

# Do artificial nails and nail polish interfere with the accurate measurement of oxygen saturation by pulse oximetry?



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## ABSTRACT

Several studies in medical publications on the effects of nail polish on pulse oximetry have yielded contradictory results. Previous studies on the effect of artificial nails on pulse oximetry have focused on acrylic nails, although there are several different types of artificial nails made of various materials that remain untested. In this study, the investigator desires to clarify the effect of nail polish; in addition, this study focuses on inexpensive "artificial nail tips" made of ABS plastic, which are sold widely in drugstores for home application. These plastic artificial nail tips tend to be quite thick; therefore, it is expedient to determine whether or not they interfere with the accurate measurement of oxygen saturation by pulse oximetry. These tips may also be painted at home with nail polish and there have been no studies on the combined effects of nail polish and artificial nails. Six colors of nail polish were tested on 23 subjects using two different types of pulse oximeter – a small portable device and a larger stationary device. The experiment was repeated using artificial nail tips made from ABS plastic that had been painted with the six colors of nail polish. Each subject had a bare index finger nail as a simultaneous control. The difference in oxygen saturation between each color finger and the control finger was determined. In addition, extended color testing was done on a single subject, using 27 different colors of various shades and brands. Colored artificial nail tips and nail polish had little or no significant effect on the measurement of oxygen saturation. There was no statistically significant effect on the measurements made by the more sophisticated stationary machine. However, with the less expensive portable device, there were trivial drops in the oxygen saturation measurement that did reach statistical significance with the blue, pink, and white nail polish and wine-colored artificial nails, but were too small to be considered clinically significant. Nail polish and plastic artificial nail tips do not interfere with the accurate measurement of oxygen saturation by pulse oximetry.

## Introduction

The objective of this study was to determine whether or not artificial nails and nail polish interfere with the accurate measurement of oxygen saturation by pulse oximetry. A pulse oximeter is, in essence, a "mini-spectrophotometer" that works by shining light through the nail and measuring how much light is absorbed, in order to determine the oxygen saturation of the blood. In this study, the investigator hypothesized that if a person wears artificial nails or nail polish, then the artificial nails or nail polish will block some of the light from shining through the nail and thus interfere with the accurate measurement of oxygen saturation.

The purpose of this research is to provide data that may aid decision-making by medical personnel. These data could help them decide whether or not to remove nail polish or artificial nails during a respiratory emergency. This is important because inhaling fumes from nail polish remover can cause asthma to worsen. Certainly, soaking fingertips in acetone for 15–20 minutes in order to remove artificial nails could be problematic. To complicate matters, both asthma and the use of nail products are widespread. According to the Centers for Disease Control, there are presently approximately 16 million asthmatics in the United States.<sup>[1]</sup>

There is some controversy in medical publications about the effect of nail polish, and this study seeks to clarify this issue. Previous studies on the effect of artificial nails on pulse oximetry have examined acrylic nails, but there are still several different types of artificial nails made of various materials that have not been tested. The artificial nails used in this study are inexpensive "artificial nail tips" made of ABS plastic, which are sold widely in drugstores for home application. These plastic artificial nail tips tend to be quite thick; therefore, it is important to determine whether or not they interfere with the accurate measurement of oxygen saturation by pulse oximetry. These tips may also be painted at home with nail polish and there have been no studies on the combined effects of nail polish and artificial nails.

## Materials and Methods

Oxygen saturation is the percentage of heme groups in the blood that have been filled with oxygen. Pulse oximetry is a commonly used non-invasive method

**Table 1: Table of experiments**

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Experiment #1 – A study of six colors of artificial nails on 23 subjects
Experiment #2 – A study of six colors of nail polish on 23 subjects
Experiment #3 – A study of 27 different colors of various brands on a single subject

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to measure oxygen saturation by clipping a probe onto the fingertip. In pulse oximetry, two wavelengths of light are beamed through the nail bed, usually at 660 nm (red) and 940 nm (near infrared) and the relative absorption is determined. Pulse oximeters are designed to single out the arterial blood pulses. They distinguish pulsating blood from bone, fingernails, and venous blood, which do not pulsate.

Three experiments were performed as shown in Table 1.

