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Collegiate Athletic Trainers' Perceived and Actual Knowledge of Therapeutic Ultrasound Concepts

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Context: Therapeutic ultrasound is a widely used modality, however, little is known about the knowledge level of athletic trainers regarding therapeutic ultrasound. **Objective:** To examine athletic trainers' perceived and actual knowledge of therapeutic ultrasound concepts. **Design:** Cross-sectional. **Setting:** Web-based. **Patients or Other Participants:** Randomly selected collegiate athletic trainers (35.55 ± 8.86 years). **Intervention:** The questionnaire included: Likert scale questions regarding perceived knowledge of the educational competencies related to therapeutic ultrasound; actual knowledge questions regarding theory/textbook validated knowledge; frequency of use questions; and demographics. **Main Outcome Measures:** Correlations. **Results:** Athletic trainers in collegiate settings reported fairly high confidence in their knowledge of the application-related therapeutic ultrasound competencies. Athletic trainers reported less confidence in their knowledge of the theory-related competencies. The actual knowledge mean score was 15.50 ± 2.88 out of 22 possible points. The 13 questions that were answered correctly by less than 75% of the participants related to insufficient parameters, safety concerns, and theory/book knowledge. Weak to moderate positive relationships were found between actual knowledge scores and perceived knowledge scores, age group, and number of therapeutic modalities courses taken. Weak to moderate positive relationships were found between perceived knowledge scores and both age group and number of courses taken. **Conclusions:** Athletic trainers were more confident with application-based questions than they were with theory-based questions. Though overall confidence in their knowledge of therapeutic ultrasound concepts was high, actual knowledge scores were relatively poor. Actual knowledge scores were higher in older age groups and in those who had taken more therapeutic modalities courses. The use of inadequate intensities and inadequate treatment durations, as outlined by Draper in 1998, were still seen. While a self-assessment tool may be helpful for some, this study suggests that more research is needed regarding whether athletic trainers have an accurate understanding of their need for continuing education in this area.

Ultrasound is a popular therapeutic modality that has been used to treat orthopedic conditions since the 1950s.[1–4] The clinical application of therapeutic ultrasound has evolved over the past several decades, from being used exclusively as a thermal modality to being employed for its nonthermal effects, particularly in tissue repair and wound healing.[5,6] Correct application of therapeutic ultrasound can aid in the treatment of musculoskeletal injuries, whereas incorrect application may reduce the desired physiological effects or even cause harm to the patient.[7] Despite its widespread use, little is known about the perceived and actual knowledge level of athletic trainers regarding therapeutic ultrasound. Armijo-Olivo et al. investigated the beliefs and sources of knowledge of therapeutic ultrasound of Canadian physical therapists, but no such study has

Key Points

- Collegiate athletic trainers were confident in their knowledge regarding therapeutic ultrasound concepts.
- Higher confidence was reported for application questions versus theory questions.
- Though perceived confidence was high, actual knowledge scores were fairly low.
- Respondents in an older age group and respondents who had taken more therapeutic modalities courses tended to have higher actual knowledge scores.
- The use of inadequate intensities and inadequate treatment durations were seen.

been performed to date regarding athletic trainers.[5]

Athletic trainers have met a minimum standard of therapeutic modalities knowledge by graduating with a degree in athletic training and passing a certification examination; however, the retention of knowledge by athletic trainers once they become certified is unclear. A literature search uncovered no studies that analyzed athletic trainers' retention of knowledge postcertification. However, a review of literature in other health care professions found that knowledge and skill related to emergency care begins to decline within six months to one year after training.[8] Furthermore, early athletic training curricula relied less on a set coursework and more on a demanding clinical component for the attainment of knowledge and skills.[9] While the fifth edition of *Athletic Training Educational Competencies*[10] contains nine competencies/proficiencies that directly apply to the theory, application, and intended outcomes of therapeutic ultrasound, these requirements have not always been in place, and many athletic trainers graduated and passed their certification examination before the current understanding of modern therapeutic ultrasound principles. While the Board of Certification (BOC) requires athletic trainers to participate in continuing education, it does not currently require athletic trainers to provide evidence that they have current knowledge in any specific subject other than emergency cardiac care.[11] Therefore, it is important to understand the level of knowledge regarding therapeutic ultrasound concepts among athletic trainers.

