3.4 Results

3.4.1 Hand Hygiene Products

Due to lack of compliance in filling out stall entry sheets, it was decided that patient census records would provide a more accurate means to calculate patient-days/week. Because of the inferred relationship that exists between patient contact and hand hygiene, the volume of product was compared to patient-days/week (Figure 3.11). No discernable relationship between the two was apparent.

Soap product usage increased by 79 ml between Day 0 and 6. By Day 13 usage had increased by 576 ml over the previous week. Day 20 marked the highest weekly soap usage during the course of study, *i.e.* 1680 ml. The lowest level of usage, *i.e.* 840 ml/week, was recorded on Day 83. A mean of 1199 ml/week was used over the course of the study (95% CI: [1070;1328]). Monitoring of soap usage for the remainder of the study showed soap usage levels not exceeding 1405 ml/week.

Weekly monitoring of WHS usage revealed the highest level of use (910 ml) approximately 3 weeks (Day 27) after its initial introduction. This quantity of WHS was not exceeded for the remainder of the study. The lowest level *i.e.,* 254 ml/week, was recorded on Day 83 with a mean of 553 ml/week (95% CI: [452;654]). Day 48's total was the second highest with 850 ml/week.

An increase (641 ml) in soap use occurred in the 2 weeks following the first 2 presentations and brochure. A modest increase (36 ml/week) in WHS use was noted as well. A slight increase in both products was seen after the third presentation (20 m/week). The week (Day 69) following the introduction of the "motivational" posters was marked with a slight decline in the use of both products (-116 ml).

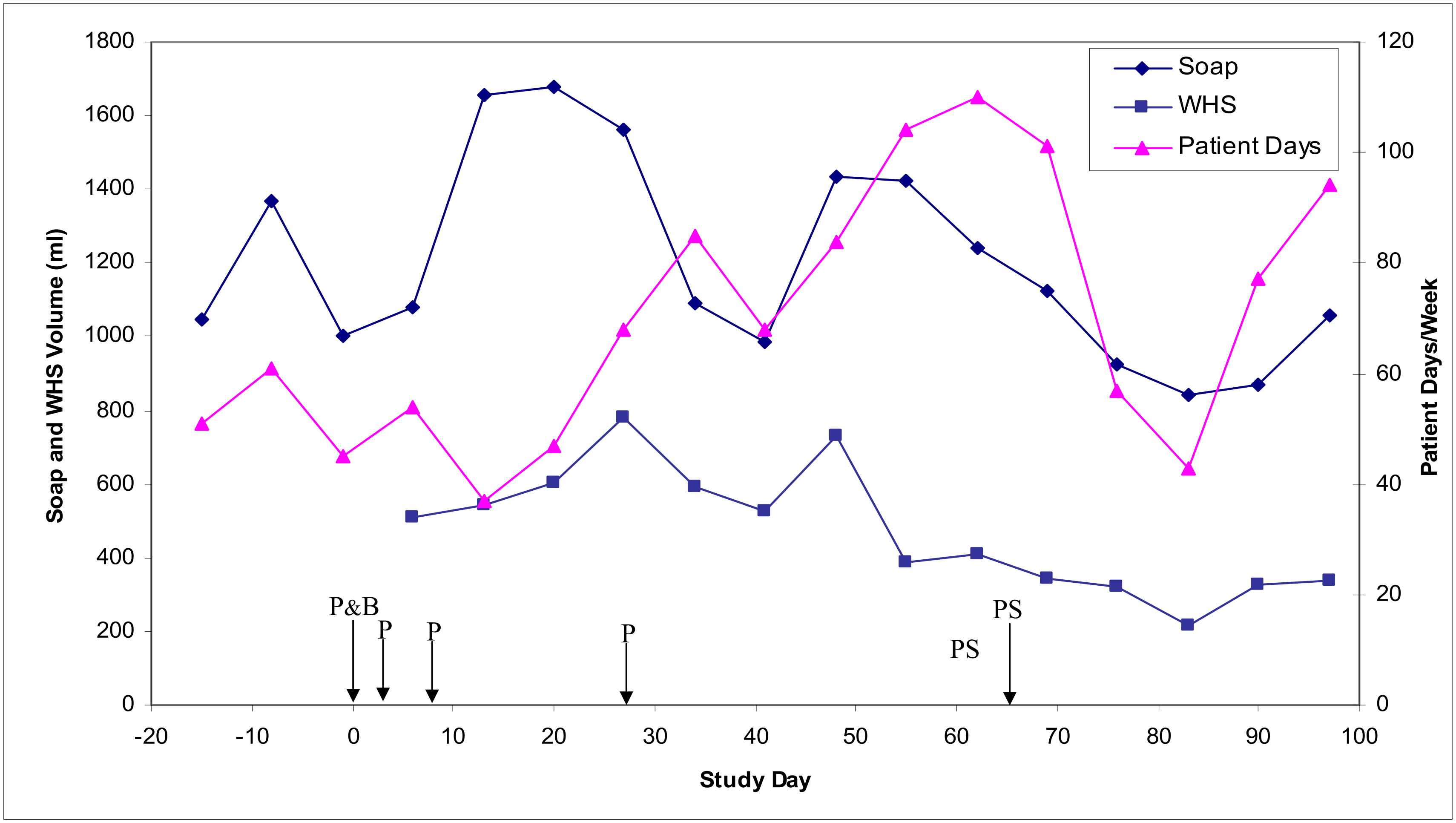

Figure 3.11 Total patient days, soap and waterless hand sanitizer volume by study day. Introductions *i.e.,* presentations (P), brochures (B), and posters (PS) are indicated by arrows.

3.4.2 Hand Bacterial Counts

No apparent difference in bacterial load was found between samples collected the before and after 12 pm. Hand bacterial counts (HBC) obtained through GJS were recorded by specific subject and expressed as CFU/ml. The bacterial growth on the hands of the 10 LAH personnel was averaged and plotted by study day.

Hand bacterial counts, on Columbia Blood agar, ranged from a low of 378 on Day -21 to a high of 23,120 CFU/ml on Day 84 with a geometric mean of 3,577 CFU/ml (95% CI: [943; 6,211]) (Figure 3.12). The mean HBC, on MacConkey selective agar, was substantially lower than that of Columbia Blood agar. Out of 160 samples, only 18 exhibited growth. Values ranged from 20 to 2,260 CFU/ml with a geometric mean of 294 CFU/ml (95% CI: [20; 2,260].

Identification of bacterial organisms found on the hands of LAH personnel is shown in Table 3.2.

