Office of Evidence Based Practice (EBP) – Critically Appraised Topic (CAT): Nail polish use and bacteria in the hands of the healthcare worker

Specific Care Question

When worn by healthcare workers who provide face-to-face patient care, does fingernail polish increase the microbial growth on the hands compared to no fingernail polish?

Recommendations Based on Current Literature (Best Evidence) Only

No recommendation is made for or against the wear of nail polish by healthcare workers in face-to-face patient care, based on the GRADE Evidence to Decision instrument[a] and The Summary of Findings Table[a]. The overall certainty in the evidence was low to very low[a]. The evidence is mixed on the impact of nail polish wear on increased microbial growth following hand hygiene.

Five studies evaluated bacterial growth on fingernails with nail polish compared to fingernails without polish (natural nails) following hand hygiene. Three of the five studies which assessed comparisons made after wearing nail polish for one day showed no difference between nails with nail polish versus natural nails. However, two single studies were in conflict; one study (Anderson et al., 2021), demonstrated less bacterial growth for one day nail polish wear compared to natural nails while another single study (Walaszek et al., 2018), demonstrated more bacterial growth on nails with one day of nail polish wear compared to natural nails.

Among the five studies reviewed, four of them also compared bacterial growth on fingernails following four to fourteen days of nail polish wear to nail without nail polish (natural nails). Two of these studies (Blackburn et al., 2020; Wynd et al., 1994), demonstrated no difference in bacterial growth following hand hygiene, but the other two studies (Anderson et al., 2021; Hardy et al., 2017), demonstrated increased bacterial growth on nails and favored no nail polish wear.

Of consideration to determine allowance of nail polish wear would be the risk of inherit infections that can be shared with immunocompromised patients and those undergoing surgeries where the operating theater must be sterile. When there is a lack of scientific evidence, standard work should be developed, implemented, and monitored.

Literature Summary

Background

Hand hygiene is crucial for healthcare workers in reducing hospital acquired infections (Anderson et al., 2021; Blackburn et al., 2020; Hardy et al., 2017). Despite thorough and stringent handwashing methods, fingernails can collect a larger number of bacteria than other areas of the hand (McNeil et al., 2001). Per the Center for Disease Control and Prevention (CDC) (2019), one in thirty-one hospitalized patients in the United States has evidence of a hospital acquired infection. The CDC (2002) recommendations on hand hygiene, hand washing, hand antisepsis, handwashing methods, gloves, artificial nails, and length of nails also reviews and makes recommendations on wearing of artificial nails and length of natural nails. However, it does not provide any recommendations regarding wearing of nail polish. Another guideline on hand hygiene from the Association of Perioperative Registered Nurses does include information on wearing of nail polish but rather than providing a defined recommendation, states the wearing of nail polish should be determined by a multidisciplinary committee after a thorough review of the evidence (Goldberg et al., 2017). It has been proven that both artificial nails and nail extenders increase hand bacteria and spread infection but guideline recommendations for nail polish have not been thoroughly addressed (Ellingson et al., 2014; Fagernes & Lingass, 2011; Rupp et al., 2008; Hautemaniere et al., 2010). This review will summarize identified literature to answer the specific care question on the topic.

Study Characteristics

The search for suitable studies was completed on September 22, 2021, by Chika Duru, DNP, MSN, BSN, RN, CIC, Jessica Rindels, MBA, BSN, RN, CIC, and Yolanda Ballam, BS, CIC, who reviewed the 28 titles and/or abstracts found in the search and identified[b] 14 single studies believed to answer the question. After an in-depth review of the identified studies[b], five were determined to answer the question.

Question Answered: Does fingernail polish increase the microbial growth on the hands compared to no fingernail polish in healthcare workers?

Anderson et al. (2021), a randomized controlled trial, recruited 40 female healthcare professionals and students from a mid-west veterinary and osteopathic medical schools to evaluate bacterial CFUs on nails with nail polish compared to natural nails. Comparisons were made on day one and day 14 of nail polish wear and data collected before and after surgical scrub method (see Figure 1).

Blackburn et al. (2020), a randomized controlled trial, recruited 89 oncology nurses from a cancer hospital in Columbus, Ohio to evaluate bacteria on polished nails compared to natural nails. Each of three nails of each nurse were randomized to one of three groups: no nail polish, one-day-old nail polish, or four-day-old nail polish Comparisons were made on day one and day four of nail polish wear and data collected at the end of shift following hand hygiene (see Figure 1).

Hardy et al. (2017), a randomized controlled trial, recruited a combination of 42 veterinary students, faculty, interns/residents, and surgical techs from a veterinary teaching hospital in Washington to evaluate bacteria on fingernails, comparing polished nails to natural nails. After one week of nail polish wear by group one, data was collected on both groups before surgical scrub, after surgical scrub, and after surgery. For this study, only the data collected after surgical scrub were reported (see Figure 1).

Walaszek at al. (2018), a cross-sectional, observational study, recruited a group of 99 healthcare professionals (either nurse or midwife) from a hospital in Poland to evaluate the bacteria present on fingernails comparing various types of fingernail polish (traditional, conditioner, hybrid-UV cured, gel-UV cured) to natural nails. Data were collected following hand hygiene using an alcohol-based hand rub. For this review, only the data of nail polished nails compared to natural nails are reported (see Figure 1).

Wynd et al. (1994), a randomized controlled trial, recruited 102 perioperative nurses from the Cleveland Clinic to evaluate bacteria on fingernails, comparing freshly painted nails and chipped nail polish nails to natural nails. Data were collected following surgical scrub for freshly polished nails (one to two days of polish with no chipping) and natural nails. This process was repeated on day four with polished nails (at least four days of wear with or without chipping) and compared to natural nails (see Figure 1).

Summary by Outcome

Colony Forming Units (CFUs) with 1 Day Nail Polish versus Natural Nails.

