Title: **Effects of nail polish on pulse oximetry**

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Introduction:
Pulse oximetry is a standard, simple, continuous, non-invasive, reliable and easy to use monitoring technique. This has revolutionized oxygen saturation (SpO_2) monitoring. It is a common belief that finger nail polish may affect the accuracy of the reading. Literature has shown conflicting results regarding this.

Coté[1] reported that black, blue and green fingernail polish significantly lowered SpO_2 by 3 to 6%. Rubin[2] also found that a blue colour fingernail polish decreased Spo_2 from 97 to 87%.

Aims and objectives:
The objective of this study was to analyse the effects of different colours of nail polish on oxygen saturation measurements using pulse oximetry.

Methodology:
Approval was obtained from the ethics committee and local research & development department of the Trust.

Ten healthy female volunteers were recruited after obtaining written, informed consent. The finger nails of each participant were inspected for any abnormalities before the pulse oximeter measurements were taken.

Nine different finger nail polish colours were used on nine fingers and the tenth finger was used as the control. They were black (1), yellow (2), brown (3), red (4), orange (5), pink (6), green (7), blue (8) and purple (9). The fingers were painted from left to right hand. Three coats of nail polish were put on. First coat of a transparent layer was followed by two layers of coloured nail polish on each finger.

On volunteer no 1, the little finger of the left hand was used as a control (unpainted). Then the colours 1 to 9 as discussed above were applied in order from left to right with purple (9) applied to the right little finger. For volunteer no. 2, the control finger was changed to the left ring finger and then the colours 1 to 8 applied from the left to right, concluding with colour 9 (purple) on the left little finger. The control finger and colours were rotated from left to right with subsequent volunteers as seen in photograph (Fig.1) to avoid confounding of the effects of nail polish with any finger effect.

The newer and widely available, Passport 2® (Datascope® Patient Monitoring) pulse oximeter was used. The volunteers were sitting comfortably to minimise inaccuracies due to motion artefacts. The finger probe was placed in the standard top to bottom position. SpO_2 was displayed continuously. Readings were taken at 30 seconds interval for 5 minutes to include the warming up of pulse oximeter. As a result, each volunteer had 10 readings per nail polish and 10 readings for control finger. Thus 100 readings per volunteer were taken.

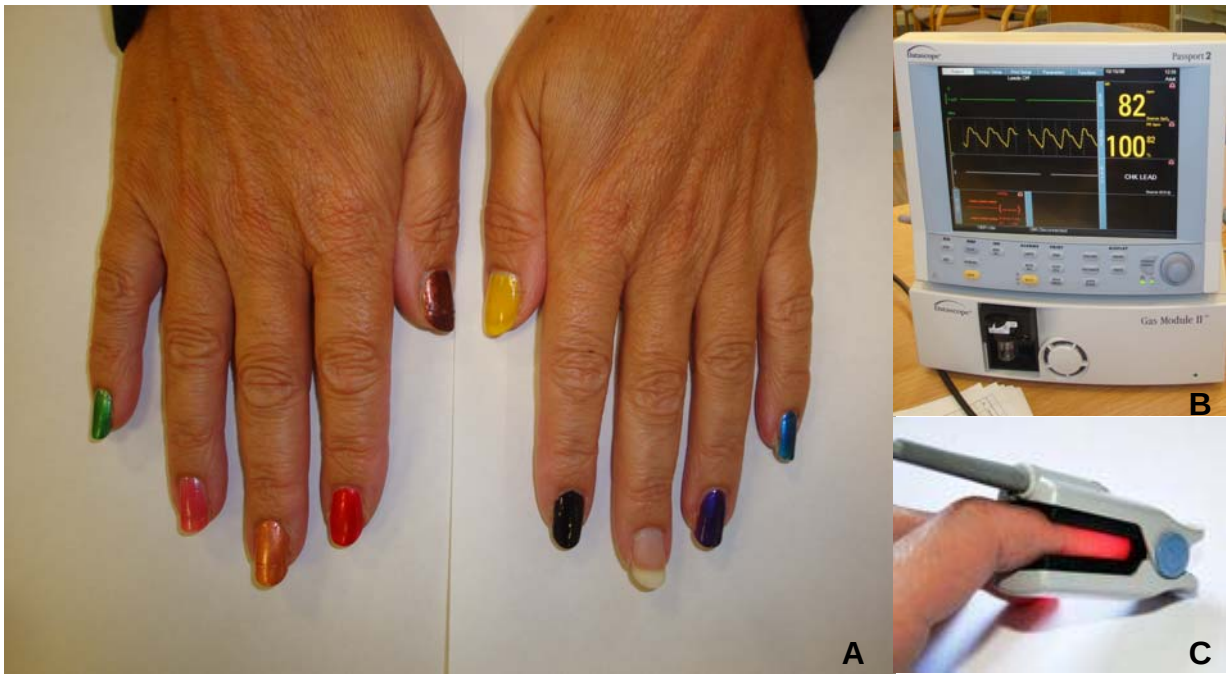

Fig 1. Setup of the study. A. Volunteer no. 3 showing the 9 different colours of nail polish on 9 fingers with left middle finger as control. B. Datascope Passport 2 pulse oximeter. C. Top to bottom position of the finger probe.