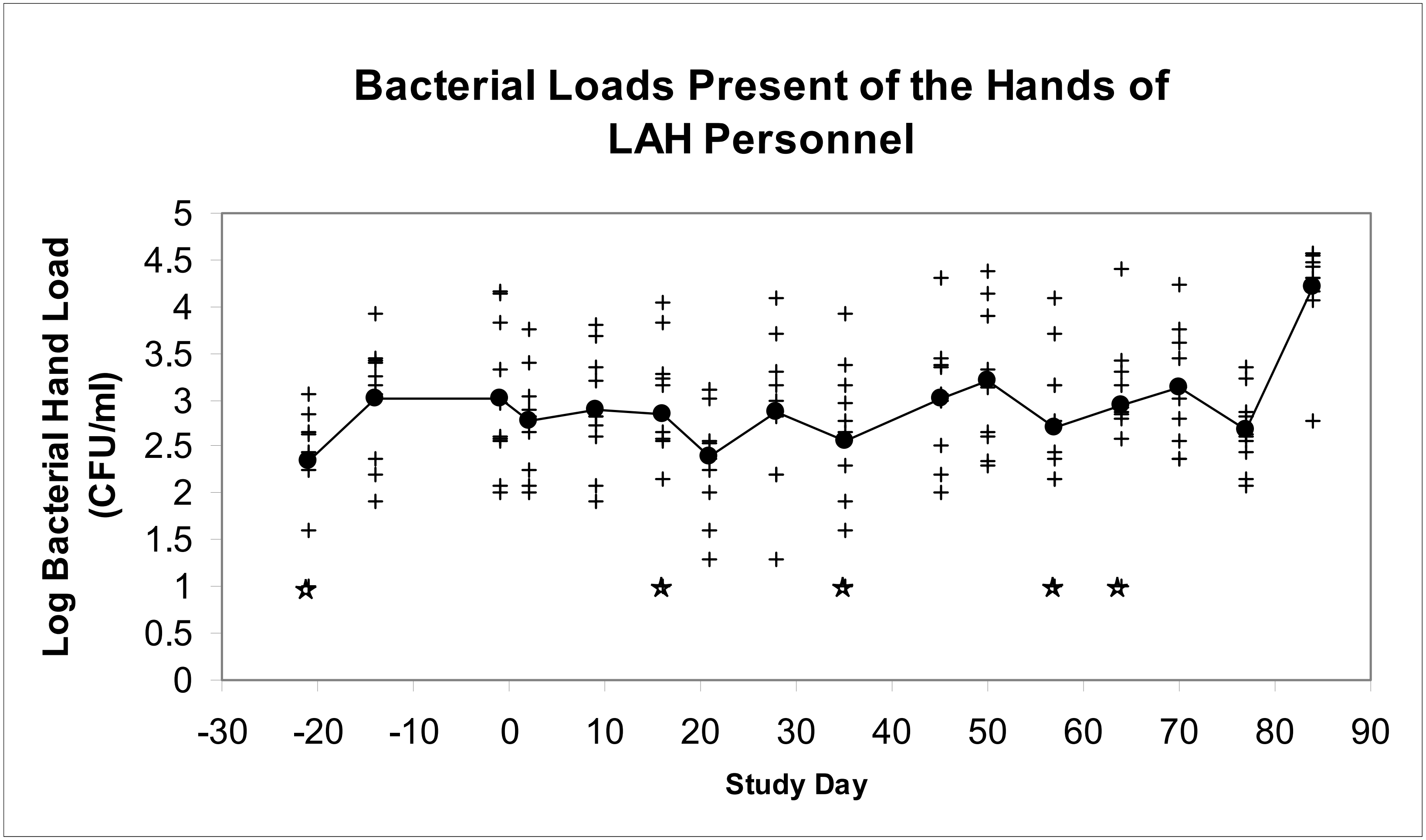

Figure 3.12. Bacterial counts on the hands of hospital personnel as a function of study day. Stars indicate recorded values of 0 CFU/cm^2 replaced with 1 CFU/cm^2 to preserve an interpretable scale.

Table 3.2 Bacterial organisms identified on hands.

Acinetobacter baumanii
Citrobacter freundii
Escherichia coli
Escherichia hermanii
Klebsiella pneumoniae
Micrococcus luteus
Neisseria sicca
Pantoea agglomerans
Pseudomonas aeruginosa
Staphylococcus aureus
Staphylococcus cohnii
Staphylococcus haemolyticus
Staphylococcus hyicus
Staphylococcus saprophyticus
Staphylococcus warneri
Staphylococcus xylosus
Streptococcus mitis
Steptococcus pyogenes
Bacillus spp.
Corynebacterium spp.
Kytococcus spp.
Macrococcus spp.
Staphylococcus spp.

3.4.3 Environmental Sampling

Environmental sample sites were grouped into 6 categories with regard to the particular object sampled *i.e.,* telephone, computer-related (includes keyboard and computer mouse), door handles, stalls (includes patient stalls, equine stock and bovine chute), cleaning implements (includes brooms, shovels and rakes) and other (includes chair, microwave and water fountain). Bacterial genera and species isolated from all groups are listed in Table 3.3.

Bacterial counts from varied from no growth to too numerous to count (CFU/12 cm^2). In order to display this data on a logarithmic scale and to produce descriptive statistics a value of "1" replaced every recorded value of 0 CFU/12 cm^2 (no growth) and paddles with growth "too numerous to count" were given an arbitrary value of 200 CFU/12 cm^2 (Figures 3.13-3.18).

Bacterial counts for sites within a category were averaged. The range was 6 to 151 CFU/12 cm^2 with a mean across all categories of 40 CFU/12 cm^2 [95% CI: (26;53)]. Average counts for "telephone" sites ranged from 6 to 29 CFU/12 cm^2 with a mean of 16 CFU/12 cm^2 [95% CI: (9;23)]. The lowest average counts were obtained from "computer-related" sites ranging from 6 to 15 CFU/12 cm^2 with a mean of 11 CFU/12 cm^2 [95% CI: (6;16)]. "Door handle" averages ranged from 7 to 63 CFU/12 cm^2 with a mean of 25 CFU/12 cm^2 [95% CI: (4;46)]. The category "stalls" had the highest average counts ranging from 72 to 151 CFU/12 cm^2 with a mean of 104 CFU/12 cm^2 [95% CI: (82;125)]. "Cleaning implements" ranged from 14 to 61 CFU/12 cm^2 with a mean of 33 CFU/12 cm^2 [95% CI: (14;52)]. "Other" environmental surfaces ranged from 9 to 22 CFU/12 cm^2 with a mean of 16 CFU/12 cm^2 [95% CI: (9;24)].

Table 3.3 Bacterial organisms identified on environmental surfaces with respect to group category.