Four studies (Anderson et al., 2021; Blackburn et al., 2020; Walaszek et al., 2018; Wynd et al., 1994) measured the number of CFUs on healthcare workers nails following hand hygiene, comparing nails with one day of nail polish to natural nails (N = 731). Two randomized controlled trials (Blackburn et al., 2020; Wynd et al., 1994), measured the number of CFUs from the nails using CFU/mL analysis (n = 246). The *MD = -265.61,* 95% CI [-638.63, 107.42], p = .16, indicated the intervention of one day of nail polish was not different to the comparator of natural nails (see Figure 2 & *Table 1*). One RCT (Anderson et al., 2021) measured CFUs as $\log_{10}$ (n = 396), *MD* = -0.32, 95% CI [-0.52, -0.12], p = .002, indicated the intervention of one day nail polish was favorable to the comparator of natural nails (see Figure 3 & *Table 1*). The average risk of CFUs with one day nail polish was .32 CFU $\log_{10}$ lower compared to natural nails following hand hygiene. One observational study (Walaszek et al., 2018), measured the number of CFUs on nails as events (n = 89), *OR* = 8.06, 95% CI [1.69, 38.57], p = .009 indicated the intervention of one day nail polish was not favorable to the comparator of natural nails (see Figure 4 & *Table 1*). The risk of CFUs on nails with one day of nail polish was 228 more per 1,000 cases compared to natural nails which was 44 per 1,000 cases.

Certainty Of The Evidence For CFUs with 1 Day Nail Polish versus Natural Nails. The certainty of the body of evidence was low for three of the RCTs (Blackburn et al., 2020; Wynd et al., 1994; Anderson et al., 2021), and very low for the observational study (Walaszek et al., 2018) based on four factors[a]: *within-study risk of bias*, *consistency among studies, directness of evidence*, and *precision of effect estimates*. The body of evidence for the two RCTs (Blackburn et al., 2020; Wynd et al., 1994) was assessed to have serious risk of bias as demonstrated by no blinding of study personnel. These two studies were also found to have serious imprecision as demonstrated by a small sample size (n = 246). The body of evidence for the single RCT (Anderson et al., 2021) was assessed to have serious risk of basis as demonstrated by one or more outcomes of interest reported incompletely and serious imprecision due to small sample size (n = 396). The body of evidence for the one observational study (Walaszek et al., 2018) was assessed to have serious imprecision as demonstrated by a small sample size (n = 89).

Colony Forming Units (CFUs) with 4-14 Days Nail Polish versus Natural Nails.
Four studies (Anderson et al., 2021; Blackburn et al., 2020; Hardy et al., 2017; Wynd et al., 1994) measured the number of CFUs on the nails of healthcare workers' nails, comparing nails with four to 14 days of nail polish to natural nails, (n = 665). For the outcome of CFUs measured as either CFU/mL (Blackburn et al., 2020; Wynd et al., 1994) or $\log_{10}$ (Anderson et al., 2021; Hardy et al., 2017). Blackburn et al. (2020) and Wynd et al. (1994), n = 244, the *MD* = 332.93, 95% CI [-368.29, 1034.14], p = .35, indicated the intervention of nail polish wear of four to 14 days was not different to the comparator of natural nails (see Figure 5 & *Table 2*). For the outcome of CFUs measured in $\log_{10}$ (Anderson et al., 2021; Hardy et al., 2017) (n = 421), the *MD* = 0.38, 95% CI [0.15, 0.61], p = .001, indicated the intervention of nail polish wear of four to 14 days was not favorable to the comparator of natural nails. The risk of CFUs with four to 14 days of nail polish wear was .38 CFU ($\log_{10}$) higher compared to natural nails (see Figure 6 & *Table 2*).

Certainty Of The Evidence For CFUs with 4-14 Day Nail Polish versus Natural Nails. The certainty of the body of evidence was low for the two RCTs that measured CFUs in CFU/mL (Blackburn et al., 2020; Wynd et al., 1994) and very low for the RCTs that measured CFUs in $\log_{10}$ (Anderson et al., 2021; Hardy et al., 2017) based on four factors[a]: *within-study risk of bias*, *consistency among studies, directness of evidence*, and *precision of effect estimates*. The body of evidence for the RCTs measuring CFUs as CFU/mL (Blackburn et al., 2020; Wynd et al., 1994) was assessed to have serious risk of bias as demonstrated by study personnel not blinded and serious imprecision as demonstrated by small sample size (n = 244). The body of evidence for the RCTs measuring CFUs as $\log_{10}$ (Anderson et al., 2021; Hardy et al., 2017) was assessed to have serious risk of bias as demonstrated by one or more outcomes of interest reported incompletely, very serious inconsistency as demonstrated by substantial Heterogeneity of 88%, and serious imprecision due to small sample size (n = 421).

Identification of Studies
Search Strategy and Results (see Figure 1)
("gel nail polish" OR "painted nails" OR "nail varnish" OR "nail polish" OR "fingernail polish" OR "gel nails" OR "natural nails" OR "nail length" OR "long nails") AND ("bacterial growth" OR "bacterial count" OR "bacterial colonization" OR "bacterial contamination" OR "microbial growth" OR "microbial count" OR "microbial burden" OR "microbial colonization" OR disinfection OR "hand hygiene") Filters: in the last 5 years

Records identified through database searching n = 28
Additional records identified through other sources n = 0

Studies Included in this Review

Citation	Study Type
*Anderson et al. (2021)	RCT
*Blackburn et al. (2020)	RCT
*Hardy et al. (2017)	RCT
*Walaszek et al. (2018)	Cohort
*Wynd et al. (1994)	Cohort

References marked with an asterisk indicate studies included in the meta-analysis

Studies Not Included in this Review with Exclusion Rationale

Citation	Reason for exclusion
Cimon et al. (2017)	Narrative review
Dickison et al. (2018)	Case report
Fagernes et al. (2011)	Incomplete data
Goldberg et al. (2017)	Self-study exercise
Hewlett et al. (2018)	Data presented in IQR
Kulkarni et al. (2018)	Wrong population

Olivares et al. (2020)	In Spanish
Walaszek et al. (2021)	In Polish
Wood et al. (2016)	Self-study exercise

Methods Used for Appraisal and Synthesis

[a]The GRADEpro Guideline Development Tool (GDT) is the tool used to create the Summary of Findings table(s) for this analysis.

