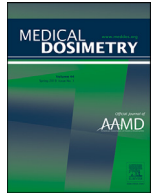




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The Impact of COVID-19 on Medical Dosimetry Education: Students' Perception on the Effectiveness of Program's Immediate Response[☆]

Mahsa Dehghanpour, Ed.D., M.S., C.M.D., Jamie Baker, Ph.D., M.Ed., C.M.D.*

Medical Dosimetry Program, The University of Texas MD Anderson Cancer Center, School of Health Professions, Houston, TX 77030, USA

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ABSTRACT

In early 2020, many medical dosimetry programs began to offer lectures and clinical rotations remotely in response to COVID-19. Faculty instituted an IRB-approved study to investigate the effectiveness of medical dosimetry educational programs' immediate response to COVID-19 and modifications to teaching practices during the pandemic. The Program Response to COVID-19 Effectiveness Questionnaire (PRCEQ) survey was developed to measure students' perceptions of their learning experience during COVID-19. The subject of the study was the medical dosimetry current and former student population who received modified education delivery during the COVID-19 pandemic. This study suggests that generally students are satisfied with the quality of their virtual didactic and clinical education as well as communication between faculty and students and students to students. Programs should develop strategies to engage students during the virtual classes to motivate them to learn; utilize a variety of formats for the evaluation of students' learning, incorporate activities to help students make connections with real-world clinical situations, and schedule clinical visits for students to learn tasks that require their physical presence in clinic.

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Medical Dosimetry educational programs include didactic and clinical education. During their education, medical dosimetry students gain knowledge in radiation physics, cross sectional anatomy, radiation biology, and other science-related disciplines to apply in their clinical rotations. The COVID-19 pandemic impacted the United States in early 2020, and many universities began offering their curriculum remotely. Many medical dosimetry programs started to offer didactic and/or clinical education online in response to the COVID-19 pandemic. The purpose of this IRB-approved study is to identify students' perceptions of the effectiveness of their medical dosimetry programs' responses to COVID-19 and to discuss potential strategies to improve didactic and clinical education as well as communication among students and between students and faculty in medical dosimetry education when the modified education delivery is utilized.

The Program Response to COVID-19 Effectiveness Questionnaire (PRCEQ) measures students' perceptions of their learning experience during the COVID-19 pandemic. The subject of the study is

the medical dosimetry current and former student population who received modified education delivery due to the COVID-19 pandemic. The PRCEQ questionnaire measures the students' assessment of 1) instructional quality in didactic education; 2) instructional quality in clinical education; 3) opportunities for and quality of interaction with faculty; 4) opportunities for and quality of interaction with peers; and 5) aspects of the medical dosimetry education and communication that have been particularly positive or negative and suggestions for improvement.

Literature Review and Research Questions

COVID-19 forced universities to pivot from a traditional or hybrid format to a strictly online method to deliver didactic content and laboratory activities. The abrupt move to online instruction has resulted in increased costs and decreased revenue sources.¹ COVID-19 challenges higher education administrators and faculty to maintain normal operations while adjusting to novel demands concerning admissions, campus safety, and online learning.² In addition to the administrative burden on university leadership, classroom and clinical instructors interact with students who are impacted emotionally and psychologically by the ill effects of COVID-19.³

The response of higher education institutions to COVID-19 included a rapid shift to online teaching, and colleges and universities dealt with the changes in varying ways. Quinn *et al.* investi-

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* Reprint requests to: Jamie Baker, Ph.D., M.Ed., C.M.D., Medical Dosimetry Program, The University of Texas MD Anderson Cancer Center, School of Health Professions, 1515 Holcombe Blvd, Unit 2, Houston, TX 77030, USA.

E-mail address: jabaker@mdanderson.org (J. Baker).