Phones	**Door Handles**	**Patient Stalls**	**Cleaning Implements**
Chryseobacti meningoseptium	*Actinetobacter baumanii*	*Aerococcus viridans*	*Acinetobacter baumanii*
Corynebacterium pseudotuberculosis	*Kocuria rosea*	CDC CE Type 2	*Candida parapsilosis*
Kocuria rosea	*Micrococcus luteus*	CDC VE Group	*Pseudomonas aeruginosa*
Micrococcus luteus	*Pantoea agglomerans*	*Citrobacter freundii*	*Staphylococcus cohnii*
Staphylococcus aureus	*Staphylococcus epidermatis*	*Citrobacter koseri/diversus*	*Staphylococcus epidermatis*
Staphylococcus epidermatis	*Staphylococcus pulvereri/vitulinus*	*Flaviomonas oryzihabitans*	*Staphylococcus sciuri*
Staphylococcus haemolyticus	*Staphylococcus xylosus*	*Klebsiella oxytoca*	*Staphylococcus xylosus*
Staphylococcus warneri	*Arcanobacterium* spp.	*Kocuria rosea*	*Streptococcus* Group D
Bacillus spp.	*Corynebacterium* spp.	*Leifsonia aquatica*	*Brevibacterium* spp.
Micrococcus spp.	*Macrococcus* spp.	*Macrococcus carouselicus*	*Corynebacterium* spp.
		Pantoea agglomerans	*Enterococcus* spp.
		Pseudomonas aeruginosa	*Macrococcus* spp.
		Pseudomonas stutzeri	*Rhodococcus* spp.
Computer-Related	**Other**	*Serratia marcescens*	*Serratia* spp.
		Staphylococcus aureus	*Stomatococcus* spp.
Kocuria rosea	*Aerococcus viridans*	*Staphylococcus epidermidis*	
Macrococcus bovis	*Macrococcus carouselicus*	*Staphylococcus haemolyticus*	
Micrococcus luteus	*Micrococcus luteus*	*Staphylococcus saprophyticus*	
Sanguibacter keddieii	*Pantoea agglomerans*	*Staphylococcus warneri*	
Staphylococcus epidermatis	*Staphylococcus aureus*	*Staphylococcus xylosus*	
Staphylococcus haemolyticus	*Staphylococcus epidermatis*	*Stenotrophomonas maltophilia*	
Streptococcus mitis	*Staphylococcus xylosus*	*Bacillus* spp.	
Vagococcus fluvialis	*Bacillus* spp.	*Enterobacter* spp.	
Bacillus spp.	*Corynebacterium* spp.	*Pseudomonas* spp.	
Corynebacterium spp.	*Micrococcus* spp.	*Staphylococcus* spp.	
Macrococcus spp.	*Staphylococcus* spp.		

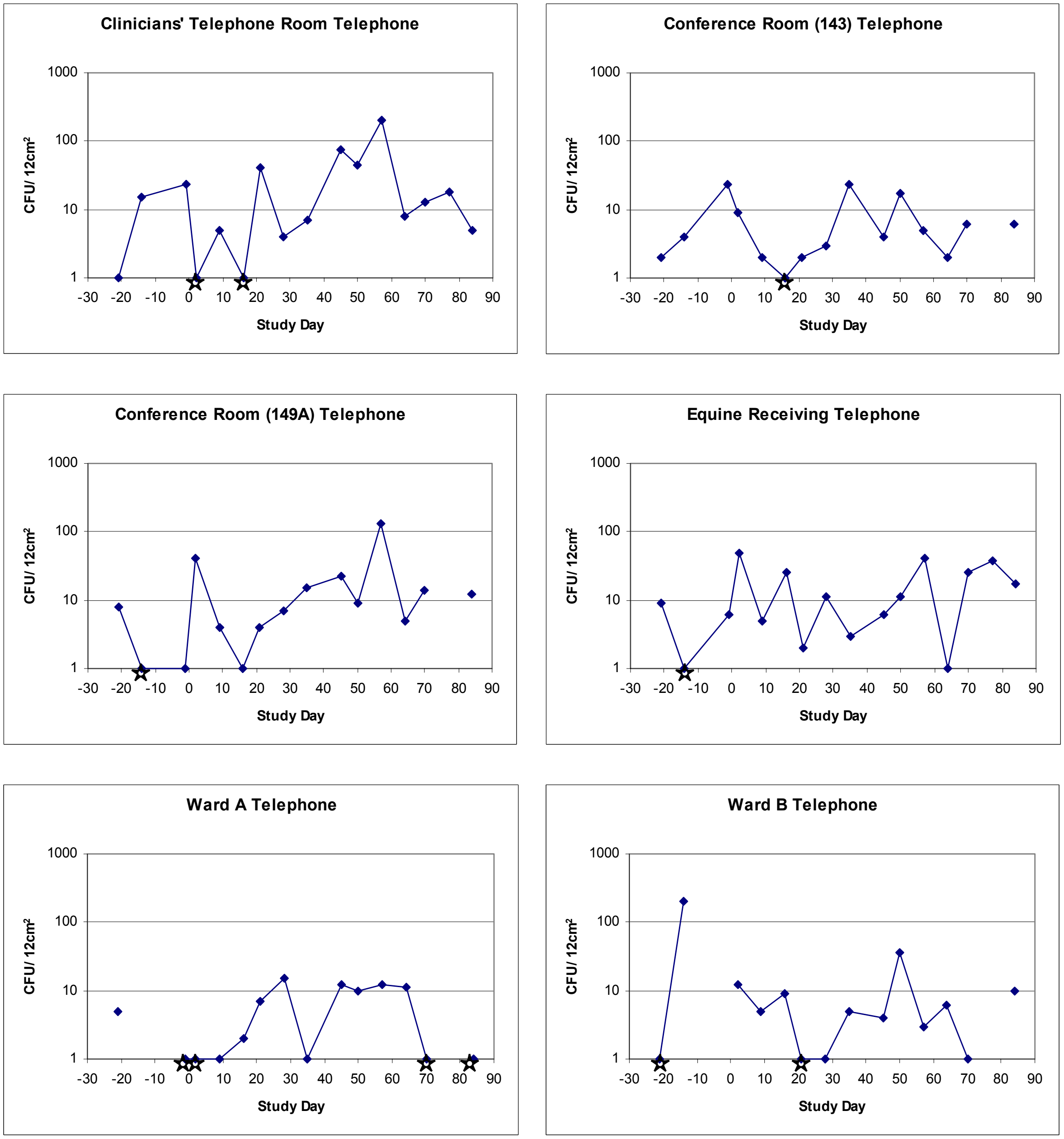

Figure 3.13. Surface bacterial load present on telephone sites. Stars indicate recorded values of 0 CFU/12 cm^2 that were replaced with 1 CFU/12 cm^2 to preserve an interpretable scale. Interrupted lines indicate that a site was not sampled on a particular day. Points above 130 CFU/12 cm^2 were considered too numerous to count and were arbitrarily assigned a value of 200 CFU/12 cm^2.

