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Impact of SARS-CoV-2 infection on veterinary medical education

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Impact of SARS-CoV-2 infection on veterinary medical education

Abstract

SARS-CoV-2 infection is considered an international disaster. The second and third waves of the SARS-CoV-2 pandemic are ongoing. The universities of most countries of the world are closed to prevent the spread of SARS-CoV-2 infection. Many universities of the globe stopped direct classroom teaching, and some started online teaching to minimise the effects of SARS-CoV-2 on education. In this manuscript, an attempt has undertaken to analyse the influence of the SARS-CoV-2 pandemic on global veterinary medical education. We have conducted a literature search in different databases following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines using different keywords to find out peer-reviewed scientific articles about the impact of COVID-19 on veterinary medical education. The literature search generated 17 eligible scientific papers for qualitative analysis of the effect of COVID-19 on veterinary medical education. The COVID-19 pandemic has a severe adverse influence on veterinary medical education. Shifting from direct classroom teaching to online teaching is one of the sweeping impacts. It might be possible to conduct online classes for veterinary medical education. But the supply of electronic devices, motivation to students in self-learning, institutional support etc., are crucial for interactive situated learning of veterinary courses. Research and development of sustainable, worthwhile methods for remote teaching veterinary medical students are essential. Reshaping the veterinary medical education programs using core theory, practical and clinical curricula is crucial for conducting uninterrupted veterinary education programs during current COVID-19 and future pandemics.

Practitioner Notes

1. This paper reports on a systematic review for veterinary medical education during COVID-19
2. Challenges of veterinary education during COVID-19 included cancellations of exams and rapid shifts to online learning.
3. Social media usage increased to proportions representative of addition among university students.
4. Access of, and technical support for, educational technologies were a direct challenge to continuity of education.
5. The online teaching changes from COVID-19 created reduced motivation for learning in students

Keywords

COVID-19, Online classes, Future pandemics, SARS-CoV-2 infection, Veterinary medical education, Veterinary medical students

Introduction

The Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2), the novel coronavirus, is the causative agent of the current COVID-19 (Coronavirus disease-19) pandemic (ICTV, 2020). SARS-CoV-2 was first identified in December 2019 as pneumonia of unknown origin in residents of Wuhan city of Hubei Province, China (Zhu et al., 2020). After its first emergence in China, the disease spread very rapidly throughout the world and the World Health Organization (WHO) declared the SARS-CoV-2 infection on March 12, 2020, as a global pandemic (WHO, 2020). At present, every country of the world is affected by the pandemic and second waves of the disease are still ongoing.

Every nation of the world has undertaken countermeasures to prevent the rapid spread of the disease (Alam et al., 2021), such as restrictions of travel in and among countries, maintaining strict individual and social distance, mandatory isolation and quarantine measures for the travellers, minimisation of gatherings in public and open places, closure of businesses, performing necessary duties while staying at home, closure of universities and colleges, and ultimately lockdowns (Bedford et al., 2020); and thus, severe adverse impacts on tourism, health, education, agriculture, and other businesses have occurred (Pragholapati, 2020).

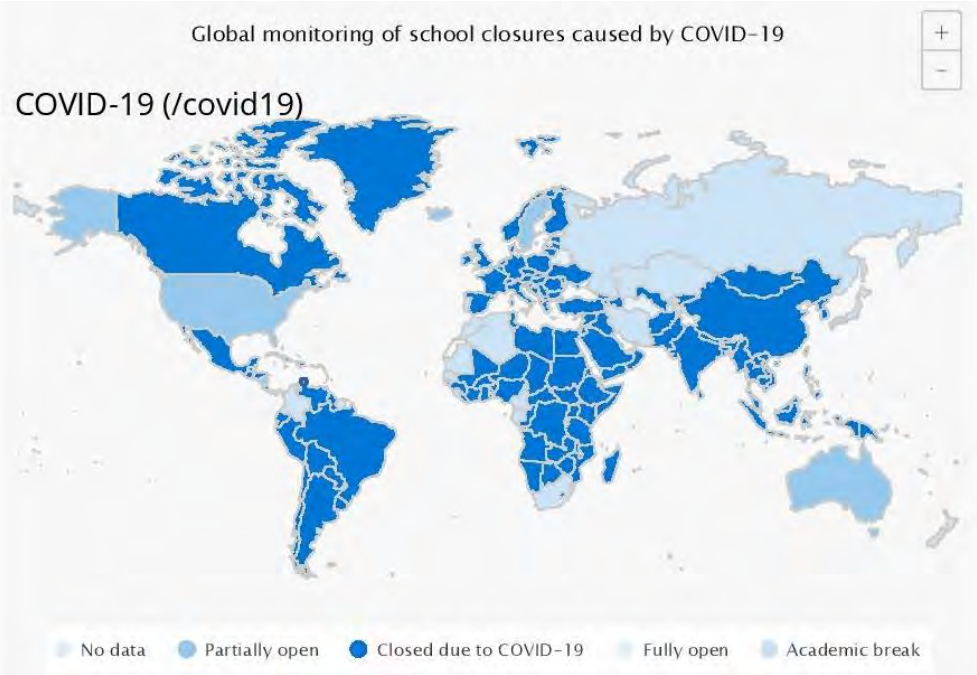
SARS-CoV-2 infection is affecting education systems at all levels in all the countries of the world (Nicola et al., 2020). There are temporary closures or rescheduled academic programs of global educational institutes that directly affect the 1.7 billion student population around the world (UNESCO, 2020). The latest scenario of the activities of educational institutes around the globe is shown in Figure 1.

