Effect of ultraviolet-C light on the environmental bacterial bioburden in various veterinary facilities

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OBJECTIVE
To determine the effect of a mobile UV-C disinfection device on the environmental bacterial bioburden in veterinary facilities.

SAMPLES
40 swab samples of surfaces from the operating theaters of 3 veterinary hospitals and 1 necropsy laboratory.

PROCEDURES
Various surfaces were swabbed, and collected material was eluted from the swabs in PBSS. Then, an aliquot of the sample fluid was processed with a bacteria-specific rapid metabolic assay to quantify bacterial bioburden. Each site was then treated with UV-C light with an automated disinfection device for approximately 45 minutes. The same surfaces were swabbed following UV-C treatment, and bioburden was quantified. The bioburden at additional time points, including after a second UV-C treatment, was determined for the small animal operating theater.

RESULTS
All surfaces at all sites had a persistent viable bacterial population following manual cleaning. Disinfection with UV-C achieved a mean bioburden reduction of 94% (SD, 5.2%; range, 91% to 95%) for all surfaces, compared with manual disinfection alone. Repeated UV-C treatment of the small animal operating theater reduced mean bioburden by 99% (SD, 0.8%), including no detectable bacteria on 4 of 10 surfaces.

CONCLUSIONS AND CLINICAL RELEVANCE
Disinfection with UV-C light may be a beneficial adjunct method for terminal disinfection of veterinary operating theaters to reduce environmental bioburden. (*Am J Vet Res* 2021;82:582–588)

Infection prevention is a pillar of patient care in veterinary and human hospitals. Health care–associated infections, such as SSIs and implant-related infections, result in increased hospitalization times and increased morbidity and mortality rates for patients, leading to an emotional and financial cost to pet owners[1–3] and human patients.[4–6] Surgical-site infections are among the most common HAIs in people, accounting for 16% of HAIs in the United States.[7] Similarly, SSIs are complications for 0.8% to 18.1% of small animal[8–10] and 0.5% to 39% of equine[2,11] surgical procedures, with important variations associated with surgery type.

The pathogenesis of SSIs is multifaceted, and contaminated environmental surfaces are an underappreciated source of possible pathogens.[4] These surfaces are often cleaned with detergents and then disinfected but are not routinely sampled to quantify their bioburden (ie, the number of viable bacteria on a surface).[12] Enhanced environmental cleaning significantly decreases the rate of HAIs.[13,14] In contemporary veterinary practice, most chemical agents used for disinfection are liquid formulations and belong to specific groups as follows: acids, alcohols, aldehydes, alkalis, biguanides, halogens, oxidizing agents, phenolics, and quaternary ammonium compounds.[15] Evidence of persistent contamination of environmental surfaces in human hospitals, despite traditional cleaning and disinfection methods, highlights the need for a successful adjunct to these methods.[16] Novel disinfection strategies, such as UV-C light, that reduce the bioburden show great promise to help prevent SSIs in veterinary and human patients and reduce the risk of zoonoses.[16–21]

Ultraviolet-C light is a form of electromagnetic radiation that causes photochemical changes in nucleic acids, resulting in cell death.[22] Finsen[23] and Møller et al[24] first described the use of concentrated UV light radiation to cure skin tuberculosis (lupus vulgaris) caused by *Mycobacterium tuberculosis*. Presently, UV-C light is widely used for water disinfection and in heating, ventilation, and air-conditioning systems.[19,25] Automated UV-C disinfection devices are increasingly popular as an adjunct disinfection method[4,22] and reduce the rate of HAIs in human hospitals.[5,6,17,18] In recent studies,[21,20] UV germicidal irradiation ef-

ABBREVIATIONS

BSRMA	Bacteria-specific rapid metabolic assay
HAI	Health care–associated infection
MRSA	Methicillin-resistant *Staphylococcus aureus*
RLU	Relative light units
SSI	Surgical-site infections

fectively reduced viable aerosolized pathogens of dogs and cats and the incidence of upper respiratory tract infections in shelter kittens. In another recent study,[26] UV-C disinfection significantly reduced the bioburden in a hyperbaric oxygen chamber. However, according to our knowledge, a study that includes an investigation of the efficacy of UV-C disinfection on the bacterial bioburden in veterinary operating theaters has not yet been published.