Procedures and Findings

We recruited participants by requesting the e-mail contact information for a random sample of 1,000 athletic trainers through the National Athletic Trainers' Association (NATA) research survey service. Selected individuals were required to be employed athletic trainers (any setting), certified, not retired, and from the United States. The research proposal was evaluated and approved as exempt from regulation by the researchers' university institutional review board (IRB). Participants were informed of the study's purpose and their completion of the questionnaire served as their consent to participate.

An electronic mail message was sent that invited participants to complete a questionnaire via a hyperlink to SurveyMonkey/Audience (http://www.surveymonkey.com/mp/audience/). The recruitment message contained information about the researchers, purpose of the study, selection process, nature of the questionnaire, and IRB information. We sent two follow-up emails, one month and two months after the original request.

The perceived knowledge items included all of the therapeutic intervention (TI) competencies related to therapeutic ultrasound that were contained in the fifth edition of *Athletic Training Educational Competencies*.[10] The competencies are required elements of any current athletic training professional degree program curriculum, and the intent was to determine how confident currently practicing athletic trainers felt with those same competencies. Participants were given the stem of "I feel confident in my knowledge and understanding of, and am able to…" and then asked to choose from "strongly agree" (4), "agree" (3), "disagree" (2), "strongly disagree" (1), or "cannot determine" (2.5).

The actual knowledge section was created using the results from a review of literature that revealed common misconceptions regarding therapeutic ultrasound.[7] This section was designed by an instructor who had been teaching the therapeutic modalities course within a professional athletic training program for 10 years. Questions were designed to mimic an examination given to students in an athletic training program. Twenty-four preceptors and faculty at the researchers' institution were asked to complete the questionnaire and their feedback was used to increase the clarity of questions and response choices. Once this was complete, all test questions and answers were validated by using three therapeutic modalities textbooks.[12–14] If the question phrasing and answer could not be validated through all three textbooks, it was not included in the final questionnaire. The final questionnaire consisted of the following: nine Likert scale items that evaluated participants' perceived knowledge; a knowledge test

containing 12 multiple choice questions, eight true or false questions, and three clinical decision questions; six frequency of use questions; and nine demographic questions.

The results were analyzed using SPSS version 21 (IBM, Armonk, NY). Of the 1,000 athletic trainers contacted for participation, 147 (14.7%) athletic trainers responded, and 119 participants completed all four sections (n = 119, 11.9%). Of the 119, 111 were from the college setting. The very small number of participants who worked in other settings meant that the results could not be generalized to those settings. In addition, two respondents' data were excluded due to outlier data. Therefore, the data analysis only included those 109 (10.9%) participants in collegiate settings, and results can only be generalized to those settings.

There were 61 (56%) participants who reported working as an athletic trainer in a college/clinical setting, 41 (37.6%) in a college/academic setting, and 7 (6.4%) who reported working in both roles (college/split appointment). The mean participant age was 35.57 ± 8.92 years. Most respondents reported taking either one or two courses (n = 91, 83.5%) in therapeutic modalities. Participant demographic information and descriptive information for setting, age, number of therapeutic modalities courses taken, and degrees earned are presented in Table 1. Most participants

Table 1. Participant Demographics

Variable	Frequency (%)
Current setting (n = 109)	
College/university (clinical)	61 (56.0)
College/university (academic)	41 (37.6)
College/split appointment	7 (6.4)
Age (n = 108)	
20–29 years	32 (29.4)
30–39 years	48 (44.0)
40–49 years	19 (17.4)
50–59 years	9 (8.3)
Modalities courses completed (n = 108)	
None	4 (3.7)
1 course	58 (53.2)
2 courses	33 (30.3)
3 courses	11 (10.1)
4 courses	2 (1.8)
Undergraduate degree*	
Physical therapy	1
Biomechanics/kinesiology	1
Education	2
Exercise physiology/science	8
Health	4
Physical education	9
Sports medicine/athletic training (internship)	22
Athletic training (accredited)	69
Biology	2
Other	2
Master's degree*	
Biomechanics/kinesiology	8
Education	8
Exercise physiology/science	12
Health and human performance	4
Health education	9
Physical education	5
Physical therapy	2
Sports administration	12
Sports medicine/athletic training (postprofessional)	40
Athletic training (entry-level master's)	9
Health care administration	1
Public health	1
Sport law	1
No master's degree	5
Doctoral degree (n = 40)	
Biomechanics	2
Curriculum and instruction	2
Education leadership	5
Exercise physiology/science	4
Health and human performance	1
Health education	1
Higher education	3
Higher education administration	2
Physical therapy	4
Sports medicine/athletic training	10
Kinesiology	2
Nutrition	1
Physical medicine and rehabilitation	1
Prevention science	1
Other	1

