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In-Person Versus "Virtual" Dental Examination: Congruence Between Decision-Making Modalities

MAYSA NAMAKIAN, MPH; PAUL SUBAR, DDS, EDD; PAUL GLASSMAN, DDS, MA, MBA; ROBERT QUADE, PHD, MBA; AND MAUREEN HARRINGTON, MPH

ABSTRACT This study evaluated the agreement of a dentist's conclusions reached through an in-person versus a virtual examination. The dentist determined whether a patient was healthy enough to be treated only by allied dental personnel in a community setting or whether the patient needed to be seen by a dentist. The study concludes that a virtual examination is a strong substitute for an in-person examination and validates the application of telehealth-enabled examinations.

AUTHORS

Maysa Namakian, MPH, is program manager, Pacific Center for Special Care, Arthur A. Dugoni School of Dentistry in San Francisco.
Conflict of Interest Disclosure: None reported.

Paul Subar, DDS, EDD, is an assistant professor and director, Special Care Clinic/Hospital Dentistry Program, Arthur A. Dugoni School of Dentistry in San Francisco.
Conflict of Interest Disclosure: None reported.

Paul Glassman, DDS, MA, MBA, is professor of Dental Practice and director of Community Oral Health, and director of the Pacific Center for Special Care, Arthur A. Dugoni School of Dentistry in San Francisco.
Conflict of Interest Disclosure: None reported.

Robert Quade, PHD, MBA, is with Quade and Associates, Sacramento, Calif.
Conflict of Interest Disclosure: None reported.

Maureen Harrington, MPH, is program manager, Pacific Center for Special Care, Arthur A. Dugoni School of Dentistry in San Francisco.
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The Pacific Center for Special Care (the Center) at the University of the Pacific School of Dentistry is demonstrating a new model of care called the "virtual dental home." This model uses telehealth technology to allow dentists to review records collected by allied dental personnel in community sites and use these records to make diagnostic and treatment decisions about the best course and location of treatment for patients. A component of this model is based on the ability of dentists to use these telehealth records to make these decisions.

Telehealth technologies have been available and used in the delivery of oral health services for quite some time. An early report on the use of technology to allow collaboration between distant providers described a system in use by the U.S. Army to transmit still color images over a modem to allow periodontists to view healing after periodontal surgery without the patient having to travel long distances.[1] A series of articles in the February 2000 issue of the *Journal of the California Dental Association* recognized the potential for telehealth, but expressed significant caution about how these technologies would develop and be used.[2,3] Now the field of telehealth has expanded and matured to the point where it is widely used and the potential to enhance the delivery of health services is widely recognized.[4] In spite of the widespread use of telehealth in medicine, there are far fewer reports in the literature on the application of telehealth concepts to the delivery of oral health services. The emphasis of those reports that are available on "teledentistry" has been on

the use of these technologies as a means to share records between dentists and dental specialists or as screening tools to determine the feasibility or urgency of need for dental treatment.[5-10] However, there are a few reports in the literature that describe the use of teledentistry to facilitate geographically distributed, collaborative dental care.[11-16] Although the potential for enhancing oral health care through the use of teledentistry is just beginning, these technologies hold great promise in improving the oral health of underserved populations through fostering and facilitating geographically distributed collaborative systems of care.

The University of the Pacific School of Dentistry (Pacific) offers a full array of dental services to patients with a range of physical, medical, and psychosocial considerations, including people with special needs and older adults. The Pacific Center for Special Care (the Center) at the University of the Pacific School of Dentistry has created best-practice models of, and advocates for, improved access to dental care for anyone with a special need, including people who have difficulty maintaining good oral health or accessing oral health services because of developmental, medical, physical, or social conditions. In the study described here, the Center evaluated the agreement between the conclusions an individual dentist reached on in-person and virtual examinations about whether a patient was healthy enough to be treated only by allied dental personnel in a community setting or whether the patient needed to be seen in person by a dentist. This decision was made using a list of allowable procedures that could be performed by allied dental personnel in the community setting.