Recently, the American Veterinary Medical Association (AVMA) surveyed 2000 respondents and concluded that SARS-CoV-2 has disastrous effects on veterinary clinical practices (AVMA, 2020). There are postponements or cancellations of in-campus activities of the students to minimise the transmission of COVID-19. It was reported that lockdown imposed to prevent SARS-CoV-2 infection significantly impacted the academic activities of radiology specialist trainees, dental students, as well as medical students (Iyer et al., 2020; Alvin et al., 2020; Mian and Khan, 2020; Rose, 2020; Kanneganti et al., 2020; Sandhu and de Wolf, 2020). There are many studies undertaken for finding out the effects of the COVID-19 pandemic on the global general student population (Ravi, 2020; Upoalkpajor & Upoalkpajor, 2020; Emon et al., 2020), and to the best of our knowledge, studies are scarce for finding the effects of the COVID-19 pandemic on the academic performances of the veterinary medical students (Mahdy, 2020; Parkes and Barrs, 2021).

In light of this paucity of research studies, we have undertaken a comprehensive systematic review of the peer-reviewed articles about the impact of COVID-19 on global veterinary medical education. This present qualitative analysis recommends measures to be taken to minimise the effects of the COVID-19 pandemic on veterinary medical education. Our purpose is also to recommend factors that should be considered in the uninterrupted teaching and learning of veterinary medical students during current COVID-19 and future pandemic events. The recommendations and suggestions of this systematic review are crucial for the development and effective implementation of an efficient veterinary medical education program during the ongoing COVID-19 pandemic, as well as for future pandemic events.

Figure 1

The latest scenario of the activities of the global educational institutions



Adapted from: United Nations Educational, Scientific and Cultural Organization (UNESCO) on 02 April 2021. (https://en.unesco.org/covid19/educationresponse#schoolclosures)

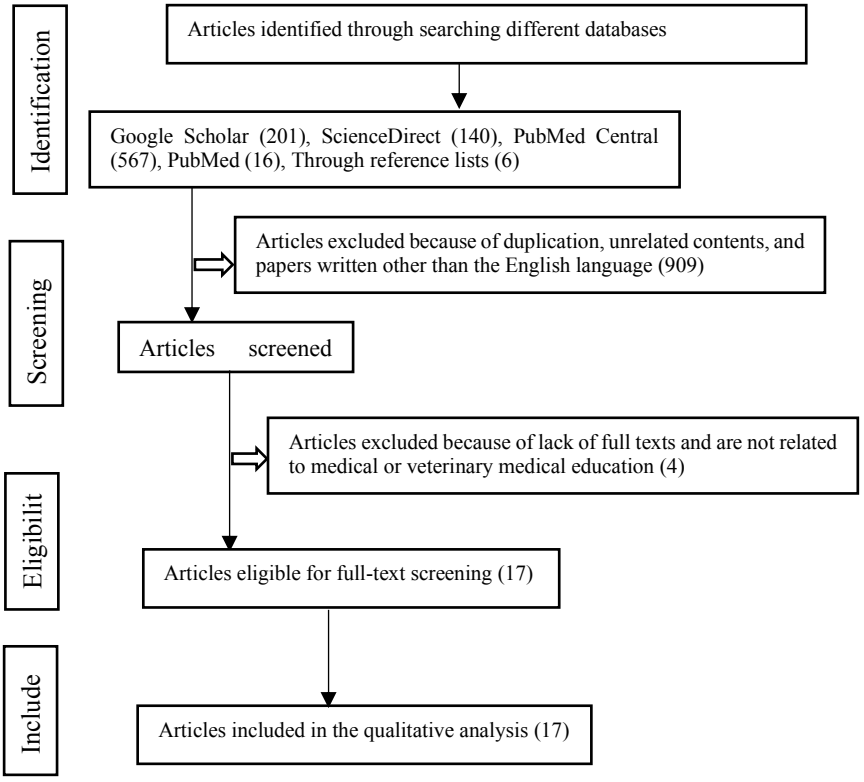
Method

Literature search

A literature search was conducted in the Google Scholar, PubMed, PubMed Central, and ScienceDirect databases on June 08, 2020, to find out the published peer-reviewed articles about the impact of the COVID-19 pandemic on global veterinary medical education using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). The keywords of the literature search were impact of SARS-CoV-2 infection on Veterinary Medical Education; COVID-19; Veterinary Graduation Programme; Veterinary Medical Students; Practical classes of Veterinary Medical Students; Veterinary Clinical Classes during pandemics; and Switch to Online Teaching.