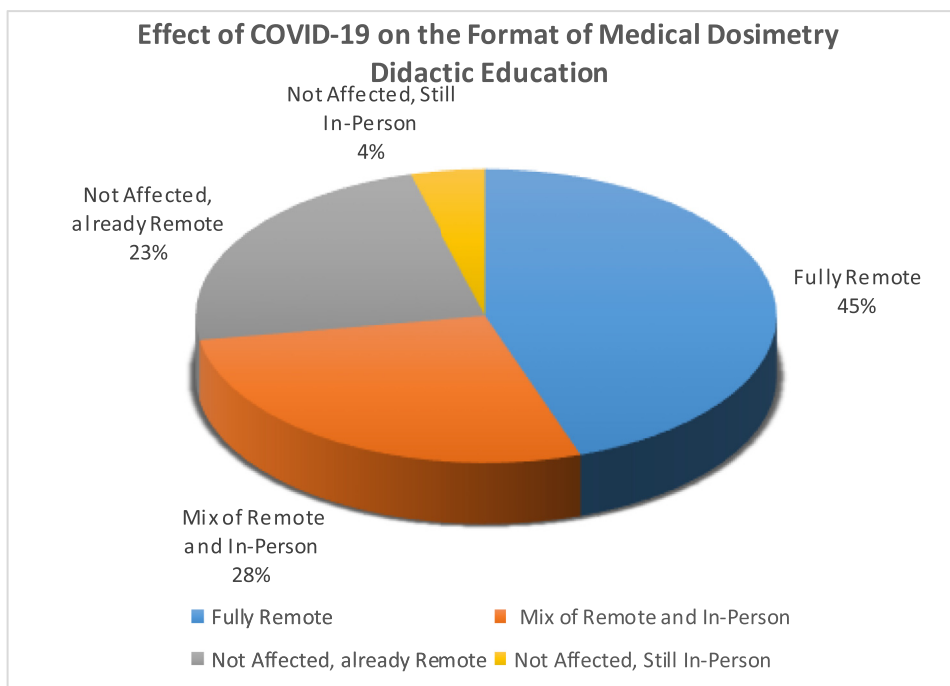


Fig. 1. Effect of COVID-19 on the Format of Medical Dosimetry Didactic Education. Color version of figure is available online.

gated the immediate response of European dental universities to COVID-19.⁴ Clinical activities of dental students were sharply curtailed during 2020, and classes were moved to online.⁴ Rajhans *et al.* studied how the system of optometry higher education has responded to disruptions caused by COVID-19.⁵ 73 of 78 surveyed optometry educators in India noted a switch to online learning. They used a variety of video conferencing platforms, learning management systems, and social media applications to communicate with their students.

Research questions included: 1) What are the perceptions of the students who experienced modified educational delivery during the COVID-19 pandemic? 2) What strategies can improve didactic and clinical education as well as communication when the modified education delivery is utilized due to the COVID-19 pandemic?

Methodology

Program Response to COVID-19 Effectiveness Questionnaire (PRCEQ)

This study used a descriptive survey research design to identify students' perceptions of the effectiveness of medical dosimetry program responses to COVID-19 and to explore potential strategies to improve didactic and clinical education as well as communication among students and between students and faculty in medical dosimetry education. The original survey instrument was called the Program Response to COVID-19 Effectiveness Questionnaire (PRCEQ) and contained three demographic, 18 Likert-scale, and six open-ended questions and was used to collect the data for this study. All collected data were anonymous and confidential. The data were aggregated, and individual medical dosimetry educational programs cannot be tied to a specific result.

The PRCEQ survey instrument measured the students' assessment of 1) instructional quality in didactic education; 2) instructional quality in clinical education; 3) opportunities for and quality of interaction with faculty; 4) opportunities for and quality of interaction with peers; and 5) aspects of the medical dosimetry education and communication that have been particularly positive or negative and suggestions for improvement.

