Health-care–associated infections in humans and other animals include nosocomial infections, some of which may be zoonotic. Nosocomial infections are the most frequently detected adverse events that develop during health-care episodes of humans in hospitals. Prevention of nosocomial infections is important in veterinary medicine; methicillin-resistant *Staphylococcus aureus* and *Staphylococcus pseudointermedius* are increasingly detected in dogs and cats, and methicillin-resistant *S aureus* carriage rates are higher for veterinary staff than they are for pet owners or people in the general population. Appropriate HH (cleaning of contaminated hands with an antiseptic agent) is the most effective method for the prevention of HCAIs. Hand hygiene is simple to perform, has low cost, and is effective; however, use of appropriate HH methods may require behavioral changes by HCWs.

Hand hygiene practices are typically measured by determination of adherence rate (the number of HH episodes [number of times HH is performed] divided by the number of HH opportunities [number of times HH is indicated]); the value of this variable is typically expressed as a percentage. The WHO has identified 5 types of HH opportunities for personnel performing clinical tasks: before touching a patient, before performance of a clean or aseptic procedure, after exposure to bodily fluids, after touching a patient, and after touching the surroundings of a patient. Results of other studies of HCWs in human medical facilities indicate rates of transmission of infectious disease organisms decrease with increased adherence to appropriate HH methods. However, rates of adherence of physicians are typically low (<50%). The role (eg, nurse or doctor), workload, logistic factors (availability of sinks, soap, and towels), and hand washing–induced dermatitis of HCWs and a lack of promotion of HH in a medical institution affect the rate of adherence to appropriate HH methods. Use of AHRs can overcome logistic factors for HH, such as inadequate or inappropriately located sinks, and inclusion of emollients in such products can reduce drying of hands associated with the use of soaps. Alcohol-based antimicrobial hand rubs are

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**Objective**—To determine the effect of an intervention (educational campaign) on hand hygiene (HH) and health-care workers’ (HCWs’) perceptions of HH.

**Design**—Prospective observational study and cross-sectional survey.

**Sample**—Observed opportunities for HH performed by HCWs before (n = 222) and after (249) intervention, measures of HH product usage, and surveys distributed to 300 HCWs.

**Procedures**—Data were collected by means of direct observation, measurement of HH product consumption, and surveys of HCWs.

**Results**—Adherence rates of HCWs for HH practices before and after the intervention were 27% (61/222 observations) and 29% (73/249 observations), respectively. Combined HH and glove use adherence rates before and after the intervention were 84% (186/222 observations) and 81% (201/249 observations), respectively. Before intervention, the highest combined HH and glove use adherence rate was detected for technicians (90% [57/63 opportunities]) and for opportunities after exposure to a patient’s bodily fluids (100% [5/5 opportunities]). Rate of use of alcohol-based antimicrobial hand rubs (AHRs) and amount of HH products used did not significantly change during the study. Survey response rates were 41% (122) and 21% (62) before and after the intervention, respectively. Availability of AHRs and role modeling of HH (performance of HH each time it is warranted) were considered the factors most likely to increase HH adherence rates by survey respondents.

**Conclusions and Clinical Relevance**—Results indicated the intervention did not increase HH adherence or use of AHRs. High rates of glove use before the start of the study may have been a confounding factor. Future educational campaigns should indicate that glove use should not supersede HH.
recommended for use during most HH opportunities, while hand washing is typically used for grossly contaminated hands.\textsuperscript{11}