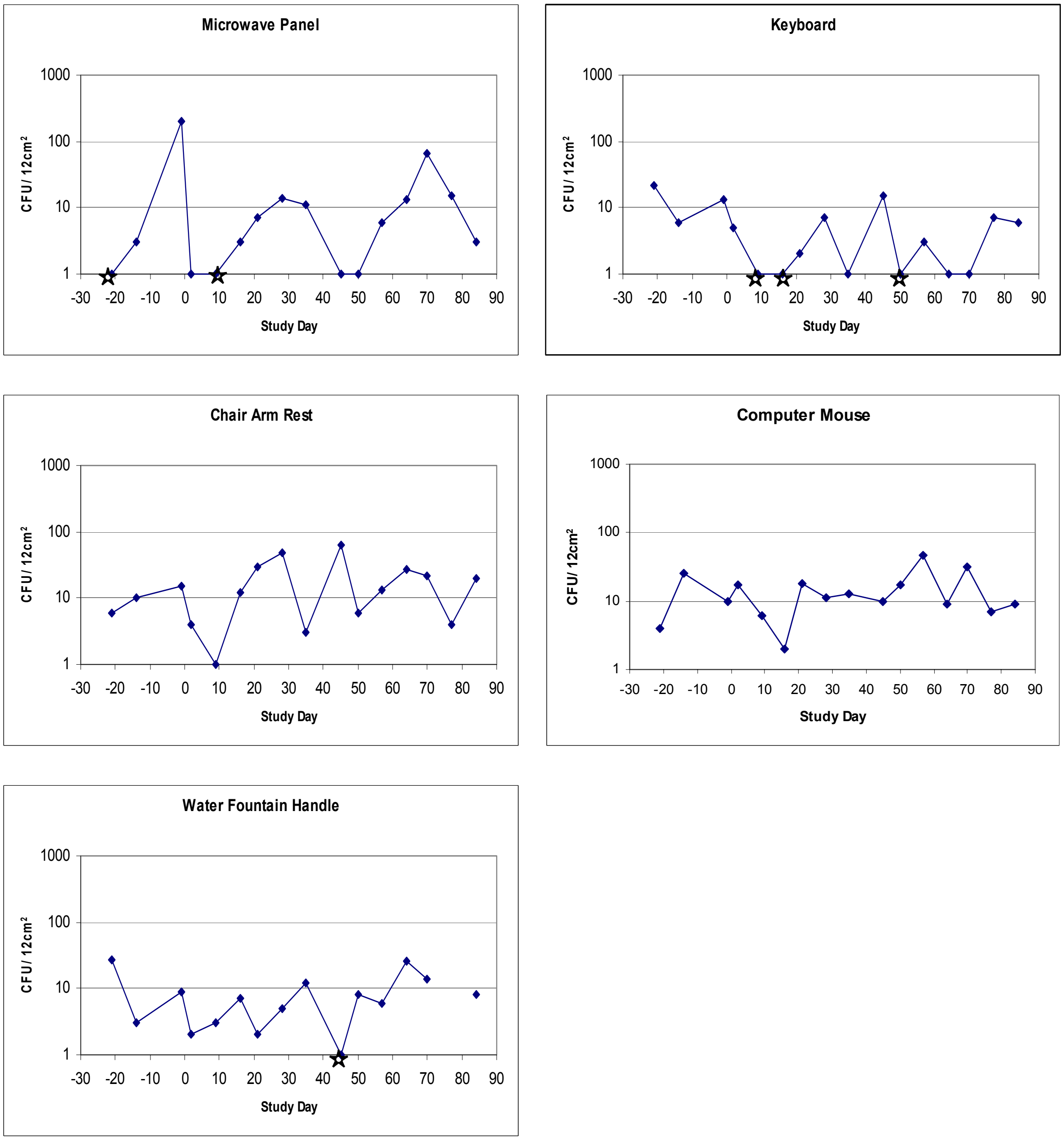

Figure 3.14. Surface bacterial load present on "computer-related" and "other" sites. Stars indicate recorded values of 0 CFU/12 cm^2 that were replaced with 1 CFU/12 cm^2 to preserve an interpretable scale. Interrupted lines indicate that a site was not sampled on a particular day. Points above 130 CFU/12 cm^2 were considered too numerous to count and were arbitrarily assigned a value of 200 CFU/12 cm^2.