For the purposes of this study, community settings included schools, nursing homes, or residential facilities. The dentist's certainty on this decision was measured during both modalities of examination. Another factor considered was the urgency of needed dental care and if a patient needed to be seen in a dental office, how soon that visit should take place. Both examinations involved the dentist's review of digital records including medical and dental history, hard- and soft-tissue charting, photographs, and radiographs. In addition, the in-person examination included a visual examination of the patient using a mouth mirror and dental explorer. The study involved three dentists, each seeing the same cohort of patients. For this reason, the study was also able to assess agreement and differences among the dentists' decisions.

THERE ARE A FEW reports in the literature that describe the use of teledentistry to facilitate geographically distributed, collaborative dental care.

In California, registered dental hygienists in alternative practice (RDHAP), registered dental hygienists working in public health programs (RDH) and registered dental assistants (RDA) who are participating in the virtual dental home program are able to provide the following services:

- Health promotion and prevention education;
- Dental disease risk assessment;
- Preventive procedures such as application of fluoride varnish, dental sealants and for dental hygienists, dental prophylaxis and periodontal scaling;
- Placing carious teeth in a holding pattern using interim therapeutic restorations (ITR) to stabilize patients until they can be seen by a dentist for definitive care. This procedure is currently authorized under a Health Workforce Pilot Project (HWPP) being conducted by the Center and approved by the Office of Statewide Health Planning and Development (OSHPD)[17,18]; and
- Tracking and supporting the individual's need for and compliance with recommendations for additional and follow-up dental services.

Dentists' decisions about whether a patient was healthy enough to be treated only by allied dental personnel in a community setting or whether the patient needed to be seen in person by a dentist was based on the dentist being calibrated to assume for the purposes of the study that they would be working with allied dental personnel who could perform the duties listed above in the community setting.

Methodology

This study took place at the University of the Pacific's Special Care Clinic (the Clinic). IRB approval was obtained and 29 adult patients with a variety of dental, developmental, medical, and psychosocial conditions, participated as a convenience sample. Two additional patients were seen for in-person examinations, but neither was seen for a follow-up examination and were therefore not included in the study. Each patient had a series of digital records collected and entered into the dental school's electronic health record system following normal dental school routines. They then received an in-person examination from each of three study dentists in which each dentist independently made three decisions:

- Whether the patient's dental care needs could be adequately delivered in the community by an allied dental

professional performing the duties listed above as opposed to being seen in a dental office by a dentist. This was scored as a yes or no decision;

- The level of certainty the dentist felt about the decision described above. This decision was scored on a scale from 1 (not certain) to 10 (certain); and
- When a referral to a dentist's office was deemed necessary, the amount of urgency with which the patient needed to be seen was scored as a timeframe in terms of days, weeks, months or years.

The in-person examination was followed after at least three weeks by a virtual examination by each of the study dentists using the same patient's digital records. Twenty-five of the cases received a second virtual examination at least two weeks after the first virtual examination, for a total of 54 virtual exams for each study dentist. In these virtual examinations, each dentist was provided with the full set of digital records described above and was asked to make the same three decisions. Typically the records included radiographs, photographs, and charting. However, no radiographs were available for one patient due to cooperation difficulties, for either the direct or the virtual exams. Because the purpose of the study was to discover whether dentists' virtual decisions agreed with their in-person examination decisions, caution was taken to minimize the possibility of the dentists being able to link the digital records with the patients they had seen in person. Toward that end, all records were blinded, at least three weeks elapsed between each review, and the order in which the records were presented was scrambled.

Analysis was conducted for study dentists individually, comparing their in-person and virtual decisions. In addition their decisions were analyzed as a group, assessing the degree to which all three study dentists agreed.

Subjects

Thirty-one patients who were registered for an appointment at the clinic and who met the following criteria were chosen for the study:

- The patient was able to give consent to participate in the study on their own or it was possible to obtain consent for participation from their guardian/representative.
- The patient was being seen for an initial appointment at the clinic. If the patient was already a patient of the clinic and had completed their initial appointment, then the patient's records were determined to be up-to-date and the patient had not had any dental treatment since collection of the most recent records. If the records were not up-to-date, then new records were collected.
- The patient was able to cooperate for collection of minimal records, including at least extra- and intraoral photographs.