The 3 most commonly used methods for determination of HH adherence are observation of HCWs, measurement of HH product consumption, and surveys of HCWs.\textsuperscript{17} Observation involves observation of HH behavior of HCWs and recording of the number of opportunities for HH in which HCWs adhere or do not adhere to recommended practices. The WHO has indicated that direct observation of HH practices is the gold-standard measurement method and is the most reliable method for determination of HCW HH adherence rates.\textsuperscript{1} Such measurements can be used to assess quality of HCW HH and identify factors that can be targeted in an educational campaign to improve HH practices. Limitations of direct observation include determination of a definition of an adequate HH technique and the fact that only a small percentage of HH opportunities are typically observed. Measurement of HH product (e.g., AHR, paper towels, liquid soap, and gloves) consumption in a hospital area during a specified time is an inexpensive method for measurement of HH adherence; however, this is an indirect method. This method is not affected by selection bias because the total amount of product used is determined for an entire day.\textsuperscript{11,16} Surveys can be used to determine characteristics of HH practices and knowledge and attitudes toward HH of HCWs; in addition, surveys can be used to determine HH product availability and satisfaction of HCWs regarding availability of such products. The validity of survey results can be affected by the quality of survey development and testing, and self-reporting by survey respondents typically results in overestimation of HH adherence rates.\textsuperscript{11,16,19} Although there are advantages and disadvantages for each method used to measure HH adherence, use of multiple methods may be helpful for development of an HH educational program.\textsuperscript{20}

Performance of appropriate HH practices by HCWs is prevented by a lack of education and training regarding reasons HH should be performed, times during which that procedure should be performed, and the method that should be used to perform that procedure.\textsuperscript{21} Training by means of an informational campaign has caused a 2-fold increase in the probability of performance of appropriate HH practices by HCWs, whereas an informational campaign without training decreased adherence to appropriate HH practices.\textsuperscript{22} The WHO has prepared a guide to implementation of improved HH practices.\textsuperscript{1} That guide indicates infrastructure for performance of HH by HCWs, knowledge and perceptions of HCWs regarding HH practices and HCAIs, and how an appropriate patient safety climate should be improved. Recommendations of the WHO indicate that HH training, competency assessments, and education should be regularly performed to improve HH practices. Results of another study\textsuperscript{23} in which HH practices in a veterinary teaching hospital were evaluated indicated use of an educational campaign that was similar to that recommended by the WHO; however, only direct observation was used in that study for evaluation of the effectiveness of the campaign, and the follow-up period was shorter than that recommended by the WHO.

The objectives of the study reported here were to determine the effectiveness of an HH educational campaign on the rates of hand washing, use of an AHR, and HH product consumption in a veterinary teaching hospital ICU and to identify perceptions of HCWs regarding the importance of HCAI and HH. The hypothesis was that an HH educational campaign would change adherence rates and attitudes of HCWs toward HH.

Materials and Methods

Study development—This study was conducted between February and April 2012 in the small animal ICU of the Veterinary Teaching Hospital at the University of Georgia College of Veterinary Medicine. The study lasted 12 weeks and was divided into a preintervention period (weeks –4 to –1) and a postintervention period (weeks 1 to 8). The intervention, or educational campaign, was performed during week 1. The study was approved by the University of Georgia Institutional Review Board for the evaluation of human subjects; informed consent was not required. Representatives of the University of Georgia Veterinary Teaching Hospital Infectious Disease Committee and the supervisor of the ICU technicians were involved in the development, implementation, and support of the study. Development of the study included adapting the methods recommended in the WHO guide for implementation of improved HH practices at the Veterinary Teaching Hospital ICU.\textsuperscript{1}

Observation of HH adherence—A single observer (ZRP), whose purpose was not disclosed to HCWs, made observations of interactions of HCWs with small animal patients during all 3 work shifts in the ICU (8 AM to 4 PM, 4 PM to 12 AM, and 12 AM to 8 AM). We estimated that 130 observations of HCW HH opportunities would be needed to detect a change in hand washing compliance from 30% before the intervention to 50% after the intervention on the basis of exemplary results.\textsuperscript{24} Scheduled times of observations were determined with a randomization procedure for each day of the 7-day week; the observation schedule was stratified to account for periods of peak activity. Twice as many observations were performed at times determined with the randomization procedure between 6 AM and 10 AM, compared with the number of observations performed at other times. The observer recorded 10 to 15 HH opportunities/observation period; observations were typically recorded during a 20-minute period. The observer underwent 1 week of training prior to initiation of data collection. This involved a veterinarian (JRS) co-observing and verifying that observations of HH were correctly recorded.

