

# Survival of *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* on Wood and Plastic Surfaces

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## Abstract

The survival of (*Escherichia coli*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus*) was tested on natural beech wood, varnished beech wood, and plastic at 5 times: immediately after surface contamination and drying; 24 and 48 hours after contamination; 24 hours after contamination the samples were cleaned with non-germicidal detergent cleaner (Triton X-100 at a 1:30 dilution with distilled water) and surface bacteria were sampled a further 24 hours after cleaning. Initial *E. coli* and *P. aeruginosa* counts were highest for plastic, followed by varnished beechwood, and lowest for the natural beech wood. On each surface these bacteria died off almost completely within 24 hours. Initial *S. aureus* counts were highest for plastic, followed by varnished beech wood, and lowest for the natural beech wood. For all surfaces, there was an initial reduction from drying, but after 24 hours the counts plateaued, suggesting that bacteria could have survived on the surfaces for quite some time. At 24 hours the counts were comparable on all 3 surfaces. However, 48 hours after surface washing *S. aureus* could not be detected on the untreated beech wood, but this was still detectable on the varnished beech wood and plastic. Implications are discussed.

**Keywords:** *Escherichia coli*; *Pseudomonas aeruginosa*; *Staphylococcus aureus*; Beech wood; Plastic

## Introduction

Pathogenic bacteria can cause a variety of diseases [1]. Some strains of the gram negative bacterium *Escherichia coli* (*E. coli*) are the leading causes of severe abdominal cramps and bloody diarrhea in children [2-4]. Opportunistic gram negative pathogenic bacteria, such as *Pseudomonas aeruginosa* (*P. aeruginosa*), can cause respiratory tract, urinary tract and ear infections [5-7]. Pathogenic gram positive bacteria, such as *Staphylococcus aureus* (*S. aureus*) can cause a range of illnesses, from minor skin infections to potential fatal diseases like pneumonia and meningitis [8]. Previous work has shown that pathogen survival is affected by the surface materials, and natural woods have better hygienic properties than plastic [8]. Maintaining a hygienic environment for a child is especially important to managing these illness risks. The present study compared immediate, 24 hours and 48 hours survival for pathogenic bacteria on natural beech wood, varnished beech wood and plastic, and it also evaluated the effects of cleaning with a sterile disinfecting solution and drying a surface on subsequent bacterial survival at 24 hours and 48 hours.

## Method

Two gram negative bacteria (*E. coli* and *P. aeruginosa*) and one gram positive bacterium (*S. aureus*) were tested on three surfaces (natural beech wood, varnished beech wood and plastic), making 9 groups in total. Each species was tested in sequence to avoid any possibility of cross contamination. For each group, 5 test coupons were cut to 2" long (~5cm) x 0.75" (~2cm) wide x 0.5" deep (~1.25cm), and then inoculated with the appropriate test bacterium and air dried at 35°C for 20 minutes. Immediately after the inoculum dried at "time 0," a single coupon from each group was harvested and enumerated. The remaining 4 coupons for each group were incubated in a foil-covered basin, with a water reservoir to increase humidity, at room temperature (~22°C) for 24 hours. After 24 hours, a single un-washed coupon from each of the 9 groups was harvested and enumerated. Two coupons from each group were randomly selected and cleaned using 0.100 ml of a non-germicidal detergent cleaner (Triton X-100 at a 1:30 dilution with distilled water). Each coupon was then cleaned with a

moist, sterile swab and subsequently dried with a dry sterile swab. The washed coupons were dried at room temperature for approximately 20 minutes. Immediately afterwards a single washed, dried coupon from each group was harvested and enumerated. The remaining coupons from each group (one washed, one not washed) were incubated at room temperature for a further 24 hours. After the second 24 hour incubation period (at time=48 hours), the two remaining coupons from each group were harvested and enumerated. The incubation times for all D/E (Dey/Engley) Neutralizing Agar plates were >48 hours to facilitate recovery of any injured bacteria. All enumerations were done by placing the samples aseptically in 10 mL sterile D/E (Dey/Engley) broth to neutralize and test any antiseptic or disinfectant effect, then vortexing vigorously, then analyzing using standard dilution and plating techniques. Because species counts were performed for single coupons, statistical methods cannot be applied to the data.