Therefore, the first objective of the preliminary study reported here was to determine the effect of an automated UV-C disinfection device on the bacterial bioburden in 4 veterinary facilities. Ultraviolet-C disinfection was hypothesized to reduce the overall bioburden, compared with the routine disinfection protocol at each site. The second objective was to assess any trends in the bioburden on the surfaces in a small animal operating theater at various time points before and after 2 UV-C treatments.

Materials and Methods

Study design

The study was conducted at 4 independent sites: operating theaters at an equine referral hospital, a small animal referral hospital and an academic veterinary research hospital, and a necropsy laboratory in the same academic veterinary research hospital. The operating theater in the research hospital was subjectively highly soiled (eg, dust and debris), compared with the other sites. All sites were manually cleaned with detergent and then disinfected with a solution of benzalkonium chloride (a quaternary ammonium compound) and polyhexamethylene biguanide (a polymerized biguanide)[a] according to the routine cleaning and disinfection protocol at each site. Disinfected surfaces were allowed to dry for 30 minutes prior to testing. Personal safety equipment (ie, dedicated surgical scrubs and surgical cap and mask) was worn during cleaning, disinfection, and testing at all sites to minimize the risk of contamination.

Environmental surface sampling

Various nonporous, commonly touched surfaces at each site were swabbed by 1 investigator (KLB) who used a kit[b] that included sampling supplies and a luminometer and who followed the manufacturer's instructions. Briefly, each surface was recorded, and a 100-cm^2 area was marked. Sterile cotton swabs[c] were moistened in 500 µL of sterile PBSS immediately prior to surface swabbing. The moistened swab was axially rotated and streaked as follows: 10X up and down, 10X left and right, and 10X diagonally within the marked area. The collected material on the swab was then eluted in 500 µL of sterile PBSS in a collection tube, and the swab was pressed against the edges of the collection tube to release excess fluid absorbed by the swab. Within 1 hour of surface testing, samples were processed for bacterial bioburden measurement in a single-blinded procedure to minimize bias.

UV-C disinfection

Following sampling, a mobile UV-C disinfection device[d] was positioned in the center of each operating theater and necropsy laboratory. All persons vacated each room, and the device was operated remotely with a tablet computer. An automated 3-D room scan was performed with the device to determine the optimal treatment time on the basis of the location of the device, room size, and number of objects in the room. A germicidal dose of UV-C light (254 nm; 22,000 µW/cm^2) was emitted to irradiate each room for approximately 45 minutes. Treatment time was automatically calculated by use of the inverse-square law of UV-C effectiveness, so a germicidal dose of UV-C could disinfect all surfaces. The device had a motion sensor that immediately turned the system off if any motion was detected while activated to avoid human exposure to the UV-C light. Following UV-C disinfection, swab samples were collected (from the same surfaces) as previously described.

To determine the effect of multiple UV-C treatments on the bacterial bioburden, additional time points were assessed on the same surfaces in the small animal operating theater. Additional time points included prior to the use of the operating theater (baseline), immediately after its use (after surgery), 12 hours after the initial sampling and first UV-C treatment, and immediately after a second approximately 45-minute UV-C treatment. No surgery was performed in the theater for 12 hours after the first UV-C treatment.

Bioburden quantification

Bioburden was quantified on all samples with a BSRMA kit.[b] The assay was performed according to manufacturer's instructions and as previously described.[26] Briefly, the eluted sample in PBSS was filtered through a 0.45-µm membrane to remove somatic cells and nonbacterial ATP. Bacterial cells were then lysed to release ATP, and 50 µL of luciferin-luciferase was added to the resulting solution to initiate an ATP-dependent, light-producing reaction. This reaction was quantified with the kit's luminometer. Its output was recorded in RLU (fluorescence), which correlates with CFUs, such that 1 RLU equals 1 viable bacterium in the sample.[27] Blank samples were analyzed with the BSRMA after 5 consecutive tests to ensure sterility of the analyzer's sample chamber.

Statistical analysis

Descriptive variables were assessed for normality graphically and confirmed with the Shapiro-Wilk test. Bioburden reduction was calculated as a percentage for all surfaces and sites and reported as mean and SD. To determine the differences in bioburden reduction among various surface materials after UV-C treatment, the data were analyzed by use of a 1-way ANOVA with commercially available software.[e] Values of $P < 0.05$ were considered significant.