Upon IRB approval, the researchers piloted the survey instrument to receive feedback regarding any problematic areas or suggestions for improvement. The pilot participants were acquired by sending an email to all current medical dosimetry senior students in the medical dosimetry program at the University of Texas MD Anderson Cancer Center, School of Health Professions with a link to the pilot survey on Qualtrics. The pilot participants were instructed that their participation was voluntary and that the researcher was wanting their feedback to improve the sur-

Table 1

Distribution of responses from medical dosimetry educational programs

School	Graduate Responses
University of Texas Health Science Center at San Antonio	5
University of Maryland Medical Center	4
Thomas Jefferson University	1
The University of Texas MD Anderson Cancer Center	23
Suffolk University	3
SUNY at Stony Brook University	7
Grand Valley State University	4
Bellevue College	4
Totals	51

vey instrument. To promote anonymity, the pilot survey contained an open-ended question at the end of the survey for the participants to provide their feedback and suggestions.

Study Sample

The sample for this study included current or former students of JRCERT-accredited medical dosimetry programs who experienced a modified education delivery since March 2020 due to COVID-19 pandemic. The Joint Review Committee on Education in Radiologic Technology (JRCERT) is the only agency for accreditation of educational programs in medical dosimetry. After the pilot survey was completed and the PRCEQ was finalized, an email was sent to all JRCERT-accredited medical dosimetry program directors with a link to the survey on Qualtrics. The researchers asked the program directors to forward that email to all of their students and former students who have been studying in the medical dosimetry program since March 2020. An estimated 135 current and former students of JRCERT-accredited medical dosimetry programs who studied in the program since March 2020 were invited to complete the survey. The emailed invitation contained the purpose of the study, informed consent disclosure, and a link to the survey. After reading the informed consent disclosure, the participants could decide if they wanted to complete the survey by clicking on the link in the email. When the survey opened, the participants also had to select "yes" to begin the survey. If the participants clicked "no," the survey would close.

The survey link was active for one month, and after that time period, the survey was closed. Results were exported from Qualtrics to Excel, and the quantitative data were analyzed. The qualitative written responses were evaluated to identify patterns and themes. The raw data and output tables are stored on a password-protected institutional computer and can only be accessed by the investigators. All data is stored behind the institutional firewall. The data were aggregated, and results are reported in a manner that no medical dosimetry program can be tied to a specific result.

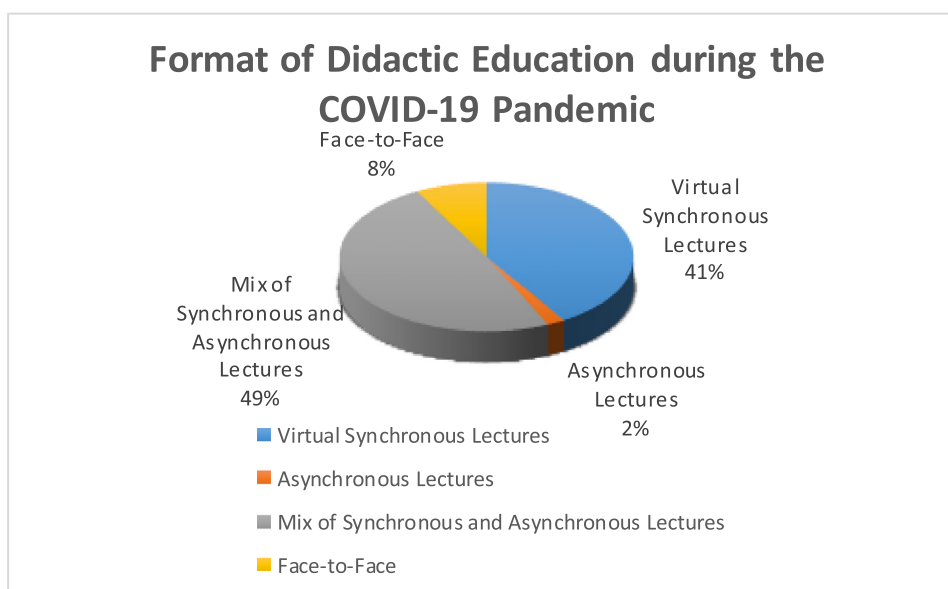


Fig. 2. Format of Didactic Education During the COVID-19 Pandemic. Color version of figure is available online.