A FACULTY DENTIST supervised patient flow in the clinic and the collection of records and recruited and trained the three study dentists.

Of the 31 patients who met these criteria, 29 finished the protocol and had an in-person examination and either one or two virtual examinations. Of these 31 patients, 14 were female and 17 were male. The patients ranged from 20 to 68 years of age with a mean age of 47. The patients had a variety of medical, developmental, and psychological conditions such as intellectual disabilities, cerebral palsy, Down syndrome, autism, seizures, HIV disease, liver disease, neurologic disorders, stroke, and schizophrenia.

Personnel

A faculty dentist supervised patient flow in the clinic and the collection of records, and recruited and trained the three study dentists. The three study dentists were all general dentists on the faculty at Pacific. One had prior experience with special needs patients; the other two dentists had been in general private practice for several decades. Each dentist devoted one day per week to the study over the course of eight months (April to December 2010). Dental faculty members and dental students were engaged in collecting patient records following normal dental school routines. A registered dental assistant (RDA) recruited patients for the study, managed patient flow, collected digital intra- and extraoral photographs, and interfaced with the study dentists. The center's staff supervised the study and participants, analyzed data, and worked with an evaluation consultant to evaluate the data collected in the study.

Training

The Clinic faculty and staff reviewed the study protocols before the onset of the project. Detailed training for the study was provided to the RDA and the study dentists. The RDA received the following training:

- Use of the intraoral camera;
- Review of the clinic's electronic health record system (Axium);
- Review of the patient database and how and where to collect data; and
- Review of protocols, consent forms, evaluation questionnaire, and the system for setting up appointments with the three study dentists involved in the project.

The study dentists received the following training:

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- Overview of the project;
- Description of dental services that can be provided in community settings by dental hygienists as described in the background section above;
- Review of the protocols for the study;
- Review of examination technique;
- Review of criteria for placement of interim therapeutic restorations (ITR);
- Use of the study evaluation questionnaire;
- Calibration on decision-making considering the scope of duties described above using case study examples; and
- Practice completing the evaluation questionnaire, and discussion of decision-making process and deviations among the dentists.

Patient Records

The faculty dentist or dental students collected a set of digital records including radiographs, charting, and medical and dental history and entered them into the school's electronic health record system as a normal part of patient intake. To complete patient records, the study RDA used the study laptop computer to capture extra- and intraoral photographs that were not part of normal patient records. The RDA followed a standard protocol to decide which photographs to take in order to depict the facial and lingual surfaces of anterior teeth, the occlusal surfaces of posterior teeth, and to visualize any other areas of concern. Once these procedures were accomplished, the patient record was said to be complete.

Equipment

The following equipment was utilized:

- A study laptop computer with intraoral camera;
- An extraoral point-and-shoot camera; and
- The dental school's electronic health record system (Axium).

Examinations

Following collection of initial patient records and prior to any treatment being provided, each patient received an in-person clinical examination by each of the three study dentists. The clinical examination consisted of a visual examination, use of a mouth mirror and dental explorer, and palpation if needed. Periodontal probing, which had previously been completed, was not redone. Instead, the study dentists relied on the probing records already in the dental school's electronic health record system. Following the in-person examination of each patient, the study dentists completed an evaluation questionnaire (**FIGURE 1**). The questionnaire results were entered onto a spreadsheet by the RDA.

WITH THREE dentists reviewing each examination, there were a total of 162 virtual examinations.

In addition to the in-person examination, each patient had one or two virtual examinations. The virtual examination involved a dentist's review of the patient's digital records. Each study dentist independently conducted a virtual examination at least three weeks after the initial in-person examination. In this step, the study dentists reviewed the digital records and then completed the same evaluation questionnaire. The virtual examination was conducted twice for 25 patients, with at least three weeks between each such exam. The RDA once again entered the data from the evaluation questionnaire into the data spreadsheet.

