercially in most cases, were also adopted as teaching/learning tools. The active learning sessions were complimented with interactive gaming applications such as Kahoot! (Kahoot! A.S., Oslo, Norway) and Slido, a polling platform (Slido s.r.o., Bratislava, Slovakia). In order to make these sessions interesting application-based activities such as formative quiz items and clinical case solving were included (Pather et al., 2020) (Table 3).

Online resources used by the students reflects on their adaptability during the pandemic and constitute significant elements of education strategies. Asynchronous sessions were very popular in this respect and students commonly accessed those online videos related to anatomy education which were freely accessible across digital platforms along with other accessible digital resources (Abdelkader & Barbagallo, 2021) (Table 3).

**United Kingdom and Republic of Ireland**

Data for the present study were collected from one original research article (Longhurst et al., 2020) and one review article (Brassett et al., 2020). Longhurst et al. conducted a questionnaire-based study and adopted a thematic analysis approach. Their study was based on data collected from 14 different universities. Brassett et al. conducted a review of actions taken after the Covid-19 outbreak, based on data collated from 10 universities. Analysis of data showed that specific education strategies were designed for online classes and a diverse bouquet of online digital tools (each tool having specific use) were utilized for successful delivery of the sessions (Tables 2 and 3).

Lectures were recorded in online digital platforms and among these the most popular one was Panopto, a video content management system (Panopto Inc., Seattle, WA). The recorded lectures were then uploaded to the virtual learning environment (VLE) for access to students in asynchronous mode. Live lecture sessions and tutorials (synchronous mode) were imparted through online digital platforms (Table 3). For practical classes digitized learning resources were used (Longhurst et al., 2020) (Table 3). Notably, access to majority of these resources (online platforms/software systems/digitized resources) were through commercial purchase.

Virtual learning environment (VLE) referred to as LEARN (Blackboard Inc., Washington, DC) was used by educators for live streaming as well for uploading prerecorded lectures along with associated study materials (online textbooks and videos). Learning management systems (LMS) were used for interactive discussions. In few instances, lectures were complimented with formative quizzes through the Moodle learning management platform (Moodle HQ, Perth, Western Australia). Remote access training was arranged for academic staff as part of implementing the education strategies through use of specific online digital tools (Brassett et al., 2020) (Table 3).

**United States of America**

For the present study, data were extracted one original research article which was a survey-based study having 20 individual questions. The study was based on data collected from members of multiple professional associations of anatomy educators (Harmon et al., 2021; Attardi et al., 2022). Analysis of the data reflected a remarkable transition from the pre-pandemic period in terms of conducting of anatomy teaching/learning sessions. In accordance with global trends, more emphasis in terms of planning and allotted hours was given to practical classes. Medical schools designed the anatomy practical classes based on mode of delivery, resources available, and student groupings.
| Authors/place of study | Core anatomy education strategies adopted during Covid-19 pandemic | Any other |
|------------------------|---------------------------------------------------------------|----------|
| Pather et al. (2020)/ Australia and New Zealand | Lectures: • Asynchronous Mode: Prerecorded lectures + short concept videos + formative assessment (most medical schools) • Synchronous Mode: Live streaming in real time lectures (few medical schools) Interactive lectures incorporating online platforms such as Kahoot and Slido (few medical schools) | Active online learning sessions: • Asynchronous Mode: Problem solving activities • Synchronous Mode: Live streaming of small group activities |
| Longhurst et al. (2020)/ United Kingdom and Republic of Ireland | Lectures: • Asynchronous Mode: Prerecorded lectures uploaded in virtual learning platforms (most medical schools) • Synchronous Mode: Live sessions and tutorials via online platforms (few medical schools) | None |
| Harmon et al. (2021)/ United States | Combination of: • Asynchronous Mode: Prerecorded lectures • Synchronous Mode: Live streamed virtual sessions | None |
| Cheng et al. (2021)/ People’s Republic of China | Lectures: • Synchronous Mode: MOOC (massive open online course) + interactive session MOOC + flipped classroom in real time + interactive session Asynchronous Mode: MOOC + flipped classroom in real time + interactive session | Practical classes were designed based on three components: • Mode of delivery Synchronous: Sessions delivered through Zoom meeting rooms and interactive sessions in dedicated “breakout rooms” (most medical schools) Asynchronous: Prerecorded sessions (few medical schools) Combination of both modes (some medical schools) • Resources available Digitized human cadaveric specimens Use of plasticized specimens Online virtual resources Student groupings Large group: Topic is assigned to students Small group: Concept building | Active learning sessions: • Problem based learning (PBL) • Team based learning (TBL) • Flipped classroom approach |
Most medical schools adopted the synchronous mode with Zoom, a video conferencing software (Zoom Voice Communications Inc., San Jose, CA), being the overwhelmingly preferred online delivery platform. A few medical schools used plasticized bodies (in virtual mode) for practical sessions, but digitized human specimens and online virtual materials were the preferred choice of anatomists. Anatomists mostly preferred delivery of practical classes in small groups for enhanced concept building (Harmon et al., 2021; Attardi et al., 2022) (Table 2). A number of institutions relied on digital resources prepared in-house as per requirements of the sessions. In addition, a wide variety of digital resources (available via library access/complimentary link on purchase of textbooks/available through commercial purchase) were utilized for implementing education strategies toward online anatomy education programs. The online digital resources (other than in-house resources) used by institutions during Covid-19 pandemic are listed in Table 3. It was noted with interest that most of the online digital resources as mentioned in Table 3 were actually in use within the anatomy curriculum even before the onset of Covid-19 pandemic (Harmon et al., 2021).

