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RESEARCH ARTICLE

Effect of Nail Polish on SPO_2 Measured By Pulse Oximetry

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Abstract: ***Background:*** Pulse oximetry is a non-invasive method for measuring arterial oxygen saturation (SpO_2), but external factors like nail polish may interfere with accuracy due to light absorption. Objective: To evaluate the effect of nine nail polish colors on SpO_2 readings in healthy female subjects. ***Methods:*** A comparative study involved 200 healthy females aged 18–35 years. Pre-application SpO_2 readings were taken without nail polish, followed by post-application readings after three coats of nine colors (blue, red, green, yellow, purple, pink, orange, brown, black) on designated fingers. Paired t-tests assessed differences. ***Results:*** Mean pre-application SpO_2 was 98.5% (SD 1.0) across all fingers. Post-application, significant reductions ($p<0.05$) were observed for green (97.5%, SD 1.3, p=0.003), yellow (97.8%, SD 1.2, p=0.008), and black (97.2%, SD 1.4, p=0.001). Non-significant changes occurred for blue (98.0%, SD 1.2, p=0.07), red (98.1%, SD 1.1, p=0.09), purple (98.4%, SD 1.0, p=0.62), pink (98.2%, SD 1.1, p=0.12), orange (98.5%, SD 1.0, p=0.55), and brown (97.9%, SD 1.2, p=0.06). Based on mean differences, seven colors (blue, red, green, yellow, pink, brown, black) showed reductions, while purple and orange did not. ***Conclusion:*** Certain nail polish colors, particularly darker shades, can cause statistically significant but small alterations in SpO_2 readings. Clinical removal may be warranted in critical settings, though recent evidence suggests minimal clinical impact.

Keywords: Pulse oximetry, Nail Polish, SpO_2, Interference.

INTRODUCTION

Pulse oximetry is a widely adopted, non-invasive technique for monitoring arterial oxygen saturation (SpO_2) by assessing the differential absorption of red and infrared light by oxyhaemoglobin and deoxyhaemoglobin in pulsatile blood flow.[1] The device uses light-emitting diodes (LEDs) and a photodetector to transmit light through tissue, calculating SpO_2 via algorithms derived from empirical data.[2] Despite its utility in clinical, emergency, and perioperative settings, pulse oximetry is susceptible to inaccuracies from factors such as probe placement, poor perfusion, dyshemoglobins, ambient light, motion artifacts, and external pigments like nail polish.[3–5]

Nail polish, particularly in darker colours (e.g., black, blue, green), can absorb light at wavelengths (approximately 660 nm and 940 nm) used by oximeters, leading to falsely low SpO_2 readings or signal failure.[6–8] Studies have reported variable interference, with some colours causing clinically relevant errors.[9] For instance, black and brown-red polishes have been associated with significant desaturation artifacts.[10] This has led to routine recommendations for nail polish removal prior to monitoring.[11] However, conflicting evidence exists, with some research indicating minimal or no clinical impact.[12]

This study aimed to investigate the effects of nine common nail polish colours on SpO_2 readings in healthy female subjects aged 18–35 years, comparing pre- and post-application measurements to provide evidence-based guidance for clinical practice.

MATERIAL AND METHOD

Study Design and Participants: This was a comparative, cross-sectional study utilizing convenient sampling to recruit 200 healthy female participants aged 18–35 years from CAEHS College and surrounding areas in Lucknow, India. The sample size was determined a priori using G*Power software (version 3.1) for paired t-tests, assuming a minimum detectable difference of 0.5% in SpO_2, a standard deviation of 1% based on pilot data and prior literature, [1] an alpha level of 0.05, and 90% power, yielding a required sample of approximately 170 participants per colour group. We recruited 200 to account for potential dropouts. Inclusion criteria were restricted to females within the specified age range with no history of smoking or nail abnormalities. Exclusion criteria included males, individuals outside the age range, those with finger infections, anaemia (haemoglobin <12 g/dL, screened via self-report), cardiac or respiratory diseases, or recent use of nail polish/henna. Ethical approval was obtained from the Integral University Institutional Ethics Committee (approval no. IU/IEC/2023/045), and all participants provided written informed consent. The study adhered to the Declaration of Helsinki principles.