Examination times in minutes were recorded for each study dentist in both in-person and virtual exams.

Findings

Findings are presented for individual dentists, comparing each dentist's decisions following in-person and virtual examinations (intradentist findings), and for all three dentists compared to one another (interdentist findings). Of the 29 patients who completed the study protocol, 25 had an in-person examination plus two virtual examinations. Four patients had an in-person examination and one virtual examination. With three dentists reviewing each examination, there were a total of 162 virtual examinations.

Intradentist Findings:

Agreement Between In-Person and Virtual Examinations

In 87.0 percent of all virtual examinations, 141 out of 162 virtual examinations for 29 patients, the study dentist's judgment in the virtual exam about whether the patient could be treated in the community or required a visit to a dental office matched that same dentist's judgment in the in-person examination for that case. **TABLE 1** shows the agreement between in-person and virtual examinations in the 25 cases for which there were two virtual exams conducted by each study dentist. Dentist A had the greatest congruence between judgments based on in-person and virtual exams, with judgments from both virtual examinations matching the judgments from the in-person exam for 22 of the 25 cases. Dentist B and Dentist C, had

Virtual Dental Home Demonstration Project
Decisions Congruence Study Patient Evaluation

Date:_____

Reviewing dentist's name:_____

Study ID:_____

Amount of time spent on examination (minutes): _____

1. The following evaluation is based on
   ❑ In-person exam + digital records ❑ Digital records only
2. At this point, is it appropriate for the patient to be seen only in the community setting (as opposed to being seen in a dental office)?
   ❑ Yes ❑ No
3. How certain are you about your decision in question 2? (circle appropriate answer)

   0 1 2 3 4 5 6 7 8 9 10

   Not certain at all — Comfortable — Absolutely certain
4. How urgent is it for the patient to be seen in a dental office?
   ❑ Patient should be seen in the next few days
   ❑ Patient should be seen in the next few weeks
   ❑ Patient should be seen in the next few months
   ❑ Patient should be seen within the year
   ❑ Patient does not need to be seen in a dental office – they can be seen again by a dentist in the future through a virtual consultation/examination
5. Please answer the following questions about the digital records you reviewed:
   a. Were X-rays available for review?
      ❑ Yes ❑ No
   b. How complete was the dental charting?
      ❑ Not present ❑ Partially completed ❑ Fully completed
   c. Rate the quality of the virtual records as a basis for decision-making
      ❑ Excellent
      ❑ Good
      ❑ Adequate
      ❑ Insufficient for full interpretation (explain in comments section)
      ❑ Insufficient for any interpretation (explain in comments section)
6. Assuming that the patient can cooperate, could any ITRs be placed based on the study ITR criteria?
   ❑ Yes ❑ No
   a. If **yes**, list the teeth number(s) where ITRs could be placed:_____
7. Comments (use other side if needed):

FIGURE 1. Evaluation questionnaire completed by the dentist after each in-person and virtual examination

judgments from both virtual examinations matching the judgments from the in-person exam for 19 of the 25 cases.

Although all dentists had high agreement between the in-person examination and the virtual examinations, ranging from 76 percent agreement to 88 percent, not all the dentists came to the same conclusion on the second virtual exam as on the first. Dentist B, in particular, was more likely to have inconsistent conclusions from the two virtual exams. In each of the six cases in which Dentist B's findings in the virtual exam differed from those of the in-person examination, that dentist's conclusions in the virtual examinations differed from one another. This was true for only one case reviewed by Dentist A and two cases reviewed by Dentist C.

In the 25 cases the level of agreement between the virtual and the in-person examination of the same case was the same as the agreement between the two virtual examinations, as shown by Cohen's Kappa scores testing intraobserver agreement[19] (**TABLE 2**). The combined level of agreement between observers was categorized as "substantial."