### People's Republic of China

Data relevant to the present study were obtained from one original research article, which was a questionnaire-based study conducted across 77 medical schools covering all provinces in mainland China as well as special administrative regions of Hong Kong and Macau (Cheng et al., 2021). Analysis of the data revealed that anatomy education moved completely to an online mode in Chinese medical schools with the onset of Covid-19 pandemic. Considerable changes were introduced in teaching/learning delivery methods to cope with the pandemic period. Education strategies designed for both lecture and practical sessions were put in place. Learning from regular online sessions were complimented with active learning sessions. The most popular form of synchronous lecture sessions utilized the massive open online course (MOOC) platforms (Chinese University MOOC, Beijing, China), which were combined with flipped classroom sessions in a few medical schools. During lecture sessions it was ensured that 50% of the allotted time would be devoted to student interaction either through voice calls or text messages. Asynchronous lectures were prerecorded videos where the anatomist can be seen to deliver the session physically or in the form of PowerPoint presentation (Microsoft Corp., Redmond, WA) where the anatomist is not visible. Practical classes heavily relied on online resources particularly the digital human anatomy software and were completed with appropriate number of images and videos accessed via online platforms. Active learning sessions comprising of established methods in the domain of education and designed for delivery in online mode were newly inducted in the anatomy curriculum during the pandemic (Cheng et al., 2021)
| Authors/place of study                  | Online digital tool (source)                                                                 | Specific usage of the digital tool                                                                 |
|----------------------------------------|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
| Pather et al. (2020)/Australia and New Zealand | • Videos/video clips (prepared in-house) • YouTube videos (YouTube LLC, San Bruno, CA) • Kahoot! (Kahoot! A.S., Oslo, Norway) • Slido (Slido s.r.o., Bratislava, Slovakia) | • For display in practical classes • For display in practical classes • As interactive application • As interactive application |
| Abdelkader and Barbagallo (2021)/Australia | • Online videos • Practice quiz items • Online interactive learning forums • Peer Assisted Study Sessions (PASS) | • Used by students for learning anatomy in asynchronous mode |
| Longhurst et al. (2020)/United Kingdom and Republic of Ireland | • Panopto (Panopto Inc., Seattle, WA) • Virtual Learning Environment (VLE) • Zoom (Zoom Voice Communications Inc., San Jose, CA) • Collate Ultra (Blackboard Inc., Washington, DC) • Big Blue Button (Big Blue Button Inc., Ottawa, Canada) • Microsoft Teams (Microsoft Corp., Redmond, WA) • Acland’s Video Atlas of Human Anatomy (Acland, 2013) • Visible Human Project (U.S. National Library of Medicine, Bethesda, MD) • YouTube Videos (YouTube LLC, San Bruno, CA) • Customized videos (prepared in-house) • Visible Body (Argosy Publishing Inc., Newton, MA) • Complete Anatomy (3D4 Medical/Elsevier, Dublin, Republic of Ireland) • Anatomy TV (Primal Pictures Ltd., Colchester, UK) • Sectra (Sectra AB, Linkoping, Sweden) • 3D Models prepared through Sketchfab (Sketchfab, New York, NY) | • Online platform for recording lectures • Online platform for uploading lectures • Online digital platforms for live sessions • Digitized cadaveric resources • 3D Virtual learning resources |
| Brassett et al. (2020)/United Kingdom and Republic of Ireland | • VH Dissector Touch (Touch of Life Technologies, Inc., Aurora, CO) • Virtual microscope system (prepared in-house) • LEARN (Virtual learning environment; Blackboard Inc., Washington, DC) • Skype (Microsoft Corp., Redmond, WA) • Moodle (Moodle HQ, Perth, Western Australia) • Canvas (Learning management system; Instructure, Salt Lake City, UT) • Kaltura Capture (Kaltura Inc., New York, NY) | • 3D Virtual learning resources • Live streaming lectures • Uploading prerecorded lectures • Remote access training of academic staff • Online digital platform for live sessions • For interactive sessions • Remote access training of academic staff |
| Authors/place of study                        | Online digital tool (source)                                                                 | Specific usage of the digital tool                                      |
|---------------------------------------------|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| Harmon et al. [2021]/United States of America | • Complete Anatomy (3D4 Medical/Elsevier, Dublin, Republic of Ireland)                      | • 3D Virtual learning resources                                        |
|                                            | • Clinically Oriented Anatomy Images (Moore et al., 2017)                                   |                                                                        |
|                                            | • University of Michigan Blue Link (BlueLink Images, University of Michigan Medical School, Ann Arbor, MI) |                                                                        |
|                                            | • Netter Presenter Atlas of Human Anatomy (Netter, 2020)                                     |                                                                        |
