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Reduction of healthcare-associated infections in a long-term care brain injury ward by replacing regular linens with biocidal copper oxide impregnated linens

A. Lazary [a,*], I. Weinberg [a], J.-J. Vatine [b,c], A. Jefidoff [a], R. Bardenstein [d], G. Borkow [e], N. Ohana [a]

[a] Brain Injury Division, Reuth Medical Center, 2 Ha'Hayil blvd, Tel Aviv 61092, Israel
[b] Outpatient and Research Division, Reuth Medical Center, Tel Aviv, Israel
[c] Department of Rehabilitation Medicine, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel
[d] Microbiology Laboratory, Kaplan Medical Center, Rehovot, Israel
[e] Cupron Scientific, Herzliya, Israel

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SUMMARY

Background: Contaminated textiles in hospitals contribute to endogenous, indirect-contact, and aerosol transmission of nosocomial related pathogens. Copper oxide impregnated linens have wide-spectrum antimicrobial, antifungal, and antiviral properties. Our aim was to determine if replacing non-biocidal linens with biocidal copper oxide impregnated linens would reduce the rates of healthcare-associated infections (HAI) in a long-term care ward.
Methods: We compared the rates of HAI in two analogous patient cohorts in a head injury care ward over two 6-month parallel periods before (period A) and after (period B) replacing all the regular non-biocidal linens and personnel uniforms with copper oxide impregnated biocidal products.
Results: During period B, in comparison to period A, there was a 24% reduction in the HAI per 1000 hospitalization-days ($p < 0.05$), a 47% reduction in the number of fever days (>38.5 °C) per 1000 hospitalization-days ($p < 0.01$), and a 32.8% reduction in total number of days of antibiotic administration per 1000 hospitalization-days ($p < 0.0001$). Accordingly there was saving of approximately 27% in costs of antibiotics, HAI-related treatments, X-rays, disposables, labor, and laundry, expenses during period B.
Conclusions: The use of biocidal copper oxide impregnated textiles in a long-term care ward may significantly reduce HAI, fever, antibiotic consumption, and related treatment costs.

1. Introduction

Copper has been used as a biocide for centuries.[1] The fungicidal, antibacterial, and antiviral properties of copper have been demonstrated in many controlled laboratory studies and are very well documented.[2,3] Copper exerts its toxicity to microorganisms through several parallel non-specific mechanisms, which include damage to the microorganisms' envelope and intracellular proteins and nucleic acids.[3] Many bacteria and fungi have different mechanisms to deal with excess copper.[2] However, above a certain threshold and time of exposure, they cannot deal with the copper overload and die. In contrast to the highly antibiotic-resistant microbes that have evolved over less than 50 years, microorganisms tolerant to copper are extremely rare even though copper has been a part of the earth for millions of years. This can be explained by the multisite and non-specific kill mechanisms of copper.[2] Significantly, copper also displays potent biocidal activity against antibiotic-resistant bacteria and antiviral-resistant viruses.[3–5]

Copper and copper-based compounds are used routinely in several health-related areas. These include the control of Legionella[6] in hospital water distribution systems, reduction of caries in dentistry,[7] reduction of food-borne diseases,[8] and the

* Corresponding author. Tel.: +972 547791928.
E-mail address: lazary@reuth.org.il (A. Lazary).

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prevention of conception.[9] Copper intrauterine devices are widely used by millions of women, are approved by the regulatory agencies, and have been applied for several decades.[9] It has recently been demonstrated in hospitals, clinics, and care homes for the elderly, that substituting the existing hard surfaces with copper-based surfaces reduces the bioburden and the transmission of nosocomial pathogens.[10,11] The US Environmental Protection Agency (EPA) approved the registration of copper alloys and polymeric surfaces containing copper oxide particles as materials with antimicrobial properties that can kill >99.9% of Gram-negative and Gram-positive bacteria within 2 h of exposure, making copper the only metal that can be used in hospitals to reduce the bioburden and for which public health claims can be made.

In the last few years, a durable platform technology has been developed that permanently embeds copper oxide particles into polymeric materials.[4] The introduction of copper oxide particles into polymeric materials endows them with potent broad-spectrum antimicrobial[4,5,12] and anti-mite properties,[4,13] and in some applications has a direct effect on physiological processes, such as enhanced wound healing.[14] Since copper oxide is a non-soluble form of copper, the copper oxide particles do not wash out during laundry and the textile products remain active for the life of the products.[4,12]

Consumer products impregnated with copper oxide particles, such as pillowcases, sheets, and diapers, are extremely safe and do not cause any skin irritation or sensitization, or any adverse reactions, both to intact and breached skin.[15] This has been demonstrated (1) in animal studies;[4,12,16,17] (2) in several double-blind clinical trials;[18–20] (3) with patients who slept on sheets containing copper oxide for a total of 300 nights;[12] and (4) in adult patients using diapers containing copper oxide for a period of 6 months, without even one adverse reaction.[21]

The innovative potential use of this technology in health-related applications include making hospital soft surfaces, like sheets, patient robes, patient pajamas, nurse clothing, and diapers, from copper oxide impregnated biocidal textiles.[4,12,16,22] It was hypothesized that the use of copper oxide containing textiles, especially sheets, pillowcases, robes, and pajamas that are in close contact with the patients, may significantly reduce the bioburden in the products themselves and in the surrounding environment and consequently reduce the risk of HAI.[22] In order to test this hypothesis we examined if the HAI rates in a long-term care ward could be reduced when all the textile products used in the ward were replaced with biocidal copper oxide containing textiles (Figure 1).