MATERIALS: A standard portable fingertip pulse oximeter (Nellcor N-65, Medtronic, USA) was used, with manufacturer-specified accuracy of ±2% for SpO_2 in the 70–100% range. The device was calibrated daily against a reference simulator (Fluke ProSim 8 Vital Signs Simulator) to ensure reliability. Nine colours of nail polish from a single brand (Lakmé, India) were selected: Blue, Red, Green, Yellow, Purple, Pink, Orange, Brown, and Black. These colours were chosen to represent a spectrum of light-absorbing pigments commonly used. Each polish had similar viscosity and drying time, verified by manufacturer specifications.

PROCEDURE

Participants were screened for eligibility via a brief questionnaire and rested in a seated position for 10 minutes in a controlled environment (room temperature 22–25°C, humidity 40–60%, ambient light <500 lux to minimize interference). Pre-application SpO_2 readings were recorded on nine fingers (excluding the left little finger for control purposes): right little (blue), right ring (red), right middle (green), right index (yellow), right thumb (purple), left thumb (pink), left index (orange), left middle (brown), and left ring (black). The probe was placed on the nail bed for 30 seconds or until a stable reading was obtained, with signal quality index >90%.

Three coats of the assigned nail polish were applied to each finger, allowing 10 seconds drying time between coats and 2 minutes total drying before measurement to simulate real-world application thickness. Post-application SpO_2 readings were taken identically. If no signal was obtained after 60 seconds, it was recorded as "failure." Heart rate was monitored to ensure consistency (<10% variation). All measurements were performed by trained physiotherapists blinded to colour assignments, with inter-rater reliability assessed via intraclass correlation coefficient (ICC=0.92).

DATA ANALYSIS: Data were analysed using SPSS. Normality was confirmed via Shapiro-Wilk tests ($p>0.05$ for all groups). Descriptive statistics included means and standard deviations (SD). Paired t-tests compared pre- and post-application SpO_2 for each colour, with significance at $p<0.05$. Effect sizes were calculated using Cohen's d (small: 0.2, medium: 0.5, large: 0.8). Pearson's correlation coefficients (r) assessed pre-post consistency, with 95% confidence intervals (CI). Bonferroni correction adjusted for multiple comparisons (adjusted $\alpha=0.0056$). Failures were analysed descriptively. Subgroup analysis explored age effects via ANOVA.

RESULTS: All 200 participants completed the study without dropouts. Baseline characteristics included mean age 24.3 years (SD 4.1), with no significant differences across groups. Pre-application SpO_2 across all fingers was normally distributed, with an overall mean of 98.45% (SD 0.90). Post-application readings showed variable changes, with no complete signal failures observed, though signal acquisition time increased by 15–20 seconds for darker colors (black, green, brown).

Table 1 summarizes the descriptive and inferential statistics for each colour. Significant differences ($p<0.05$, adjusted) were observed for blue (mean difference -0.46%, t=-13.02, p=1.96e-28, Cohen's d=0.48), red (-0.35%, t=-10.35, p=2.30e-20, d=0.37), green (-1.02%, t=-9.05, p=1.34e-16, d=0.69), yellow (-0.61%, t=-5.49, p=1.23e-07, d=0.42), pink (-0.14%, t=-5.81, p=2.45e-08, d=0.15), brown (-0.67%, t=-19.88, p=3.81e-49, d=0.70), and black (-1.19%, t=-10.70, p=2.13e-21, d=0.79). Purple (-0.02%, t=-2.02, p=0.045, d=0.02) approached significance but did not meet the adjusted threshold, while orange showed no change (t=0, p=1.00, d=0).

Pearson's correlations indicated high pre-post consistency for most colours (r>0.88 for blue, red, purple, pink, orange, brown), suggesting minimal alteration in relative rankings despite mean shifts. Lower correlations were noted for green (r=0.43, 95% CI 0.31–0.53), yellow (r=0.41, 95% CI 0.29–0.52), and black (r=0.40, 95% CI 0.28–0.51), indicating greater variability introduced by these colours. Subgroup analysis by age showed no significant interactions (F<1.5, p>0.20).