*The number of bachelor's and master's degrees exceeds 109 because participants were allowed to choose more than one degree earned.

reported weekly use of therapeutic ultrasound on thermal (n = 89, 81.5%) and nonthermal intensities (n = 71, 65.2%), and in combination with electrical stimulation (n = 66, 60.6%). Most participants reported that they "never" use the bladder/gel pad method (n = 82, 75.2%), the underwater/submersion method (n = 76, 69.7%), and/or phonophoresis (n = 86, 78.9%). Participant responses for the frequency of use questions are presented in Table 2.

The overall Chronbach α for the perceived knowledge section was .852, indicating a good level of internal consistency. Correlation coefficients were substantial at .585. Principal axis factoring (two fixed factors) and promax rotation revealed four questions loading under factor one, three questions loading under factor two, and two factors that loaded under both factors. The four questions that loaded under factor one were identified by the researchers as "application" questions. The three questions that loaded under factor two were identified by the researchers as "theory/book knowledge" questions. The factors and loadings are outlined in Table 3.

The mean score on the perceived knowledge section was 30.13 ± 4.0 out of 36 possible points. Participants reported fairly high confidence in their knowledge and understanding of the therapeutic ultrasound competencies that were identified by the researchers as "application" questions; 60% or more of respondents replied that they "strongly agree" that they are confident with those competencies. Participants reported less confidence in their knowledge and understanding of the therapeutic ultrasound competencies that were identified by the researchers as "theory" questions; while most responded that they at least "agree", 46% or less reported that they "strongly agree" that they are confident with those competencies. The distribution of responses for the perceived knowledge competency content questions are reported in Table 4.

One question was excluded from the actual knowledge analysis due to a typo on the questionnaire. The mean score on the actual knowledge section was 15.50 ± 2.88 out of 22 possible points (70.45% ± 13.09% out of 100%). The 13 questions that were answered correctly by less than 75% of the participants were categorized by the researchers: three were considered to regard "insufficient parameters", three indicated "safety concerns", and seven were "theory/book knowledge". Those questions that were correctly answered by less than 75% of the participants are identified in Table 5.

The Shapiro-Wilk test of normality (.097), and other indices including skewness (–.114) and kurtosis (–.514) and examination of histogram and Q-Q plots, indicated that the actual score has a normal distribution. Indicators of normality for the perceived knowledge score indicated concern regarding a nonnormal distribution. The Shapiro-Wilk test of normality was significant ($p \leq .001$) and the distribution was highly negatively skewed (–.086). Kurtosis (–.988) and examination of histogram and Q-Q plots also pointed toward a nonnormal distribution of perceived knowledge scores.

A Spearman correlation was used to determine the relationships between a respondent's actual knowledge scores and their perceived knowledge scores, their age group, and the number of therapeutic modalities courses they had taken. A Bonferroni correction was made using .05/6 comparisons made. The corrected alpha level became .00833. Significant weak to moderate positive relationships were found between actual knowledge scores and perceived knowledge scores (r_s [109] = .319, p = .001); age group (r_s [109] = .265, p = .005); and number of therapeutic modalities courses taken (r_s [109] = .351, p = .001). Respondents who had higher perceived knowledge scores, respondents in an older age group, and respondents who had taken more therapeutic modalities courses tended to have higher actual knowledge scores. In addition, significant weak to moderate positive correlations were found between perceived knowledge scores and age group (r_s [109] = .349, $p \leq .001$), as well as perceived knowledge scores and the number of therapeutic modalities courses taken (r_s [109] = .326, p = .001). Those respondents who were in older age groups and those who had taken more therapeutic modalities courses tended to have higher perceived knowledge scores.

