

Assessing most practical and effective protocols to sanitize hands of poultry catching crew members



M. Racicot^{a,*}, A. Kocher^b, G. Beauchamp^c, A. Letellier^d, J.-P. Vaillancourt^c

^a Canadian Food Inspection Agency, 59 Camelot, Ottawa, Ontario, Canada K1A 0Y9

^b École nationale vétérinaire de Toulouse, 23 chemin des Capelles, 31076 Toulouse Cedex, France

^c Université de Montréal, Faculté de médecine vétérinaire, Epidemiology of Zoonosis and Public Health Research Unit, CP 5000, St-Hyacinthe, Québec, Canada J2S 7C6

^d Université de Montréal, Faculté de médecine vétérinaire, NSERC Industrial Research Chair in Meat Safety, GRESA, CP 5000, St-Hyacinthe, Québec, Canada J2S 7C6

ARTICLE INFO

Article history:

Received 7 August 2012

Received in revised form 11 March 2013

Accepted 24 March 2013

Keywords:

Hand washing

Hand sanitizer

Catching crew

Biosecurity

Poultry

Hygiene and public health

ABSTRACT

Catching crew members can heavily contaminate their hands with organic material. They can act as mechanical vector and spread diseases between farms. Hand hygiene is an important issue for the industry as a whole and for human health by reducing contamination risks. Many studies, in human medicine, tend to make hand rub a standard for hand hygiene. However, few studies have tested the effectiveness of hand hygiene products on visibly contaminated hands. The objective of this study was to evaluate the effectiveness of practical hand sanitization protocols: water and soap, degreasing cream and hand wipes, all combined with alcohol-based hand gel. The use of alcohol-based gel alone was also evaluated. For the reduction of coliforms after washing, there was no statistically significant difference between protocols when the initial level of bacterial contamination was low to moderate. When hands were highly contaminated, the alcohol-based gel alone was less effective than the degreasing cream combined with the alcohol-based gel ($p = 0.002$). As for the reduction in total aerobic bacteria counts, there was no difference between protocols when the initial level of bacterial contamination was low. The water, soap and alcohol-based gel protocol was more effective than the scrubbing wipes and alcohol-based gel protocol when hands were moderately ($p = 0.002$) and highly contaminated ($p = 0.001$). All protocols were effective in neutralizing *Salmonella* on hands. Reducing the level of bacterial contamination on hands before using an alcohol-based gel seems important to ensure effective hand sanitation for highly and moderately contaminated hands. This can be done by using a degreasing cream or water and soap. Based on the survey, catching crew members preferred using warm water and soap compared to a degreasing cream.

Crown Copyright © 2013 Published by Elsevier B.V. All rights reserved.

1. Introduction

The normal density of bacteria found on human skin ranges between 10^2 and 10^3 CFU/cm² (colony forming

units per square centimeter) (Widmer, 2000). By handling animals and farm equipment, hands are exposed to pathogens. For example, genetic material of the respiratory and reproductive syndrome virus was detected under nails of people following a contact with infected pigs (Amass et al., 2000). The movement of personnel and equipment between poultry farms, especially when catching crew members partially depopulate a flock, was identified as an important risk factor in several studies (Slader et al., 2002; Wendelke et al., 2007; Hue et al., 2010; Newell et al.,

* Corresponding author. Present address: 59 Camelot Drive, Ottawa, Ontario, Canada. Tel.: +1 613 773 7366; fax: +1 613 773 7175.

E-mail addresses: manon.racicot@inspection.gc.ca, manon.racicot@umontreal.ca (M. Racicot).

2011; Patriarchi et al., 2011; Ridley et al., 2011). As it is the case for other visitors, catching crew members travel from farm to farm with their own vehicle, equipment, boots and clothing. Their farm activities are however a high risk considering the level of contamination they are exposed to and the close contact with birds that may remain in the barn. Changing boots and clothing when entering a poultry barn are mandatory for visitors in Canada. However, recommendations on hand hygiene are unclear since there is a lack of information on the efficacy of hand washing techniques and products.

Hand hygiene is also important to prevent zoonotic agents contamination such as *Escherichia coli* O157 (Shukla et al., 1995; Milne et al., 1999) and *Salmonella enteritidis* (Friedman et al., 1998) for which human health consequences can be serious.