Figure 2

Schematic diagram demonstrating the procedure of article selection for analysis



Findings

The search algorithm yielded 930 peer reviewed articles from Google Scholar, PubMed, PubMed Central, and ScienceDirect databases. After removal of papers having unrelated contents, duplications, and papers written in languages other than English, 21 articles were scanned. Again, 04 articles were removed because of lack of full texts and contents were not related to medical or veterinary medical education. The search of the literature in the databases finally identified 17 eligible scientific articles about the impact of COVID-19 pandemic on global medical and veterinary medical education (Figure 2). The inclusion criteria for the identified articles are accessibility to full texts, papers written in the English language, and impact of COVID-19 on medical or veterinary medical education in different regions of the world. The scarcity of research articles on the impact of the COVID-19 pandemic on veterinary medical education obliged us to include opinion papers, correspondences and communications, round table discussions, and review papers (Figure 2 and Table 1). The summary of the 17 articles used for qualitative analysis is shown in Table 1.

Table 1

The impact of COVID-19 on the global medical and veterinary medical education

Sl. no	Country of study	Field/level of education	Study methods	Major impact	Major recommendations	Reference
01	United States of America (USA)	Veterinary Medical	Reviewing data sources and evaluation of student rotations	There were a transition of clinical rotations from in-person to a virtual format	Simulations or virtual reality experiences for clinical skills or client communication should be undertaken that could be delivered entirely remotely.	Ward et al., 2021
02	Malaysia	Medical	Survey	Suspended clinical teachings and assessments	Develop infrastructure, equipment supply, and uninterrupted internet supply	Rashid et al., 2020
03	92 different countries	Veterinary Medical	Online survey	About 96.7% of participants were affected by varying degrees to their academic activities	Supply electronic devices, provide training to lecturers, improve internet speed	Mahdy, 2020
04	Nigeria	Veterinary Medical	Cross-sectional questionnaire based web survey	Semesters cancelled. Inadequate online tools or facilities to perform virtual education. Mental health problems of students	Urgent attention targeting towards promoting strategic educational planning required. Virtual learning facilities should be provided	Adebowale et al., 2020
05	USA, United Kingdom (UK), Greece	Medical	Systematic review	Implementation of virtual consults, telemedicine, and simulation & virtual reality	There is a great need for qualitative and quantitative studies on the proposed methodologies.	Dedeilia et al., 2020
06	UK	Medical	Opinion	Disruptions to teaching, cancellation of clinical electives and exams,	Medical education and clinical training has been reshaped to facilitate the	Rainbow and Dorji, 2020

Sl. no	Country of study	Field/level of education	Study methods	Major impact	Major recommendations	Reference
				abandonment of research projects	continuation of studies, financial support	
07	Libya	Medical	Cross-sectional survey	There are disruptions of medical education and training	Make changes to medical education and training, the introduction of online training and virtual clinical experience	Alsoufi et al., 2020
08	Ireland, Scotland, UK, Germany	Medical	Review	Hands-on examination of cadaveric specimens, dissection, and student engagement, cannot be substituted for by online methods alone	The strengths and weaknesses of online anatomical teaching in practice must be rigorously tested to develop a protocol for teaching anatomy during future pandemics.	Brassett et al., 2020
09	Hong Kong	Veterinary Medical	An online survey, Descriptive analysis	Online teaching has both positive and negative impacts on veterinary medical education	Strategies need to optimise peer interactions, application of flipped classrooms of learning	Parkes and Barrs, 2021
10	India	Veterinary Medical	Multiple-choice questions using Google Forms questionnaire	E-learning techniques were adapted to the veterinary students and teachers that are mostly useful for sound income family students	Policymakers can make a strategic plan for the implementation of effective teaching-learning for veterinary medical students	Das et al., 2021
11	USA, UK, Australia, The Netherlands	Veterinary Medical	Round Table Discussion	Online lecturing using recorded lectures, interactive classes using Microsoft Teams, difficult interactive teaching	Measures should be taken to minimise reduced hands-on practical training, especially for the day-1 competency skills	Amanda, 2020

Sl. no	Country of study	Field/level of education	Study methods	Major impact	Major recommendations	Reference
12	UK	Medical	Correspondence and Communications	Introduction and successful implementation of a virtual clinic for skin cancer patients in reducing patient footfall to the clinic	Setting up more virtual clinics in any subspecialties of plastic surgery to reduce pressure on health care services in future	Maheshwari et al., 2020
13	All over the world	Medical	Questionnaire-based cross-sectional study	Students have psychiatric illnesses such as depression, anxiety, obsessive-compulsive disorder and post-traumatic stress syndrome. Students have faced problems with memorising, concentration, and perceived overall trouble with learning	Student counselling and proper support. Clinical trial for stress counselling, management, and resilience training for medical students. Delineate the perpetrating impairment on the student learning	Aftab et al., 2021
14	Germany	Medical	Collaborative learning in breakout rooms, annotation assignments and multiple-choice questions	Implementation of an online-only format histology course based on video conference software.	There is a need for a synchronous learning environment with partially personnel-intensive small group settings to overcome passivity and inequality aspects, and to foster active learning elements.	Darici et al., 2021
15	Singapore	Medical	Opinion	Coordinated responses of academic medical centres in sustaining medical education during COVID-19 and future pandemics	Approaches such as leveraging on decentralised modes of medical education delivery, maintaining the integrity of formative and summative assessments and developing action plans for the sustenance of	Ashokka et al., 2020