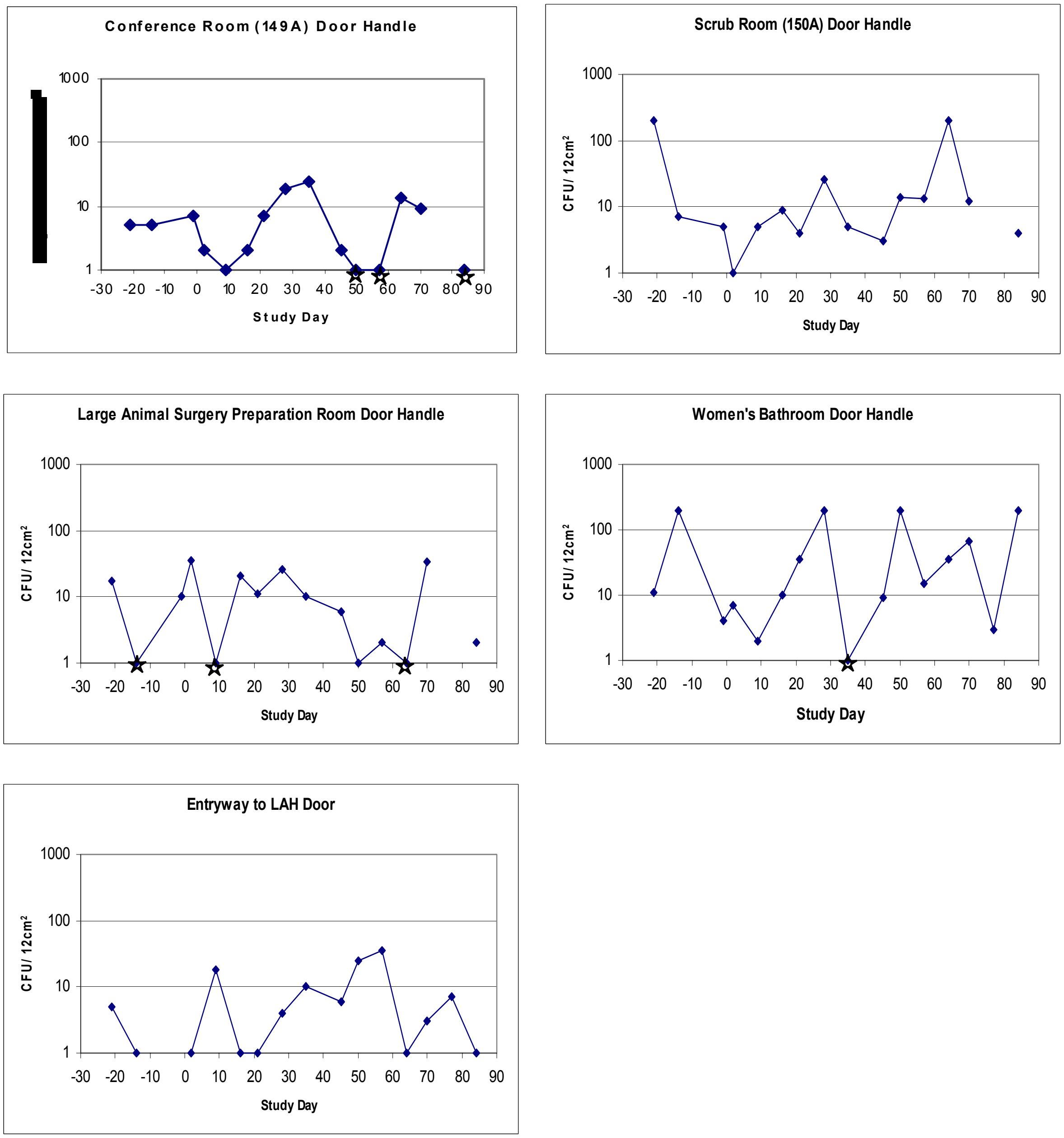

Figure 3.15. Surface bacterial load present on "door handle"sites. Stars indicate recorded values of 0 CFU/12 cm^2 that were replaced with 1 CFU/12 cm^2 to preserve an interpretable scale. Interrupted lines indicate that a site was not sampled on a particular day. Points above 130 CFU/12 cm^2 were considered too numerous to count and were arbitrarily assigned a value of 200 CFU/12 cm^2.

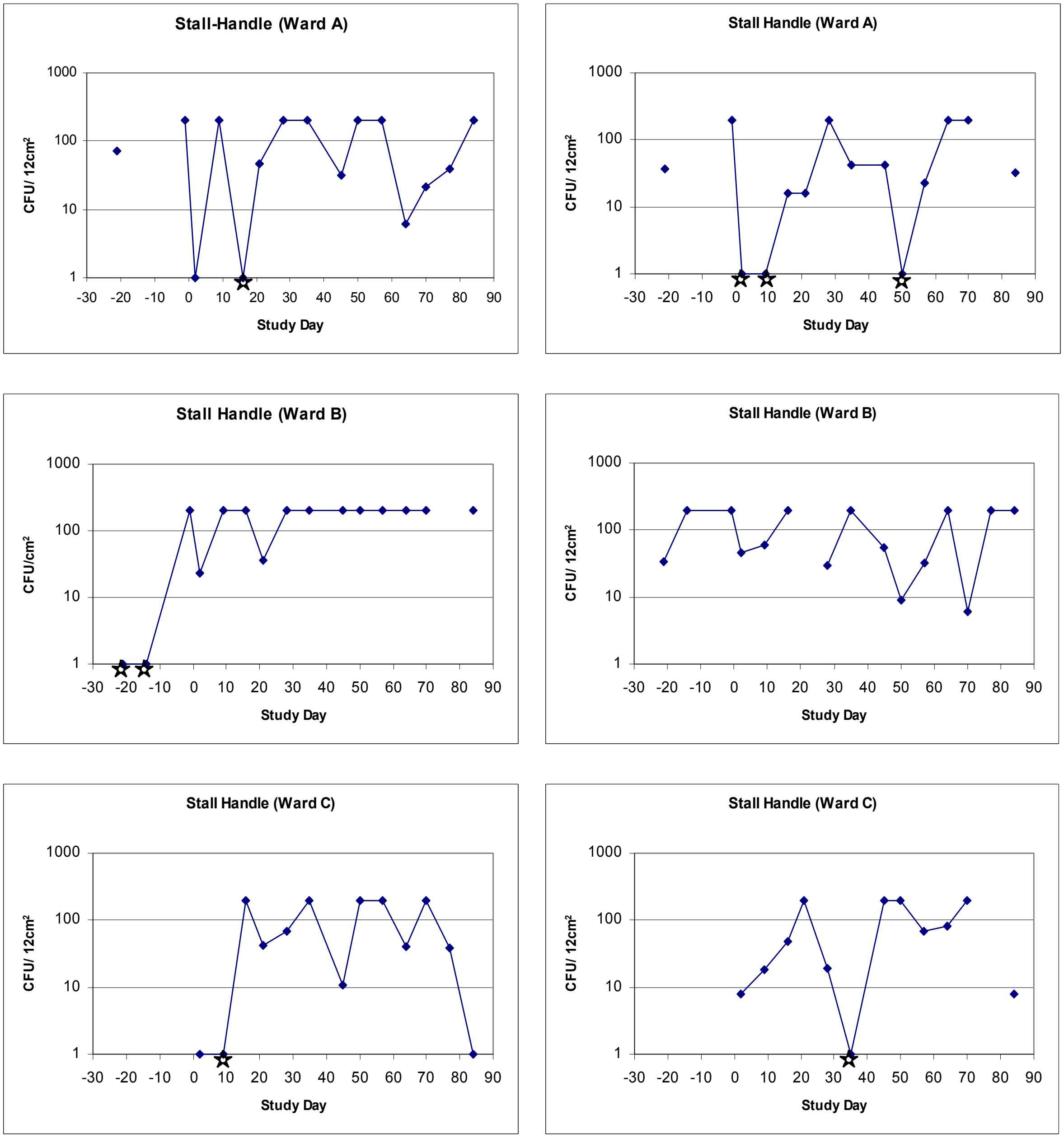

Figure 3.16. Surface bacterial load present on stall sites. Stars indicate recorded values of 0 CFU/12 cm^2 that were replaced with 1 CFU/12 cm^2 to preserve an interpretable scale. Interrupted lines indicate that a site was not sampled on a particular day. Points above 130 CFU/12 cm^2 were considered too numerous to count and were arbitrarily assigned a value of 200 CFU/12 cm^2.