[b]Rayyan is a web-based software used for the initial screening of titles and / or abstracts for this analysis (Ouzzani, Hammady, Fedorowicz & Elmagarmid, 2017).

[c]Review Manager (Higgins & Green, 2011) is a Cochrane Collaborative computer program used to assess the study characteristics as well as the risk of bias and create the forest plots found in this analysis.

[d]The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram depicts the process in which literature is searched, screened, and eligibility criteria is applied (Moher, Liberati, Tetzlaff, & Altman, 2009).

References to Appraisal and Synthesis Methods

[a]GRADEpro GDT: GRADEpro Guideline Development Tool (2015). McMaster University, (developed by Evidence Prime, Inc.). [Software]. Available from gradepro.org.

[b]Ouzzani, M., Hammady, H., Fedorowicz, Z., & Elmagarmid, A. (2016). Rayyan-a web and mobile app for systematic reviews. *Systematic Reviews, 5*(1), 210. doi:10.1186/s13643-016-0384-4

[c]Higgins, J. P. T., & Green, S. e. (2011). *Cochrane Handbook for Systematic Reviews of Interventions [updated March 2011]* (Version 5.1.0 ed.): The Cochrane Collaboration, 2011.

[d]Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097 **For more information, visit www.prisma-statement.org.**

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Acronyms Used in this Document

Acronym	Explanation
AGREE II	Appraisal of Guidelines Research and Evaluation II
CAT	Critically Appraised Topic

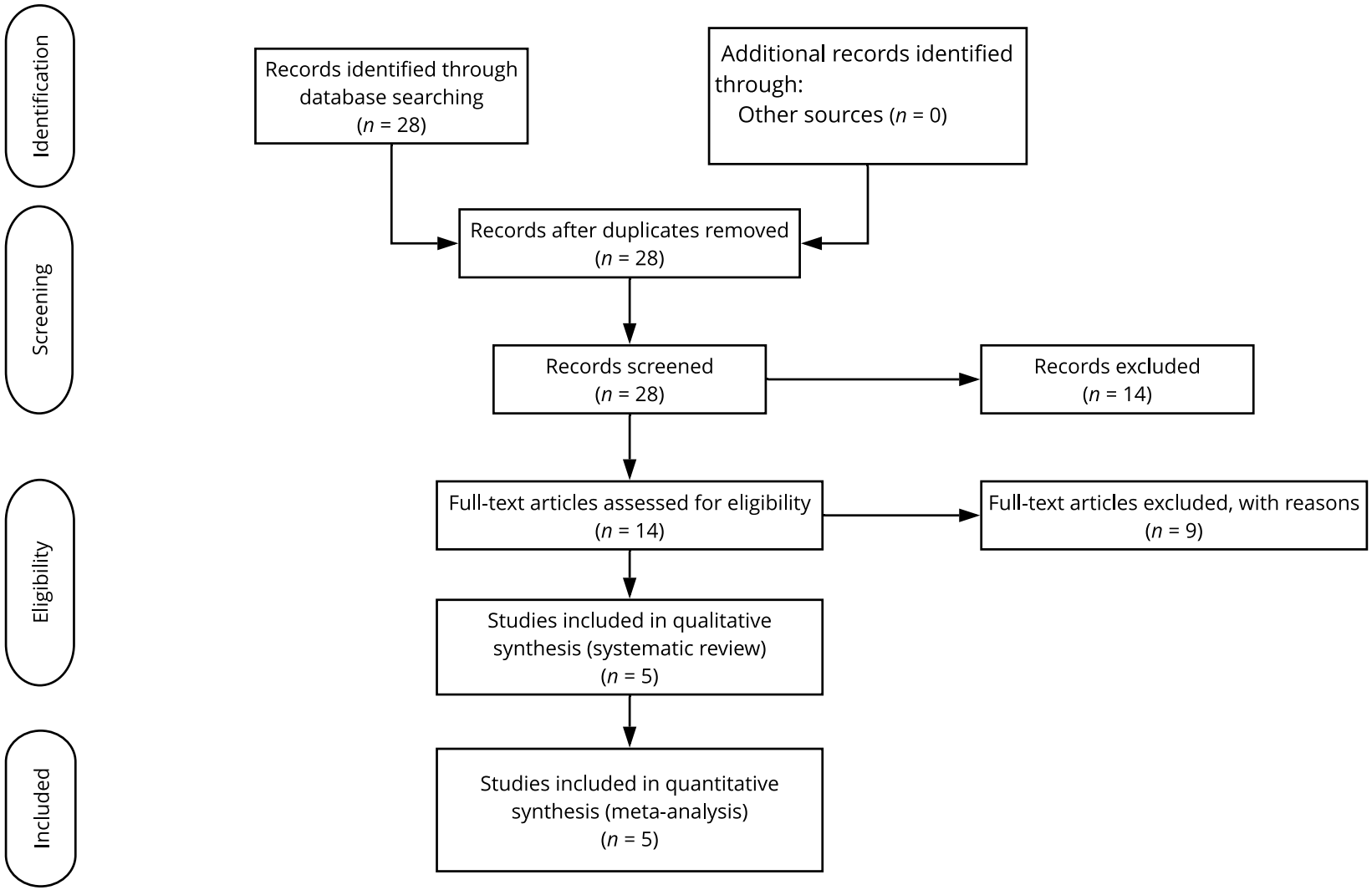
CFU	Colony Forming Units
EBP	Evidence Based Practice
mL	Milliliters
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Statistical Acronyms Used in this Document

Statistical Acronym	Explanation
CI	Confidence Interval
I^2	Heterogeneity test
M or $\bar{X}$	Mean
n	Number of cases in a subsample
N	Total number in sample
OR	Odds Ratio
P or p	Probability of success in a binary trial
RCT	Randomized controlled trial
RR	Relative risk
SD	Standard deviation
SE	Standard error
SR	Systematic Review

Figure 1

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRIMSA)[d]



Summary of Findings Table(s)
Table 1

Summary of Findings Table[a]: Colony Forming Units (CFUs) After Hand Hygiene 1 Day Nail Polish vs. No Polish