Many products are available to sanitize hands: nonantimicrobial and antimicrobial soap used with water, waterless alcohol-based hand rubs and waterless hand wipes. In human medicine, scientific evidence tends to make alcohol-based hand rub a standard for hand hygiene. Indeed, this technique is microbiologically more effective *in vivo* (clinical trials) and *in vitro* (laboratory experiments), is easier to use, saves time and improves hand hygiene compliance (Widmer, 2000; Girou et al., 2002; Trampuz and Widmer, 2004). Hand hygiene compliance still rarely exceeds 50% (Pittet, 2001; Boyce and Pittet, 2002). However, these studies were performed on hands that were not visibly soiled. In the poultry industry, catching crew members can have heavily contaminated hands. Therefore, they represent a good proxy for heavy hand contamination by visitors. Furthermore, soap and water hand washing can be inconvenient since sinks are not always available in barns. It is still important to reduce the microbial load on hands by performing effective hand sanitation. An alternative would be the use of alcohol-based hand gels. There is only one study that tested alcohol-based hand gels as an alternative to soap and water after handling animals. Davis et al. (2005) did not find any difference between treatments.

No study has investigated the effectiveness of hand hygiene techniques in the actual context. The objectives were to evaluate the efficacy of practical hand sanitation methods and to determine the most practical approach in order to increase compliance.

2. Materials and methods

2.1. Selection of participants

This experimental study was conducted under field conditions, from July to August 2010. A catching crew company was selected based on the proximity with the Faculty of Veterinary Medicine of the University of Montreal, where the investigators were based. One crew was followed during normal working hours and four volunteers were selected. The selection was based on their availability and willingness to participate in the assessment of the efficacy of different hand sanitizing protocols. Since the purpose of the study was to compare different hand washing products/protocols, it was important to have a limited

number of participants to limit the diversity of hand washing practices.

In order to determine the most practical approach (i.e., to get the opinion of a larger group of employees), the products tested were provided to all employees (catching crew members) of this company.

2.2. Hand sanitation protocols

Four hand sanitation protocols were tested. In the first one, hands were sanitized with a waterless alcohol hand rub (alcohol-based gel) containing 62% ethanol (Purell-Johnson & Johnson, Markham, ON, Canada). In the second protocol, hands were washed with water and an antibacterial soap containing triclosan (Dial Spring Water-Henkel Consumer Goods Inc., Oakville, ON, Canada), dried with a disposable paper and sanitized with the same alcohol-based gel. The third protocol consisted in using a degreasing pumice-added cream without water (Motomaster Heavy-duty Hand Cleaner with pumice-Motomaster Canada, Toronto, ON, Canada) and wiping with paper followed by the use of the same alcohol-based gel. The last protocol consisted in using antimicrobial wipes (Big Wipes-Sycamore Israel, Petach Tikva, Israel) followed by the alcohol-based gel.

To be as close as possible to field conditions, no specific time and quantity were required for washing or rubbing hands with the different products. An explanation was given on how to perform the four protocols (different steps) without indicating specific time or quantity to use. However, the time spent by each person for each protocol (the time spent to wash hands before applying the alcohol-based gel and the time spent to rub hands with the alcohol-based gel) was recorded using a video camera and the quantity of alcohol-based gel used was estimated by recording the number of times each participant pressed on the delivery device fixed on the alcohol-based gel container. All explanations were given in French and the supervisor simultaneously translated in Spanish, the language spoken by most participants. In order to be included in the study, all participants had to sign a confidentiality agreement. This agreement was available in French and Spanish.

2.3. Data collection

Thirty two repetitions were done per protocol. Four catching crew members applied each protocol eight times (32 repetitions per crew member). Therefore, the total number of samples was 256 samples (128 before and 128 after applying a protocol). A sample size of 4 in each treatment would provide about 80% power to detect a difference between a treatment with on average a 2 log reduction in germ numbers and another with a 1.3 log reduction, assuming a standard deviation among subjects of about 0.3 in log scale. Log reduction values of this magnitude would produce a relative reduction in germ numbers ranging from 95 to 99%, in line with our prior expectation of hand cleaning efficiency for different products. The standard deviation was estimated using a pilot study.

Data were collected on several farms over a two month-period. Once the crew completed a bird load, participants were asked to rub their hands together to reduce any potential difference between the right and the left hands (although most of the time, they used both hands to catch birds). To evaluate the initial bacterial contamination, a pre-treatment sample was taken on one hand by applying the sampling cloth on the inside of the hand and rubbing it with five circular motions going from the center of the hand to the periphery. Following this sampling, each participant sanitized their hands following one of the four protocols. All participants were systematically assigned to one of the protocols and the order of treatments from one load to another varied randomly among participants. For each bird load, the four protocols were thus performed each time by at least one employee. A second sample (post-treatment) was then taken on the other hand (the one not selected for pre-treatment sampling) using the same method as for the first sample.