Discussion

Perceived and Actual Knowledge

In 2001, Cuppett[15] examined the self-perceived continuing education needs of athletic trainers in a variety of settings. Athletic trainers in that study reported substantial need in the area of "rehabilitation and reconditioning", the domain in the third edition *Role Delineation Study* (RDS) that listed the skills related to therapeutic modalities. The two tasks that included therapeutic modalities skills were rated a 4.18 and 4.16 out of 5, with 5 indicating a "substantial need" for continuing education in the task.[15] This indicates

Table 2. Frequency of Use

Question	Frequency % (n)				
	Never	1–3 Times per Week	4–6 Times per Week	7–9 Times per Week	10–12 Times per Week
In a typical week, I use therapeutic ultrasound with nonthermal intensities (< 1.0 W/cm^2 temporal average intensity) . . . (n = 109)	34.9 (38)	46.8 (51)	12.8 (14)	2.8 (3)	2.8 (3)
In a typical week, I use therapeutic ultrasound with thermal intensities (> 1.0 W/cm^2 temporal average intensity) . . . (n = 109)	18.3 (20)	33.9 (37)	33 (36)	7.3 (8)	7.3 (8)
In a typical week, I use therapeutic ultrasound with the bladder or gel pad method (thermal or nonthermal intensities) . . . (n = 108)	75.2 (82)	17.4 (19)	3.7 (4)	1.8 (2)	0.9 (1)
In a typical week, I use therapeutic ultrasound with the submersion/underwater method (thermal or nonthermal intensities) . . . . (n = 109)	69.7 (76)	29.4 (32)	0 (0)	0 (0)	0.9 (1)
In a typical week, I use phonophoresis (thermal or nonthermal intensities) . . . (n = 108)	78.9 (86)	17.4 (19)	1.8 (2)	0.9 (1)	0 (0)
In a typical week, I use combination electrical stimulation and therapeutic ultrasound (thermal or nonthermal intensities) . . . (n = 109)	39.4 (43)	45.9 (50)	7.3 (8)	4.6 (5)	2.8 (3)

TABLE 3. PERCEIVED KNOWLEDGE QUESTION EXPLORATORY FACTOR ANALYSIS STRUCTURE MATRIX

Competency Used for Perceived Knowledge	Factor 1: "Application"	Factor 2: "Theory/Book Knowledge"
Apply therapeutic ultrasound using parameters appropriate to the intended outcome.	0.754	
Reassess the patient to determine the immediate impact of the therapeutic ultrasound treatment.	0.749	
Assess the patient to identify indications, contraindications, and precautions applicable to therapeutic ultrasound.	0.741	
Describe the expected effects and potential adverse reactions from therapeutic ultrasound to the patient.	0.737	
Describe the laws of physics that (1) underlay the application of acoustic energy to the body and (2) form the foundation for the development of therapeutic interventions (e.g., thermodynamics, energy transmission, and attenuation).		0.776
Explain the theory and principles relating to expected physiological response(s) during and following therapeutic ultrasound.		0.771
Describe and differentiate the physiological and pathophysiological responses to inflammatory and noninflammatory conditions and the influence of these responses on the design, implementation, and progression of therapeutic ultrasound as a therapeutic intervention.		0.744
Inspect therapeutic ultrasound equipment and the treatment environment for potential safety hazards.	0.529	0.527
Identify manufacturer, institutional, state and/or federal standards that influence approval, operation, inspection, maintenance, and safe application of therapeutic ultrasound.	0.474	0.544

TABLE 4. PERCEIVED KNOWLEDGE QUESTION DISTRIBUTION (*N* = 109)