2. Materials and methods

The study was conducted in the Head Injury Ward, following approval by the hospital institutional review board. Since all

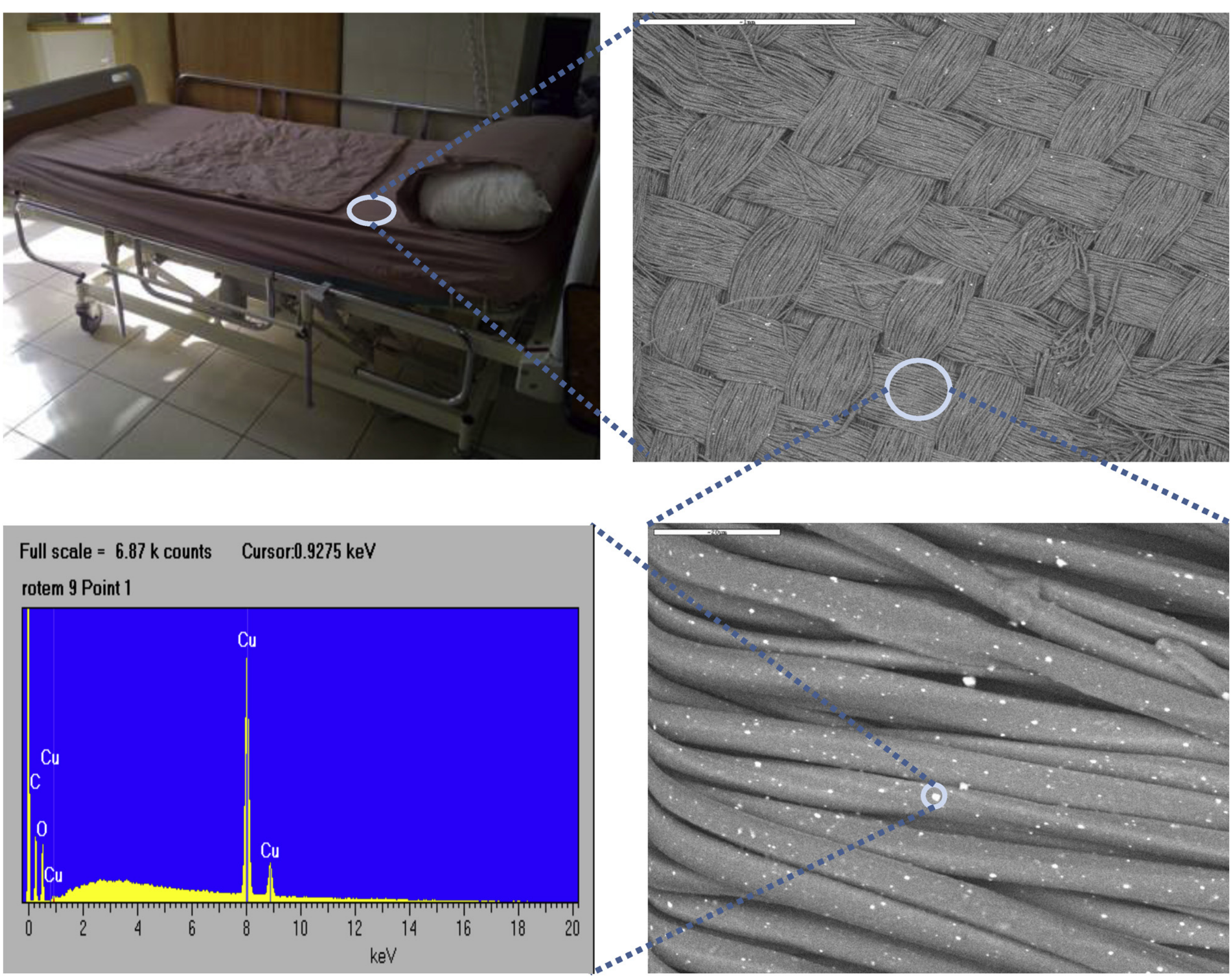

Figure 1. Two scanning electronic microscope images (taken with a Jeol JMS 840 scanning electron microscope) of a representative pillowcase are shown. The white dots are the copper oxide particles embedded in the polyester fibers. The chart is an X-ray photoelectron spectra analysis (done with a Shimadzu XRD 6000, TN-5500 X-ray analysis system) of the encircled white dot, showing a peak at 8 KeV corresponding to copper.