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Rapid Review: What is known about the efficacy and cost-effectiveness of copper materials to reduce transmission of viruses?

Prepared for: Public Health Agency of Canada (PHAC)

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Date: June 12, 2020

Suggested Citation:

National Collaborating Centre for Methods and Tools. (2020, June 12). *Rapid Review: What is known about the efficacy and cost-effectiveness of copper materials to reduce transmission of viruses?* https://www.nccmt.ca/knowledge-repositories/covid-19-rapid-evidence-service

The National Collaborating Centre for Methods and Tools (NCCMT) is hosted by McMaster University and funded by the Public Health Agency of Canada. The views expressed herein do not necessarily represent the views of the Public Health Agency of Canada.

Version 1: June 12, 2020

Executive Summary

Introduction

While the antimicrobial properties of copper are well established, copper has also been proposed to have antiviral properties. If true, this may have important implications for current and future viral pandemics. A number of private companies are now manufacturing copper-infused personal protective equipment (PPE) such as facemasks and promoting them as offering superior protection against viruses.

This rapid review was produced to support the Public Health Agency of Canada's response to the coronavirus disease 2019 (COVID-19) pandemic. This review seeks to identify, appraise, and summarize emerging research evidence to support evidence-informed decision making.

This rapid review includes evidence available up to June 9, 2020.

In this rapid review, we provide the most recent research evidence to answer the question: **What is known about the efficacy and cost-effectiveness of copper materials to reduce transmission of viruses?**

Key Points

- A comprehensive search of the literature found no evidence on the efficacy or cost-effectiveness of copper-treated PPE in hospital or public settings to reduce transmission of any viruses, and no reports were found of hospitals using copper-treated PPE to protect against COVID-19 or other viruses.
- One high quality synthesis of seven randomized controlled trials found that use of copper-treated surfaces and textiles resulted in a 6-43% reduction in risk of hospital-acquired infections (which included both bacterial and viral infections).
- Among the studies that compared several viruses, responses differed by the type of virus tested. This suggests that findings from the most commonly studied viruses (HIV, influenza, norovirus) may not be applicable to the virus causing COVID-19.
- One moderate quality study found no difference in the risk of viral infections during an outbreak in two long-term care wings that did and did not have high-touch surfaces treated with copper.
- Several laboratory-based studies suggested that viral infectivity over time decreases faster after exposure to a copper-treated textile or surface compared to a control.
- Study quality is low; findings are consistent. It is very likely the results will change with more evidence.
- This question should be reexamined as more information becomes available.

Overview of Evidence and Knowledge Gaps

- Among the laboratory-based studies, study quality was not appraised, and findings are inconsistent. Three of eight studies were conducted by an independent company that produces copper-treated products.
- Among laboratory-based studies, it is difficult to compare findings and identify the type of materials or concentration that may be most effective due to a wide variety of viruses, copper surfaces, testing protocols, and time periods of evaluation.

Methods

Research Question

What is known about the efficacy and cost-effectiveness of copper materials to reduce transmission of viruses?

Search

On June 8 and June 9, 2020, the following databases were searched:

- Pubmed's curated COVID-19 literature hub: LitCovid
- Trip Medical Database
- World Health Organization's Global literature on coronavirus disease
- Joanna Briggs Institute COVID-19 Special Collection
- COVID-19 Evidence Alerts from McMaster PLUS™
- Public Health +
- COVID-19 Living Overview of the Evidence (L·OVE)
- Cochrane Rapid Reviews Question Bank
- Prospero Registry of Systematic Reviews
- NCCMT COVID-19 Rapid Evidence Reviews
- MedRxiv preprint server
- PubMed database
- EMBASE database

A copy of the search strategy is available on request.

Study Selection Criteria

The search results are first screened for recent guidelines and syntheses. Single studies are included if no syntheses are found, or if they were published after the search was conducted in the included syntheses or guidelines. English-language, peer-reviewed sources and sources published ahead-of-print before peer review are also included. Grey literature and surveillance sources were excluded. When available, findings from syntheses are presented first as these take in to account the available body of evidence and therefore can be applied broadly to populations and settings.

	Inclusion Criteria	Exclusion Criteria
Population	Individuals or surfaces exposed to viruses	Exposure to bacterial or fungal pathogens
Intervention	Copper-infused textiles or PPE (including masks, gloves and gowns) and copper surfaces.	
Comparisons	Non-copper PPE, textiles or surfaces	No comparison
Outcomes	Transmission of virus, survival time of virus, cost	

Data Extraction and Synthesis

Data on study design, setting, location, population characteristics, interventions or exposure and outcomes were extracted when reported. We synthesized the results narratively due to the variation in methodology and outcomes for the included studies.