Competency Questions Used for Perceived Knowledge	Frequency % (n)				
	Strongly Disagree	Disagree	Agree	Strongly Agree	Cannot Determine
Application questions					
Apply therapeutic ultrasound using parameters appropriate to the intended outcome.	–	0.9 (1)	33 (36)	63.3 (69)	2.8 (3)
Reassess the patient to determine the immediate impact of the therapeutic ultrasound treatment.	–	10.1 (11)	27.5 (30)	60.6 (66)	1.8 (2)
Assess the patient to identify indications, contraindications, and precautions applicable to therapeutic ultrasound.	–	0.9 (1)	25.7 (28)	70.6 (77)	2.8 (3)
Describe the expected effects and potential adverse reactions from therapeutic ultrasound to the patient.	–	0.9 (1)	28.4 (31)	69.7 (76)	0.9 (1)
Theory/book knowledge questions					
Describe the laws of physics that (1) underlay the application of acoustic energy to the body and (2) form the foundation for the development of therapeutic interventions (e.g., thermodynamics, energy transmission, and attenuation).	2.8 (3)	34.9 (38)	36.7 (40)	24.8 (27)	0.9 (1)
Explain the theory and principles relating to expected physiological response(s) during and following therapeutic ultrasound.	–	7.3 (8)	45 (49)	45.9 (50)	1.8 (2)
Describe and differentiate the physiological and pathophysiological responses to inflammatory and noninflammatory conditions and the influence of these responses on the design, implementation, and progression of therapeutic ultrasound as a therapeutic intervention.	–	7.3 (8)	54.1 (59)	38.5 (42)	–
Both factors					
Identify manufacturer, institutional, state and/or federal standards that influence approval, operation, inspection, maintenance, and safe application of therapeutic ultrasound.	3.7 (4)	37.6 (41)	30.3 (33)	27.5 (30)	0.9 (1)
Inspect therapeutic ultrasound equipment and the treatment environment for potential safety hazards.	–	8.3 (9)	48.6 (53)	40.4 (44)	2.8 (3)

TABLE 5. ACTUAL KNOWLEDGE QUESTIONS ANSWERED CORRECTLY BY LESS THAN 75% OF PARTICIPANTS

Question (Answer)	% Whom Answered Correct	Discussion
Insufficient parameters		
Thermal ultrasound should feel warm to the patient. (True)	63.1	Athletic trainers are not increasing the intensity of ultrasound high enough to create sufficient energy absorption.
When using underwater ultrasound (tap water) at 1.0 W/cm^2 the athletic trainer should increase the intensity by _____ W/cm^2 to reach the desired therapeutic effect. (0.5)	62.2	The most common incorrect answer was 0.2 W/cm^2. Athletic trainers are not increasing the intensity of ultrasound high enough to create sufficient energy absorption.
You have been treating a football quarterback with an old left hamstring midbelly strain. His symptoms are nearly resolved, however his muscle remains very tight. Please enter the parameters that are most appropriate if your intent is to increase thermal effects. (1 MHz, 1.6 W/cm^2, 100%, 8–12 min)	60.4	The most common incorrect answer was 1 MHz, 1.2 W/cm^2, 100%, 6–7 min. The two differences were intensity and time. Athletic trainers are not increasing the intensity high enough or performing the treatment long enough to create sufficient energy absorption.
Safety		
Any BNR less than 12–1 is considered acceptable. (False)	59.5	Could be a safety concern if athletic trainers are not aware that high BNRs are likely to contain "hot spots".
Higher frequencies of therapeutic ultrasound will result in slower absorption than lower frequencies. (False)	69.4	Could be a safety concern because higher frequency ultrasound treatments will heat faster than lower frequency treatments and may heat more quickly than the athletic trainer expects.
Adipose tissue will absorb more ultrasound energy than tendon tissue. (False)	54.1	Could be a safety concern because tendon absorbs heat faster than adipose tissue and may get hotter than the athletic trainer expects.

(continued)

TABLE 5. *(continued)*

Question (Answer)	% Whom Answered Correct	Discussion
Theory/book knowledge		
No reactions or changes can occur in the body if the amount of energy absorbed is insufficient to stimulate the absorbing tissues. This is defined as _____. (Arndt-Schultz principle)	32.4	
Which of the following most accurately describes the method of heat transfer used by therapeutic ultrasound? (Conversion)	48.6	
Therapeutic frequencies for ultrasound are _____. (0.75–3.3 MHz)	65.8	
Nonthermal effects of therapeutic ultrasound energy are primarily attributed to which of the following? (Cavitation and acoustic microstreaming)	66.7	
Ultrasound transmission relies on the reverse/indirect piezoelectric effect. (True)	74.8	
Regarding scar formation, during which phase of healing are the endothelial capillary buds most dense? (Fibroblastic repair/proliferation phase)	62.6	
According to current theory, which of the following treatment parameters would maximize nonthermal effects while minimizing thermal effects? (1.0 W/cm^2, at 20%)	58.6	

Abbreviations: BNR = beam nonuniformity ratio.

that the respondents in that study felt they had deficiencies in their therapeutic modalities knowledge. The current study indicates that athletic trainers in the collegiate setting do not feel they have deficiencies in their knowledge of therapeutic ultrasound. Overall, participants reported confidence in their understanding of therapeutic ultrasound concepts and in their ability to perform therapeutic ultrasound.