Certainty assessment							Summary of findings				
Participants (studies) Follow-up	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence	Study event rates (%)		Relative effect (95% CI)	Anticipated absolute effects	
							With no nail polish	With nail polish		Risk with no nail polish	Risk difference with nail polish
CFU/mL after hand hygiene (1 day nail polish vs. no polish)											
246 (2 RCTs)	serious[a]	not serious	not serious	serious[b]	none	⨁⨁◯◯ Low	123	123	-	The mean CFU/mL after hand hygiene (1 day nail polish vs. no polish) was **0**	MD **265.61 lower** (638.63 lower to 107.42 higher)
CFUs (log_{10}) after hand hygiene (1 day nail polish vs. no polish)											
396 (1 RCT)	serious[c]	not serious	not serious	serious[b]	none	⨁⨁◯◯ Low	198	198	-	The mean CFUs (log10) after hand hygiene (1 day nail polish vs. no polish) was **0**	MD **0.32 lower** (0.52 lower to 0.12 lower)
CFUs after hand hygiene (1 day nail polish vs. no polish)											
89 (1 observational study)	not serious	not serious	not serious	serious[b]	none	⨁◯◯◯ Very low	2/45 (4.4%)	12/44 (27.3%)	**OR 8.06** (1.69 to 38.57)	44 per 1,000	**228 more per 1,000** (from 28 more to 598 more)

Notes
a. Study personnel not blinded
b. Small sample size
c. One or more outcomes of interest are reported incompletely

Table 2

Summary of Findings Table[a]: Colony Forming Units (CFUs) After Hand Hygiene 4-14 Days Nail Polish vs. No Polish

Certainty assessment							Summary of findings				
Participants (studies) Follow-up	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence	Study event rates (%)		Relative effect (95% CI)	Anticipated absolute effects	
							With no nail polish	With nail polish		Risk with no nail polish	Risk difference with nail polish
CFU/mL after hand hygiene (4-to-14-day nail polish vs. no polish)											
244 (2 RCTs)	serious[a]	not serious	not serious	serious[b]	none	⨁⨁◯◯ Low	123	121	-	The mean CFU/mL after hand hygiene (4–14-day nail polish vs. no polish) was **0**	MD **332.93 higher** (368.29 lower to 1034.14 higher)
CFUs (log_{10}) after hand hygiene (4-to-14-day nail polish vs. no polish)											
421 (2 RCTs)	serious[c]	very serious[d]	not serious	serious[b]	none	⨁◯◯◯ Very low	210	211	-	The mean CFUs (log10) after hand hygiene (4–14-day nail polish vs. no polish) was **0**	MD **0.38 higher** (0.15 higher to 0.61 higher)

Notes

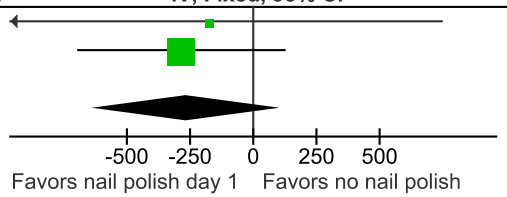
a. Study personnel not blinded
b. Small sample size
c. One or more outcomes of interest are reported incompletely
d. Heterogeneity is substantial; I^2 = 88%

Meta-analysis(es)
Figure *2*

Comparison: Nail Polish Day 1 versus No Nail Polish, Outcome: CFU/mL After Hand Hygiene

	Nail polish day 1			No polish				Mean Difference	Mean Difference	Risk of Bias
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI	IV, Fixed, 95% CI	A B C D E F G
Blackburn2020	599	2,710.7605	89	771	3,489.1425	89	16.5%	-172.00 [-1089.95, 745.95]		+ ? − + + ? ?
Wynd 1994	153.82	427.96	34	437.94	1,136.67	34	83.5%	-284.12 [-692.37, 124.13]		+ ? + ? + + +
Total (95% CI)			123			123	100.0%	**-265.61 [-638.63, 107.42]**		

Heterogeneity: Chi² = 0.05, df = 1 (P = 0.83); I² = 0%
Test for overall effect: Z = 1.40 (P = 0.16)



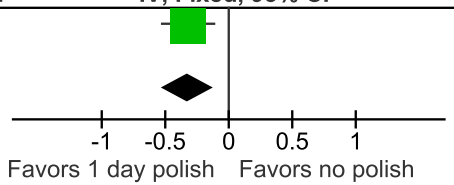
Risk of bias legend
(**A**) Random sequence generation (selection bias)
(**B**) Allocation concealment (selection bias)
(**C**) Blinding of participants and personnel (performance bias)
(**D**) Blinding of outcome assessment (detection bias)
(**E**) Incomplete outcome data (attrition bias)
(**F**) Selective reporting (reporting bias)
(**G**) Other bias

Figure *3*

Comparison: Nail Polish Day 1 versus No Nail Polish, Outcome: CFUs (log_{10}) After Hand Hygiene

	Nail polish day 1			No polish				Mean Difference	Mean Difference	Risk of Bias
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI	IV, Fixed, 95% CI	A B C D E F G
Anderson2021	0.35	0.89	198	0.67	1.17	198	100.0%	-0.32 [-0.52, -0.12]		? ? + ? + − +
Total (95% CI)			198			198	100.0%	**-0.32 [-0.52, -0.12]**		

Heterogeneity: Not applicable
Test for overall effect: Z = 3.06 (P = 0.002)



Risk of bias legend
(**A**) Random sequence generation (selection bias)
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(**C**) Blinding of participants and personnel (performance bias)
(**D**) Blinding of outcome assessment (detection bias)
(**E**) Incomplete outcome data (attrition bias)
(**F**) Selective reporting (reporting bias)
(**G**) Other bias

Figure *4*

Comparison: Nail Polish Day 1 versus No Nail Polish, Outcome: CFUs After Hand Hygiene

Study or Subgroup	Nail polish day 1 Events	Total	No polish Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Walaszek2018	12	44	2	45	100.0%	8.06 [1.69, 38.57]
Total (95% CI)		**44**		**45**	**100.0%**	**8.06 [1.69, 38.57]**
Total events	12		2			