The ICU accommodated up to 40 patients and had 4 AHR dispensers, 1 hand washing sink, and 1 wet table. Health-care workers were defined as veterinary assistants (animal restrainers), veterinary technicians, students, interns, residents, and faculty. The observer used an abbreviated version of the WHO HH observation form\textsuperscript{25} to record data. For each possible HH opportunity during the data collection periods, recorded data included the occupation of the observed HCW, the indication for HH, and whether HH was performed.
Hand hygiene included hand washing or the use of an AHR. Indications for HH included before contact with a patient, before performance of an aseptic procedure, after exposure to bodily fluids, after patient contact, and after contact with a patient’s surroundings (eg, cage door or walls). For HH opportunities during which an HCW did not perform HH, the observer recorded whether the HCW was wearing gloves. Hand hygiene adherence rate was defined as the number of times HH was performed divided by the number of opportunities for performance of HH. An educational campaign was conducted during study week 1. Preintervention observations were conducted during study weeks –3 through –2, and postintervention observations were conducted during study weeks 6 through 7.

**Measurement of HH product consumption**—The daily consumption of HH products in the ICU was recorded. These products included liquid soap refills, packets of disposable paper towels, roll towels, and boxes of gloves. Preintervention measurements were conducted during study weeks –4 through –1, and postintervention measurements were conducted during study weeks 1 through 4 to assess the immediate effects of the intervention and during weeks 5 through 8 to assess durable effects of the intervention.

**Survey of HCWs**—An anonymous online survey of HCWs was conducted by use of survey software during study weeks –4 through –2 (before the educational campaign) and during weeks 6 through 8 (after the educational campaign). The survey was adapted from one intended for medical doctors; it was pretested by 3 faculty members. A University of Georgia e-mail list was used to distribute the invitation to faculty, interns, residents, veterinary assistants and technicians, and incoming and current senior veterinary students to participate in the survey, and a reminder to complete the survey was sent 2 weeks later to HCWs. Participants were offered a gift certificate to an online retailer as an incentive to complete the survey during both survey periods. Questions were asked about the respondents’ demographics, perception of the importance and impact of HCAIs (estimated percentage from 0% to 100%), effectiveness and ease or difficulty of performing HH (scored on a 5-point Likert scale), and self-reported adherence to HH (estimated percentage from 0% to 100%).

**Educational campaign and intervention**—A low-cost multimedia educational campaign was initiated during week 1 of the study. A modified version of a WHO HH education presentation was used. A video was presented on 3 occasions to faculty, interns, residents, veterinary assistants and technicians, and incoming and current senior veterinary students during an orientation. Twenty-four of 65 (37%) small animal interns, residents, and faculty and 100 of 103 (97%) incoming senior veterinary students attended this presentation; the number of current senior students and technicians who attended the presentation was not recorded because of the failure of individuals to sign an attendance record.

Twenty-five posters were placed in the ICU area, wards for small animals, and small animal clinic hallways to remind HCWs to perform HH. These posters were rotated among locations every 3 weeks during the study; this was intended to ensure HCWs noticed the posters. Sixteen posters were placed next to AHR dispensers to indicate the appropriate technique for use of that product. Twelve posters were placed near hand washing sinks to indicate correct hand washing techniques.

**Statistical analysis**—Normality of data was determined with the D’Agostino and Pearson test. Percentage adherence of HCWs to recommended HH practices before and after the educational campaign intervention was compared by means of the Fisher exact test (for 2 X 2 comparisons; eg, during the preintervention period, a technician used or did not use an AHR vs during the postintervention period, a technician used or did not use an AHR) or the $\chi^2$ test. The amount of HH products used during each period was compared with a 1-way ANOVA by use of 2 methods; analysis was performed with raw values and raw values divided by the number of animals hospitalized in the ICU during the observation period. Survey data obtained before and after the educational campaign intervention were compared by use of a 2-way paired $t$ test (for continuous data) or a $\chi^2$ test (for categorical data). Values of $P < 0.05$ were considered significant. Analyses were performed with software.