A questionnaire was also provided to all the catching crew members of the company to determine the most practical approach. The questionnaire was available in French and Spanish, as well as the confidentiality agreement.

2.4. Microbiological analysis

The materials used to collect samples were cloths soaked with a Neutralizing broth (D/E Neutralizing Broth, Lab M, Bury, Lancs; Roberts D (1995)) contained in sterile sampling bags. The product was certified sterile by Labplas Inc., Ste-Julie, Quebec, Canada. The sampling material was kept at 4 °C and carried on farms in a cooler with ice packs. After collection, the samples were transported back to the laboratory in another cooler with icepacks. All samples were analyzed at the Faculty of Veterinary Medicine the morning following the collection (within 12 h). An enrichment media (10 ml of buffered peptone water) was added to sampling bags which were stomached for 30 s, in order to obtain a homogeneous sampling solution. The solution was serially diluted and spread on Aerobic and *E. coli*/Coliform 3 M Petrifilms (3 M, St Paul, MN, US) to count total aerobic bacteria, *E. coli* and coliforms population according to the MFHPB-33 and MFHPB-34 procedures of Health Canada. Then 20 ml were added to the sampling bags for the pre-enrichment for *Salmonella* detection. The bags were then homogenized and incubated at 37 °C for 18–24 h and after that, the solution was spread on MRSV plates containing novobiocine in order to detect the presence of *Salmonella* according to the MFLP-75 procedure of Health Canada.

2.5. Statistical analysis

Numbers of total coliforms and aerobic bacteria were log₁₀ transformed to normalize distributions. A linear mixed model was used with the transformed number of bacteria on cleaned hands as the dependent variable. The protocol was a fixed factor, the number of bacteria on dirty hands was a co-factor and the participant was a random factor (to consider repeated measurements for each

participant). Variables such as the amount of alcohol-based hand gel (number of times a participant pressed on the delivery device fixed on the alcohol-based hand gel container) and duration of rubbing hands were also included as co-factors. Using estimates from the model, we performed pairwise comparisons between the means from the different protocols. These contrasts were performed at different levels of initial hand contamination, the co-factor in the analysis, to evaluate whether differences between protocol means varied depending on the initial level of contamination. In view of the large number of pairwise comparisons that we performed, the Bonferroni sequential procedure was used to adjust comparison-wise alpha level to ensure a family-wise error rate at the set alpha level (0.05). Statistical analyses were performed using SAS v.9.2 (Cary, NC). Unless otherwise stated, we present means and standard deviations (SD).

3. Results

3.1. Descriptive results

In protocol 1, the average time to rub hands with the alcohol-based gel was 23.1 s (1.9). The average time to wash hands across all repeats for the same individual was 38.9 s (8.5) in protocol 2 (water and soap), 40.4 s (7.4) in protocol 3 (degreasing) and 35.5 s (7.2) in protocol 4 (wipes). Across all repeats for the same individual, the average number of times each participant pressed on the delivery device fixed on the alcohol-based gel container was 4.9 (2.2) for protocol 1, 2.8 (1.2) for protocol 2, 3.1 (1.1) for protocol 3 and 3.1 (1.3) for protocol 4. Table 1 presents the mean (SD) number of coliforms and total aerobic bacteria (in log₁₀) depending on the protocol across the four crew members and the mean difference (in log₁₀ and in percentage) before and after applying each protocol. For each participant, the mean number of bacteria was calculated across all replicates, and then the mean was calculated across participants was calculated. At the participant level, the difference in log means, for each participant, represents the differences between the mean number of bacteria in log before and after treatment. The mean of participant results is presented. The difference in percentage means that, for each participant, the differences between the mean number of bacteria pre-treatment and the mean number of bacteria post-treatment were calculated, divided by the initial number of bacteria, pre-treatment, and expressed in percentage. For example, a percentage of 93.4 means that there is a reduction of 93.4% of the bacterial population. The mean of participant results is presented.

3.2. *Salmonella* contamination

Twenty seven (10.5%) dirty hands tested positive for *Salmonella* (6 before applying the alcohol-based hand gel, 3 before washing hands with water and soap, 9 before using the degreasing cream and 9 before using wipes). With every protocol, all washed hands proved negative for *Salmonella*.

Table 1

Mean (SD) number of coliforms and total aerobics (in log) depending on the protocol and the mean difference (in log and in percentage) before and after applying the protocol.