Heterogeneity: Not applicable

Test for overall effect: Z = 2.61 (P = 0.009)

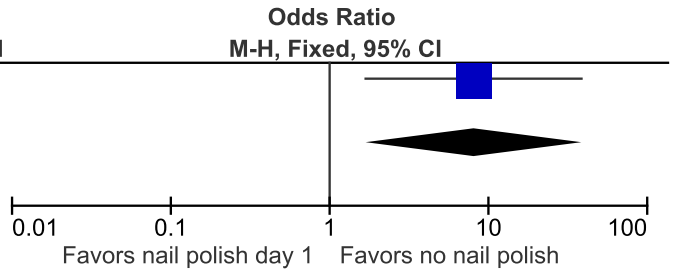


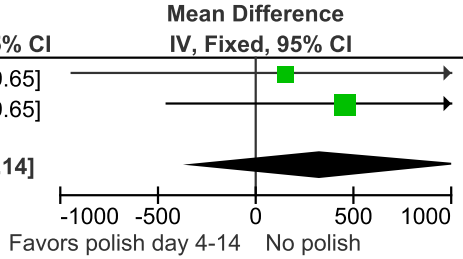
Figure *5*

Comparison: Nail Polish Day 4-14 versus No Nail Polish, Outcome: CFU/mL After Hand Hygiene

Study or Subgroup	Nail polish day 4-14 Mean	SD	Total	No nail polish Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI	Risk of Bias A B C D E F G
Blackburn2020	925	3,909.8451	87	771	3,489.1425	89	41.0%	154.00 [-941.65, 1249.65]	+ ? − + + ? ?
Wynd 1994	895	2,465.6	34	437.94	1,136.67	34	59.0%	457.06 [-455.53, 1369.65]	+ ? + ? + + +
Total (95% CI)			**121**			**123**	**100.0%**	**332.93 [-368.29, 1034.14]**	

Heterogeneity: Chi² = 0.17, df = 1 (P = 0.68); I² = 0%

Test for overall effect: Z = 0.93 (P = 0.35)



Risk of bias legend

(**A**) Random sequence generation (selection bias)
(**B**) Allocation concealment (selection bias)
(**C**) Blinding of participants and personnel (performance bias)
(**D**) Blinding of outcome assessment (detection bias)
(**E**) Incomplete outcome data (attrition bias)
(**F**) Selective reporting (reporting bias)
(**G**) Other bias

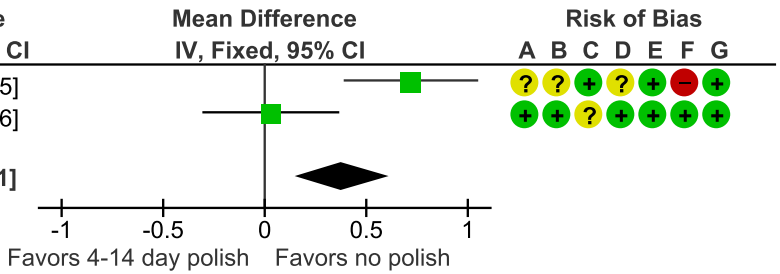
Figure *6*

Comparison: Nail Polish Day 4-14 versus No Nail Polish, Outcome: CFUs (log_{10}) After Hand Hygiene

Study or Subgroup	Nail polish day 4-14 Mean	SD	Total	No nail polish Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Anderson2021	2.88	1.68	190	2.16	1.55	189	50.9%	0.72 [0.39, 1.05]
Hardy2017	1.13	0.6	21	1.1	0.49	21	49.1%	0.03 [-0.30, 0.36]
Total (95% CI)			**211**			**210**	**100.0%**	**0.38 [0.15, 0.61]**

Heterogeneity: Chi² = 8.48, df = 1 (P = 0.004); I² = 88%

Test for overall effect: Z = 3.22 (P = 0.001)



Risk of bias legend

(**A**) Random sequence generation (selection bias)
(**B**) Allocation concealment (selection bias)
(**C**) Blinding of participants and personnel (performance bias)
(**D**) Blinding of outcome assessment (detection bias)
(**E**) Incomplete outcome data (attrition bias)
(**F**) Selective reporting (reporting bias)
(**G**) Other bias

Characteristics of Intervention Studies

Anderson et al. 2020

Methods	**Randomized Control Trail**
Participants	**Participants:** female healthcare professionals and students **Setting:** A mid-west university veterinary medicine and osteopathic medicine programs **Randomized into study:** *N* = 40 individuals; 400 nails • **Group 1, gel polished nails, day 1** *n* = 20 • **Group 2, no gel polished nails, day 1:** *n* = 20 **Completed Study:** *N = 40 individuals;* 396 nails on day 1; *N* = 379 nails on day 14 • **Group 1, day 1, post-surgical scrub:** *n* = 198 • **Group 2, day 1, post-surgical scrub:** *n* = 198 • **Group 1, day 14, post-surgical scrub:** *n* = 190 • **Group 2, day 14, post-surgical scrub:** *n* = 189 **Gender, males (as defined by researchers):** all participants were female • **Group 1:** *n* = 0 (0%) • **Group 2:** *n* = 0 (0%) **Race/ethnicity or nationality (as defined by researchers):** • This information was not provided **Age, mean/median in months/years:** • This information was not provided **Inclusion Criteria:** • Students and faculty from the veterinary medicine and osteopathic medicine programs at Lincoln Midwest University in Harrogate, Tennessee • Student participants must have previously learned and practiced surgical scrub techniques during their curriculum **Exclusion Criteria:** • None listed **Power Analysis:** Analyses completed using Stata version 14.2 (StataCorp, 2015) indicating sample size needed would be a total of 364 nails (182 polished and 182 unpolished) for a conservative effect size based on prior work from Hardy et al.
Interventions	**Both:** Each participant had her fingernails numbered and randomly assigned for gel nail polish or no nail polish so each participate would have five gel polished nails and five unpolished nails randomly assigned across both hands.