Level of Certainty

Study dentists rated how certain they were about their conclusions. They were slightly more certain about the conclusions they reached on the in-person examination (mean certainty = 8.70 out of 10.0; SD = 1.5) than they were on virtual exams (mean certainty = 8.06 out of 10.0; SD = 1.4). The means of the certainty measures were significantly different, with a p-value <.0008 using a two-tailed t-test on the difference between means. Uncertainty came from not being as used to making decisions based on virtual records and from the fact that in a number of cases there was no clear-cut "correct" answer.

Conservatism

Both Dentist A and Dentist C judged that the patient could be seen in the community in 70.4 percent of the virtual case reviews. However, Dentist C's conclusions based on the virtual exam were more conservative than on the in-person exam (70.4 percent versus 75.9 percent in the in-person exam), whereas Dentist A's conclusions between in-person and virtual exams were more often the same and were slightly more conservative in the in-person exam (70.4 percent versus 69.0 percent in the in-person exam). Dentist B was generally conservative in both modalities, judging that community care was appropriate in only 55.2 percent of the in-person exams and 59.3 percent of the virtual exams (**FIGURE 2**).

Time Spent per Patient

The in-person examinations were accomplished in a mean of 4.20 minutes per case [SD = 1.6]. The mean for virtual examinations was 2.83 minutes per case [SD = 1.0]. The means were significantly different, with a p-value of 8.60*10-15 using a two-tailed t-test on the difference between means assuming equal variances. On average, the virtual examinations saved 1.37 minutes per case (32.8 percent of in-person exam time), and if a dentist were to work continuously, they could "see" 14 patients per hour through in-person exams or 21 patients per hour through virtual exams.

Interdentist Findings

Findings were evaluated to examine the extent to which the three study dentists' conclusions agreed with one another. Based on the in-person examinations, all three study dentists agreed that the patient could be seen in the community in 16 out of the 29 cases (55.2 percent), and all three dentists

TABLE 1

Virtual Examination Agreement With In-Person Examination (Virtual Case Count)

	Dentist A	Dentist B	Dentist C
Both virtual examinations agree with in-person examination	22	19	19
One virtual examination agrees with in-person examination	2	6	4
Neither virtual examination agrees with in-person examination	1	0	2

TABLE 2

Intra-Observer Agreement

	Dentist A	Dentist B	Dentist C	Combined
Cohen's Kappa[19]	0.80	0.50	0.61	
Agreement (based on Landis and Koch guidelines)[20]	Substantial	Moderate	Substantial	Substantial

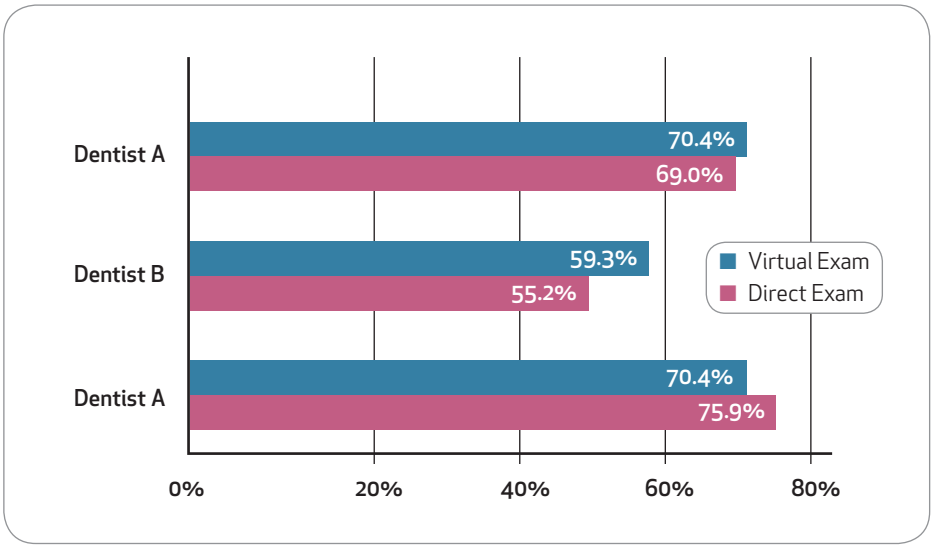

FIGURE 2. Proportion of cases in which dentist judged patient could be seen in the community.