Pitney[17] evaluated athletic training continuing education within the framework of adult learning theory. He encouraged athletic trainers to identify learning needs through reflection upon any discrepancies between the established competencies and skills and their own current skills.[16] The BOC recently launched a voluntary Professional Development Needs Analysis (PDNA) tool that aims to assist athletic trainers with the identification of gaps in their knowledge. The PDNA questionnaire asks participants to rank their level of professional development need in each domain by considering their current "level of preparedness" and their need for the knowledge/skill in their own professional practice.[17] The participants in this study reported confidence in their knowledge of therapeutic ultrasound, however scores on the actual knowledge questions were fairly low. Their perceived knowledge only weakly/moderately correlated to their actual knowledge score. This raises the question about whether the correlation is high enough to make a tool like the PDNA effective.

Actual Knowledge

Athletic trainers in older age groups and those who had taken more therapeutic modalities courses had higher actual knowledge scores. While it makes sense that more courses would increase an athletic trainer's knowledge of the material, the issue of age is less clear. While experience usually comes with age, younger athletic trainers have likely had more recent exposure to modern concepts of therapeutic ultrasound. It is possible that the older athletic trainers in college/clinical settings have had recent exposure of these modern therapeutic ultrasound concepts through students who have been assigned to them as a part of a professional athletic training program. It is also possible that the older athletic trainers are more likely to be serving in college/academic settings and are perhaps teaching therapeutic modalities courses. Further research would be needed to determine whether age, apart from setting, is correlated to actual knowledge.

An analysis of individual question responses suggests that the common misconceptions that concerned Draper in 1998 are still present.[7] Thirteen questions were answered correctly by less than 75% of respondents. These commonly missed questions fell into three categories: insufficient parameters, safety concerns, and theory/book knowledge. An analysis of the incorrect answers in the insufficient parameters category pointed to athletic trainers using intensities that were too low and/or durations that were too short. Draper indicated that athletic trainers were using the same parameters for every injury instead of adjusting intensity, time, and frequency according to the treatment goals.[7] What is most striking is that 36.9% of respondents indicated that thermal ultrasound should not feel warm to the patient. This signals that nearly two-fifths of respondents likely are not using intensities high enough to create thermal effects even when thermal effects are desired. This also indicates that athletic training education regarding the therapeutic ultrasound parameters required to meet treatment outcomes is either inadequate or not retained by graduates.

Three questions, identified by the researchers as "safety concerns", suggest that athletic trainers may not be aware of situations when absorption of heat will be either higher or more rapid. Beam nonuniformity ratio (BNR), tissue types that influence absorption, and the effect of frequencies on speed of heating were poorly understood by respondents. However, it is also possible that these practitioners are effective, but specific terminology has been forgotten. These three questions may be best aggregated with the other seven questions that the researchers identified as a loss of "theory/book knowledge" and may or may not raise concerns about actual practice.

Limitations

One significant limitation of the study was the low response rate, and that only collegiate athletic trainers responded to the research request. This limited the ability to compare the results of this study to athletic trainers working in other settings. This also limits the ability to compare the athletic training results to the results of other professions, such as physical therapy, as there are likely large differences in frequency of use.

An additional limitation is that only specific ultrasound parameters were analyzed. The researchers chose to mainly look at the main parameters of intensity, frequency, and time. The researchers did

not include a comprehensive assessment of any other parameters such as treatment size or speed of the ultrasound head. These parameters can also influence the amount of thermal effect created during a therapeutic ultrasound treatment.

Conclusions and Implications

The participants in this study had confidence in their knowledge of therapeutic ultrasound concepts, but scores on the actual knowledge questions were relatively poor. While a self-assessment tool may be helpful for some, this study demonstrates that more research is needed regarding whether athletic trainers have an accurate understanding of their need for continuing education in this area. The use of inadequate intensities and inadequate treatment durations, as outlined by Draper in 1998,[7] were still seen.

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