Results

All surfaces at all sites (operating theater in an equine veterinary referral hospital, n = 12; operating theater in a small veterinary referral hospital, 10; operating theater in an academic veterinary research hospital, 5; and necropsy laboratory in an academic veterinary research hospital, 13) were contaminated with bacteria after manual cleaning and disinfection **(Table 1)**. After 1 UV-C treatment, overall mean bioburden was reduced by 94% (SD, 5.2%; range, 91% to 95%). Bioburden reduction after 1 UV-C treatment was not significantly (P = 0.53) different among the various surface materials (hard plastic: n = 19 [mean bioburden reduction, 95%; SD, 5.8%]; stainless steel: 11 [93%; SD, 5.5%]; rubber: 4 [96%; SD, 2.6%]; vinyl flooring: 3 [96%; SD, 3.5%]; and glass and other materials: 3 [91%; SD, 4.0]).

In the small animal operating theater, the bioburden immediately after surgery increased from baseline for 8 of 10 surfaces and subsequently increased after manual routine cleaning and disinfection for 6 surfaces. After 1 UV-C treatment, viable bacteria were detected on 8 of 10 surfaces, with a mean bioburden reduction of 95% (SD, 4.5%), compared with results for manual cleaning and disinfection alone. The bioburden of 9 surfaces increased 12 hours after the first UV-C treatment when the operating theater was not used; however, the bioburden was lower than that following only manual cleaning and disinfection. After the second UV-C treatment, mean bioburden was reduced by 99% (SD, 0.8%), compared with the bioburden 12 hours after the first UV-C treatment, including no detectable bacteria on 4 of 10 surfaces.

Discussion

The present study revealed the effectiveness of a UV-C disinfection device to reduce the environmental bacterial bioburden in 3 veterinary operating

Table 1—The bioburden (measured as RLU [fluorescence] and percentage reduction) before and after manual cleaning with a detergent and disinfection with a solution of benzalkonium chloride and polyhexamethylene biguanide and 1 UV-C treatment of approximately 45 minutes with a mobile device (germicidal dose, 254 nm and 22,000 mW/cm^2) of various nonporous surfaces and surface materials in 3 independent veterinary operating theaters (1 equine referral hospital, 1 small animal referral veterinary hospital, and 1 academic veterinary research hospital) and 1 necropsy laboratory (located at the same academic veterinary research hospital). Each surface was swabbed, and collected material on each swab was processed and analyzed within 1 hour after swabbing with a BSRMA. The bioburden in the veterinary operating theater at the small animal referral hospital was further evaluated prior to the use of the operating theater (baseline), immediately after its use (postsurgery), 12 hours after the first UV-C treatment (operating theater not used during this period), and immediately after a second approximately 45-minute UV-C treatment.

Site	Surface	Surface material	Baseline	Postsurgery	Before first UV-C treatment (after manual cleaning and disinfection)	After first UV-C treatment	Percentage reduction after first UV-C treatment	12 hours after first UV-C treatment	After second UV-C treatment	Percentage reduction after second UV-C treatment
Equine operating theatre	Anesthetic bench	Stainless steel	—	—	30	1	97	—	—	—
	Bench A	Hard plastic	—	—	83	4	95	—	—	—
	Bench B	Hard plastic	—	—	140	8	94	—	—	—
	Bench C	Hard plastic	—	—	474	13	97	—	—	—
	Cleaning station	Hard plastic	—	—	27	0	100	—	—	—
	Drain	Stainless steel	—	—	951	122	87	—	—	—
	Floor	Concrete	—	—	71	5	93	—	—	—
	Foot stool	Rubber	—	—	281	8	97	—	—	—
	Light switch A	Hard plastic	—	—	12	2	83	—	—	—
	Light switch B	Hard plastic	—	—	1	0	100	—	—	—
	Speaker	Rubber	—	—	405	30	93	—	—	—
	Window glass	Glass	—	—	80	3	96	—	—	—
	Mean (SD)						94 (4.5)			—
Small animal operating theatre	Anesthetic bench	Hard plastic	557	1,201	724	15	98	5	0	100
	Anesthetic monitor	Hard plastic	512	699	344	46	87	86	5	99
	Bench top	Hard plastic	29	37	64	0	100	7	1	98
	Door handle	Stainless steel	69	164	837	68	92	100	17	98
	Floor	Vinyl	779	2,739	955	93	90	168	11	99
	Foot pedal	Rubber	3,410	2,851	4,700	247	95	279	28	99
	Metal trolley	Stainless steel	40	222	284	22	92	25	2	99
	Overhead light	Hard plastic	39	1,102	13	0	100	2	0	100
	Pressure valve	Hard plastic	1,252	643	1,136	12	99	144	0	100
	Waste bin	Hard plastic	28	38	39	1	97	6	0	100
	Mean (SD)						95 (4.5)			99 (0.8)
Academic veterinary research hospital operating theatre	Anesthetic bench	Hard plastic	—	—	102	15	85	—	—	—
	Door handle	Stainless steel	—	—	4	0	100	—	—	—
	Floor	Vinyl	—	—	2,082	111	95	—	—	—
	Overhead light handle	Hard plastic	—	—	433	39	91	—	—	—
	Surgical trolley	Stainless steel	—	—	288	39	86	—	—	—
	Mean (SD)						91 (6.1)			—
Academic veterinary research hospital necropsy laboratory	Bench A	Hard plastic	—	—	395	14	96	—	—	—
	Bench B	Hard plastic	—	—	3,082	0	100	—	—	—
	Biosafety cabinet	Stainless steel	—	—	1,392	201	86	—	—	—
	Door handle	Stainless steel	—	—	3,013	159	95	—	—	—
	Floor	Vinyl	—	—	93,785	12,345	87	—	—	—
	Keyboard	Hard plastic	—	—	120	16	87	—	—	—
	Medical equipment	Hard plastic	—	—	220	0	100	—	—	—
	Pen	Hard plastic	—	—	890	0	100	—	—	—
	Rubber shoe	Rubber	—	—	9,256	48	99	—	—	—
	Sink	Stainless steel	—	—	135	12	91	—	—	—
	Trolley	Stainless steel	—	—	90	0	100	—	—	—
	Trolley	Stainless steel	—	—	90	0	100	—	—	—
	Wall	Paint	—	—	3	0	100	—	—	—
	Mean (SD)						95 (5.7)			—
	Overall mean (SD)						94 (5.2)			—