We evaluated the quality of most of the included evidence using critical appraisal tools as indicated by the study design below. Quality assessment was completed by one reviewer and verified by a second reviewer. Conflicts were resolved through discussion. For some of the included evidence a suitable quality appraisal tool was not found, or the review team did not have the expertise to assess methodological quality. Studies for which quality appraisal has not been conducted are noted within the data tables.

Study Design	**Critical Appraisal Tool**
Synthesis	Health Evidence™ Quality Appraisal Tool

Completed quality assessments for each included study are available on request.

Findings

Quality of Evidence

This document includes two completed syntheses and nine single studies for a total of 11 publications included in this evidence review. The quality of the evidence included in this review is as follows:

		Total	Quality of Evidence
Syntheses	Completed	2	1 High 1 Low
	In Progress	0	---
Single Studies	Completed	9	1 Moderate 8 Not appraised

Warning

Given the need to make emerging COVID-19 evidence quickly available, many emerging studies have not been peer reviewed. As such, we advise caution when using and interpreting the evidence included in this rapid review. We have provided a summary of the quality of the evidence as low, moderate, or high to support the process of decision making. Where possible, make decisions using the highest quality evidence available.

Important to this question, we did not assess the methodological quality of laboratory-based studies. Due to the highly technical nature of these studies, we highly recommend consulting a content-area expert to inform decision making.

Table 1: Syntheses

Reference	Date Released	Description of Included Studies	Summary of Findings	Quality Rating: Synthesis	Quality Rating: Included Studies
Albarqouni, L., Byambasuren, O., Clark, J., Scott, A. M., Looke, D., & Glasziou, P. (2020). Does Copper treating of commonly touched surfaces reduce healthcare acquired infections? A Systematic Review and meta-analysis. *medRxiv Preprint*.	May 26, 2020 (Search completed Mar 26, 2020)	This meta-analysis included seven randomized controlled trials looking at the effect of copper-treated surfaces (furniture, equipment, bed linens, clothing) in hospital rooms vs. standard rooms on hospital acquired infections, both bacterial and viral. • Studies were conducted in the USA (n = 3), Chile (n = 2), France and Israel • Settings included intensive care units (n = 4), long-term care (n = 2) and acute care wards • Sample size ranged from 65 to 9961	It is important to note that within included studies, all infections (both bacterial and viral) were classified as 'hospital-acquired infections'. Therefore, it is not possible to separate the antimicrobial and antiviral effects of copper. Overall, the pooled Relative Risk (RR) = 0.73, 95% Confidence Interval (CI): 0.57 to 0.94. In other words, copper-treated surfaces resulted in a statistically significant 27% reduction in infections, with the 95% CI ranging from a 6% to a 43% reduction. Two studies focused on copper-treated linens and clothes, pooled RR = 0.75, 95% CI: 0.58 to 0.98. This is a statistically significant reduction in infections of 25%, with the 95% CI ranging from a 2% to a 42% reduction. Four studies focused on copper-treated surfaces did not report a statistically significant reduction in infections, pooled RR = 0.76, 95% CI: 0.56 to 1.04. Overall a 24% reduction in infections was found with the 95% CI ranging from a 44% decrease to a 4% increase.	High	Low

Walji, S.D., & Aucoin, M.G. (2020). A critical evaluation of current protocols for self-sterilizing surfaces designed to reduce viral nosocomial infections. *American Journal of Infection Control.* Epub ahead of print.	Mar 20, 2020 (No search date provided)	This synthesis critically evaluated protocols used for testing the effect of self-sterilizing surfaces (such as copper) on viral transmission. A total of 38 studies were identified but only five were reported on, all evaluating hard copper surfaces. Viruses included influenza, human immunodeficiency virus (HIV), and norovirus.	While a standard protocol for testing virucidal properties exists, none of the 38 studies used it. The authors noted that humidity, time, and temperature control in the laboratory setting was often missing. No two studies, even from the same research group, used the same testing protocols, making comparisons challenging.	Low	Not reported