TABLE 3

Decisions About Whether This Patient Can Be Seen in the Community (Based On In-Person Examination)

Finding	Count	Proportion
All three dentists say "yes"	16	55.2%
Two dentists say "yes"	3	10.3%
Only one dentist says "yes"	4	13.8%
All three dentists say "no"	6	20.7%

TABLE 4

In-Person and Virtual Agreement That the Patient Can or Cannot Be Seen in the Community

Finding	Count	Proportion
All three dentists agree on in-person exam	22 cases/ 66 exams	100%
All three dentists agree on virtual exam	22 cases/ 132 virtual exams	92.9%

TABLE 5

Intra-Observer Agreement

	Dentist A	Dentist B	Dentist C	Combined
Cohen's Kappa	0.82	0.73	0.56	0.71
Agreement	Substantial	Moderate	Substantial	Substantial

TABLE 6

Validity Measures for All Cases

Statistical Measure	Dentist A	Dentist B	Dentist C	Combined
Specificity[a]	94.7% [88.8-100.7%]	90.6% [82.9-98.4%]	81.6% [71.2%-91.9%]	88.9% [84.0-93.7%]
Sensitivity[b]	87.5% [78.7-96.3%]	81.8% [71.5-92.1%]	81.3% 70.8-91.7	83.3% 77.6-89.1
Positive Predictive Value[c]	94.7% [88.8-100.7%]	87.9% [79.2-96.6%]	91.4% [83.6-98.7%]	91.4% [87.1-95.7%]
Negative Predictive Value[d]	87.5% [78.7-96.3%]	85.7% [76.4-95.0%]	65.0% [52.3-77.7%]	78.9% [72.7-85.2%]

a=Correct judgment that the patient can be treated in the community.
b=Correct judgment that the patient cannot be treated in the community.
c= Proportion of patients correctly identified in the virtual exam as having a dental condition that requires the patient travel to dental facilities for treatment.
d=Proportion of patients correctly identified in the virtual exam as not having a dental condition that requires the patient travel to dental facilities for treatment.

agreed that the patient could not be seen in the community in another six cases (20.7 percent.) The three dentists did not all agree in the remaining seven cases (24.1 percent) (TABLE 3).

In the 22 cases in which all three dentists reached the same conclusion in the in-person examination, 92.9 percent of the combined judgments from the virtual exams matched those conclusions. More than half of the disagreements (five of nine disagreements) occurred on a single case (TABLE 4).

Cohen's Kappa scores were calculated to test agreement among all three dentists (TABLE 5).

Validity tests, including specificity and sensitivity, and positive and negative predictive values, were conducted for all cases whether or not the three dentists reached the same judgment in the in-person exam. In these tests, the combined specificity and sensitivity scores exceeded the standard test accuracy threshold of 160 for all study dentists, both individually and combined. Positive and negative predictive values also documented validity (TABLE 6).

Discussion

The results of this study make clear that a dentist can make a valid judgment about whether a patient can be treated in the community or should be seen in a dental office based solely on a virtual exam from complete records provided by allied dental personnel in the field. Based on patient information collected in the field that includes intra- and extraoral radiographs, photographs, and charting collected by an RDA, a dentist can, with a great degree of certainty, decide on the best next action for that patient. In this study, individual dentists were consistent in their decisions about a specific patient whether the examination was in-person or virtual. Validity tests underscored that the virtual exam is a strong substitute for an in-person exam.

Moreover, there was agreement across dentists about the next best step for each patient. In more than three-fourths of cases, the three study dentists reached the same conclusion in the in-person examination on whether the patient could be seen in the community, and the findings in the virtual examination matched that agreement in the large majority of cases. Most of the disagreement occurred in a single case, and for that case all the study dentists felt that more information was necessary. This study environment was actually more difficult for the dentists than these decisions would be in an actual field environment. In the field, a dentist conducting a virtual exam would have the option of asking for additional information or talking over the findings with the allied dental personnel who collected the records, thus reducing the likelihood of such disagreements in practice.