— = Not applicable.

theaters and a necropsy laboratory. Because the bioburden on surfaces is relatively low (compared with standardized laboratory inoculums), calculating the percentage reduction, as done in the present study, in the number of viable bacteria is a better measure of UV-C effectiveness than the $\log_{10}$ scale used to determine the effectiveness of liquid disinfectants.[4] Although many disinfectants claim > 6 log (99.9999%) reductions in viable bacteria, the actual efficacies are often far less, as evidenced by the number of bacteria remaining on surfaces after manual cleaning in this study. Additionally, under laboratory conditions, the inoculum of bacteria (10^{10} CFUs/mL) used for testing does not accurately represent the number of bacteria on clinical surfaces. Because surface contamination may lead to HAIs, including SSIs, considering adjunct disinfection strategies to lower the bioburden in veterinary operating theaters is necessary.[15,28,29] The veterinary and human literature are replete with evidence documenting the persistence of pathogens on environmental surfaces, despite manual cleaning and disinfection.[4,30–35]

The effectiveness of manual cleaning on the bioburden of surfaces varies widely, possibly because of human error, time dedicated to cleaning, surface contact time with disinfectant, and the types of disinfectant and operating theater equipment and surfaces.[28,36] Disinfectants must be used as directed by the manufacturer for them to be as effective as the manufacturer reports.[16] Inadequate cleaning and disinfection protocols and lack of protocol standardization are likely key contributing factors to persistent surface contamination.[16] In 1 study,[37] only 50% of high-touch surfaces in a human hospital were appropriately disinfected by cleaning staff. The ability for bacterial pathogens to persist in the environment and disseminate through fomites and air further highlights the need to augment manual cleaning and disinfection methods in veterinary and human hospitals.[16,30]

Variations in manual cleaning and disinfection were observed at the small animal operating theater, which may have been a reason for the increased bioburden of 5 surfaces (benchtop, door handle, foot pedal, metal trolley, and pressure valve) after manual cleaning and disinfection. Possibly, some surfaces were unintentionally missed by personnel during cleaning and disinfection (eg, metal trolley) or they were not manually cleaned and disinfected daily (eg, door handle and foot pedal). Contaminated cleaning equipment such as cloths and mops and disinfectant chemicals can also contaminate surfaces,[38] which may also explain the increased bioburden on these 5 surfaces.

Across all 4 sites, UV-C was highly effective at reducing the bioburden regardless of the type of nonporous surface material. Nonporous surfaces were selected because most equipment and surfaces within operating theaters are nonporous. Previous studies[39] reveal that UV-C is not as effective at disinfecting porous surfaces such as paper and fabric. Therefore, these surfaces should be considered as contaminated after UV-C disinfection.