Sl. no	Country of study	Field/level of education	Study methods	Major impact	Major recommendations	Reference
					continuing professional development is crucial.	
16	Indonesia	Medical	Systematic review	Introduction of online lectures, classes, laboratory practices, and clinical skills classes for continuing medical education.	Constant evaluation, review, and improvement of online medical education are crucial. Evaluation of the performance of students after introducing an online system to discover the best methods during current and future pandemics.	Kelly et al., 2020
17	UK	Medical	Systematic review	Virtual learning has several weaknesses such as technical challenges, reduced student engagement, confidentiality issues, loss of assessments, and ultimately affects the mental health of students.	Further development of virtual resources and the adoption of a more holistic approach to student education are crucial. Improvement of security and technology of virtual platforms are necessary.	Wilcha, 2020

Discussion

Impact of COVID-19 on global veterinary medical education

Veterinary medical education is considered one of the most practically oriented education to produce skilled technical graduates to provide a robust service to society. After getting admission in the veterinary medical program, students have undergone intensive clinical practices and academic workloads (for 4 or more years) amidst their cohort of elite and equally meritorious classmates (Crane et al., 2015; Zenner et al., 2005; Viner, 2010). Veterinary medical education programs started over 200 years ago, intending to produce only veterinary clinicians to treat clinically ill animals (Edwards, 2004). Now the responsibilities of the veterinarians have changed from the only clinician role (treat ill animals) to serve the entire society. The diverse role played by the veterinarian (a veterinary graduate) in the society includes managing food safety and security, contributing to biodiversity and the environment in maintaining optimum health of animals, along with the welfare of animals and humans (Islam et al., 2018; Naide et al., 2018; Islam et al., 2020). For getting maximum service from a veterinarian, the veterinary medical education system should be sound enough to produce an efficient veterinarian. Due to the countermeasures taken to combat the spread of COVID-19, the effective implementation of the veterinary medical education program was also compromised globally (Mahdy, 2020). COVID-19 has an enormous negative impact on the veterinary medical education program (Figure 3). The transition from direct classroom teaching to online teaching is one of the most negative impacts.

Shifting of direct face to face classroom teaching to online teaching

Due to the effects of COVID-19, many veterinary universities and colleges suspended classroom teaching (a traditional system of teaching), and initiated online teaching and learning (e-learning system) (Sahu, 2020; Yamin, 2020; Ward et al., 2021; Das et al., 2021) (Figure 3). This alternate form of learning is essential to minimise direct contact among students or between students and teachers (Pragholapati, 2020; Ravi, 2020). However, only an online education system sometimes cannot fulfil the competencies of veterinary medical students (Murray and Sischo, 2007; Das et al., 2021; Kelly et al., 2020; Amanda, 2020; Ward et al., 2021). Previously, it has been reported that online systems of learning cannot be easily implementable for medical students (Alsoufi et al., 2020). But the online system of education for medical and veterinary medical students has several advantages, such as convenience for students in terms of better time management (Abbasi et al., 2020; Parkes and Barrs, 2021; Abushammala et al., 2021). It is possible to utilise a variety of web-based resources in this system, and there is wider acceptability of this system by the students (Wilcha, 2020). There is the opportunity to combine smaller groups into a larger group in an online system, thus, decreasing the frequency of lecturing/teaching (Amanda, 2020), and there is the provision of the students to watch recorded lectures over and over again at their convenience (Amanda, 2020; Biswakarma et al., 2021). However, for the effective implementation of medical and veterinary medical education using an online system, the following factors must be considered.

1. Availability of electronic devices

Electronic devices such as smartphones, laptops, MacBooks (personal computers) etc. are essential items for participating in online classes (Abushammala et al., 2021). Mahdy (2020) reported that the most common electronic devices used by veterinary medical students during online classes in the COVID-19 pandemic were smartphones, laptops, and personal computers (Figure 3). For accessing social media and for learning online mathematics classes, students have used smartphones, laptops, tablets/iPads, and personal computers previously (Mulenga and Marbán, 2020; Wickramanayake and Muhammad Jika, 2018). It was previously also reported that mobile phones have a positive influence on the learning experiences of South African medical students,

while attending online anatomy classes (Lazarus et al., 2017). However, many students from underprivileged countries cannot afford electronic devices due to economic problems (UNESCO, 2020a; Adebowale et al., 2020; Das et al., 2021). Thus, they cannot attend classes conducted by an online system that ultimately negatively affects their online learning (Xu and Xu, 2019). The University Grants Commission of Bangladesh has reported that about 14% of students in public universities in Bangladesh have no smartphones (TBS News, 2020). A similar study should be undertaken by every nation to find out how many students have no electronic devices to attend online classes.