	• On day one, participants received a manicure by a licensed manicurist who performed the manicure on every participant. • Hands were thoroughly washed, including scrubbing fingernails with 4% chlorhexidine gluconate • All nails were filed to less than 2-mm, cuticles trimmed, and surface of nails were buffed • Assigned nails had gel nail polish applied by manicurist following manufacturer recommendations and cured with ultraviolet light between applications of one-layer base coat, two layers of gel nail polish and one layer of topcoat • On day 14, participants' fingernails were sampled before and after performing a presurgical hand scrub as on day one
Outcomes	**Primary outcome(s):** • *Bacterial viability following a surgical hand scrub **Secondary outcome(s)** • Bacterial viability with damaged gel painted nails • Bacterial viability with longer nails (length measured in mm) • Bacterial viability with handedness **Safety outcome(s):** • Same as primary outcome *Outcomes of interest to the CMH CPG or CAT development team
Notes	• Twenty-nine fingernail observations were missing bacteria count data to complete calculations on all 800 fingernail observations resulting in 771 total observations. • All data presented were from bacterial growth on blood agar plates. • Descriptive statistics were used for $\log_{10}$ bacterial viability count (CFU/ml). • Spearman's correlation analyses were used and demonstrated a positive correlation between longer fingernail length and viable bacterial count (rho = .46, $p < .0001$), following surgical scrub.

Risk of bias

Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Insufficient evidence and information about random sequence generation methods to permit judgment of low risk or high risk
Allocation concealment (selection bias)	Unclear risk	Concealment methods not described
Blinding of participants and personnel (performance bias)	Low risk	There was no blinding of participants or personnel but the review authors judge that the outcome is not likely to be influenced by lack of blinding
Blinding of outcome assessment (detection bias)	Unclear risk	Insufficient information to permit judgement of low or high risk
Incomplete outcome data (attrition bias)	Low risk	Reasons for missing outcome data unlikely to be related to true outcome (for viable bacterial counts on gel polished vs. no polished fingernails).

Selective reporting (reporting bias)	High risk	One or more outcomes of interest in the review are reported incompletely so that they cannot be entered in a meta-analysis
Other bias	Low risk	No conflict of interests reported. Funding was provided by intramural grant from the University but unlikely to have impact on completed research.

Blackburn et al. 2020

Methods	**Randomized Control Trial**
Participants	**Participants:** Direct patient care oncology nurses **Setting:** Arthur G. James Cancer Hospital & Richard J. Solove Research Institute in Columbus, Ohio **Randomized into study:** *N = 89* • **Group 1, no polish nails:** *n = 89* • **Group 2, *day-old polished nails*:** *n = 89* • **Group 3, 4-day-old polished nails** *n = 89* **Completed Study:** *N = 87* • **Group 1:** *n = 89* • **Group 2:** *n = 89* • **Group 3:** *n = 87* **Gender, males (as defined by researchers):** • **Group 1:** *n* = 1 (1.1%) • **Group 2:** *n* = 1 (1.1 %) • **Group 3:** *n* = 1 (1.1%) **Race / ethnicity or nationality (as defined by researchers):** • 86% Caucasian • 3% African American **Age, mean/median in months/years, (range/IQR)** • **Group 1:** 40 years (11.3 SD) • **Group 2:** 40 years (11.3 SD) • **Group 3:** 40 years (11.3 SD) **Inclusion Criteria:** • On day of cultures nurses must have worked a shift immediately prior to culture collection • The nurses must not have had a manicure or nail polish applied within the month before participation • The nurses' nails could not be exposed to artificial sources of ultraviolet (UV) light for duration of participation **Exclusion Criteria:** • Nurses without full time direct patient care duties • Self-identified nail biters **Power Analysis:** probability of at least 0.93 of detection control/treatment differences of at least 1.75 CFUs, 87 participants needed to reach power

Interventions	• Each participant's three middle nails received an unpolished nail, polished nail cultured at day one, and polish nail cultured at day four. • The nails were randomized to determine which would be painted with nail polish
Outcomes	**Primary outcome(s):** • *Bacterial growth **Secondary outcome(s)** • *Chipping of nail polish *Outcomes of interest to the CMH CPG or CAT development team
Notes	• CFU means were less than the no-polish or four-day CFU means. • For gram-positive organisms, one day-old polish was less than unpolished nail (p = .04), • Four-day-old, polished nails had more microorganisms than the one-day-old, polished nails (p = .03) • By day 4, 100% of nails were chipped • Significant number of CFUs for gram-positive and gram-negative increased as chipping increased (p-value not provided)

Risk of bias

Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	GraphPad Software was used to produce random assignment of nails for each polish group.
Allocation concealment (selection bias)	Unclear risk	Not reported in the study
Blinding of participants and personnel (performance bias)	High risk	Blinding of personnel was not possible, behavior could have changed based on inability to blind.
Blinding of outcome assessment (detection bias)	Low risk	Nail swab collectors swabbed each nail on designated individual swabs for each nail, and only nails that were scheduled to be swabbed were sent for culture.
Incomplete outcome data (attrition bias)	Low risk	No missing outcome data with missing participants on day 4 explained. Study still met power of 87 participants.
Selective reporting (reporting bias)	Unclear risk	Unsure when no nail polish nail was cultured.
Other bias	Unclear risk	No financial relationships disclosure statement is provided.