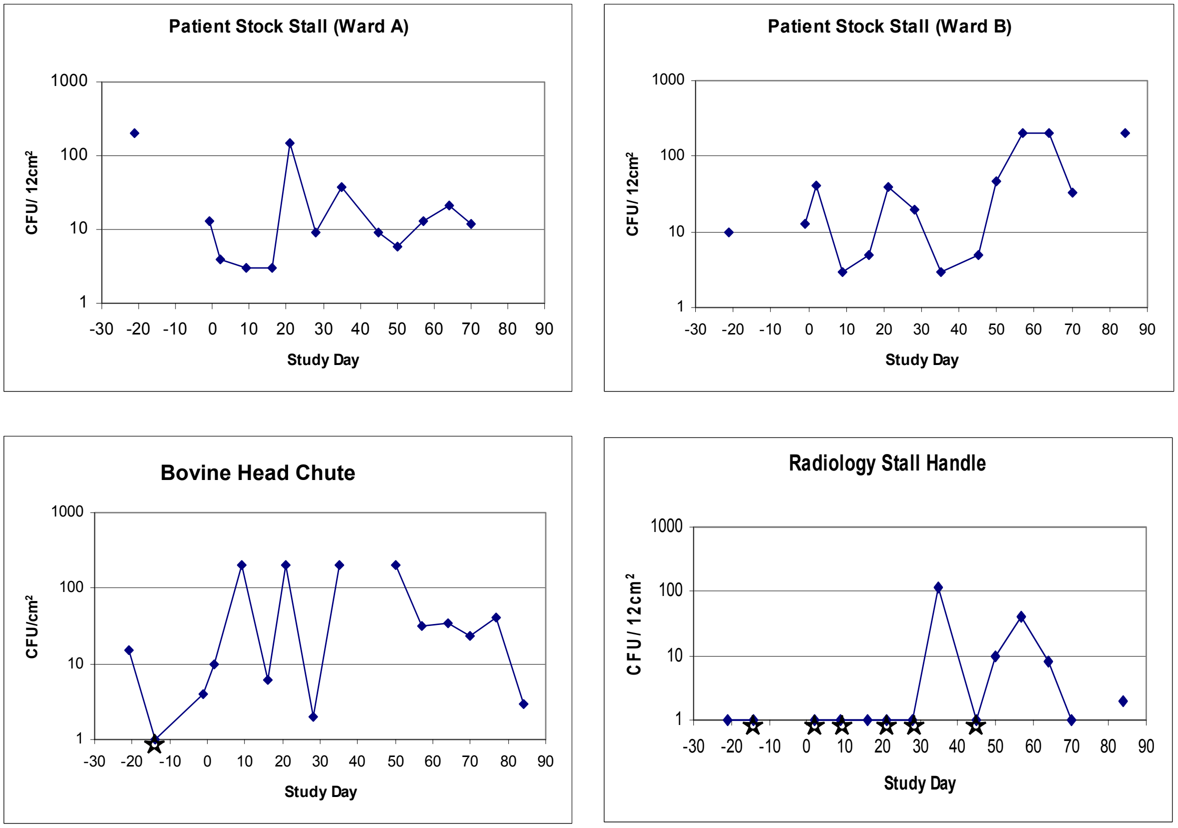

Figure 3.17. Surface bacterial load present on stock, chute and radiology stall sites. Stars indicate recorded values of 0 CFU/12 cm^2 that were replaced with 1 CFU/12 cm^2 to preserve an interpretable scale. Interrupted lines indicate that a site was not sampled on a particular day. Points above 130 CFU/12 cm^2 were considered too numerous to count and were arbitrarily assigned a value of 200 CFU/12 cm^2.

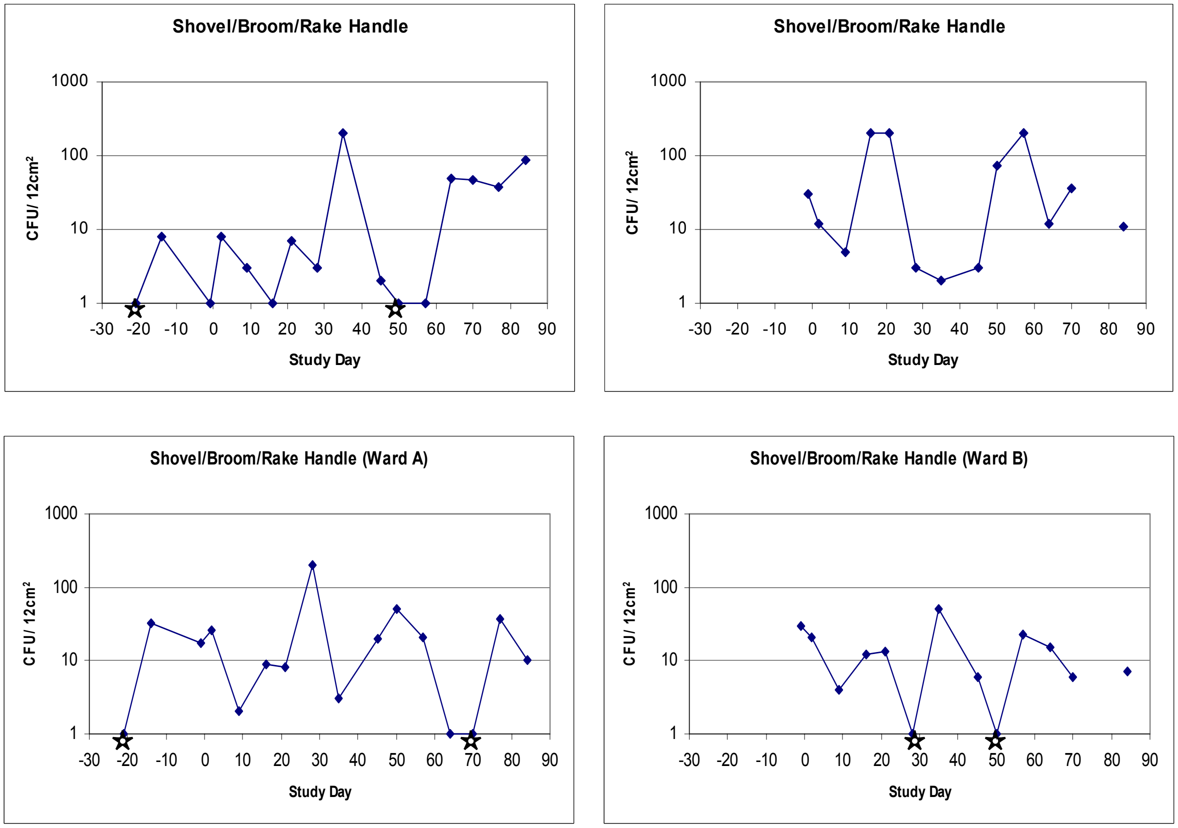

Figure 3.18. Surface bacterial load present on "cleaning implements". Stars indicate recorded values of 0 CFU/12 cm^2 that were replaced with 1 CFU/12 cm^2 to preserve an interpretable scale. Interrupted lines indicate that a site was not sampled on a particular day. Points above 130 CFU/12 cm^2 were considered too numerous to count and were arbitrarily assigned a value of 200 CFU/12 cm^2.

3.4.4 Waterless Hand Sanitizer Efficacy Study

A reduction in bacterial load was seen when HBC were determined immediately before and after WHS use ($P < 0.0001$; Figure 3.19). When no growth was observed, values were reported as 19 CFU/ml, 1 CFU/ml below the limit of detection. Before WHS use, HBC ranged from 19 to 48,800 CFU/ml with a geometric mean of 6,926 CFU/ml [95% CI: (2,689; 17,837)]. Counts after WHS use ranged from 19 to 23,400 with a geometric mean of 1,152 CFU/ml [95% CI: (403; 3,290)] (Figure 3.19). Differences (before minus after) ranged from -4,000 to 48,200 CFU/ml with a median of 9,700 CFU/ml. In two instances (20%), HBC increased after WHS application. The logarithmic reduction in bacterial load before and after WHS use was 0.78 (79.7%).