Table 2
Distribution of credentials

Degrees	Number/Percentage
Master of Science Degree	6/11.76%
Bachelor Degree	28/54.90%
Certificate	17/33.33%
Totals	51/100%

Table 3
Respondents' satisfaction level with didactic education delivery and learning

Didactic Education	Satisfied	Unsatisfied
What is the level of your satisfaction with your program's immediate response to COVID-19 in terms of your didactic education?	96.08%	3.92%
What is your level of your satisfaction with learning didactic material in a new format during the pandemic?	80.39%	5.88%

Results

Eight out of 17 JRCERT-accredited medical dosimetry programs participated in this study. The program directors sent the survey questionnaire to a total of 135 students and graduates who received their education during the pandemic. The Qualtrics system received 51 responses from January 11 to February 12, 2021. Responses with at least one answer to the 27 items were considered valid. There were 51 valid responses that were included in the data analysis, which demonstrates a 37.8% response rate for the survey. The distribution of credentials among respondents included 33% certificate, 55% Bachelor of Science or Bachelor of Arts, and 12% Master of Science. The respondents included 31% male and 65% female. 4% of the respondents preferred not to answer the question concerning gender.

Didactic Education

The first category in the PRCEQ survey involved medical dosimetry students' and graduates' perceptions about their medical dosimetry program's response to COVID-19 as it relates to their didactic education. A total of 73% of respondents indicated that their didactic education was affected during the pandemic and became either fully remote (45%) or a mix of remote and in person (28%). A total of 27% of respondents indicated that their didactic education was not affected because they were already offered remotely (23%) or continued to be face-to-face (4%).

The participants' responses about their satisfaction with their didactic education were divided into "satisfied" and "unsatisfied." The responses of "very satisfied" and "satisfied" were coded as "satisfied," while the answer choices of "unsatisfied" and "very unsatisfied" were interpreted as "unsatisfied." A total of 96% of respondents were satisfied with their program's response to COVID-19 in terms of didactic education, and 80% were satisfied with learning didactic material in the new delivery format.

Table 4
Distribution of positive aspects of the remote clinical education

Positive Aspects	Percent of Responses
Effective communication with mentors	11.35%
Remote access to treatment planning creating a time flexibility to practice	17.03%
Independence in learning	16.59%
Less stress due to time flexibility and no commute	13.10%
Learning new skills in communication	10.92%
Exposure to new communication technologies (e. g. Zoom, Skype, MS TEAMS, WebEx, GoToMeeting)	13.10%
Adequate resources available to me, which facilitated my learning	7.86%
Mentors giving me specific and practical information remotely that helped me improve my skills	9.17%
Others	0.87%
Total	100%

Students indicated that their programs utilized a variety of tools to facilitate didactic education including online Learning Management Systems, virtual communication platforms, Respondus Monitor, and Lock Down browser. They indicated that during the pandemic, didactic classes were conducted using virtual synchronous lectures (41%), asynchronous lectures (2%), a mix of synchronous and asynchronous (49%), and face-to-face (8%).

When asked about their learning experience during the pandemic compared to pre-pandemic, we coded the answer choices of slightly or significantly declined as "declined" and slightly or significantly improved as "improved." 49% of respondents felt that their learning experience was equivalent to pre-COVID-19 while 16% felt an improvement and 36% felt a decline.

Clinical Education

A total of 66% of respondents indicated that their clinical education was affected by the COVID-19 pandemic while 26% indicated no change. The remainder of respondents have already completed their clinical education or have not started it at the time of the survey or received their clinical education in their home hospital. A total of 41% of respondents indicated that their clinical education was offered remotely as a result of the pandemic while it was a mix of remote and in person for 25% of respondents. A total of 2% indicated that there was no change to their clinical education because it was already offered remotely and for 24%, the clinical education continued to be face-to-face.

When asked about access to a good mix of patients, problems and clinical experience during the pandemic, 61% of respondents experienced a good mix of cases while 16% did not experience that.