2. Internet access

The Internet is a prerequisite in launching an online teaching and learning environment (Souza et al., 2021; Abushammala et al., 2021), but there is unequal access to the internet among the global student population (Emon et al., 2020; Das et al., 2021), and thus, a negative impact on the online education system (Xu and Xu, 2019; Tiellet et al., 2010). There may be scarcity of internet access for underprivileged students from emerging countries (Adebowale et al., 2020; Abbasi et al., 2020). Students who have no access to the internet cannot participate in online classes. This will render a significant global disparity of veterinary medical education programs (Edwards, 2004). Furthermore, the speed of the internet is also crucial. Online lecturing systems require high-speed uninterrupted internet supply (Adebowale et al., 2020). It is crucial in solving this disparity to provide uniform veterinary medical education throughout the world.

3. Impact on practical classes

The COVID-19 pandemic will tremendously affect the practical classes in veterinary medical education (Mahdy, 2020). In an online lecturing system, it might be possible to conduct theory classes, but it is not feasible to conduct some of the practical classes (Amanda, 2020; Abbasi et al., 2020). Some preclinical courses, such as Anatomy and Histology, require direct macroscopic and microscopic demonstration of different organs and structures of different animals to the students (Brassett et al., 2020). Some courses, such as Medicine, Surgery, and Theriogenology (Gynecology, Obstetrics, and Andrology), require direct handling of clinically-ill animals to learn the management of critically ill animal species (Dedeilia et al., 2020). Without effective practical demonstration, there will be a lack of knowledge in students for the aforementioned subjects (Brassett et al., 2020; Dedeilia et al., 2020), and that will ultimately affect the students in the long term (Figure 3). Due to the lack of on-site clinical attachment, the development of the interpersonal and client communication skills of veterinary medical students will also be compromised (Rainbow and Dorji, 2020; Ward et al., 2021; Abushammala et al., 2021).

4. Lack of technical personnel

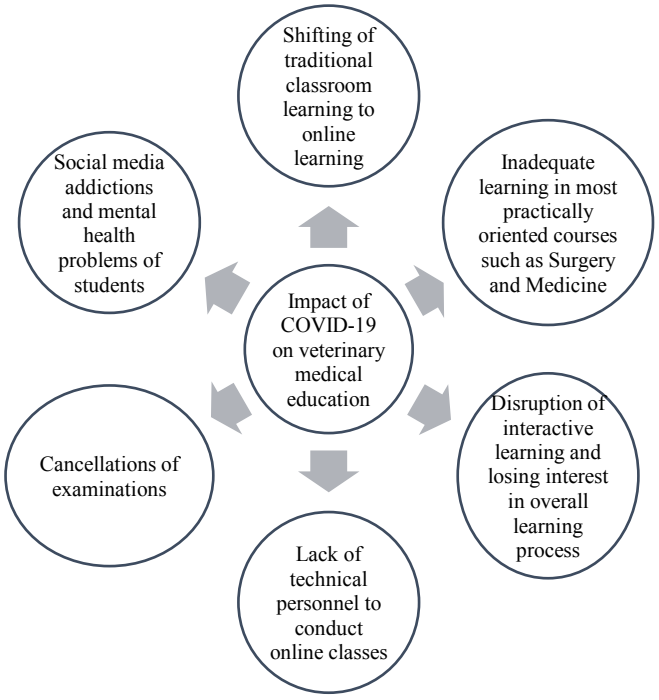
Traditional face-to-face teaching did not require any expert knowledge of lecturers on certain techniques (handling of sophisticated electronic instruments, software etc.) that are essential for online teaching-learning systems (Murray and Sischo, 2007; Arora and Srinivasan, 2020). A sudden change from traditional classroom teaching to online teaching requires certain technological skills of lecturers to deliver lectures effectively using the online system (Rainbow and Dorji, 2020; Wilcha, 2020).

5. Disruption of interactive learning

During traditional classroom teaching, students were interactive with the lecturers. An engaged learning community and good student support are key criteria for interactive learning of veterinary courses (Sherry, 1996; Childs et al., 2005; Murray and Sischo, 2007), but in the online system, there is no face to face contact between students and lecturers (Mahdy, 2020; Abbasi et al., 2020). Thus, classes become monotonous and the learning from those online classes are compromised (Kelly et al., 2020).

Figure 3

Impact of COVID-19 on veterinary medical education



6. Losing interest in the overall learning process

Students feel sleepy, tired, and lose their motivation to participate in online learning, if the online classes are conducted for a long time (Mahdy, 2020; Wilcha, 2020). Furthermore, in online classes, there was no eye contact between students and professors, leading to students ultimately losing their interest in learning (Kheng, 2008; Parkes and Barrs, 2021).