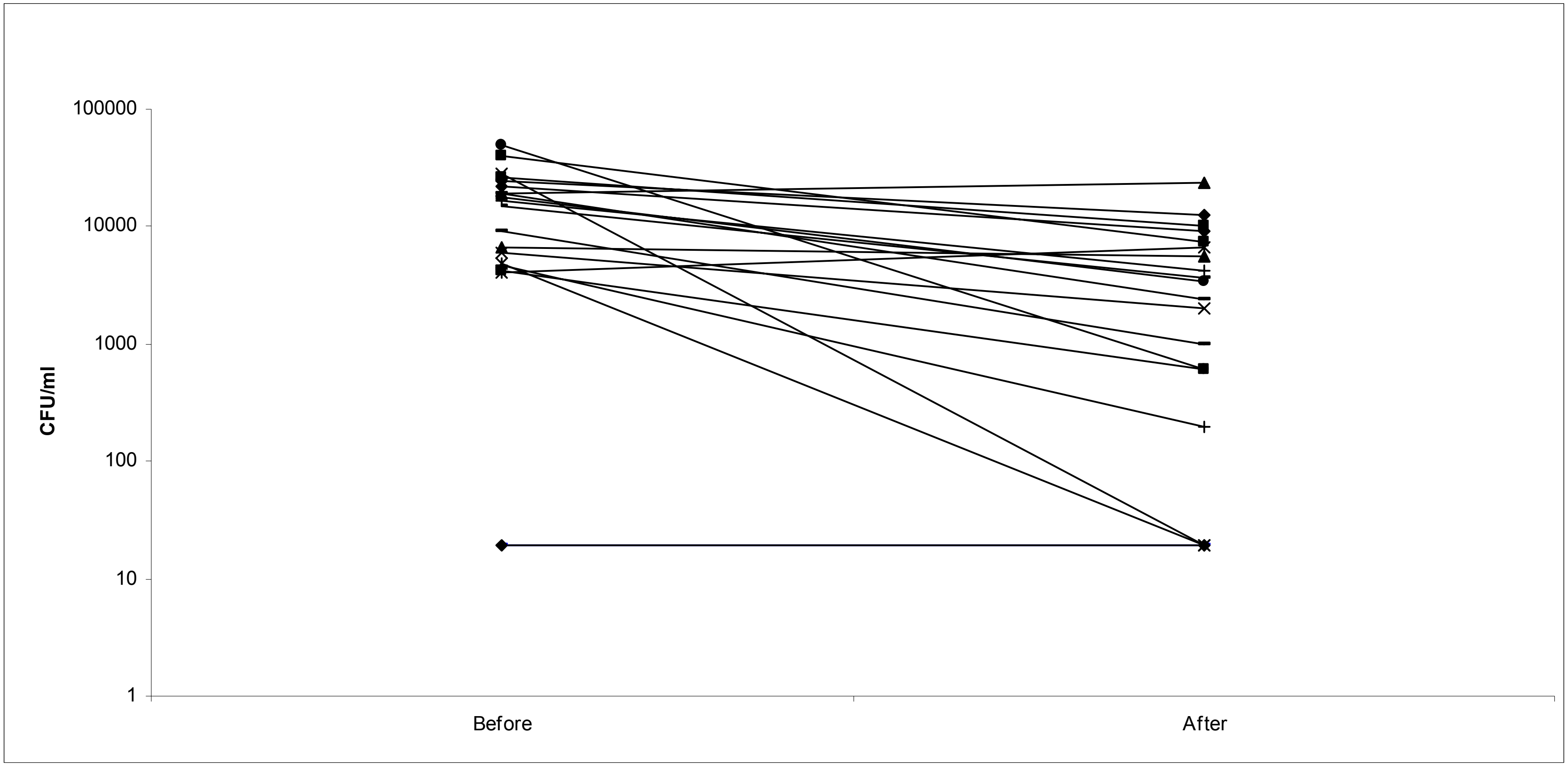

Figure 3.19. Bacterial load on hands before and after waterless hand sanitizer use. When no growth was observed, values were reported as 19 CFU/ml, 1 CFU/ml below the limit of detection.

3.4.5 LAH Personnel Questionnaire

A total of 37 LAH personnel answered the questionnaire, of which 68% (25/37) were women, 32% (12/37) men, 8% (3/37) faculty, 30% (11/37) staff and 62% (23/37) students. Fourteen percent of respondents (5/37) never and 5% (2/37) rarely used WHS. Reasons given were forgetfulness, 16% (6/37) and "don't like WHS" or it causes irritation of their skin, 19% (7/37). Convenience, 32% (12/37), was the reason given by respondents who stated they used WHS occasionally, 38% (14/37), or frequently, 43% (16/37). Approximately 19% of respondents indicated that they used WHS for the following reasons: "it kills germs" (2/37), they were adhering to LAH policy procedures (2/37), they were supporting the study (1/37), they did not feel the need to use WHS because of adequate traditional handwashing (1/37) and person responding did not feel the need to use WHS because they did not enter patient stalls (1/37).

When LAH personnel were asked if their use of soap and water for handwashing changed with the introduction of WHS, 65% (24/37) of persons responded "no", 30% (11/37) responded "yes" and 5% (2/37) of students responded "not applicable" because they were students and their large animal rotations began after the WHS had been introduced into the LAH.

Personnel were also asked if they used WHS in any place other than the LAH. Fifty-one percent (19/37) of individuals responded "no" while the other 38% (14/37) did not respond or stated they kept WHS in their purse, car, or used it during travel 11% (4/37).

Finally, when asked if WHS should be continued to be used in the LAH, 62% (23/37) people said "yes, if a significant reduction in bacterial load can be demonstrated", 32% (12/37) people said "yes, even if a significant reduction in bacterial load cannot be demonstrated" and 5% (2/37) respond "no".

3.5 Discussion and Conclusions

3.5.1 Hand Hygiene Products

The initial publicity of the study may have influenced the quantity of hand hygiene products used during the beginning of the study. This is shown by the increase in soap usage before the formal presentations and literature release occurred. Afterwards, continued increases in soap usage were noted for the next 3 weeks.

A gradual increase in WHS was noted during the first 4 weeks after introduction into the LAH. This may be attributed to the effects of the presentations, study literature and/or the overall novelty of the WHS in the LAH.

The appearance of the "informational" and "motivational" posters did not appear to have an immediate effect on hand hygiene product usage. In fact, a gradual decline in both products was detected for 2 weeks after poster introduction. However, 3 weeks after the posters were put in place, an increase in the usage of both products was seen. When the motivational tools of presentations and posters are compared, oral presentations appear to have a more immediate effect on hand hygiene practices due to their ability to reach larger populations simultaneously.

Mody *et al.,* (2003) in relation to a human, long-term healthcare facility, stated that hand hygiene, based on self-assessment, did not change immediately after the introduction of WHS or other interventions aimed at increasing compliance. However, by the end of the study period, the frequency of hand hygiene had increased significantly.