Protocol ^a	Mean number of bacteria in log (SD)		Difference between pre and post-treatment	
	Pre-treatment	Post-treatment	In log	In percentage
Coliforms				
1	3.66 (0.62)	2.38 (0.57)	1.3	93.4
2	3.44 (0.48)	2.11 (0.44)	1.3	95.2
3	3.40 (0.24)	1.69 (0.17)	1.7	97.7
4	4.00 (0.47)	1.90 (0.27)	2.1	99.1
Total aerobics				
1	7.83 (0.06)	6.59 (0.44)	1.2	91.0
2	7.82 (0.10)	6.03 (0.30)	1.8	98.2
3	7.92 (0.09)	6.39 (0.55)	1.5	95.4
4	7.95 (0.07)	6.83 (0.40)	1.1	89.8

^a Protocol 1 was alcohol-based hand gel alone; protocol 2 was water, soap and alcohol-based hand gel; protocol 3 was degreasing cream and alcohol-based hand gel; protocol 4 was wipes and alcohol-based hand gel.

3.3. Analytic results – total coliform counts

The linear model revealed a statistically significant effect of protocol on mean total coliform counts ($p=0.04$) and a positive effect of initial hand contamination level (β [SE]: 0.23 [0.086], $p<0.0001$; Fig. 1). Protocol and initial hand contamination interacted significantly ($p=0.001$) suggesting that the effect of protocol varied depending on initial hand contamination. Neither number of alcohol-based hand gel pushes ($p=0.82$) nor time to rub hands with the gel ($p=0.31$) influenced total coliform counts after cleaning. Pairwise comparisons between protocol means were conducted at three levels of initial contamination: first quartile (lower 25% level of contamination), median (50%), and third quartile (level of

contamination corresponding to the upper 25% of contamination). The values corresponding to quartiles were 2.59 log 10 CFU (25%), 3.08 log 10 CFU (50%) and 3.65 log 10 CFU (75%). The minimum was 1.48 log 10 CFU and the maximum was 4.30 log 10 CFU. There was no statistically significant differences between protocol means when initial hand contamination was low or median ($p>0.008$; non-significant after Bonferroni adjustment). At high initial contamination levels, mean contamination level on the clean hand was higher for protocol 1 (alcohol-based hand gel) than for protocol 3 (degreasing and alcohol-based hand gel) ($p=0.002$).

In a separate model excluding protocol 1, the time needed to wash hands was added as a co-factor along with the same fixed and random factors as before. There was no statistically significant effect of time needed to wash hands on total coliform counts after cleaning ($p=0.33$).

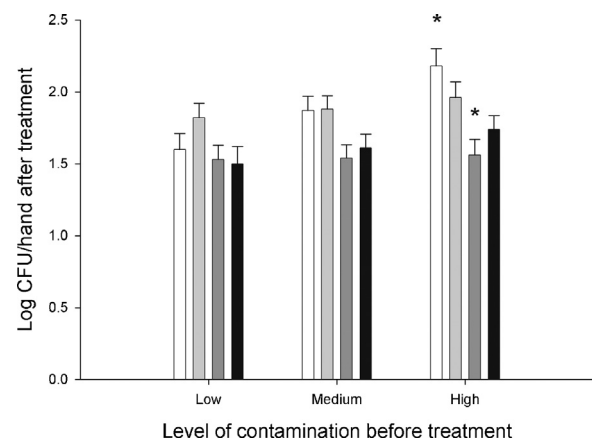


Fig. 1. Comparison of the mean log 10 number of coliforms before and after applying each protocol for three different levels of initial contamination. Error bars show one standard error.

*Indicates that differences were statistically significant between the two bars marked with this symbol

□ Alcohol-based hand gel alone.

▒ Water, soap and alcohol-based hand gel.

▓ Degreasing cream and alcohol-based hand gel.

■ Wipes and alcohol-based hand gel.

Pairwise comparisons between protocol means were conducted at three levels of initial contamination: first quartile (lower 25% level of contamination), median (50%), and third quartile (level of contamination corresponding to the upper 25% of contamination).

3.4. Analytic results – total aerobic bacterial counts

The linear model revealed no statistically significant effect of protocol on mean total aerobic bacterial counts ($p=0.15$) and a positive effect of initial hand contamination level (β [SE]: 0.54 [0.24], $p<0.0001$; Fig. 2). Protocol and initial hand contamination did not interact significantly ($p=0.08$), although the trend was in the same direction, as noted earlier for coliform counts. Neither number of alcohol-based hand gel pushes ($p=0.08$) nor time to rub hands with the gel ($p=0.34$) influenced total aerobic bacterial counts after cleaning. Pairwise comparisons between protocol means were conducted at three levels of initial contamination, as described earlier. The values corresponding to quartiles were 7.53 log 10 CFU (25%), 7.75 log 10 CFU (50%) and 8.02 log 10 CFU (75%). The minimum was 4.28 log 10 CFU and the maximum was 8.42 log 10 CFU. There was no statistically significant differences between protocol means when initial hand contamination was low ($p>0.009$; non-significant after Bonferroni adjustment). The mean contamination level on the clean hand was lower for protocol 2 (water, soap and alcohol-based hand gel) than for protocol 4 (wipe and alcohol-based hand gel) when initial hand contamination was median ($p=0.002$) and high ($p=0.001$).