7. Cancellations of examinations

During the COVID-19 pandemic, only theory-based examinations were conducted in the form of quizzes, multiple-choice questions, etc. but practically-oriented examinations on clinical disciplines were cancelled (Rainbow and Dorji, 2020; Abushammala et al., 2021) in most veterinary medical colleges and universities (Kelly et al., 2020; Wilcha, 2020) (Figure 3). General practice-based attachments in different medical and veterinary medical service centres were also cancelled, and thus, had an adverse impact on the veterinary medical and medical education programs (Brassett et al., 2020; Ward et al., 2021).

8. Internet and other social media addictions

During the COVID-19 pandemic, many governments are providing free internet service and loans for purchasing electronic devices for students (BBC, 2020). The students might misuse this opportunity, and they may become addicted to YouTube, Facebook, LinkedIn, Twitter, Instagram, Sharerit, Uber, Viber, WhatsApp and other social media apps, and lose their valuable times of academic learnings (Mubassira and Das, 2019; Adebowale et al., 2020; Son et al., 2020); thus, there is a severe impact on the academic activities of students.

9. Mental health problems

Mental health problems are one of the critical impediments to the academic success of students. Without sound mental health, there is no effective learning in academic classes (Wilcha, 2020). Due to the COVID-19 pandemic, students are staying longer at home, and they fear for their health and the health of their loved ones. As a result, students may suffer from depression, anxiety, or other mental health issues, including suicidal thoughts (Dedeilia et al., 2020; Son et al., 2020; Adebowale et al., 2020) (Figure 3). Furthermore, the parents of many students have dismissed their income-generating activities, creating financial difficulties for students and frustration (Polikoff et al., 2020; Abbasi et al., 2020; Abushammala et al., 2021).

10. Access to sports facilities

Due to the effects of the COVID-19 pandemic, students may have limited interaction with their friends and may have limited access to the sports facilities (Adebowale et al., 2020), which ultimately will negatively affect the physical fitness of the students, and eventually, their academic performance (Son et al., 2020).

Measure to minimise adverse impact

A range of measures to be taken to minimise the adverse impact of the COVID-19 pandemic on veterinary medical education have been identified.

1. Supply of electronic devices

The most commonly used electronic devices for participating in online classes during the COVID-19 pandemic are smartphones, laptops, tablets, and personal computers, but many students from emerging countries have no electronic devices to attend online classes; hence, they cannot participate in online classes (Abushammala et al., 2021). The government of Bangladesh has undertaken a program to provide an interest-free loan to students beyond the capacity to purchase electronic devices to attend online classes (TBS News, 2020) (Figure 4). A similar program should be undertaken by all nations globally for the effective implementation of online classes during this current pandemic (Adarkwah, 2021). Furthermore, the interaction among professors and students can be increased during online classes by the introduction of the Mentimeter application.

2. Availability of the internet

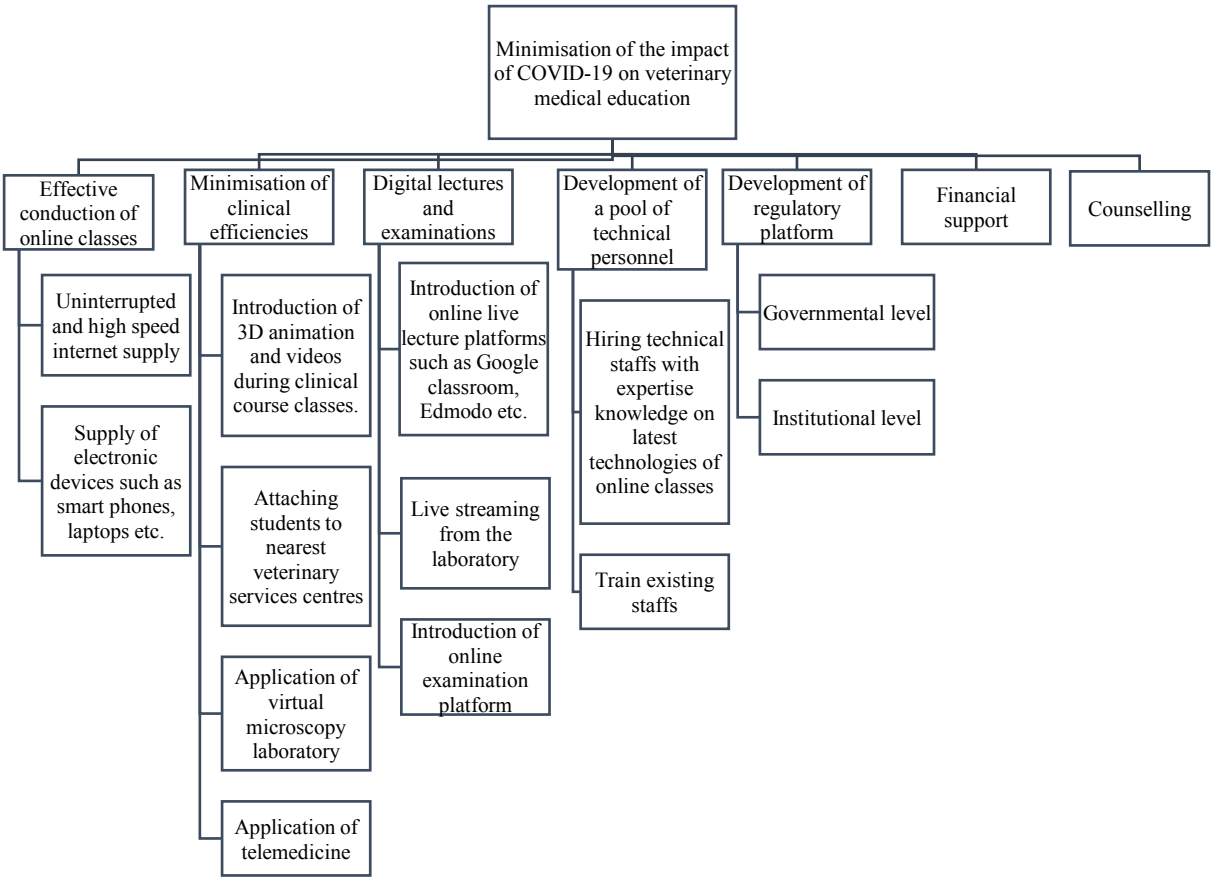
The Internet is the part and parcel of effective online learning. Many students from underprivileged nations have no access to the internet. It was reported that the government of the United Kingdom provided vouchers to 10,000 poor students to get free internet access for six months (BBC News, 2020) to attend online classes. A similar program was also undertaken by the government of Malaysia (Ramij and Sultana, 2020). Such a program should be extended until the COVID-19 pandemic dissipates, and other nations of the world must undertake a similar scheme for effective implementation of online classes (Abushammala et al., 2021; Adarkwah, 2021)). Furthermore, uninterrupted internet supply and high speed of the internet (either 4G or 5G) should be ensured worldwide during this pandemic. Other technical difficulties in remote teaching such as overloaded university servers and frequent crashing of software must also be prevented (Biswakarma et al., 2021).