Results:

Table 1: Details of the volunteers.

Volunteers Demographics		(n=10)
Age (years)	25 - 35	02
	36 - 45	03
	46 - 60	05
Sex	Female	10
	Male	00
Smoker	No	10
	Yes	00
Race	Caucasian	07
	Non Caucasian	03
Nail abnormalities	Nail bites	00
	None	10

SpO_2 readings were plotted against nail polish colours and different fingers (Fig. 2 & 3). Both box and whisker plots show that most readings were ≥ 97%**.**

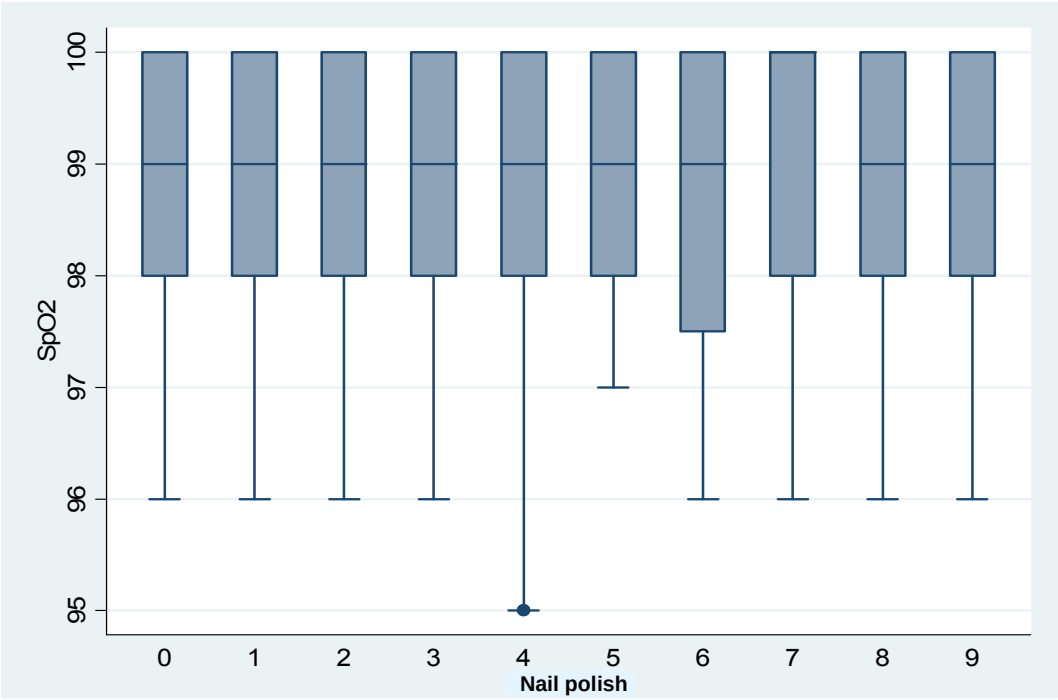

Fig. 2: Box and whisker plots: Nail polish (X-axis) and SpO_2 (Y-axis).
(0 = control, 1= black, 2= yellow, 3= brown, 4= red, 5= orange, 6= pink, 7= green, 8= blue, 9= purple.)