Table 2: Single Studies

Reference	Date Released	Study Design	Surface	Virus	Summary of findings	Institution	Quality Rating:
Zerbib, S., Vallet, L., Muggeo, A., de Champs, C., Lefebvre, A., Jolly, D., & Kanagaratnam, L. (2020). Copper for the Prevention of Outbreaks of Health Care-Associated Infections in a Long-term Care Facility for Older Adults. *Journal of the American Medical Directors Association*, *21*(1), 68-71.e1.	Apr 3, 2019	Cohort	High touch surfaces (door handles, handrails, grab-bars)	Any	Over the study period, four outbreaks occurred in a long-term care facility (Influenza A, Adenovirus, and Norovirus (n = 2)). Overall no difference was found between wings which did and did not have copper surfaces, RR = 0.7, 95% CI: 0.4 to 1.1.	Reims University	Moderate
Hodek, J., Zajícová, V., Lovětinská-Šlamborová, I., Stibor, I., Müllerová, J., & Weber, J. (2016). Protective hybrid coating containing silver, copper and zinc cations effective against human immunodeficiency virus and other enveloped viruses. *BMC Microbiology*, *16*(1), 56.	Apr 1, 2016	Lab-based	Hybrid silver, copper and zinc coating	HIV and other enveloped viruses	HIV titers were reduced by 75-100% after 20 minutes of exposure depending on the coated surface. Dengue, herpes and influenza virus titers were slower to decrease. Little reduction in viral titers was seen for coxsackie B3 virus.	Institute of Organic Chemistry and Biochemistry AS CR	Not appraised
Warnes, S.L., & Keevil, C.W. (2013). Inactivation of Norovirus on Dry Copper Alloy Surfaces. *PLOS ONE*, *8*(9), e75017.	Sep 9, 2013	Lab-based	Dry copper alloy surface	Norovirus	Infectivity of murine norovirus was decreased on copper and copper alloy surfaces within 5 minutes of contact at 4 degrees C, but not stainless steel. Virus inactivation is greater in a dry environment than wet. Increasing temperature appears to slow virus inactivation.	University of Southampton	Not appraised
Imai, K., Ogawa, H., Bui, V.N., Inoue, H., Fukuda, J., Ohba, M., Yamamoto, Y., & Nakamura, K. (2012). Inactivation of high and low pathogenic avian influenza virus H5 subtypes by copper ions incorporated in zeolite-textile materials. *Antiviral Research*, *93*(2), 225–233.	Feb 1, 2012	Lab-based	Copper-infused cotton fabric held by zeolites	H5N1, H5N3 avian influenza	Infectivity of both viruses decreased after a short period of exposure to the fabric.	Obihiro University of Agriculture and Veterinary Medicine	Not appraised
Borkow, G., Lara, H.H., Covington, C.Y., Nyamathi, A., & Gabbay, J. (2008). Deactivation of Human	Feb 2008	Lab-based	Copper-oxide	HIV-1	A dose-response reduction was seen in viral infectivity in response to copper-impregnated	Cupron Inc	Not appraised

Immunodeficiency Virus Type 1 in Medium by Copper Oxide-Containing Filters. *Antimicrobial Agents and Chemotherapy*, *52*(2), 518–525.			containing filters		fibers. The authors propose that a filter such as this could reduce HIV transmission from mother to child through blood donations or breast milk.		
Borkow, G., Sidwell, R.W., Smee, D. F., Barnard, D.L., Morrey, J.D., Lara-Villegas, H.H., Shemer-Avni, Y., & Gabbay, J. (2007). Neutralizing Viruses in Suspensions by Copper Oxide-Based Filters. *Antimicrobial Agents and Chemotherapy*, *51*(7), 2605–2607.	Jul 2007	Lab-based	Copper-infused fabric	10 enveloped and 2 non-enveloped viruses	A reduction in infectious virus titers was seen in copper-containing fabrics vs. controls; reduction was dependent on the type of virus.	Cupron Inc	Not appraised
Noyce, J.O., Michels, H., & Keevil, C.W. (2007). Inactivation of Influenza A Virus on Copper versus Stainless Steel Surfaces. *Applied and Environmental Microbiology*, *73*(8), 2748–2750.	Apr 2007	Lab-based	Copper surface	Influenza A	The amount of viable virus on copper after 60 minutes of exposure was equivalent to 24h of exposure to the control condition (stainless steel).	University of Southampton	Not appraised
Han, J., Chen, L., Duan, S.M., Yang, Q.X., Yang, M., Gao, C., Zhang, B.Y., He, H., & Dong, X.P. (2005). Efficient and quick inactivation of SARS coronavirus and other microbes exposed to the surfaces of some metal catalysts. *Biomedical and Environmental Sciences: BES*, *18*(3), 176–180.	Jun 2005	Lab-based	Copper surface	SARS	SARS-CoV infectivity decreased after 5 minutes of exposure to copper-infused surface.	Institute for Viral Disease Control and Prevention, China Center for Disease Control and Prevention	Not appraised
Borkow, G., & Gabbay, J. (2004). Putting copper into action: copper-impregnated products with potent biocidal activities. *The FASEB Journal*, *18*(14), 1728–1730.	Sep 2, 2004	Lab-based	Latex gloves, polyester filter	HIV-1, West Nile virus	HIV-1 infectivity was reduced in a dose-dependent manner when exposed to latex gloves containing copper over 4 days. HIV-1 and West Nile virus concentrations were also reduced after exposure to copper filters over 6 days.	Cupron Inc	Not appraised

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