3. Financial support

During the COVID-19 pandemic, many students have lost their income from tutorials, assistantships, as well as from part-time jobs which ultimately severely hampered the students' learning. Financial support as a form of special incentive should be provided to the students who are greatly affected by the COVID-19 pandemic (Biswakarma et al., 2021; Abushammala et al., 2021) (Figure 4). Adequate funding should also be ensured for making a skilled workforce and good IT infrastructures and services (Favale et al., 2020) of veterinary institutes.

Figure 4

Minimisation of the impact of COVID-19 pandemic on veterinary medical education



4. Minimisation of clinical efficiencies of veterinary medical students

Interactive tools such as 3D (three-dimensional) animation and videos during online learning must be introduced in some preclinical courses such as Anatomy and Histology. Previously, it was reported that students from both medical and veterinary medical fields showed a higher motivation to web-based learning, such as tablet technology than traditional classroom learning for morphology, anatomy, and surgery courses (Lazarus et al., 2017; Avila et al., 2017; Smith et al., 2018; Gbolahan Balogun, 2019; Masic, 2008).

The successful use of 3D animation has been previously described for the teaching of veterinary surgery (Asma & Eddine, 2014), management of ruptures of cranial cruciate ligament of dogs (Clements et al., 2013), and obstetric learning of dystocia (difficult parturition) of horses (Gao et al., 2020). The learning deficiencies in clinical courses such as Medicine, Surgery, and Theriogenology may be minimised by attaching students to the convenient nearest veterinary services centres, where students can participate in managing clinically ill animals maintaining strict personal hygiene and social distance.

Demonstrating some of the veterinary medical procedures in realistic situations by providing virtual resources is also crucial to minimise the learning of clinical procedures. Previously, it was reported that medical students were more interested in the virtual microscopic laboratory for histology classes than regular microscopic laboratory (Darici et al., 2021; Harris et al., 2001). A telemedicine system of learning that involves a virtual visit to the real patient undertaking in the direct handling of clinically ill patients under the supervision of an attending veterinarian (Alsoufi et al., 2020; Makhni et al., 2020) (Figure 4) must be introduced. Recently, medical students have provided positive feedback regarding their virtual clinical experience from an emergency medicine area that has directly handled patients under the supervision of a clinician (Chandra et al., 2020).

5. Digital lectures and examinations

Online live lecture platforms, such as Microsoft Teams or Zoom, will allow lecturers and students to record the live stream and will permit students to fully engage in sessions. The chatbox and questions & answers functions (Rainbow and Dorji, 2020) and customised online Meet-Up program (Crowley-Cyr & Hevers, 2021) must be introduced in the aforementioned platforms in every veterinary medical institution for conducting lectures and examinations during this ongoing pandemic. Previously, WhatsApp was widely used by veterinary medical students in participating in online academic classes (Malhotra and Bansal, 2017). Previously, it was reported that Google Meet, WebEx, Zoom, and Microsoft Teams software were more widely used for online learning of medical students than other general students (Rashid et al., 2020). The aforementioned software, as well as Skype and Edmodo, can be introduced for conducting online classes of veterinary medical students based on students' preferences and performance of individual software (Abbasi et al., 2020) (Figure 4). The authenticity and realism can be enhanced in the teaching-learning environment by the introduction of virtual reality apps (Tiellet et al., 2010); thus, there is the minimisation of learning gaps and effective learning from online classes.