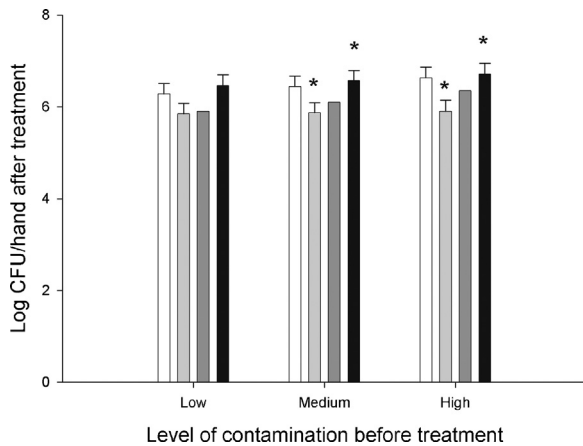


Fig. 2. Comparison of the mean log number of total aerobic counts before and after applying each protocol for three different levels of initial contamination. Error bars show one standard error.

*Indicates that differences were statistically significant ($p \leq 0.05$) between the two bars marked with this symbol

□ Alcohol-based hand gel alone.

■ Water, soap and alcohol-based hand gel.

■ Degreasing cream and alcohol-based hand gel.

■ Wipes and alcohol-based hand gel.

Pairwise comparisons between protocol means were conducted at three levels of initial contamination: first quartile (lower 25% level of contamination), median (50%), and third quartile (level of contamination corresponding to the upper 25% of contamination).

In a separate model excluding protocol 1, the time needed to wash hands was added as a co-factor along with the same fixed and random factors as before. There was no statistically significant effect of time needed to wash hands on total aerobic bacterial counts after cleaning ($p = 0.85$).

3.5. Questionnaire

Of the 46 employees (all men) of the catching crew company, 38 accepted to fill out a questionnaire on their knowledge and opinions relative to hand washing (Tables 2 and 3). On average, they were 28.7 years old, the youngest being 18 and the oldest, 47. They had a mean of 7.5 years of experience catching poultry. This ranged from only four weeks to 34 years. It appears that many started catching birds in their mid-teens. About two-thirds of them already had some poultry experience prior to their current job. Although the majority reported washing their hands while on the job, if given the opportunity, almost 40% did not. The overwhelming reason to wash hands was to avoid getting sick. Very few claimed doing it to avoid poultry disease transmission between flocks. An important difference in knowledge about poultry diseases and zoonotic conditions such as *Salmonella* seemed to prevail between the Hispanic employees (almost all from Guatemala) and Canadian born employees. Respondents were more likely to have used soap and water to wash hands compared to the other options included in the questionnaire. It was also the most preferred approach to washing hands (Table 3). Using a disinfecting gel was equally appreciated by respondents. When asked to comment about the different protocols, almost all negative comments pertained to a dislike for

having to wash hands with cold water (12 respondents) and to the stickiness associated with using the degreasing pumice-added cream (6 respondents) or the wipes (2 respondents).

4. Discussion

Hand hygiene is important for reducing mechanical transmission of pathogens between farms. In the poultry industry, it is common to divide flocks into batches for slaughter (i.e., leaving birds behind for later pick up, hence providing an opportunity for pathogens to infect the remaining birds; on multi-age sites, this may lead to the spread of these pathogens). The practice, known as partial pick up, is also seen in the chicken industry. Hens are sent to slaughter first, leaving behind males for a longer growing period. This strategy has been known to favor the transmission of infectious laryngotracheitis through fomite contamination such as boots, clothing, and equipment (Johnson et al., 2004). Since bird catchers normally do not wear gloves, it is also possible that their hands may contribute to disease transmission. Hand hygiene is also important to reduce the risk of zoonoses, particularly *Salmonella* and *Campylobacter* infections. In these contexts, even if catching crew members were the group of interest for this study, the results should also be of value to many other industry personnel such as growers, farm employees, technicians, and veterinarians.