|                                            | • Anatomy: A Photographic Atlas (Rohen et al., 2015)                                        |                                                                        |
|                                            | • Grant’s Dissector Videos (Detton, 2016)                                                   |                                                                        |
|                                            | • Gray’s Anatomy Images (Drake et al., 2020)                                                |                                                                        |
|                                            | • Essential Clinical Anatomy Images (Moore et al., 2014)                                     |                                                                        |
|                                            | • Anatomy & Physiology Revealed (Schneider et al., 2020)                                     |                                                                        |
|                                            | • Visible Body (Argosy Publishing Inc., Newton, MA)                                          |                                                                        |
|                                            | • Kenhub Human Anatomy (Kenhub Anatomy, Kenhub, GmbH, Leipzig, Germany)                     |                                                                        |
|                                            | • Anatomy TV (Primal Pictures Ltd., Colchester, UK)                                          |                                                                        |
|                                            | • The Biodigital Human (Biodigital, New York, NY)                                            |                                                                        |
|                                            | • VH Dissector Touch (Touch of Life Technologies, Inc., Aurora, CO)                          |                                                                        |
|                                            | • BodyViz 3D Anatomy (Visual Medical Solutions, LLC, Clive, IA)                              |                                                                        |
|                                            | • Bassett Collection of Stereoscopic Images of Human Anatomy (Stanford School of Medicine, Stanford, CA) |                                                                        |
|                                            | • Anatomy Tool (Leiden University Medical Center, Leiden, The Netherlands and Maastricht University, Maastricht, The Netherlands) |                                                                        |
|                                            | • Netter 3D Anatomy (Elsevier Inc., Cyber Anatomy Corporation, Philadelphia, PA)            |                                                                        |
|                                            | • VIVED Anatomy Videos (VIVED Learning, Coatsville, IA)                                     |                                                                        |
|                                            | • 3D Organon (Metis Media Pvt Ltd., Gold Coast, Queensland, Australia)                      |                                                                        |
|                                            | • OsiriX Dicom Viewer (Pixmeo SARL, Geneva, Switzerland)                                    |                                                                        |
|                                            | • Adland’s Video Atlas of Human Anatomy (Adland, 2020)                                       | • Digitized cadaveric resources                                         |
|                                            | • University of Wisconsin School of Medicine and Public Health Dissection Videos (Video Library, University of Wisconsin School of Medicine and Public Health, Madison, WI) |                                                                        |
|                                            | • Dartmouth Geisel School of Medicine Anatomy Resources (Human Anatomy Learning Modules, Geisel School of Medicine at Dartmouth, Hanover, NH) |                                                                        |
|                                            | • University of British Columbia Anatomy Videos (Clinical Anatomy Website, University of British Columbia, Vancouver, Canada) |                                                                        |
|                                            | • Thieme My Course Dissector (Gould et al., 2015)                                            |                                                                        |
|                                            | • University of Arkansas for Medical Sciences Anatomy Resources (University of Arkansas, Fayetteville, AR) |                                                                        |
|                                            | • Georgetown University Medical Center Videos (Georgetown University, Washington, DC)       |                                                                        |
|                                            | • Zoom (Zoom Voice Communications Inc., San Jose, CA)                                        | • Online digital platform for live sessions                             |