The most important finding to come out of this study is that the exam modality (in-person or virtual) does not appear to affect a dentist's judgment about whether a patient can be treated in the community under the circumstances described for this

study. The investigation was designed with the knowledge there would be some cases in which all three dentists would reach a clear decision about whether the patient needed treatment in dental facilities, but there would be other cases in which different dentists might reach different conclusions. This assumption was borne out by the study. Those cases in which the study dentists reached the same conclusions were also clear enough that there were good to excellent measures of agreement between the two modalities using any measure of validity. Even when the cases in which all dentists did not agree were included, there was still good to excellent agreement between the modalities of in-person and virtual examination for individual dentists. The high levels of validity for each dentist's judgments on each case show that the conclusions a dentist reaches on a virtual exam are unlikely to differ from that dentist's conclusions on an in-person exam.

Although the dentists generally expressed lower certainty about the conclusions they reached from virtual examinations than from the in-person exams, that lower certainty might be attributed either to less information available for the decision or to the dentists being out of their "comfort zones" using an approach that was new to them. High levels of certainty did not correlate with an expectation that other dentists would reach the same conclusion, as some of the cases in which the dentists did not reach the same conclusion nonetheless had high confidence scores.

Where dentists' conclusions do not agree with each other from in-person exams, as happened with fewer than one-fourth of the cases in this study, one should expect, in fact, a lack of agreement between the virtual and in-person examination for those patients, particularly if the source of the ambiguity is the existence of multiple legitimate interpretations of the case.

Implications for Practice

Considering the application of these findings in the field, there will undoubtedly be dentists who tend to be more conservative in their interpretation of virtual examinations. Additional training may mitigate this tendency and/or refined protocols for the virtual exam that may, among other things, strengthen the information gathering for the virtual examinations.

One of the major benefits of being able to rely confidently on virtual examinations to answer the question of whether a patient can be treated in the community is that virtual examinations offer potential time savings to dentists and patients. The time savings for dentists can be important in helping to address a shortage of dentists willing to serve underserved and vulnerable patients. However, the greatest time savings will accrue to those patients and their caregivers who are spared a visit to dental facilities through these examinations. Given that two-thirds of the examinations, both virtual and in-person, conducted on patients in this study found that the patient had conditions that could be adequately treated in the community, enormous time savings can be anticipated as virtual examinations become integrated into patient care.

THE CONCLUSIONS a dentist reaches on a virtual exam are unlikely to differ from that dentist's conclusions on an in-person exam.

Another major benefit of the virtual examination is the ability for dentists to evaluate and make decisions about individuals who do not traditionally visit dental offices and clinics. The ability to reach these individuals, make decisions about the best course of treatment, and increase the likelihood that that treatment will be carried out has the potential for tremendous improvements in oral health of these individuals.

The results of this study set the stage for new kinds of delivery systems, where dentists do not need to be physically present in order to make diagnostic and treatment decisions, decide the best course of action for a particular patient, and provide general supervision for activities carried out in community settings. The use of this application of telehealth to dental care has the potential to increase access to dental care while reducing the amount of time a dentist needs to make a judgment about the need for a patient to be seen in dental facilities.

Recent legislation in California, AB 415 recognizes that technology has evolved to be a useful tool in several fields for expanding access to health care.[20,21] However, regulatory barriers and reimbursement issues still need to be addressed in dentistry as in other fields as the movement toward telehealth advances. These new tools and increasingly proven modalities are not just substitutes for the existing paradigm, they provide significant advantages in terms of distribution of professional labor, costs of care, and increased access for underserved populations. ■■■■

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TO REQUEST A PRINTED COPY OF THIS ARTICLE, PLEASE CONTACT
Maysa Namakian, MPH, Pacific Center for Special Care, University of the Pacific Arthur A. Dugoni School of Dentistry, 2155 Webster St., San Francisco, Calif., 94115.