The most common tools used to facilitate clinical learning included treatment planning systems, online Learning Management Systems, virtual communication

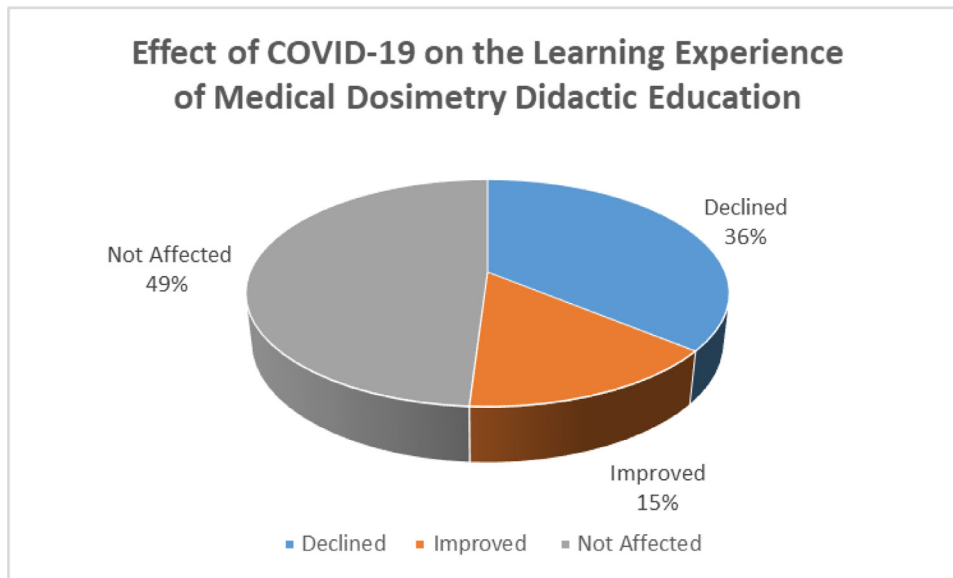


Fig. 3. Effect of COVID-19 on the Learning Experience of Medical Dosimetry Didactic Education. Color version of figure is available online.

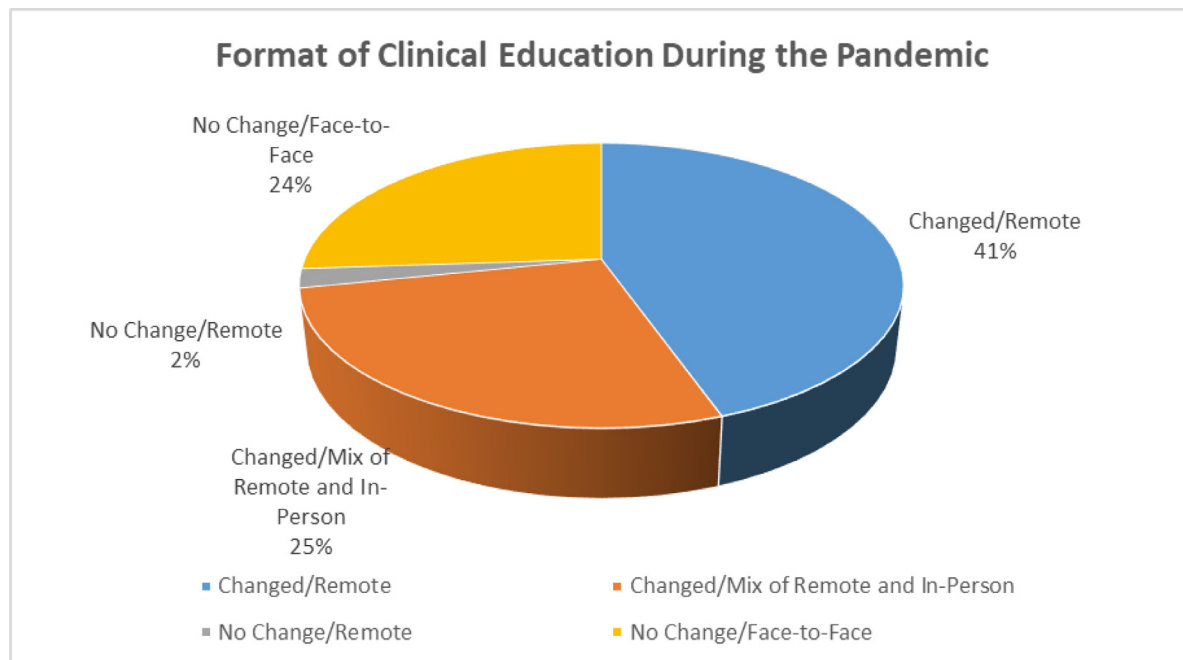


Fig. 4. Format of Clinical Education During the Pandemic. Color version of figure is available online.

platforms, Respondus Monitor, video content management systems, and Lockdown Browser.