Hardy et al. 2017

Methods	Randomized Control Trail, Crossover Design
Participants	**Participants:** Veterinary students, faculty, interns/residents, and surgical techs **Setting:** Veterinary Teaching Hospital, March – April 2015 **Randomized into study:** *N = 42* • **Group 1, nail polish week 1:** *n* = 21 • **Group 2, nail polish week 2:** *n* = 21 **Completed Study:** *N* = 42 • **Group 1:** *n* = 21 • **Group 2:** *n* = 21 **Gender, males (as defined by researchers):** • **Group 1:** *n* = 5 (24 %) • **Group 2:** *n* = 5 (24 %) **Race / ethnicity or nationality (as defined by researchers):** • Not reported **Age, mean/median in months/years:** • Not reported **Inclusion Criteria:** • All small animal orthopedic and soft tissue surgery personnel at a veterinary teaching hospital. **Exclusion Criteria:** • Evidence of dermatitis or skin abnormality • Allergy to chlorhexidine gluconate-based hand scrubs **Power Analysis: not reported**
Interventions	**Both groups:** Samples for culture were taken from the surface and from the subungual areas of the nails on both hands with sterile cotton swabs and toothpicks. Samples were obtained prior to scrubbing, immediately after routine scrubbing with 2% chlorohexidine for a minimum of 5 minutes scrub time) and immediately after surgery (at scrub-out time). One of the study investigators monitored all scrubbing activities to ensure there was no qualitative variance in the scrubbing technique used by the surgical staff. • **Group 1:** Wore nail polish for week 1, then none for week 2 • **Group 2:** No nail polish for week 1, wore nail polish for week 2
Outcomes	**Primary outcome(s):**

	• *Evaluate bacterial counts on the fingers of surgical personnel with and without nail polish **Secondary outcome(s)** • *Identify risk factors for increased bacterial load on or under fingernails in surgical personnel with or without nail polish *Outcomes of interest to the CMH CPG or CAT development team

Notes	**Results:**
	• No difference in mean total bacterial count between polish and no-polish in pre-scrubbing, post-scrubbing and post-surgery samples.
	• No difference in polished and unpolished in other variables assessed: nail biters, sample collection date, time in surgery, type of surgery, hand dominance, duration of nail polish application, chipped vs non-chipped.
	• Two independent variables were associated with statistical significance-
	  ○ Increase in bacterial count: pre-scrubbing sample type and length of nail.
	  ○ Nails longer than 2 mm showed significant increase in bacterial count.
	• Recommended staff keep nails shorter than 2 mm.

Risk of bias

Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Randomization performed using online randomization generator.
Allocation concealment (selection bias)	Low risk	Participants have no way of predicting whether they would be painted or unpainted for the first week
Blinding of participants and personnel (performance bias)	Unclear risk	Knowing what group you are in could change behavior
Blinding of outcome assessment (detection bias)	Low risk	Samples of polished and unpolished fingers were sent to be evaluated in a lab, where lab technicians had no knowledge of group assignment.
Incomplete outcome data (attrition bias)	Unclear risk	No missing outcome data. All participants who started study finished. No power analysis
Selective reporting (reporting bias)	Low risk	All expected outcomes were reported.
Other bias	Low risk	Confounding factors such as presence of nail-biting habit and experience level of staff were accounted for in results.

Wataszek et al. 2018

Methods	**Cohort**
Participants	**Participants:** Nurses and midwives in a hospital setting **Setting:** Hospital units at a hospital in Matopolska, Poland **Number enrolled into study:** *N* = 99 • **Group 1, Traditional nail polish** (nail varnish applied directly to the nail plate – durability is short)**:** *n* = 10 • **Group 2, Varnish-type nail conditioner** (nail conditioner applied directly on the nail plate)**:** *n* = 11 • **Group 3, Hybrid ultraviolet (UV)- cured coatings** (varnish which is cured with UV rays following its application. It is durable and glossy, does not chip of and has a non-porous structure)**:** *n* = 15 • **Group 4, Gel UV-cured coatings** (varnish which cures and extends the nail plate; varnish is smooth, non-porous and very hard): *n* =7 • **Group 5, Natural fingernails, no polish:** *n* = 45 **Gender, males (as defined by researchers):** • This information was not provided **Race / ethnicity or nationality (as defined by researchers):** • All participants were Polish healthcare workers **Age, mean in years, for the entire study group:** • 45 years **Inclusion Criteria:** • Healthcare workers with healthy and undamaged hand skin and healthy fingernails **Exclusion Criteria:** • Dermatological conditions on the hands **Covariates Identified:** • None identified
Interventions	**Both:** • All participants were informed about the rules of hand hygiene according to the Ayliffe technique. • All samples were taken at the place of work of the study participants and always after alcohol-based hand rub • The researcher assessed the condition of the hands and nails including length of fingernails (short nails defined as those ≤ .2 cm • There were no individuals with artificial nails • Each nail was swabbed over 3 points of the nail area: the nail plate, the nail base and under the nail plate. • Nails on both hands were assessed the same way following hand hygiene and the results were pooled from both hands of one person to count as one result. This was repeated for each study subject.

Outcomes	**Primary outcome(s):** • *Decrease in bacteria on nails of healthcare workers following proper hand hygiene regardless of nail varnish, no nail varnish or nail length. **Secondary outcome(s):** • None provided **Safety outcome(s):** • None provided *Outcomes of interest to the CMH CAT development team
Notes	**Results:** • No association was found between nail length or nail coating and the number of commensal flora, *OR* = 2.1, 95% CI [0.88, 5.12], *p* = .170) • Potential pathogenic micro-organisms found more frequently with longer fingernails *OR* = 7.1, 95%CI [1.83, 27.39], *p* = < .001 • Potential pathogenic micro-organisms found more frequently with varnished nails regardless of the type of varnish, *OR* = 6.1, 95%CI [1.29, 29.12], *p* = < .05 • Nails covered with hybrid and gel UV-cured nails increased the risk of ineffective hand disinfection when compared to nails with no varnish or polish *OR* = 7.2, 95%CI [1.25, 40.91], *p* = < .05 and *OR* = 9.2, 95% CI [1.29, 65.37], *p* = < .05, respectively **Limitations:** • The study protocol did not include how long the nail polish (of any variety) was in place. • Small number of participants/subjects. • Method for assessment of the flora forming the normal hand skin flora was qualitative vs. quantitative and focused on the nail rather than the entire hand.

Wynd et al. 1994

Methods	**Randomized Control Trial**
Participants	**Participants:** Perioperative nurses **Setting:** Cleveland Clinic Foundation **Randomized into study:** *N* = 102 • **Group 1,** freshly polished fingernails**:** *n* = 34 • **Group 2,** chipped nail polish: *n* = 34 • **Group 3,** natural fingernails: *n* = 34 **Completed Study:** *N* = 102 • **Group 1:** *n* = 34 • **Group 2:** *n* = 34 • **Group 3:** *n* = 34 **Gender, males (as defined by researchers):** • Not reported **Race / ethnicity or nationality (as defined by researchers):** • Not reported **Age, mean/median in months/years:** • Not reported **Inclusion Criteria:** • Perioperative nurses at Cleveland Clinic • Perioperative nurses that provided written, informed consent **Exclusion Criteria:** • Not stated **Power Analysis:** Thirty-four subjects per group provided a power of .80 for establishing statistical significance using a three-long reduction in CFUs.