(Continues)
TABLE 3 (Continued)

| Authors/place of study | Online digital tool(s)ource | Specific usage of the digital tool |
|------------------------|-----------------------------|-----------------------------------|
| Cheng et al. (2021)/People’s Republic of China | • Tencent Classroom (Tencent Holdings Ltd., Shenzhen, China)  
• Zoom (Zoom Voice Communications Inc., San Jose, CA)  
• MOOC Platforms:  
  • Chinese University MOOC (Chinese University MOOC, Beijing, China)  
  • Xuetang Online (Tsinghua University, Beijing, China)  
  • Zhihuishu (Abe-Elec Co Ltd., Shanghai, China)  
  • PMPH MOOC (People’s Medical Publishing House, Beijing, China)  
• Rain Classroom (Tsinghua University, Beijing, China)  
• Xueexitong (Tsinghua University, Beijing, China)  
• Blackboard (Blackboard Inc., Washington, DC)  
• Moodle (Moodle HQ, Perth, Western Australia)  
• Camtasia (TechSmith Corp., Okemos, MI)  
• Corel Video Studio (C&J Marketing Software Co., Ltd., Suzhou, China)  
• QQ Yingyin (Tencent Holdings Ltd., Shenzhen, China)  
• WeChat (Tencent Holdings Ltd., Shenzhen, China)  
• SoJump (Shanghai Information Technology Co., Shanghai, China)  
• Online digital platform for live sessions |  

Kim et al. (2020); Park et al. (2021); and Yoo et al. (2021)/Republic of Korea | • Blackboard Collaborate (Blackboard Inc., Washington, DC)  
• e-Teaching and Learning System (Seoul National University, Seoul, Korea)  
• MOOC Platforms (all are learning management systems/LMS)  
• e-Anatomy Videos (Panmun Education, Seoul, Korea)  
• Complete Anatomy (Elsevier, Amsterdam, The Netherlands)  
• Visible Human Korean (Park et al., 2006)  
• Facebook (Meta Platforms Inc., Menlo Park, CA)  
• Twitter (Twitter Inc., San Francisco, CA)  
• Used for delivery of lectures (live and recorded) |  

Nimavat et al. (2021); Patra et al. (2021); and Singal et al. (2021)/India | • Zoom (Zoom Voice Communications Inc., San Jose, CA)  
• Microsoft Teams (Microsoft Corp., Redmond, WA)  
• Google Meet (Google LLC, Mountain View, CA)  
• Google Classroom (Google LLC, Mountain View, CA)  
• Skype (Microsoft Corp., Redmond, WA)  
• Cisco WebEx (Cisco Systems Inc., San Jose, CA)  
• YouTube Videos (YouTube LLC, San Bruno, CA)  
• In-House Videos  
• Sectra virtual dissection tables (Sectra AB, Linkoping, Sweden)  
• Anatomage virtual dissection tables (Anatomage, Santa Clara, CA)  
• Facebook (Meta Platforms Inc., Menlo Park, CA)  
• WhatsApp (WhatsApp LLC., Menlo Park, CA)  
• Online digital platform for live sessions  
• For display in practical classes  
• 3D Virtual learning resources  
• Exchange of learning materials  
• Communication/Networking |  

Abbreviations: 3D, three-dimensional; LMS, learning management system; MOOC, massive open online course.
In most of the medical institutions in India, lectures in the form of PowerPoint and practical sessions comprising of recorded demonstration from prospected specimens were uploaded on Institutional websites which would then be accessed by the students (Akella & Suvvari, 2021). Online digital resources used for delivering anatomy education during practical classes mostly included YouTube videos and in-house videos prepared as per need mostly from prospected specimens (Nimavat et al., 2021; Patra et al., 2021) (Table 3). For the purpose of networking and sharing of education materials, social network service Facebook and messenger service WhatsApp were incorporated within the education strategies adopted during Covid-19 pandemic (Nimavat et al., 2021; Soundariya & Deepika, 2022) (Table 3).

**DISCUSSION**

The ongoing Covid-19 pandemic led to emergence of unforeseen challenges for the education sector (Coleman et al., 2020; Kim et al., 2020). Anatomists across the globe scrambled for education strategies that would be as far as possible ideal to tide over the imminent crisis (Cuschieri & Agius, 2020). Education strategies were designed with focus on continuation of the education delivery process and consequently the entire structure of ongoing curriculum was molded to an online form (Flynn et al., 2021; Babacan & Dogru Yuvarlakbas, 2022). In the present review, detailed analysis of the data from the selected literature revealed that implementation of the education strategies for online delivery of anatomy curriculum during the Covid-19 pandemic involved a number of pertinent issues which are discussed below in details.