When asked about the level of clinical learning during the pandemic compared to pre-pandemic, 51% indicated an equivalent clinical learning experience, 2% indicated an improvement and 47% indicated a decline.

When asked about the positive aspects of the remote clinical education, the top three responses were remote access to treatment planning creating a time flexibility to practice, independence in learning, and less stress due to not having to commute. When asked about the negative aspects of the remote clinical education, the top three responses were lack of interaction with radiation oncology team members except mentors, not being able to participate in all dosimetry related activities and inability to do certain tasks requiring their presence in clinic.

Communication

Faculty-Students. 98% of respondents indicated an effective communication between faculty and students. 96% indicated that the communication methods of faculty were effective to their overall education and learning environment experience.

When asked how the school faculty can improve their communication with students, the top three responses were 1) schedule one-on-one meetings between faculty and students, 2) set expectations for an effective meeting instead of a chaotic meeting, and 3) spend time to learn the virtual platform for effective use.

Students-Students. 90% of respondents indicated that peer communication was effective in their overall education and learning environment. When asked how the school faculty could improve student-to-student communication, the top three responses were 1) encourage students' communication, 2) schedule a regular communication for students, and 3) provide a platform for students' communication.

Positive and Negative Aspects of Didactic Education

Participants were asked open ended questions about the positive and negative aspects of their didactic education during the pandemic. The most cited positive aspects included time flexibility, ability to watch recorded lectures, high level of communication with peers and mentors, and reduced commute. The most cited negative aspects included internet and connectivity issues, which particularly make the test taking stressful; not being able to ask questions and clarify concepts in per-