**Results**

During the preintervention period, data for 222 observations of HH opportunities of HCWs were collected; during the postintervention period, data for 249 observations of HH opportunities of HCWs were collected. The overall preintervention HH adherence rate was 27% (appropriate HH performed for 61/222 opportunities for students) to 48% (30/63 opportunities for technicians). The overall postintervention HH adherence rate was 29% (73/249 opportunities); postintervention HH adherence rates for each type of HCW ranged from 13% (11/88 opportunities for students) to 47% (8/17 opportunities for assistants). No significant ($P = 0.76$) difference was detected between the overall pre- and postintervention HH adherence rates. An increase in the rate of glove use was detected for technicians, assistants, and faculty between pre- and postintervention periods, although results were not significant. The rate of glove use by students was significantly ($P = 0.014$) higher during the preintervention period (62/88 [70%] opportunities) than it was during the postintervention period (47/90 [52%] opportunities). The overall combined rate of HH and glove adm
No significant difference was detected between pre- and postintervention overall rates of HH adherence ($P = 0.08$) or combined rates of HH and glove use adherence ($P = 0.40$) for data analyzed to detect differences among various types of HH opportunities (Table 2). During the preintervention period, AHRs and hand washing were used for 18% and 82% of HH episodes, respectively. During the postintervention period, AHR and hand washing were used for 30% and 70% of HH opportunities, respectively. No significant ($P = 0.11$) differences were detected between pre- and postintervention periods regarding the percentage of times each HH technique was used. Results of analysis controlled for the number of patients in the ICU during each ICU work shift period indicated no significant differences in the number of roll towels ($P = 0.92$), paper towels ($P = 0.44$), liquid soap refills ($P = 0.29$), or boxes of gloves ($P = 0.54$) used among preintervention weeks 1 through 4, postintervention weeks 1 through 4, and postintervention weeks 5 through 8.

The preintervention survey response rate was 41% (122/300 surveys were returned), and the postintervention survey response rate was 21% (62/300 surveys were returned). The percentage of survey respondents who indicated HH was very or extremely effective for reducing HCAIs in patients after removal of gloves was significantly ($P = 0.005$) higher after the educational campaign intervention (67% [37/56 responses]) than it was before the intervention (44% [31/71 responses]). The percentage of survey respondents who indicated it was very or extremely easy to perform HH before touching a clean site (eg, IV catheter hub) was significantly ($P = 0.026$) higher before the educational campaign intervention (77/98 [79%] responses) than it was after the intervention (33/56 [59%] responses).

The weighted mean score for the survey respondents’ perceived efficacy of HH at reducing HCAI for each clinical task was calculated by summing the item responses and dividing by the number of respondents (Figure 1). The mean efficacy of HH for all of the tasks was calculated to be 85%, which was similar to the estimated overall efficacy of HH (83%; question asked later in the survey). The weighted mean score for the respondents’ perceived ease of performing HH for each opportunity was calculated from the survey responses. The mean ease of performing HH was calculated to be 76%, which was similar to the estimated overall ease of performing HH (72%; question asked later in the survey). The weighted mean score for self-reported HH adherence was calculated from the survey responses. The mean HH adherence of the individual opportunities was calculated to be 59%, which was slightly lower than the value (66%) determined when participants were asked to rank their overall compliance (question asked later in the survey).

Survey respondents ranked availability of AHR stations as the most effective intervention for decreasing HCAIs in patients and ranked role modeling (ie, performance of HH each time it is warranted) of appropriate
HH practices as the second most effective intervention. Although respondents ranked poster displays as the least effective intervention for decreasing HCAIs in patients, the proportion of respondents who ranked that intervention as very or extremely effective increased from 12% (12/100 responses) for preintervention surveys to 38% (21/55 responses) for postintervention surveys; these results were significantly ($P < 0.001$) different.