In human medicine, several studies have evaluated the efficacy of different protocols and products for washing hands. Widmer (2000) reported that alcoholic compounds used as hand rub kill 3.2–5.8 log₁₀ CFU, compared with the 1.8–2.8 log₁₀ CFU removed in 30 s with medicated soap. Also, compliance improved significantly by switching from hand washing to using a hand rub gel. Another study reported a 4–7 log₁₀ reduction using alcohol-based hand hygiene agents applied for 15–30 s (Dharan et al., 2003). Girou et al. (2002) showed that, when hands are not heavily contaminated, the median percentage reduction in bacterial contamination was significantly higher with hand rubbing with a gel than with hand washing (83% vs 58%, $p = 0.01$). However, it was reported that the presence of organic material reduces the antibacterial activity of alcohols by 0.2–0.7 log₁₀ CFU (Trampuz and Widmer, 2004). Most studies on hand washing are done in a hospital context where hands are often not visibly soiled. In the work environment of poultry catchers, hands can be heavily contaminated with organic material. Thus, comparison between these studies and the present one is not straightforward, since the protocols, the laboratory tests, the study design and the levels of bacterial contamination before applying the protocols are not the same. It was then important to obtain scientific data to guide hand hygiene recommendations in the poultry industry context. Furthermore, the use of disinfecting gel is a common practice in this industry. Considering that compliance might be better with this product, it was important to evaluate its efficacy.

Based on the results, when hand bacterial contamination was low, all protocols worked well. This is consistent with studies mentioned above. However, when bacterial contamination was higher, soap and water followed by a

Table 2
Participants' knowledge and opinions about hand washing and its purpose.

Variable	Percent who agree (number of respondents)
When possible, I always wash hands after catching birds	62.2% (37)
The most important reason to wash my hands is	23 Respondents
a) To avoid spreading microbes between farms	13.0%
b) To avoid soiling equipment, clothing, vehicle	4.3%
c) To avoid getting sick	82.6%
I know at least one disease that can be transmitted to poultry	
a) Hispanic	5.3% (19)
b) Non Hispanic	66.7% (18)
I have heard of <i>Salmonella</i>	
a) Hispanic	5.3% (19)
b) Non Hispanic	89.5% (19)
I have heard of <i>Campylobacter</i>	
a) Hispanic	5.3% (19)
b) Non Hispanic	10.5% (19)
The best way to wash hands (before using a disinfecting gel) is	37 Respondents
a) Soap and water	78.4% ^a
b) Degreasing pumice-added cream without water	13.5%
c) Only disinfecting gel	2.7%
d) Detergent and antimicrobial wipes	0.0%
Before the initiation of this project, I have washed my hands with	38 Respondents
a) Soap and water	60.5%
b) Soap and water, and disinfecting gel	34.2%
c) All four techniques (soap and water; gel; degreasing cream; wipes)	5.3%
During the project, I used the products made available to me	77.1% (35)
When I do not wash my hands, it is mainly because	32 Respondents
a) I do not have time	3.1%
b) I do not have what I need to do it	90.6%
c) I do not think about it	3.1%
d) I do not believe I need to do so between flocks	3.1%

^a Best way to wash hands: in addition to water and soap, one respondent responded also "only gel", and one respondent responded "only gel" and "degreasing cream."

disinfecting gel seemed better to control aerobic bacterial count, and using a degreasing waterless cream followed by a disinfecting gel was better against coliforms. Clearly, all protocols had some value, and the difference between protocols was not as important as expected. However, there is merit in using either soap and water or a degreasing cream when hand contamination is elevated. Detergent and antimicrobial wipes cannot be recommended at this point. In places where water access is an issue, using a waterless degreasing cream would be valuable prior to using a disinfecting gel. However, if given a choice, it is important to know that the majority of the 38 catchers who responded to the survey preferred soap and warm water to the degreasing cream. Finally, it is interesting to note that the amount of disinfecting gel and the time spent rubbing it did not have a significant impact on decontamination.

However, the participants often pressed more than once on the delivery device fixed on the alcohol-based gel container. The intent was to stay as close as possible to field conditions. Results could have been different if the quantity of products and the time spent to perform hand sanitation would have been set as part of the study design. Also, the number of volunteers being small may not represent the full diversity of hand washing practices, limiting the extent to which the results may be extrapolated to a larger population. However, as stated above, the intent was mainly to contrast the protocols and not to determine how to achieve the best hand decontamination. If this were to have been the objective, employees would have been guided to apply each protocol, for example, for a minimal period of time. Another limiting factor with a possible impact on hand sanitation is the dryness of hands after using soap and water.

Table 3
Practicality of washing protocol expressed in percentage of respondents that considered them not, fairly, or very practical.