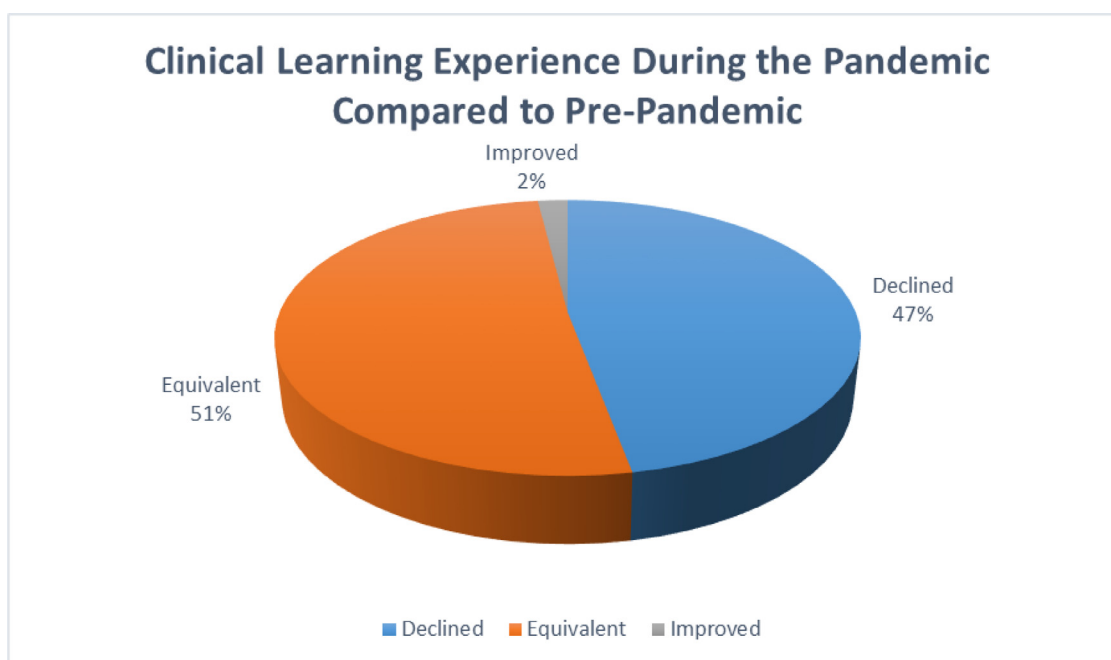


Fig. 5. Clinical Learning Experience During the Pandemic Compared to Pre-Pandemic. Color version of figure is available online.

Table 5
Distribution of negative aspects of the remote clinical education

Negative Aspects	Percent of Responses
Communication with mentors	8.06%
Access to treatment planning and other related software	3.76%
Low speed of treatment planning software affecting efficiency	10.22%
Lack of available cases due to patient volume	8.06%
Limited knowledge of clinical instructors in delivering remote clinical education	3.23%
Availability of mentors	3.76%
Inadequate evaluation and feedback	1.61%
Lack of interaction with rad-onc team members except mentors	16.13%
Inability to do certain tasks requiring presence in clinic	11.83%
Feeling like I was forgotten	5.91%
Wasting a lot of clinical time doing nothing due to lack of appropriate instruction	3.76%
Not able to participate in all dosimetry related activities	12.90%
Not being adequately prepared for my career	3.76%
Lack of personal motivation and accountability	3.23%
Others	3.76%
Total	100%

son; instructors' lack of familiarity with the virtual learning; and reduced students' personal motivation and participation in didactic classes.

Positive and Negative Aspects of Clinical Education

Participants were asked open ended questions about the positive and negative aspects of their clinical education during the pandemic. The most cited positive aspects included remote access to treatment planning software, more time to practice, working at one's own pace, learning independently, time flexibility, save time on commute, the ability to work with multiple dosimetrists, and preparation for the future remote work. The most cited negative aspects included lack of patient interaction, less clinical time, inability to perform certain clinical activities requiring a physical presence, missing out on hospital staff discussions and clinical scenarios, wasting time due to waiting for the mentors to be available to teach or answer questions, not being able to see real life examples, less likely to see rare procedures, low patient load, no "safe" space to work in a small house, lack of motivation during on-line sessions, computer issues, and not seeing the clinical environment making it difficult to relate ideas to real situations.

Table 6
Strategies to improve faculty-students communication

Strategy	Percent of Responses
Use a better virtual platform	7.69%
Make better preparation prior to the virtual meeting	10.77%
Spend time to learn the virtual platform for effective use	12.31%
Use a better organization in scheduling virtual meetings	7.69%
Setup frequent and regular virtual meetings instead of sporadic meetings	10.77%
Set expectations for an effective meeting instead of a chaotic meeting	16.92%
Prefer more one-on-one meetings with faculty and individual students	23.08%
Others	10.77%
Total	100%

Table 7
Strategies by faculty to improve communication between students

Strategy	Percent of Responses
Encourage communication	31.43%
Schedule a regular communication for students	18.57%
School faculty don't need to be involved in communication among students	11.43%
Provide a platform for students' communication	17.14%
Assign students to small groups to encourage communication	15.71%
Others	5.71%
Total	100%

Discussion

The vast majority of respondents were satisfied with their program's response to COVID-19 in terms of didactic education and were satisfied with their level of learning. However, about one-third of respondents experienced a decline in their didactic learning experience. Incorporating innovative teaching strategies improve students' learning outcomes. One strategy is to mimic a face-to-face classroom in a virtual environment by conducting synchronous lectures; utilizing webcams to visually connect with stu-

dents; engaging students during the virtual classes by asking questions; using the polling options to encourage participation; utilizing break out rooms to encourage small group discussions; and using portable document cameras to show problem solving sessions clearly to students. Furthermore, setting aside time at the end of synchronous lectures or scheduling virtual office hours for questions, utilizing a variety of evaluation formats and proctoring options such as Respondus and Lock Down Browser, and providing access to recorded presentations after each lecture are strategies to improve didactic education. These are possible only if faculty are familiar with the use of technology so it is vital that faculty spend time to fully learn these systems.