Interventions	**All groups:**
	• Each participant was provided an envelope with how to prepare their nails (randomly assigned by biostatisticians).
	• Cultures from participant's fingernails were collected from the participant's dominant hand at the beginning of their shift and before their firsthand scrub of the day.
	• All participants completed a basic 30-stroke anatomical scrub method over five minutes.
	• Culture collection was repeated post-surgical scrub using the same method as prior to surgical hand scrub
	  ○ **Group 1:** fresh nail polish applied within 2 days
	  ○ **Group 2:** Visibly chipped nail polish and/or applied 4 days prior to culture collection

	○ **Group 3:** Natural nails with no nail polish within 4 days of data collection
Outcomes	**Primary outcome(s):** • *bacterial carriage on fresh nail polish, chipped nail polish or natural nails **Secondary outcome(s)** • bacterial carriage on lengths of fingernails **Safety outcome(s):** • Not reports *Outcomes of interest to the CM CAT development team
Notes	• Developed surgical scrub observation tool (SSOT) and validated prior to nail polish study (tool provided) • Cultures sent to microbiology laboratory for incubation and analysis • Used the Wilcoxon rank sum test for statistical analysis due to data not normally distributed • Although nail length (measured in mm) was found to be longer in nurses with nail polish, average of 3.50mm, (fresh or chipped) compared to nurses with natural nails, average 2.38 mm, no significant correlations were found on nail length and bacterial growth.

Risk of bias

Bias	**Judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Randomization technique used with envelopes prepared by biostatisticians and then distributed randomly for group assignment.
Allocation concealment (selection bias)	Unclear risk	Randomization scheme utilized however no description of envelopes being opaque or sealed.
Blinding of participants and personnel (performance bias)	Low risk	No blinding of participants but review authors' judge the outcome is unlikely to be influenced by lack of blinding.
Blinding of outcome assessment (detection bias)	Unclear risk	Insufficient evidence to determine judgement for low or high risk
Incomplete outcome data (attrition bias)	Low risk	No missing data
Selective reporting (reporting bias)	Low risk	Both outcomes reported
Other bias	Low risk	The study appears to be free of other sources of bias.

References

References marked with an asterisk indicate studies included the meta-analysis.

*Anderson, S. L., Wisnieski, L., Achilles, S. L., Wooton, K. E., Shaffer, C. L., & Hunt, J. A. (2021). The impact of gel fingernail polish application on the reduction of bacterial viability following a surgical hand scrub. *Vet Surg*. https://doi.org/10.1111/vsu.13703

*Blackburn, L., Acree, K., Bartley, J., DiGiannantoni, E., Renner, E., & Sinnott, L. T. (2020). Microbial Growth on the Nails of Direct Patient Care Nurses Wearing Nail Polish. *Oncol Nurs Forum*, *47*(2), 155-164. https://doi.org/10.1188/20.Onf.155-164

Center for Disease Control and Prevention. (2002). Guideline for hand hygiene in health-care settings: recommendations of the healthcare infection control practices advisory committee and the HICPAC/SHEA/APIC/IDSA hand hygiene task force. *Morbidity and Mortality Weekly Review, 51*(16), 1-56.

Centers for Disease Control and Prevention. (2019, April 29). *Hand hygiene in healthcare settings*. Centers for Disease Control and Prevention. Retrieved December 29, 2021, from https://www.cdc.gov/handhygiene/index.html

Fagernes, M., & Lingass, E. (2011). Factors interfering with the microflora on hands: a regression analysis of samples from 465 healthcare workers. *Journal of Advanced Nursing, 67*(2), 297-307. doi: 10.1111/j.1365-2648.2010.05462.x

Goldberg, J. L. (2017). Guideline implementation: hand hygiene. *Aorn j*, *105*(2), 203-212. https://doi.org/10.1016/j.aorn.2016.12.010

*Hardy, J. M., Owen, T. J., Martinez, S. A., Jones, L. P., & Davis, M. A. (2017). The effect of nail characteristics on surface bacterial counts of surgical personnel before and after scrubbing. *Vet Surg*, *46*(7), 952-961. https://doi.org/10.1111/vsu.12685

Hautemaniere, A., Cunat, L., Diguio, N., Vernier, N., Schall, C., Daval, M., Ambrogi, V., Tousseul, S., Hunter, P.R., & Hartemann, P. (2010). Factors determining poor practice in alcoholic gel hand rub technique in hospital workders. *Journal of Infection and Public Health, 3*(1), 25-34.

McNeil, S.A., Foster, C.L., Hedderwick, S.A., Kauffman, C.A. (2001). Effect of hand cleansing with antimicrobial soap or alcohol-based gel on microbial colonization of artificial fingernails worn by health care workers. *Clin Infect Dis*, *32*, 367-372.

Rupp, M.E., Fitzgerald, T, Puumala, S., Anderson, J.R., Craig, R., Iwen, P.C., Jourdan, D., Keuchel, J., Marion, N., Peterson, D., Sholtz, L., & Smith, V. (2008). Prospective, controlled, cross-over trial of alcohol-based hand gel in critical care unit. *Infection Control and Hospital Epidemiology, 29*(1), 8-15.

*Wałaszek, M. Z., Kołpa, M., Różańska, A., Jagiencarz-Starzec, B., Wolak, Z., & Wójkowska-Mach, J. (2018). Nail microbial colonization following hand disinfection: a qualitative pilot study. *J Hosp Infect*, *100*(2), 207-210. https://doi.org/10.1016/j.jhin.2018.06.023

*Wynd, C. A., Samstag, D. E., & Lapp, A. M. Bacterial carriage on the fingernails of OR nurses. *AORN Journal*, *60*(5), 796.