Muto *et al.,* (2000), who mounted WHS units on every door in 2 wards of a hospital, stated no change in hand hygiene compliance after launching an educational campaign and making WHS available. In fact, a decrease in compliance was noted over the next 2 months. Naikoba and Hayward (2001) observed that educational interventions appeared to have a short-lived effect on handwashing behavior. The results of the present study appear to reflect similar behavior.

Hand hygiene product usage was expected to correlate positively with patient population *i.e.,* more product would be consumed when patient load was higher. No apparent relationship was seen in this study. Paradoxically, the week with the lowest in-patient population yielded the highest amount of soap usage. This may be due to the increased amount of time LAH personnel have to devote to hand hygiene when patient loads are low, although this cannot be definitively stated, especially since a later downturn in soap and WHS usage coincided with a drop in patient-days.

3.5.2 Hand Bacterial Counts

Bacterial loads on the hands of LAH personnel did not appear to decrease during the course of the study. The mean HBC remained fairly constant for the entirety of the study. Mody *et al.,* (2003), in a comparison of hand colonization before and after efforts to promote hand hygiene, also reported no significant difference in HBC after the introduction of educational materials and making WHS available.

Twenty different species of organisms along with unspeciated isolates of 5 genera were found to be present on the hands of LAH personnel. These include organisms noted for causing opportunistic and nosocomial infections such as: *Acinetobacter, Citrobacter, Escherichia, Klebsiella, Panteoa, Pseudomonas, Serratia, Staphylococcus,* and *Streptococcus* (Boerlin *et al.*, 2001; Fox *et al.*, 1981; Glickman, 1981; Johnson, 2002; Seguin *et al.*, 1999).

3.5.3 Environmental Sampling

Bacterial loads on the surfaces of environmental sites sampled during the study followed the same pattern as bacterial loads on hands. No definable pattern of change in bacterial load was noted on these objects over the course of the study.

Identification of organisms present on environmental sites revealed some of the same organisms found on the hands of LAH personnel. “Stalls” and “cleaning implements” had the greatest diversity of potential nosocomial agents.

These included the genera *Citrobacter, Pseudomonas, Serratia, Staphylococcus, Streptococcus* and *Candida*.

Although no previous research analyzing the effects of WHS on environmental surface contamination over a period of time has been noted, several researchers have concluded that environmental sites, similar to the ones sampled in this study, have the capability of becoming reservoirs for potentially pathogenic bacteria (Alothman *et al.*, 2003; Bebbington *et al.*, 2003; Bures *et al.*, 2000). It is apparent that efforts should be taken by veterinary hospital personnel to practice adequate hand hygiene in order to prevent nosocomial infections.

3.5.4 Waterless Hand Sanitizer Efficacy Study

Based on the results of the experiment testing the efficacy of waterless hand sanitizer, it can be concluded that WHS is useful at reducing hand bacterial loads in veterinary medical settings. A logarithmic reduction of approximately 80% (0.78) was seen. The Food and Drug Administration's Tentative Final Monograph for Healthcare Antiseptic Drug Products (TFM) requires at least a 2 $\log_{10}$ reduction of bacterial load in order to meet efficacy standards (McDonald *et al.*, 2003). It should be noted however, in this study the TFM protocol which calls for the intentional contamination of the hands with an indicator organism under controlled experimental conditions was not used (McDonald *et al.*, 2003). This evaluation was performed using hands naturally contaminated with a variety of organisms in the realistic setting of a large animal hospital. Although TFM guidelines exist, investigators continue to use a variety of methods to evaluate efficacy of hand hygiene products. In the published research addressing WHS efficacy, one study used a technique similar to that used here and one used a method similar to TFM protocols (Fendler *et al.*, 2002; Kampf *et al.*, 2002; Marena *et al.*, 2002; Mody *et al.*, 2003).

On two occasions in the current study, HBC increased after WHS application. Occasionally, when hand rubbing or washing is performed for a long enough time, the physical action dislodges resident flora from the hands. When this occurs, bacterial counts may actually be elevated at the time of sampling.

With this in mind, it is plausible that two applications may be needed in order to achieve the 2 $\log_{10}$ reduction required by TFM. Wiping the hands with a paper towel between the first and second application may be helpful.

3.5.5 LAH Personnel Questionnaire

Responses given to questions regarding WHS usage were similar to those in other studies promoting hand hygiene to healthcare workers. Large animal personnel sited "convenience" as the primary incentive for practicing hand hygiene with WHS. They also reported "skin irritation" and "forgetfulness" as two factors influencing the frequency with which they practiced hand hygiene (Boyce and Pittet, 2002; Mody *et al.*, 2003). Although the questions provided noteworthy information, no direct connection could be made to hand bacterial count results.

3.5.6 Additional Observations

Various attitudes were encountered with regard to study participation. The majority of individuals seemed eager to participate. This might be attributed to the study's direct relationship with the hospital biosecurity program. A *Salmonella* outbreak occurring in the LAH during 2001 made personnel keenly aware of the need for enhanced efforts to prevent nosocomial infections.

Large animal hospital personnel were interested in the results of their GJS. It is believed that even though every effort was taken to portray otherwise, alterations in behavior occurred when individuals realized that they were being observed and sampled.

A minority of persons displayed particularly disturbing attitudes regarding the study. Some seemed especially irritated by the added effort required, specifically the GJS and the stall entry sheets. Such individuals rarely participated in GJS procedures. In one instance, an effort by the investigators to increase the use of stall entry sheets was met with heated resistance and ended with an individual stating that they did not have time to place entries on the sheets. On several occasions stall entry sheets were used as scrap paper or turned over to put notes on patient stall doors. This is one of the reasons why the data on these sheets were thought to be unreliable and why compliance rates could not be determined. A suggestion to improve study participation may be to offer some incentive (*e.g.* money) or take disciplinary measures (*e.g.* poor job performance evaluation) although this may artificially influence hand hygiene behavior and therefore produce aberrant results.

With regard to LAH personnel and the questionnaire, it is thought that answers may have been affected by the fact that the investigator directly administered the questions. Although names were not recorded, the behavior of individuals questioned led the investigator to believe some answers were untruthful and may have been given just to please.

Hand bacterial count data may have been skewed by the desire to have exceptionally clean or dirty hands when sampled. For future experimentation, it may be beneficial to have GJS of the same individuals throughout the course of the study, although the possibility of behavior alterations may still exist in this group due to study awareness. Results of environmental sampling may be improved by using a collection method that allows dilution of samples to report more accurate data.

Study design might also be improved by decreasing the number of things studied and looking at the effects of motivational interventions and WHS separately. Perhaps looking at 2 large animal teaching hospitals comparable in personnel and patient type, with 1 serving as a control would permit a more accurate assessment.

Despite these limitations, the investigator believes that the present study positively influenced hand hygiene in the LAH. Just the fact that a study was conducted, which observed and promoted hand hygiene, made LAH personnel aware of how much individual control they possess with regard to influencing the occurrence of nosocomial infections.

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