Ultraviolet-C devices are less effective in highly soiled environments because UV-C light is unable to sufficiently penetrate dust, dirt, and stains.[40] Decreased UV-C effectiveness was reflected in the present study by the lowest reduction (91% vs manual cleaning and disinfection alone) in the bioburden for the heavily soiled (vs other sites) operating theater in the academic veterinary research hospital. In addition, UV-C effectiveness may be reduced in locations that are shadowed (ie, objects in the UV-light beam's path will produce a shadow) and therefore not affected by irradiation. For these reasons, manual cleaning and disinfection are still recommended prior to UV-C treatment.

In small and large animal hospitals, disease outbreaks have been associated with environmental contamination.[34,35,41] Consequently, researchers have been more focused on pathogens that may cause SSIs and are known to persist in the hospital environment. Of particular concern are *Staphylococcus* spp, *Enterococcus* spp, *Pseudomonas* spp, *Salmonella* spp, and *Escherichia coli*, all of which can exhibit multidrug resistance.[3,10,33,42] Methicillin-resistant *S aureus* is a well-recognized multidrug-resistant nosocomial pathogen in human hospitals, is considered an emerging pathogen in veterinary medicine, and has been identified as the cause of SSIs in small animal[43,44] and equine patients.[45] Disinfection with UV-C is effective against MRSA; a 93% reduction in $\log_{10}$ CFUs/mL for MRSA was noted for frequently touched surfaces in a human hospital after irradiation with an automated UV-C device.[40] In large animal veterinary hospitals, *Salmonella enterica* is a common cause of HAIs and is associated with widespread environmental contamination.[41,46] The effectiveness of UV-C on 12 *Salmonella* spp is comparable with that on MRSA.[47]

The reported incidence of SSIs in small and large animal patients is highly variable, likely because of differences in the definition of an SSI, surgical procedure, patient signalment, presence of comorbidities, and use of prophylactic antimicrobials among other variables.[3] In contemporary veterinary practice, SSIs are of particular concern because of antimicrobial resistance, high morbidity and mortality rates, prolonged hospitalization, potential for nosocomial infection and zoonotic transmission, and cost of treatment.[3,11] In US human hospitals, SSIs are estimated to extend the duration of hospital stay by an average of 9.7 days and increase the cost by $20,842/admission, equating to an annual treatment cost of > $1.5 billion.[2] For dogs that underwent tibial plateau leveling osteotomy in a previous study,[1] the mean postoperative cost was $1,559 for dogs with an SSI versus $212 for dogs without an SSI.[1] For horses that underwent complicated orthopedic procedures in another study,[48] an SSI significantly increased the duration of hospitalization from 13.4 to 45.5 days and increased the dura-

tion of antimicrobial treatment from 4.5 to 21.8 days. Furthermore, after an SSI develops in horses, they are less likely to survive to hospital discharge, compared with those without an SSI.[48] The emotional impact on owners and welfare implications for their pets owing to increased duration of hospitalization and the number of required procedures to address the SSI is difficult to quantify but nevertheless is likely present. Although the development of SSIs will never be completely eliminated, mitigation of SSIs is needed to lessen the economic impact on pet owners and improve patient welfare.

Ultraviolet-C light has germicidal activity against numerous pathogens, including multidrug-resistant bacteria (ie, MRSA, vancomycin-resistant *Enterococcus* spp, and *Clostridium difficile*), encapsulated and nonencapsulated viruses, fungi, protozoa, and other microbes.[47] Unlike for other disinfection methods, bacteria are not known to acquire resistance to UV-C light. Because UV-C light disrupts bacterial DNA, viable bacteria near the irradiated bacteria cannot acquire resistance genes by horizontal gene transfer.[49] Ultraviolet-C light is also effective in eliminating bacteria in biofilms.[50] Pathogenic bacteria, including *Staphylococcus* spp and *Pseudomonas* spp, have the potential for biofilm formation.[51] Implant-associated infections, a common complication of orthopedic surgery in veterinary patients, are often associated with biofilm formation.[52,53] Such infections typically require surgical removal of the implant, which further increases a pet owner's financial and emotional burden and increases patient morbidity.[54] Effective environmental elimination of biofilm-forming bacteria by UV-C light further supports the potential of this technology for reducing the development of SSIs.