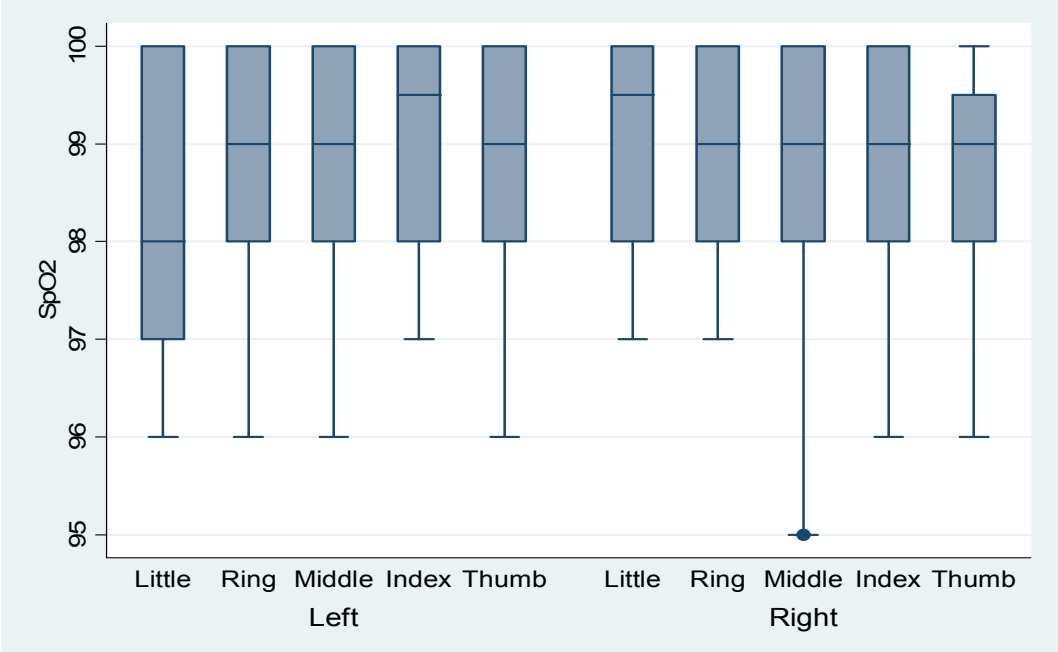

Fig.3: Box and whisker plots: Fingers (X-axis) and SpO_2 (Y-axis).

Statistical analysis:
The data was analysed using a repeated measures regression model using the xtreg command on Stata® version 10.1.

Finger (1 to 5) and hand (left to right) were included as factors in the regression model, as was nail polish (0 to 9), with zero as the control.

Table 2: Regression estimates

SpO_2 % saturation	Coef.	Std. Err.	z	P>|z|	[95% CI]	
Reference condition	98.608	.3383928	291.40	0.000	97.94476	99.27124
Nail polish_1	.14	.0956573	1.46	0.143	-.047485	.327485
Nail polish_2	.06	.0956573	0.63	0.531	-.127485	.247485
Nail polish_3	.17	.0956573	1.78	0.076	-.017485	.357485
Nail polish_4	.13	.0956573	1.36	0.174	-.057485	.317485
Nail polish_5	.33	.0956573	3.45	0.001*	.142515	.517485
Nail polish_6	.1	.0956573	1.05	0.296	-.087485	.287485
Nail polish_7	.41	.0956573	4.29	0.000*	.222515	.597485
Nail polish_8	.18	.0956573	1.88	0.060	-.007485	.367485
Nail polish_9	.28	.0956573	2.93	0.003*	.092515	.467485
little finger	-.215	.06764	-3.18	0.001*	-.3475719	-.0824281
middle finger	-.075	.06764	-1.11	0.268	-.2075719	.0575719
index finger	.125	.06764	1.85	0.065	-.0075719	.2575719
thumb	-.185	.06764	-2.74	0.006*	-.3175719	-.0524281
right hand	.204	.0427793	4.77	0.000*	.1201542	.2878458

(* suggest p<0.05 which are statistically significant)

The reference condition is no nail polish, on the ring finger of the left hand, in which condition the mean saturation was 98.6% as shown in Table 2. All other coefficients represent the mean changes in % saturation for the appropriate changes to the reference condition.

All colours of nail polish resulted in a very slight increase in the oxygen saturation, some of which were statistically significant ($p<0.05$) e.g. nail polish 5 (orange), 7 (green) and 9 (purple). However, all of the systematic differences were < 0.5% and therefore, were of no clinical importance.

Effects of similar sizes (<0.5%) were also found between fingers and between left and right hands, but again these differences are of little or no clinical significance.
Only 2.75% of the total variance of the saturation data was explained by the three factors as nail polish, finger and hand in the model and over 97% of the variation is explained by random factors.

Discussion:
Establishing the effect of nail polish on saturation is relevant in clinical practice as removing the nail polish requires both clinical time and supplies.

A study by McMorrow[3] mentioned that presence of carboxyhemoglobin, methaemoglobin & sickle haemoglobin; methylene blue; indocyanine green: blue, black & green nail polish; ambient fluorescent & xenon lamps and motion artefact were likely to affect pulse oximetry readings.

There were some limitations in our study. The volunteers were healthy, hence did not represent a patient population with cardiac or respiratory disease where SpO_2 is low. Nine different colours were used, but, these were not quantified by colorimetry. We did not

analyse the effects of artificial nails. These results only apply to Datascope Passport 2 pulse oximeter.

Conclusion:
We conclude that different colours of nail polish do not cause a clinically significant change in pulse oximeter readings in healthy volunteers.

In clinical, surgical and emergency settings, finger nail polish is routinely removed. Valuable time, resources and money may be saved if this can be avoided.

Further study is required to identify the effect of different artificial nails, nail polish with glitter and using other makes of pulse oximeters.

References:

1. Coté CJ, Goldstein A, Fuchsman WH, et al. The effect of nail polish on pulse oximetry. *Anesthesia and Analgesia* 1988; **67**: 683-6.
2. Rubin AS. Nail polish color can affect pulse oximeter saturation [letter]. *Anesthesiology* 1988; **68**: 825.
3. McMorrow RCN, Mythen MG. Pulse oximetry. *Current Opinion in Critical Care* 2006; **12:** 269–271.