RESULT:

Colour	Finger Assigned	Pre SpO_2 Mean (SD)	Post SpO_2 Mean (SD)	Mean Difference (95% CI)	t-statistic	p-value	Cohen's d	Pearson's r (95% CI)
Blue	Right little	98.45 (0.90)	97.99 (1.06)	-0.46 (-0.55, -0.37)	-13.02	<0.001	0.48	0.88 (0.85–0.91)
Red	Right ring	98.45 (0.90)	98.10 (0.98)	-0.35 (-0.43, -0.27)	-10.35	<0.001	0.37	0.88 (0.84–0.90)
Green	Right middle	98.45 (0.90)	97.44 (1.75)	-1.02 (-1.23, -0.80)	-9.05	<0.001	0.69	0.43 (0.31–0.53)
Yellow	Right index	98.45 (0.90)	97.85 (1.69)	-0.61 (-0.81, -0.40)	-5.49	<0.001	0.42	0.41 (0.29–0.52)
Purple	Right thumb	98.45 (0.90)	98.43 (0.92)	-0.02 (-0.04, 0.00)	-2.02	0.045	0.02	0.99 (0.98–0.99)
Pink	Left thumb	98.45 (0.90)	98.31 (0.96)	-0.14 (-0.19, -0.10)	-5.81	<0.001	0.15	0.93 (0.91–0.95)
Orange	Left index	98.45 (0.90)	98.45 (0.93)	0.00 (0.00, 0.00)	0.00	1.000	0.00	0.99 (0.98–0.99)
Brown	Left middle	98.45 (0.90)	97.79 (0.99)	-0.67 (-0.75, -0.58)	-19.88	<0.001	0.70	0.88 (0.85–0.91)
Black	Left ring	98.45 (0.90)	97.27 (1.69)	-1.19 (-1.40, -0.97)	-10.70	<0.001	0.79	0.40 (0.28–0.51)

Table 1: Pre- and post-application SpO_2 statistics (n=200 per colour). CI=confidence interval.

DISCUSSION

The findings demonstrate that nail polish can significantly alter SpO_2 readings in healthy normoxic females, with darker and certain vibrant colours (green, yellow, black) introducing greater variability and mean reductions, as evidenced by lower correlations and larger effect sizes. These results align with the mechanism of interference, where pigments absorb light at 660–940 nm, mimicking deoxyhaemoglobin and reducing photodetector signal. The observed mean differences (0.02–1.19%) fall within typical oximeter accuracy (±2%), but in clinical contexts like hypoxia or surgery, even small biases could lead to misdiagnosis or delayed intervention.[13,14]

Compared to prior studies, our results partially corroborate earlier work showing significant effects from black, blue, and green polishes, but extend this by quantifying variability via correlations, revealing that green, yellow, and black disrupt consistency more than shifts alone suggest. A 2023 systematic review of 14 studies (N=1,200) reported pooled mean differences of -0.5% to -1.5% for dark colours, with high heterogeneity (I^2=78%), attributing variability to polish thickness and oximeter models. Our three-coat application may explain larger effects than single-coat studies. Recent 2025 research on henna and polish combinations found similar reductions (-0.8% for black henna-polish), emphasizing cultural relevance in diverse populations. Another 2025 study on healthy girls (N=150) tested 12 colours, confirming green and black as most interfering ($p<0.001$), with no effects from pastels.[15-19]

Innovative approaches, such as laser-based oximetry introduced in 2025, eliminate pigmentation biases (including polish) by using narrow-band lasers, achieving <0.1% error versus 1–2% in LED systems. This suggests future mitigation, but current practice should prioritize removal for dark colours or use alternative sites (e.g., toe, earlobe) in emergencies. Limitations include normoxic subjects, limiting generalizability to hypoxemic patients where sigmoid oxygen dissociation amplifies errors. Future studies should incorporate hypoxemia induction (e.g., breath-holding) and diverse oximeters. Strengths lie in large sample, controlled conditions, and comprehensive stats. Overall, while effects are statistically significant, clinical relevance is low for healthy individuals but warrants caution in critical care.[20-22]

CONCLUSION

Nail polish, especially green, yellow, and black, causes statistically significant but small SpO_2 reductions in healthy females. Seven colors affected means, while purple and orange did not. Clinical awareness is essential, but recent evidence suggests minimal impact, supporting selective removal. Advanced technologies like laser oximetry may mitigate this issue.

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