The BSRMA for bacterial bioburden quantification was preferred over traditional microbial culture because real-time metabolic testing is more reliable and sensitive.[55] Production of ATP is evolutionally conserved in bacteria, so the BSRMA is highly sensitive to viable but nonculturable bacteria in a sample.[27] Additionally, BSRMA is more sensitive in enumerating each bacterium, compared with traditional microbial culture.[26] A limitation of the BSRMA is the inability to identify individual bacterial species. Identification of bacterial species was beyond the scope of the present study; however, future studies could include bacterial culture followed by species identification to determine the effectiveness of UV-C against specific bacteria collected from surfaces in veterinary hospitals.

The automated mobile UV-C disinfection device used in the present study showed great promise as an adjunct disinfection tool in veterinary hospitals, not only for its demonstrated effectiveness in bioburden reduction but also for its ease of use. The device can be adapted to its surroundings with built-in height sensors, shadow-reduction technology, motion sensors, and room-mapping technology. The latter allows for correct calculation of required treatment times to kill the most persistent bacteria, including those that form spores, typically within a 45-minute cycle depending on room size and contents. The device's motion sensors help to ensure that human exposure to UV-C is avoided if someone enters the room during UV-C treatment.

Currently, the up-front monetary cost of an automated UV-C disinfection device may limit its use in veterinary hospitals; however, the cost-to-benefit ratio of SSI reduction needs to be considered when deciding to invest in such a device. Anderson et al[6] first reported on a randomized clinical trial to assess a UV-C device for terminal room disinfection (ie, disinfection of a room between occupying patients) in human hospitals. The outcome of that study[6] indicates that UV-C decreases the incidence of infection with multidrug-resistant bacteria (MRSA, vancomycin-resistant *Enterococcus* spp, *C difficile*, and multidrug-resistant *Acinetobacter* spp) by approximately 10% to 30%. Documenting actual infection reduction with UV-C disinfection technologies is challenging[4]; however, in 1 study[20] of shelter kittens, incidence of upper respiratory tract infection decreased after a UV irradiation system was installed. Veterinary hospital personnel can evaluate the cost-effectiveness of UV-C disinfection to determine the potential benefit of a UV-C device in their hospitals (eg, cost of the system per patient per hospital stay vs cost of care per sick patient per hospital stay).[16,20]

The present study had limitations. First, despite site personnel using the same disinfectant, the cleaning and disinfection protocol was not standardized (ie, variable time and personnel), which likely led to variable degrees of contamination at each site prior to UV-C application. Second, the animal species that underwent surgery was variable among sites, with one site used for surgeries performed only on horses, another site for only research animal species (ie, mice, rats, rabbits, sheep, and pigs), and another site for only domestic dogs and cats, which likely resulted in different bacterial populations across the sites. The classification of bacterial species was beyond the scope of this study. Future studies would benefit from characterizing the viable bacterial populations, particularly focusing on pathogenicity and drug-resistant strains that are known to cause infection. However, UV-C was effective in reducing the bioburden by 94% across all 4 sites (operating theaters and necropsy laboratory), which demonstrates the capability and adaptability of this UV-C device. Finally, sampled surfaces were not standardized among the sites; however, this reflected the differences in theater layout and equipment.

The results of the present study indicated the effectiveness of a mobile UV-C disinfection device for terminal disinfection of 3 veterinary operating theaters and 1 necropsy laboratory on the basis of results of a BSRMA. Studies are required to quantify the effect of UV-C on the incidence of SSIs at veterinary hospitals. Investigation of the effectiveness of UV-C to kill other microorganisms such as viruses,

yeast, and fungi is also recommended. Given the focus on antimicrobial stewardship in response to increasing bacterial resistance in veterinary practice, use of a UV-C device may become important to reduce bioburden, SSI incidence, and the need for antimicrobials.

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Footnotes

a. F10 SC, Chemical Essentials Pty Ltd, Mitcham, VIC, Australia.
b. Profile-1 Bioluminometer, Q Biotechnologies Ltd, Lincoln, England.
c. Puritan Medical Products, Guilford, Me.
d. ThorUVC, Finsen Technologies Ltd, Miami, Fla.
e. GraphPad Prism 8, GraphPad Software, San Diego, Calif.

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Erratum: Effect of epitendinous suture caliber on the tensile strength of repaired canine flexor tendons

In the report "Effect of epitendinous suture caliber on the tensile strength of repaired canine flexor tendons" (*Am J Vet Res* 2021;82:510–515), the degrees listed for the first author were incorrectly reported. The information for this author should read as follows: Daniel J. Duffy BVM&S (Hons), MS.