Washing protocol ^a	The protocol used was considered		
	Not practical	Fairly practical	Very practical
Disinfecting gel only	6.1	33.3	60.6
Soap and water	6.3	40.6	53.1
Degreasing pumice-added cream	45.2	35.5	19.4
Detergent and antimicrobial wipe	26.7	26.7	46.7

^a Number of respondents: gel only: 33; water and soap: 32; degreasing cream: 31; wipes: 30.

The residual moisture left on hands after washing is a critical determinant of the effectiveness of hand sanitation. Drying hands reduces the bacterial translocation on surfaces (Patrick et al., 1997). While our conclusions do not extend beyond hand washing, surely the level of contamination after hand washing must interact with any potential effect of residual moisture. Finally, all protocols seem to work well against *Salmonella*. This was not really a surprise since it has been shown that alcohol-based products are highly efficient in reducing *Salmonella* contamination (Bloomfield et al., 2007).

This study also highlighted the needs to enhance education and awareness related to zoonotic risks. Few respondents were aware of the pathogen *Campylobacter* which is a major issue in public health. Most Hispanic respondents did not know about *Salmonella* either. A high motivation to comply with hand washing recommendations may be difficult to achieve if the sources of infection and the consequences are not well understood. This difference between Hispanic and non-Hispanic respondents has been reported in other studies evaluating knowledge on food safety. Knowledge score was significantly higher among whites compared to Hispanics (Meer and Misner, 2000). Meer and Misner also reported that 88% (205/233) of respondents, independently of ethnicity, could not identify the sources of *Campylobacter*. In addition to knowledge, studies also identified age, education, ethnicity and income as factors influencing safe behaviors. It is therefore recommended to target risk communication efforts for groups at risk and those with the greatest need (e.g., lack of knowledge) regarding zoonotic risks (Patil et al., 2005). Educational efforts should go toward poultry industry personnel likely to have a limited degree of education, such as catching crew members. This study only involved one catching company limiting the external validity of the results. However, most companies have a rapid turnover and still need to enhance education and training.

The results of this study may not only be applicable with respect to poultry workers or livestock industries. They could also guide hand washing recommendations for events such as open farms or other attractions where the general public and especially children may have contact with animals or environments contaminated by animals. However, it would be important to consider if there are other factors that would limit the relevance of this study to other environments.

5. Conclusion

This study provided scientific data to guide hand hygiene recommendations when hands are heavily contaminated. In this context, it was important to reduce the level of bacterial contamination on hands before using a hand rub. Although the various protocols achieved a 90 to 99% reduction in bacterial contamination load, better results might have been recorded if each participants would have been trained to apply each protocol in an optimal way. Therefore, this aspect of employee training should be considered to improve hand decontamination. The use

of warm water and soap was the preferred solution considering catching crew member preferences.

Acknowledgment

This project was funded by The Poultry Industry Council, Ontario, Canada.