Furthermore, effective digital lectures require hiring more technical support staff with specialised knowledge, purchasing sophisticated electronic devices, and training existing staff in using these new devices and platforms effectively (Rainbow and Dorji, 2020; Biswakarma et al., 2021; Adarkwah, 2021). The introduction of web-based theory courses are crucial during current and future pandemics to convey the core knowledge of a subject matter (Murray and Sischo, 2007). The introduction of live streaming from the laboratory to the students is crucial to minimise deficiencies of laboratory-based learning during this current pandemic. These novel methods of learning were welcomed previously by students as well as their lecturers due to conveniences and flexibility (Avila et al., 2013), but the video & image resolution and quality of description of the procedures should be better (Baran et al., 2010; Tiellet et al., 2010). Research should be undertaken to find out more effective ways of delivering lectures online (Abbasi et al., 2020).

It is essential to introduce an online examination platform to produce efficient veterinary medical graduation timely (Tapper et al., 2020; Arandjelovic et al., 2020). Previously, it was reported that the performance of examinations taught via traditional classroom lecturing and online lecturing were often similar for medical students (Pei and Wu, 2019), but prevention of disadvantages of online examination platforms such as question paper leakage is essential (Alsoufi et al., 2020). The application of monitoring software such as Proctorio and ProctorU can prevent cheating during online examinations (Biswakarma et al., 2021).

6. Development of regulatory platforms at either the Government level or institutional level

A regulatory platform is crucial to oversee the programs undertaken during this COVID-19 pandemic for the effective learning of veterinary medical students (Biswakarma et al., 2021). UNESCO formed a Global Education Coalition in supporting educational activities during the

COVID-19 pandemic (UNESCO, 2020b). The development of high-quality curricula including core theory, practical, and clinical veterinary courses are essential for conducting online-only classes during pandemics (Sherry, 1996; Childs et al., 2005; Murray and Sischo, 2007; Crawford, 2021). A paradigm shift is required for incorporating online education modalities as core components of the teaching-learning methods used in veterinary institutions (Murray and Sischo, 2007). Adequate funding from the government and other donor agencies must be ensured (Figure 4) for the continuation of the educational program during pandemics (Adarkwah, 2021).

7. Counselling

During the COVID-19 pandemic, many students are frustrated about their future. Adequate counselling to the students by an experienced clinical psychologist is essential to keep the students mentally fit regarding their future careers (Son et al., 2020; Abbasi et al., 2020; Abushammala et al., 2021) (Figure 4). Veterinary universities should work collaboratively with the respective authorities to implement measures recommended by the World Health Organization in keeping sound mental health of veterinary students (Salman et al., 2020). Motivation should be given to less proactive students to self-learning to minimise learning gaps during current and future pandemics (Biswakarma et al., 2021; Alghamdi, 2021).

Conclusions

This study explored the impact of COVID-19 pandemic on veterinary medical education. Findings revealed that the SARS-CoV-2 infection has a severe impact on the veterinary medical education system. It might be possible to conduct teaching-learning of veterinary medical education programs using an online system, but the supply of uninterrupted internet, necessary electronic devices, institutional support to students and teaching staff, and motivation to students in self-learning are crucial for conducting online-only classes. Attachment of veterinary medical students to the convenient nearest veterinary services centres and effective collaboration between veterinary educational institutes and veterinary services centres are essential to minimise the learning deficiencies of students in most clinically oriented veterinary courses. All of these approaches can provide a strong foundation for interactive learning of veterinary medical courses from which veterinary medical students and teaching staff can propel themselves forward.

Limitations and suggestions for further research

Due to the scarcity of research work about the impact of the COVID-19 pandemic on veterinary medical education, we have selected some of the works from human medical education. The teaching-learning systems of veterinary medical education is different from human medical education in many aspects, but we believe scientific papers from human medical education about the impact of COVID-19 pandemic provide a broader, initial understanding of the teaching-learning to veterinary medical students, and lay the groundwork for more conclusive future studies.

Recommendations and suggestions for future works were threaded throughout the discussion. Considering the negative impact of the present COVID-19 pandemic on veterinary medical education as a catalyst, research and subsequent development of sustainable effective methods and technologies for remote teaching veterinary medical students during future pandemics are crucial. Emphasis should be given to developing effective methods of delivering veterinary practical and clinical courses remotely. The developed remote teaching tools, in future, could support students when they are sick or unable to attend classes in person. Development of a new learning pattern or reshaping of a veterinary medical curriculum for continuous situated learning opportunities for the students with simultaneous avoidance of difficulties during current and future pandemics are essential. We hope that the findings and recommendations of this paper will become a valuable tool for all those engaged in veterinary medical education.

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Ethics clearance

Not applicable.

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