**Practical sessions prioritized over lecture classes in online mode**

Educators perceived that online delivery more suited the practical classes, hence more time and planning were devoted to designing online practical classes (Pather et al., 2020). This can be attributed to the fact that it is difficult to maintain student engagement and attentiveness for long hours or over a long content in the online mode of education (Paul & Jefferson, 2019). Practical classes are usually planned with a short topic (having a succinct content) with emphasis on active learning (through interaction) among a small number of students as the audience. Hence it is easier for the academic staff to deliver the contents of a practical session effectively while engaging the students in online platform (Khalil et al., 2020). Moreover, the use of high-end technology-enhanced online digital tools (more suited for practical classes) provided significant support to the academic staff for engaging small group of students during delivery of practical classes via online mode (Zalat et al., 2021). Therefore, with the onset of pandemic period, lecture sessions were designed keeping in mind the ability of students to grasp the content within the stipulated time and considering the online mode of delivery.

**India**

Data relevant to the present study were extracted from one original research article (Singal et al., 2021), one review article (Nimavat et al., 2021), and one letter to editor (Patra et al., 2021).

The information documented in these three articles represented medical schools across India. Analysis of data from the three articles reflected on the education strategies implemented for delivery of anatomy sessions (theory and practical) in online mode during the pandemic period (Table 2). Significant changes were noted in terms delivery of anatomy education as compared to pre-pandemic times. Medical schools having robust networking facilities (particularly the autonomous ones) mostly relied on synchronous mode and accordingly practical classes involved live demonstration from prospected human specimens, complimented with available digital resources (Table 3). However, institutes with more traditional outlook and those situated in remote areas with limited networking facilities adopted the combination mode (synchronous and asynchronous) with minimal reliance on online digital resources (Nimavat et al., 2021; Singal et al., 2021).

**Republic of Korea**

Data for the present study were collected from three original research articles which were questionnaire-based studies and involved participants from multiple medical schools under the Korean Association of Medical Colleges (Kim et al., 2020; Park et al., 2021; Yoo et al., 2021). Analysis of the data from the three articles showed that with the onset of Covid-19 pandemic, the Korean medical schools adopted a blended learning approach which includes online lectures, prerecorded laboratory dissection videos and use of three-dimensional (3D) online digital anatomy applications for delivering sessions (Table 2). Significantly, all the online components of anatomy education were complimented with condensed offline cadaver dissection from late April 2020 as the number of confirmed Covid-19 patients decreased considerably. Education strategies implemented for online delivery of both lecture and practical classes relied significantly on online digital tools (Table 3). After start of offline dissection classes from late April 2020, students attended the condensed dissection course (10 h a day and three times the content of single class from pre-Covid times) once or twice in a week. However, the students were still required to submit their respective assignments related to cadaveric dissection via 3D virtual learning platforms (Yoo et al., 2021).
Precisely, it was ensured that lecture topics were kept short, crisp, and digestible for each session while taking into consideration their obvious limitations in online education (Pather et al., 2020).

Digital resources incorporated to complement online classes

As anatomy education entered online mode the traditional tools of teaching/learning became inoperative. As a logical measure, educators began looking for new resources that would make the process of transition to the new teaching/learning environment a smooth one. In such a scenario, online digital tools emerged as a popular resource entity and very soon became an integral element of online education programs. During these challenging times, online delivery platforms meant for live streaming of sessions in synchronous mode as well as those platforms designed for uploading sessions for smooth access by the end user (with dedicated space for interaction and exchange of views) played a stellar role in the overall anatomy education process and in a way shaped its online outlook (Shah et al., 2020; de Carvalho Filho et al., 2021). These online platforms are powered by latest cutting-edge digital technology and in the given situation emerged as a rational alternative to in person anatomy learning sessions (Dash et al., 2022). Online digital resources in its multifaceted structure (digitized resources, 3D resources, online professional materials, copyrighted resources etc.) were lapped up by the educators as per suitability of the content, mode of delivery and the economical scope (Longhurst et al., 2020; Pather et al., 2020; Cheng et al., 2021; Harmon et al., 2021; Nimavat et al., 2021; Park et al., 2021; Patra et al., 2021; Singal et al., 2021; Yoo et al., 2021) (Table 3). A few institutes developed their own in-house digital resources which were customized as per requirement of teaching/learning objectives. Although bulk proportion of these in-house videos were prepared after the onset of pandemic, a few of them were already in place from pre-pandemic times (Cheng et al., 2021; Harmon et al., 2021). Among digitized education materials resourced from external sources, such as YouTube videos, videos as well as photographs tagged with popular anatomy textbooks and those collections of digitized resources which were accessible through libraries of prominent universities/educational institutions were already available prior to pandemic (Longhurst et al., 2020; Cheng et al., 2021; Harmon et al., 2021). However, the onset of pandemic witnessed the emergence of more evolved online digital resources (in terms of technology) which enhanced the online teaching/learning experience considerably (Pather et al., 2020; Harmon et al., 2021; Patra et al., 2021). On the flipside, the technology powered online digital platforms and evolved digital education resources were licensed products and thereby accessible solely through commercial purchase (De’ et al., 2020; Golinelli et al., 2020). Unsurprisingly, the use of these high-end online resources was limited to institutions with sound economic health (Nimavat et al., 2021; Soundariya & Deepika, 2022). The existing gap in terms of affordability for use of expensive online digital tools can have a serious impact on anatomy education among developing countries with low budgetary allocation for health education. The induction of advanced digital resources undoubtedly enhanced the teaching/learning experience of online classes during pandemic period. However, there is no denying the fact that convenience comes with a price tag and therein lies the risk of limited outreach for this key element of online anatomy education programs.