## Results

At time 0, the survival of *E. coli*, *P. aeruginosa* and *S. aureus* was lowest for natural beech wood and highest for plastic. Results at 24 hours show that *E. coli* and *P. aeruginosa* survival times were brief on all three surfaces. However, after 24 hours the *S. aureus* counts were highest for the plastic, lower for the varnished beech wood and lowest for the natural beech wood. At 48 hours, *S. aureus* counts were comparable on all 3 surfaces. After cleaning *S. aureus* was not detectable on the 24 hours sample of natural birch wood but it was detectable at comparable low levels for the varnished beech wood and the plastic (Figure 1).

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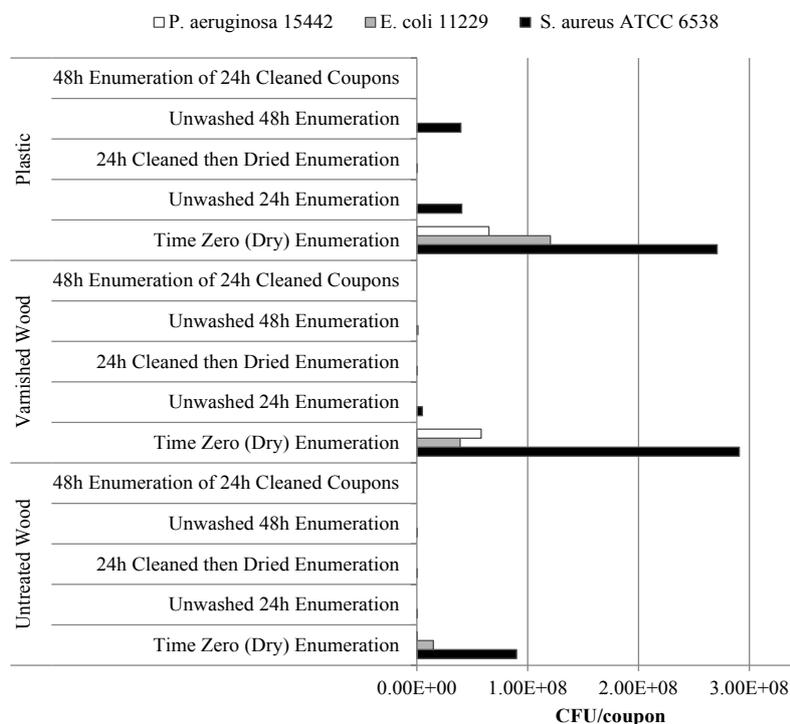


Figure 1: Surface survival of bacteria at each stage of the study.

## Discussion

Research has shown for *E. coli* and *E. faecium*, pine and oak have better hygienic performance than plastic, possibly due to the hygroscopic properties of wood and the effects of wood extractives [9]. Reductions in bacterial numbers are also seen for spruce, larch, poplar and beech when compared with plastic [9]. Present findings confirm and extend these earlier results and show that for all surfaces gram negative bacteria (*E. coli* and *P. aeruginosa*) failed to survive within 24 hours, suggesting that these materials offer a low surface-mediated contact transmission risk. The gram negative bacteria tested were similar to pathogens implicated in surface-mediated disease transmission, such as *Salmonella*, *Shigella*, and *Campylobacter*, so these organisms could reasonably be expected to display the same quick and natural (24 hour) die-off due to desiccation alone. Although there is evidence that *Salmonella* can become acclimatized to desiccation stress, and induction of the desiccation stress response in bacterial cells makes them more resistant to the dry conditions in which they are present [10]. However, with natural wood there is also an effect of porosity that also reduces surface bacteria counts.

For all surfaces there was an initial reduction in the *S. aureus* count from drying, but residual contamination at 48 hours suggests that *S. aureus* may survive on dry surfaces for more extended periods. This also may occur with other gram positive bacteria, like *Enterococcus* and *Streptococcus*. Interestingly, current hospital pathogens of concern include MRSA (methicillin-resistant *Staphylococcus aureus*) and VRE (Vancomycin-resistant *Enterococci*) and both are gram positive, and *Clostridium difficile* which has great surface survival capability in its endospore form.

Natural beech wood was the most effective of the 3 surfaces tested

in this study with fewest recoverable bacteria immediately after initial drying of the inoculum. This could have been a result of either a "quick initial killing" property of the wood, or more likely, from the bacteria irreversibly entering cavities in the wood and subsequently desiccating. From observation when the inoculum was applied to the different surfaces it spread farther over the natural beech wood surface and dried quickest, and this would result in fewer bacteria per unit of surface area than the inoculated area of either the varnished beech wood or plastic and this in turn lowers the risk for transfer from a single, fingerpad-sized surface touch contact events.

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