The majority of respondents experienced a remote or hybrid clinical education due to the pandemic. About half of the respondents (47%) indicated that their clinical education declined as a result of the pandemic. Programs should identify teaching strategies to improve students' clinical education. Providing remote access to treatment planning software and available mentors; scheduling an introductory meeting for students to meet their mentors at the beginning of the rotation and learn expectations; training mentors on the use of communication platforms and available tools; utilizing the screen share option of communication platforms to review cases and provide feedback; scheduling a regular time frame for students' virtual meetings with their mentors to ask questions; utilizing cameras to visually connect to students; providing alternative ways to ask for help when the mentor is not available; and utilizing the chat option of virtual platforms such as Skype for Business for quick questions are strategies that can be used. Programs should work with clinical instructors to ensure students have access to a good mix of patient and clinical cases. Furthermore, programs should consider allowing students to have some exposure to face-to-face clinical education for the procedures that require their presence in the clinic and to have interaction with members of the radiation oncology team. Scheduling students at different time frames ensures social distancing and adhering to safety guidelines.

An overwhelming number of students indicated a great level of communication between students and faculty. Some suggestions include faculty being transparent so students can prepare for what is coming, scheduling more one-on-one meetings, providing opportunities for students to communicate with therapy staff and physicians, planning for students and clinical faculty to have the same schedule and work format, scheduling optional regular study groups or office hours, creating communication standards, and scheduling daily check-ins each morning to set goals for the day and checking advancements throughout the day. To further build trust and relationship, one strategy is for faculty to introduce themselves at the beginning of the school year while utilizing webcams and share some personal information about hobbies, pets, and family as well as providing time for students to introduce themselves. Fun activities can be conducted by faculty to help students get to know each other better.

The vast majority of respondents indicated that communication was great among the students; they used MS Teams, Zoom, Group Me and other platforms. Some suggestions for improvement included providing a platform for students to communicate to one another, scheduling time for a regular communication between students, and suggesting students to communicate more. Program directors can incorporate regular students' communication time on the calendar and suggest a platform to encourage and assist students' communication. This helps students who are shy and do not regularly take part in communication with the class and is helpful

at the beginning of the school years when students do not know each other well.

Limitation

The limitation of this study is related to the sample size. About half of the medical dosimetry programs across the United States did not participate in this study (53%) and the number of students and graduates from each program who responded to the questionnaire was limited. Higher participation would have captured a richer data that could be generalized.

Conclusion

COVID-19 brought challenges to educational programs across the nation. The health sciences programs faced an additional challenge due to the clinical component of their programs. Many of the medical dosimetrists were asked to work from home and students were not allowed in clinic. Many of the medical dosimetry programs offered their education virtually by utilizing technology and providing students with remote access to treatment planning software.

This study suggests that generally students are satisfied with the quality of their virtual didactic and clinical education as well as communication between faculty and students and students to students. They found time flexibility, independence in learning, and reduced commute as benefits of their virtual education. Programs should develop strategies to engage students and to motivate them to learn and incorporate activities to help students make connections with real-world clinical situations. The future working format of medical dosimetrists may have changed forever as the result of the pandemic, which directly affect students' clinical education. Future studies are suggested to capture data during a different phase of the pandemic when the social distancing and communication guidelines are less strict due to the introduction of COVID-19 vaccination and many dosimetrists continued to work from home or in a hybrid format to determine the best strategies for clinical education of medical dosimetry students. Another suggestion for continued study would be to follow the cohort of medical dosimetry students whose education was affected by COVID-19 as they begin professional careers and draw conclusions about their preparedness for the workforce.

Figures 1-5 and Tables 1-7

Conflict of Interest

The authors whose names are listed certify that they have NO affiliations with or involvement in any organization with any financial interest in the subject matter discussed in this manuscript.

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