Increased workload for academic staff during pandemic period

A salient feature of online education programs during the pandemic was the workload management by the academic staff as they tried to adapt with the changed work environment and unexplored tools of trade. To put it straight, the onset of online classes and subsequent adoption of online digital resources led to remarkable increase in workload for the academic staff (Pather et al., 2020). Firstly, they got themselves acclimatized to the rapidly changing scenario followed by learning to use the digital resources and finally incorporating them within the respective sessions so as to maximize their impact in terms of achieving learning objectives (Longhurst et al., 2020; Pather et al., 2020; Cheng et al., 2021; Harmon et al., 2021). The situation got even complicated as the onset of pandemic unfolded another unexplored dimension of human life, “work-from-home” that again involved a certain degree of adjustability particularly on part of the academic staff as most of them live with their families. Considering the “work-from-home” scenario and enhanced workload toward delivering online classes, the personal and family lives of academic staff were adversely affected (Hilburg et al., 2020). This was more so in cases of female academic staff as evidence suggests that academic activities (in terms of submission of projects and posting preprints) of female academics are on the lower side as compared to their male counterparts since the start of the pandemic (Viglione, 2020; Woitowich et al., 2021). The transition to online classes emerged as a tough challenge for educators to balance their academic/professional and personal life as workload increased considerably. Introduction of “work-from-home” norms led to overlapping of both the dimensions of life thus leading to an even more perplexed situation.

Conduction of online classes required learning of information technology skills

The implementation of education strategies and delivery of online classes following the incorporation of appropriate digital resources required a certain level of information technology skills among the academic staff (Seymour-Walsh et al., 2020). As online anatomy education programs were adopted worldwide at a rapid pace hence minimal preparation time was available (Khurshid et al., 2020). In other words, most medical schools across the globe relied on the existing information technology skills of academic
staff for undertaking online classes. This emerged as a potential handicap as in most places the academic staff were used to offline delivery of sessions and honed their skills accordingly across all these years (Totlis et al., 2021). The possible way out from this situation was either self-training (upgradation) or arrangement of structured training program for academic staff on part of the institute (Brassett et al., 2020; Harmon et al., 2021). The second option could not be implemented in most places primarily due to lack of time (as training would have to undergo parallel with ongoing online classes and this would have enhanced the already heavy workload) and secondly due to scarcity of resources in terms of manpower as well as funds (Pather et al., 2020; Brassett et al., 2020). Hence the first option was adopted by academics not by choice but by default. In other words, it was a “sink or swim” situation. Conduction of online classes with full utilization of its potential mandates educators to attain information technology skills. This is so because they have to venture into an unchartered territory of online platforms as well as digital tools that have been developed through application of technology. There is considerable literature gap on this issue which limits the scope for further discussion. However, it can be assumed that this issue was handled by educators mostly at individual level with limited support at institutional level.

There is scope for offline (physical) human dissection in regions with low infectivity rate