**Discussion**

The objective of the educational intervention in the present study was to increase adherence of HCWs in a veterinary teaching hospital to appropriate HH practices. The interventions were developed in accordance with WHO recommendations and comprised a presentation and posters intended to remind HCWs to perform HH and instruct those workers regarding the proper method for HH. The methods used to determine efficacy of the intervention were determined on the basis of WHO recommendations and included direct observation, measurement of the amount of HH products that was used, and a survey of HCWs regarding their perceptions of HH. Therefore, the study included 4 of the 5 steps of the WHO multimodal HH improvement strategy; the fifth step of that strategy, which was not included in this study, is development of an ongoing sustainable action plan and review cycle.

Health-care workers in ICUs in human medical hospitals have lower HH adherence rates than HCWs in other areas of such hospitals. Results of the present study indicated the overall pre- and postintervention combined adherence rate was found for senior students in this study. This finding may be attributable to student ignorance of HH guidelines or a belief that glove use obviates the need for HH.

Results of the present study indicated the lowest HH adherence rate was detected for performance of HH prior to patient care, although the use of an AHR station in the hallway at the entrance to the ICU ward was not included in observations in this study. Unsurprisingly, the highest HH adherence rates were detected for personnel handling of blood or patient bodily fluids. This pattern of HH adherence for various clinical tasks detected in the present study was similar to patterns detected in other studies of HCWs in human medical facilities. Hand hygiene performed after contact with bodily fluids is typically intended to protect HCWs from infection. Hand hygiene is performed for different reasons prior to touching a patient; performance of HH during such types of opportunities may depend on attitudes of HCWs or to peer pressure.

The overall pre- and postintervention combined HH and glove use adherence rates were > 80% in the present study. However, the WHO recommends that the wearing of gloves does not replace the need for HH because of the potential for holes in gloves. The educational campaign of the present study seemed to be successful in conveying to HCWs that performance of HH after wearing of gloves was an effective measure to decrease HCAIs in patients. However, results of other studies indicate HH adherence rates decrease when gloves are worn by HCWs. We were unable to evaluate such an effect of glove use because the present study was performed in a hospital ward where wearing of gloves was mandatory. The effect of decreased HH adherence rates after glove use on the overall rate of HCAIs is unknown, to the authors’ knowledge. However, the wearing of gloves as a substitute for performance of HH can lead to glove contamination, subsequent hand contamination when the gloves are removed, and contamination of glove boxes, making such glove boxes an environmental reservoir of pathogens.

Future educational campaigns in our hospital should have high emphasis on the WHO indications for the wearing of gloves and associated HH practices.

Results of this study indicated an insignificant increase in HH adherence rates after the educational campaign and a decrease in glove adherence by students, so that the overall HH and glove adherence rate slightly decreased. The students included in the postintervention observations included students who had recently started clinical rotations; these students may not have adapted to the mandatory glove-wearing policy in the ICU ward at the time of the observations. Another possible explanation for the decrease in postinterven-
tion HH or glove adherence of other types of HCWs may have been that the Hawthorne effect (a change in people’s behavior because they know they are being observed) may have caused an increase in the preintervention adherence rate.1,17 Although the HCWs were not made aware of the purpose of the observer, no attempt was made in this study to conceal her presence in the ward; therefore, HCWs may have changed their behavior during the first observation period but may have become accustomed to the observer’s presence during the second observation period. We initially planned to use security cameras for observations in this study to minimize the Hawthorne effect. However, the area recorded by these cameras was inadequate for a comprehensive assessment of HH practices in the ICU.

Measurement of HH product use can be a cost-effective method for indirect determination of HH performance as an alternative to labor-intensive direct observation. That method can be used to determine the total amount of products used during a day and therefore is not affected by selection bias.1,17 However, that method cannot be used to determine how often HH is indicated, when personnel fail to use HH, or why such failures to use HH occur. Thus, measurement of product use cannot be used to identify a group or task for which HH adherence rates may not be affected by educational interventions. The method of recording HH product use in this study was determined on the basis of the quantities of products that were needed to restock the ICU area. The design of the AHR dispensers precluded accurate weighing of contents, which may have been a more precise measurement of changes from hand washing to the use of AHR during the postintervention period, compared with the method that was used.

