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Brief report

# Lower infection rates after introduction of a photocatalytic surface coating

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Health care facilities contain potentially contaminated surfaces that are either difficult to sanitize or prone to recontamination. Photocatalytic materials exhibit antimicrobial activity when exposed to light and provide a safe, durable coating on a wide range of surfaces. We assessed infection rates before and after introduction of a photocatalytic coating in our facility. Infection rates decreased overall by 30%, a change that was statistically significant ($P = .02$). Similar changes to the built environment merit additional investigation.



Health care–acquired infections (HAIs) are a challenge that require constant effort to control. Multiple sources of HAIs are known and include both personnel behaviors and the built environment.[1] The built environment in health care contains potentially contaminated surfaces (fomites) that are either difficult to sanitize or prone to recontamination. A variety of approaches to sanitization of surfaces are available, including chemical treatments and ultraviolet light (UV) irradiation. Recontamination causes the benefits of these important tools to be time limited. The use of copper and copper alloys rather than ferrous metals on multiple touch points provides durable antimicrobial effects,[2] but this approach is localized and requires relatively expensive alterations to the built environment.

Photocatalytic materials use the energy of light to create chemically potent but short-lived reactive oxygen species, principally the hydroxyl radical, from water vapor. The reactive oxygen species exhibit highly surface-localized antimicrobial activity,[3,4] along with a range of other interesting properties that may help provide a more hygienic environment.[5] Generally speaking, the magnitude of antimicrobial activity of photocatalytic materials is a function of both time and photocatalytic efficiency under the applied illumination conditions. Photocatalytic efficiency is a function of the composition of the material.

Multiple photocatalytic substances are known, and a commonly used material is anatase titanium dioxide ($TiO_2$), which has the benefit of good photocatalytic efficiency and excellent safety. However, photocatalysis by this material requires light of wavelengths shorter than 388 nm, which is in the UV range. This characteristic can be altered by introduction of certain elements, resulting in compositions that exhibit photocatalysis under common interior lighting, but they also can use UV.[5] Notwithstanding these reported improvements, it was unclear that such materials would provide discernable benefit in health care facilities, which have widely varying illumination.

We sought to achieve widespread durable surface microbial reduction in our facility by use of an interior photocatalytic coating as an adjunct to our routine procedures. We evaluated the approach by comparing infection rates for the year prior and up to 17 months after this change.

## METHODS

### *Health care environment*

The facility is a 250-bed, postacute, and long-term care facility. Ongoing infection control procedures were maintained without change over the course of the study, and infections were monitored and recorded according to well-established institutional protocols.

### *Photocatalytic coating*

We used a vendor-applied product (WELL Shield, WELL Shield LLC, Boca Raton, FL) composed primarily of anatase $TiO_2$, but with small quantities of silicon and zinc included to maximize effectiveness under interior illumination. Application requires that areas

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**Table 1**
Average infection rates by CDC-defined category* and in total, comparing the 12 months prior to and the 12 and 17 months after introduction of a photocatalytic coating

| | 12 months prior | 12 months post | | 17 months post | |
|---|---|---|---|---|---|
| CDC category* | Rate | Rate | *P* value | Rate | *P* value |
| GI | 0.36 | 0.33 | .86 | 0.30 | .63 |
| SST | 1.02 | 0.77 | .19 | 0.91 | .54 |
| BSI | 0.03 | 0.02 | .56 | 0.04 | .76 |
| EENT | 0.71 | 0.37 | .11 | 0.35 | .04 |
| UTI | 1.68 | 1.03 | .08 | 0.98 | .03 |
| URI | 0.22 | 0.05 | .22 | 0.06 | .16 |
| LRI | 0.53 | 0.65 | .54 | 0.50 | .84 |
| All infection types | 4.57 | 3.17 | <.01 | 3.23 | .02 |

*BSI*, blood stream infection; *CDC*, U.S. Centers for Disease Control and Prevention; *EENT*, eyes, ears, nose, and throat; *GI*, gastrointestinal; *LRI*, lower respiratory infection; *SST*, soft skin tissue; *URI*, upper respiratory infection; *UTI*, urinary tract infection.
*Rates are the average events per 1,000 patient days.

to be coated be vacated and thoroughly cleaned. The applicator used an electrostatic spray method that both generates finely atomized droplets and also causes the droplets to more uniformly cover irregular objects because of electrostatic charge. Very little material is actually deposited ($<0.15$ g/m$^2$), allowing the coating of items, such as keyboards and remote controls. All available surfaces were coated, including walls, floors, furniture, privacy curtains, bath facilities, call buttons and remote controls in patient rooms and hallways, offices, visitor restrooms, elevators, stairwells, kitchen, rehabilitation gym, and nurse's stations (including computers). Equipment was also coated, including wall computer kiosks, blood pressure cuffs, wheelchairs, lifts, and carts. Areas were reoccupied after the coating was dry, generally <2 hours after application. The coating was very difficult to detect after application, which took about a week overall, moving progressively through the facility.

*Data collection and analysis*

We extracted data from our infection control system records dating 12 months prior to 17 months after the application of the coating. The absolute numbers of U.S. Centers for Disease Control and Prevention-defined infections[6] and the actual patient census were used to calculate the rate of each infection for each month of the evaluation interval, as events per 1,000 patient days. Comparisons across time were made using standard spreadsheet computations. All analyses were anonymized with respect to individual patient data. We also reviewed all memoranda directed to house staff to determine if there were any institutional changes to patient care.

## RESULTS AND DISCUSSION

There were fewer total infections for the full year after applying the coating ($n = 185$) compared with the year prior to applying the coating ($n = 275$). After the application of the coating, every quarterly total count was lower than any quarterly total count before application. The monthly rates for each U.S. Centers for Disease Control and Prevention-defined infection category were calculated and averaged for the 12 months prior to application of the coating and compared with the average of either 12 or 17 months after application. Table 1 reports these average infection rates along with *P* values based on a 2-tailed homoscedastic *t* test.

As a group, infection rates declined by approximately 30%, and this decline was statistically significant. Most of the 7 infection categories showed a decline in their average rates; however, not all infections were equally affected. Both the individual categories of eyes, ears, nose, and throat (EENT) and urinary tract infection (UTI) achieved statistical significance ($P < .05$), even in this small data set.

These results are encouraging and suggest that broad interior use of a durable photocatalytic coating may reduce the incidence of at least some types of infections in health care settings such as ours. Review of our records found no institutional initiatives affecting patient care during the observation interval.

Nevertheless, there are multiple limitations inherent to any retrospective evaluation. We cannot be certain that factors other than the coating did not play a role; it is of course possible that some undetected change occurred with a similar timing. In any event, this report should be viewed as indicative of a need for studies of more definitive design.

To our knowledge, this is the first report indicating that photocatalytic coatings may provide the practical benefit of reduced infection rates; however, the magnitude of this benefit remains undefined. The result is consistent with the known properties of photocatalytic materials[3] and with the expected impact of reduced microbial burdens in the environment, as reviewed elsewhere.[7] Further, the reduction in urinary tract infection argues that our observation is not simply the result of a particularly severe respiratory infection season prior to introduction of the coating, as does the trend to lower rates more broadly across categories. We used the coating throughout the facility because of its convenience, and this may have contributed to its effectiveness. The unobtrusive coating we used is both compatible with and complementary with other emerging approaches (eg, UV irradiation), suggesting possible combinations in the future. Additional studies to confirm our observation and to better define the magnitude of benefit in a variety of settings are appropriate.

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