Implementation of education strategies for online anatomy education programs on a global basis resulted in offline hands-on human dissection-based teaching taking a back seat within the medical education curriculum (Iwanaga et al., 2021). It is a harsh reality that physical human dissection-based sessions simply could not be continued in the face of rapidly spreading devastating pandemic and ever-increasing number of infected cases (Franchi, 2020). Nevertheless, there is no denying the fact that lack of exposure to this unique teaching/learning tool may seriously impact the skills (surgical as well as discipline independent) of the future physicians who are being trained in anatomical sciences during the pandemic (Ghosh, 2017a; Kumar Ghosh & Kumar, 2019; Banovac et al., 2021; Chytas et al., 2021). No amount of sophistication achieved in terms of developing digital tools or any level of online teaching cannot supplement the objectives achieved through physical human dissection within the realm of medical education (Ghosh, 2017b, 2020). This particular lacunae in terms of education strategies for imparting online anatomy education amidst the ongoing covid-19 pandemic has been highlighted in recent literature (Ghosh, 2022). However, as a silver lining, a noteworthy variation (with respect to other parts of the world) was observed in Republic of Korea, where condensed cadaveric dissection sessions were conducted in offline (physical) mode from late April 2020 as the number of positive cases showed a downward trend (Yoo et al., 2021) (Table 2). Exposure to hands-on dissection experience during Covid-19 times is priceless when compared with other parts of the world and is undoubtedly a positive element of the ongoing anatomy education program in this region. This positive development in terms of anatomy education is worth emulating in regions with low infectivity while following necessary precautions and abiding with prevalent administrative guidelines.

Core education strategies were not widely variant across geographical regions

In the present review it was observed that the core education strategies adopted for delivery of online anatomy education during Covid-19 pandemic were quite similar in outlook with only subtle differences across different geographical regions in the world. The core strategies comprised of lecture classes and practical/tutorial sessions being delivered online in various combinations of synchronous and asynchronous mode (Table 2). This finding points to the fact that the baseline response of anatomy educators during the pandemic period was identical in essence. This can be attributed to the fact that the elements required for baseline response (to line up a class in online mode with actual execution not being the focal point) are quite simple and available even in remote areas of the world: internet connection, computer system, streaming platform, and in-house online tools. Streaming platforms in their basic forms such as Google Classroom (Google LLC, Mountain View, CA), Zoom etc. were available for free to use for a limited number of participants and for a limited period in a day. Similarly, online tools such as YouTube videos (with questionable reliability) and in-house videos made from prospected specimens or handmade models were available for use irrespective of any geographical region. Moreover, social networking platforms such as Facebook and messenger systems such as WhatsApp (both are free to the user) were available for use for networking and interaction among the students and academic staff. In other words, the factors that can lead to variations in education strategies (accessible resources, profile of stakeholders, curricular structure) did not come into play while launching the baseline response. Hence the baseline response during pandemic period was almost identical in fabric across the globe thus giving a similar outlook to the core education strategies adopted in different geographical regions.

Possible disparity in learning outcomes based on socio-economic profile of a region

In-depth analysis of the education strategies adopted during pandemic period with particular emphasis on the implementation component reflects upon a phenomenon which is in sharp contrast to the baseline response (classes lined up in online mode with actual execution not being the focal point). Precisely, this is where the induction of advanced online digital tools comes in picture as they
were critical toward effectively implementing the core education strategies. These online digital applications were key to enhancing the quality of online anatomy education delivery as actual execution of core strategies became the focal point. It was noted with interest that anatomy education in the United States of America and in the United Kingdom and Republic of Ireland utilized a diverse bouquet of digital tools toward enhancing the learning experience and achieving the desirable learning objectives during the Covid-19 pandemic (Longhurst et al., 2020; Harmon et al., 2021) (Table 3). The list of these digital tools is truly elaborate and is testimony of the volume of effort the academic staff from these regions have invested while preparing and delivering the online sessions during the testing times. The positive outcome can be primarily attributed to the understanding of different pedagogy involved in online teaching/learning and adapt accordingly to incorporate the same in anatomy education. Another noteworthy fact is that in the United States of America and China, most of the online digital tools utilized for delivering sessions during the pandemic were already in use and were incorporated within the anatomy curriculum prior to the onset of pandemic (Cheng et al., 2021; Harmon et al., 2021). A very evident contrast was apparent in India as most of the medical schools (except few autonomous institutes which are either private or government funded) relied on skeletal digital resources for delivery of online anatomy classes during the pandemic (Nimavat et al., 2021; Patra et al., 2021; Singal et al., 2021) (Table 3). Due to economic constraints, most of the institutions did not have access to the globally popular online platforms for uploading lectures/practical classes or related study materials/resources (Soundariya & Deepika, 2022). Whereas, the autonomous institutions (government or private) with robust financial health used a wide variety of online digital resources for delivering online classes (Table 3). Notably, most of these online education delivery platforms are licensed on commercial basis and are very useful for online education programs for accessing sessions in asynchronous mode as they provide window for interactive activities (Longhurst et al., 2020). The apparent disparity can be attributed to the difference in socio-economic status as India is still a developing country with obvious economic constraints, while all other geographical regions assessed in the present review represent the developed world with comparatively sound economic condition (Khairnar et al., 2017). In other words, the factors that can lead to variations in education strategies (accessible resources, profile of stakeholders, curricular structure) came to the surface during implementation of core education strategies due to existing gap in socio-economic profile across geographical regions. This led to considerable variations in the usage of advanced digital tools among different regions in accordance with their socio-economic profile (Table 3). The scenario in India with regards to use of online digital resources reflects the situation in other geographical regions of the world comprising of countries with a developing economy as per emerging reports (Pacheco et al., 2020; Okafor & Chia, 2021). Impediment in terms of availability of online digital tools (those requiring commercial purchase) can possibly have an impact on the quality of delivery of online classes as it limits the scope of interaction and participation of the students during online classes. The issue becomes more pertinent as it is anyway difficult to maintain student engagement and attentiveness during online classes. Precisely, the situation is not very encouraging for an active learning environment. Therefore, the issue can potentially affect student learning outcomes eventually leading to variations in anatomical knowledge across geographical regions due to existing gap in socio-economic profile.