An HH educational campaign performed at another veterinary teaching hospital increased the observed baseline rate of hand washing and use of AHR from 15% to 41% of patient interactions after 2 weeks.23 The baseline rate of hand washing and use of AHR from this veterinary teaching hospital increased the observed adherence rate.1,17 Although the HCWs were not made aware of the purpose of the observer, no attempt was made in this study to conceal her presence in the ward; therefore, HCWs may have changed their behavior during the first observation period but may have become accustomed to the observer’s presence during the second observation period. We initially planned to use security cameras for observations in this study to minimize the Hawthorne effect. However, the area recorded by these cameras was inadequate for a comprehensive assessment of HH practices in the ICU.

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An HH educational campaign performed at another veterinary teaching hospital increased the observed baseline rate of hand washing and use of AHR from 15% to 41% of patient interactions after 2 weeks.23 The rate of wearing of gloves by HCWs decreased from 6% to < 1% during that study. The educational campaign in the present study may not have caused a significant increase in the rate of AHR use because of the high baseline rate of HH and glove use (84%) and because the postintervention observations were performed 6 weeks after completion of the campaign. The increase in rate of HH compliance detected in the other study23 may have occurred in our study but during a short period, so that the increase was not detected at 6 weeks postintervention.

Limitations of the use of survey results in the present study included a low response rate and the use of self-reporting. However, there seemed to be some correlation between perception of the most effective opportunity to perform HH to decrease HCAIs and self-reported adherence of HH for different clinical tasks. Survey respondents indicated the most efficacious time to perform HH was before touching a clean site, and this indication for HH had a high self-reported adherence rate. Self-reported and observed HH or glove use adherence rates were highest after exposure to bodily fluids and lowest before contact with a patient in this study. Results of other studies9,14–16 regarding HH in human medical facilities indicate similar results. This finding suggested that beliefs and intentions of HCWs affected the behaviors of such personnel regarding HH. Therefore, education of HCWs in which beliefs or intentions are addressed may increase rate of adherence to proper HH practices.

The survey respondents in this study considered the most effective intervention for increasing HH adherence to be access to AHRs. The high perceived importance of this intervention has also been indicated by human physicians.22 Provision of AHRs is the first step of the WHO multimodal HH improvement strategy.21 The ICU ward of the present study accommodated up to 40 patients, and that area had 4 AHR dispensers; this was an appropriate number of dispensers because the recommended ratio is 1 dispenser/10 patients.21 Performance of HH in human medical facilities is influenced by external factors (eg, workload or the availability of AHR dispensers), rather than internal factors (eg, knowledge, skills, and attitudes).34–36 Provision of training and display of posters or technique guidelines were ranked as the least effective methods for increasing the rate of HH adherence by survey respondents in the present study; however, this finding may have been attributable to another finding that 84% of participants in the study had already received postqualification HH training and thus may have considered that the posters did not add to their training. Role modeling of good HH practices (ie, performance of HH each time it is warranted) was also ranked highly as an effective method for increasing HH adherence by survey respondents in this study. Thus, a cultural shift in support of HH must occur to effect change in the workplace.36 Active participation of personnel in HH practices is a component of the final step in the WHO multimodal HH improvement strategy.21

Results of the present study suggested that HCWs believed it was important to perform HH. However, HH adherence may have been attributable to peer pressure and a perception of high self-efficacy by participants, rather than knowledge regarding the effects of HH practices on patient safety.11,17 Despite similarities in attitudes between human and veterinary medical HCWs, the HH educational campaign of the present study did not cause an increase in the rate of use of AHRs. High rates of glove use by HCWs in the ICU ward before performance of this study may have been a confounding factor. Future HH educational campaigns should be used to educate HCWs that the wearing of gloves does not obviate the need for performance of HH.

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