References

- Amass, S.F., Stevenson, G.W., Anderson, C., Grote, L.A., Dowell, C., Vyverberg, B.D., Kanitz, C., Ragland, D., 2000. Investigation of people as mechanical vectors for porcine reproductive and respiratory syndrome virus. *J. Swine Health Prod.* 8 (4), 161–166.
- Bloomfield, S.F., Aiello, A.E., Cookson, B., O'Boyle, C., Larsen, E.L., 2007. The effectiveness of hand hygiene procedures in reducing the risks of infections in home and community settings including handwashing and alcohol-based hand sanitizers. *Am. J. Infect. Control.* 35 (10), S27–S64.
- Boyce, J.M., Pittet, D., 2002. Guideline for hand hygiene in health-care settings. *Am. J. Infect. Control.* 30 (8), 1–46.
- Davis, M., Sheng A.H., Newman J., Hancock D.D., Hovde C.J., 2005. Comparison of a waterless hand-hygiene preparation and soap-and-water hand washing to reduce coliforms on hands in animal exhibit setting, *Epidemiology and Infection*, Short Report, 1–5.
- Dharan, S., Hugonnet, S., Sax, H., Pittet, D., 2003. Comparison of waterless hand antiseptics agents at short application times: raising the flag of concern. *Infect. Control Hosp. Epidemiol.* 24 (3), 160–165.
- Friedman, C.R., Torigan, C., Shillam, P.J., Hoffman, R.E., Heltzel, D., Beebe, J.L., Malcolm, G., DeWitt, W.E., Hutwagner, L., Griffin, P.M., 1998. An outbreak of salmonellosis among children attending a reptile exhibit at a zoo. *J. Pediatr.* 132 (5), 802–807.
- Girou, E., Loyalau, S., Legrand, P., Oppein, F., Brun-Buisson, C., 2002. Efficacy of handrubbing with alcohol based solution versus standard handwashing with antiseptic soap: randomised clinical trial. *Br. Med. J.* 325 (7360), 1–5.
- Hue, O., Le Bouquin, S., Laisney, M., Allain, V., Lalande, F., Petetin, I., Rouxel, S., Quesne, S., Gloaguen, P., Picherot, M., Santolini, J., Salvat, G., Bougeard, S., Chemaly, M., 2010. Prevalence of and risk factors for *Campylobacter* spp. contamination of broiler chicken carcasses at the slaughterhouse. *Food Microbiol.* 27, 992–999.
- Johnson, Y.J., Colby, M.M., Tablante, N.L., Hegngi, F.N., Salem, M., Gedamu, N., Pope, C., 2004. Application of commercial and backyard poultry geographic information system databases for the identification of risk factors for clinical infectious laryngotracheitis in a cluster of cases on the Delmarva peninsula. *Int. J. Poultry Sci.* 3 (3), 201–205.
- Meer, R.R., Misner, S.L., 2000. Food safety knowledge and behavior of expanded food and nutrition education program participants in Arizona. *J. Food Prot.* 63 (12), 1725–1731.
- Milne, L.M., Plom, A., Strudley, I., Pritchard, G.C., Crooks, R., Hall, M., Duckworth, G., Seng, C., Susman, M.D., Kearney, J., Wiggins, R.J., Mouldsdale, M., Cheasty, T., Willshaw, G.A., 1999. *Escherichia coli* O157 incident associated with a farm open to members of the public. *Commun. Dis. Public Health* 2 (1), 22–26.
- Newell, D.G., Elvers, K.T., Dopfer, D., Hansson, I., Jones, P., James, S., Gittins, J., Stern, N.J., Davies, R., Connerton, I., Pearson, D., Salvat, G., Allen, V.M., 2011. Biosecurity-based interventions and strategies to reduce *Campylobacter* spp. on poultry farms. *Appl. Environ. Microbiol.* 77 (24), 8605–8614.
- Patil, S.R., Cates, S., Morales, R., 2005. Consumer food safety knowledge, practices, and demographic differences: findings from a meta-analysis. *J. Food Prot.* 68 (9), 1884–1894.
- Patriarchi, A., Fox, A., Maunsell, B., Fanning, S., Bolton, D., 2011. Molecular characterization and environmental mapping of *Campylobacter* isolates in a subset of intensive poultry flocks in Ireland. *Foodborne Pathog. Dis.* 8 (1), 99–108.
- Patrick, D.R., Findon, G., Miller, T.E., 1997. Residual moisture determines the level of touch-contact-associated bacterial transfer following hand washing. *Epidemiol. Infect.* 119 (3), 319–325.
- Pittet, D., 2001. Improving adherence to hand hygiene practice: a multi-disciplinary approach. *Emerg. Infect. Dis.* 7 (2), 234–240.
- Ridley, A., Morris, V., Gittins, J., Cawthraw, S., Harris, J., Edge, S., Allen, V., 2011. Potential sources of *Campylobacter* infection on chicken farms: contamination and control of broiler-harvesting equipment, vehicles and personnel. *J. Appl. Microbiol.* 111 (1), 233–244.

- Slader, J., Domingue, G., Jørgensen, F., McAlpine, K., Owen, R.J., Bolton, F.J., Humphrey, T.J., 2002. Impact of transport crate reuse and of catching and processing on *Campylobacter* and *Salmonella* contamination of broiler chickens. *Appl. Environ. Microbiol.* 68 (2), 713–719.
- Shukla, R., Slack, R., George, A., Cheasty, T., Rowe, B., Scutter, J., 1995. *Escherichia coli* O157 infection associated with a farm visitor centre. *Commun. Dis. Rep.* 5 (6), 86–90.
- Trampuz, A., Widmer, A.F., 2004. Hand hygiene: a frequently missed lifesaving opportunity during patient care. *Mayo Clin. Proc.* 79 (1), 109–116.
- Wendelke, E.A.K., De Koeijer, A.A., Jacobs-Reitsma, W.F., Mangen, M.J., Wagenaar, J.A., 2007. Assessing interventions to reduce the risk of *Campylobacter* prevalence in broilers. *Risk Anal.* 27 (4), 863–876.
- Widmer, A.F., 2000. Replace hand washing with use of a waterless alcohol hand rub? *Clin. Infect. Dis.* 31 (1), 136–143.