Future scope of research

The education strategies during the Covid-19 pandemic are still evolving as observations related to outcome analysis are being added to ever growing volume of published literature on this topic (Delgado et al., 2021). Critical variations in the education strategies implemented for online anatomy education programs have been focused on in the present review primarily based on the online digital resources used across different geographical regions of the world. However, there may be possible variations regarding the implementation of the education strategies within the online education program when more experiences are shared by academics and more significantly by the students who happens to constitute the other pole of the stakeholders. For instance, the data on specific hurdles faced by the academics while preparing or delivering online classes could be interesting to explore. The feedback from the students regarding the overall learning experience from online classes and analysis of assessment-based outcome of the online teaching/learning programs are some areas worth venturing into as more literature on this topic keeps surfacing in the scientific domain.

Limitations of the study

Five limitations of the narrative review were identified after detailed analysis. First, data analysis was not comprehensive due to heterogeneous nature of published items explored from multidisciplinary databases. However, data relevant to the topic of the study were explored, analyzed, and discussed in a robust manner. Second, preprints and non-peer-reviewed items were excluded which may have important data considering the rapidly changing landscape of this topic. However, focus on peer-reviewed published studies in a way validate the findings of the present study in spite being limited in nature. Third, for each of the geographical regions mentioned in the review, data were extracted from very few studies and even solitary studies. This was in accordance with the literature search method adopted for the study and analyses were drawn from these data based on the interpretation that these are individual assessments of research groups from respective regions. Fourth, as studies which were not in English (English translations also not available) were excluded hence findings from few geographical regions may have been missed. Nevertheless, this review presented an overview with
CONCLUSIONS

The core education strategies adopted for implementing online anatomy education programs in different parts of the world during the Covid-19 pandemic were not widely different. This implies that the baseline response from anatomy educators was similar in outlook across geographical regions. However, a close look into the attributes particularly in relation to the use of online digital tools for delivery of online classes revealed intriguing variations. It was noted that institutions in the United States of America and United Kingdom and Ireland used diverse online digital tools in a very elaborate manner for conducting online classes. It was also observed that institutions in the United States of America and China were using online digital tools for anatomy classes even before the onset of the pandemic. Hence it is evident that online digital tools were an integral element of the education strategies adopted by anatomists. It was identified that considerable gap exists in terms of the variety and number of online digital tools used for enhancing the online anatomy learning experience between other geographical regions included in this review (developed economy) and India (developing economy). Majority of technology-enhanced high-end online digital tools requires commercial purchase and their use was limited to institutions with sound financial health. This aspect is worth taking into consideration as it may impact the learning outcomes for students and may even lead to variations in the anatomical knowledge by region during the pandemic based on existing economic conditions. Notably, in South Korea, condensed cadaveric dissection sessions in offline (hands-on) mode were incorporated along with ongoing online practical classes from late April 2020 onwards as positive cases reduced significantly. This is a positive development in terms of anatomy education amidst the pandemic and worth emulating elsewhere based on cautious assessment of the prevailing situation. From a broader perspective, implementation of education strategies for delivery of online classes in the face of ongoing Covid-19 pandemic has given an evolved outlook to the fabric of anatomy education.

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CONFLICT OF INTEREST

The author hereby declares that there is no potential conflict of interest in any form concerning him.

ORCID

Sanjib Kumar Ghosh https://orcid.org/0000-0002-7293-6735

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AUTHOR BIOGRAPHY

Sanjib Kumar Ghosh, M.D., is an associate professor in the Department of Anatomy at All India Institute of Medical Sciences, Phulwarisharif, Patna, India. He teaches anatomy, genetics, and embryology to first-year medical students as well as first-year nursing students and his research interest is in anatomy education, gross anatomy, and history of anatomical sciences.

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