In Experiment #1, after obtaining informed consent, 23 subjects were tested to determine the effect of six colors of painted artificial nails. Fing'rs French Manicure Nail Kits (Natural Sport Length French plastic artificial nail tips) were purchased for experimentation. The investigator painted the plastic artificial nail tips with the following colors of Avon Quick Dry Nail Polish: white (Snowflake), red (Red Red), blue (Sizzling Sky), pink (Carnival), and wine (Red Wine), Clear. Each artificial nail tip was painted with two coats of color and one clear top coat. One fingernail was left bare to serve as a simultaneous control. Then, the investigator measured the oxygen saturation on each finger of the test subject. Each subject's color reading was subtracted from the control reading to determine the change in oxygen saturation. This experiment was done twice using two different types of pulse oximeters – Nonin Onyx, and Nellcor N-395. The Nonin Onyx is a very compact portable pulse oximeter that might be used for spot checks in a doctor's office, while the Nellcor N-395 is a stationary machine used for continuous monitoring in intensive care units.

In Experiment #2, the same six colors of nail polish were tested on 23 subjects and the oxygen saturation readings were measured. The same procedure as in Experiment #1 was performed, except that nail polish was painted directly on the nails, rather than on artificial nails. Again, two color coats and one clear top coat were used, reflecting common practice.

In Experiment #3, extended color testing was performed on a single subject, using 27 different colors of a variety of brands. Some of these colors included metallic and frost finishes.

Statistical analysis was performed in Experiments #1 and #2 to determine the mean change in oxygen saturation, standard deviation, standard error of the mean, and 95% confidence intervals for each color test. These calculations were repeated to determine the mean difference between each color and the control.

Standard deviation is a statistical measure of how spread out the data is from the mean. A statistical calculator on a website was used to determine the standard deviation (S) and 95% confidence intervals (CI).

$$\sigma = \sqrt{\frac{\sum_{i=1}^N x_i - (x)^2}{N}}$$

Standard error of the mean (SEM) is another statistical measure of spread which is more appropriate than standard deviation when dealing with samples rather than the entire true population. The SEM was calculated by using the equation:

$$S_x = \frac{\sigma}{\sqrt{N}}$$

where  $\sigma$  is the standard deviation and  $N$  the number of measurements.

A range of plausible values are indicated by the 95% confidence intervals. The 95% confidence intervals are estimated by multiplying the SEM times two. In this experiment, if the confidence intervals cross zero, there is no statistically significant change.

For Experiment #3, the change in the oxygen saturation readings was calculated.

## Results and Discussion

Contrary to the hypothesis, the results showed that

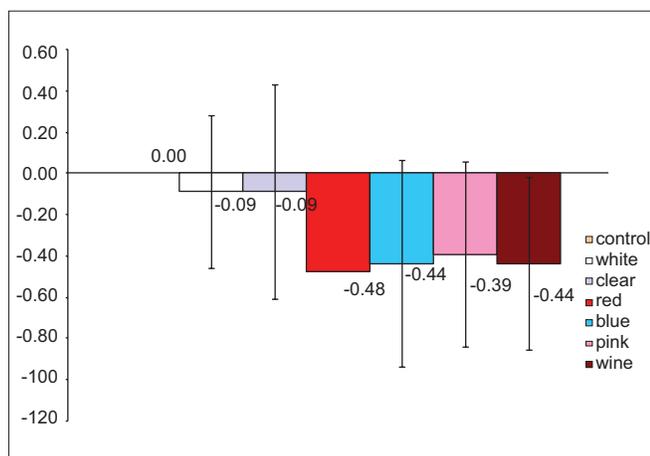


Figure 1: Mean change in Oxygen saturation readings (%pt.) Experiment #1: Artificial Nail Experiment on 23 Subjects Nonin Pulse Oximeter

most colors of artificial nails and nail polish had little or no significant effect on the accurate measurement of oxygen saturation by pulse oximetry. Instead, the null hypothesis was supported. The results of Experiment #1 are shown in Figures 1 and 2.

There were a few tiny, though statistically significant, drops in some readings with certain colors when measured by one of the pulse oximeters (Nonin) in Experiments #1 and #2 [Figures 1 and 2]. However, these tiny drops with the blue, pink, and white nail polish and wine-colored artificial nails were too small to be clinically significant.

For example, in Experiment #1 with the Nonin pulse oximeter, the wine-colored artificial nails caused a mean drop in saturation reading of 0.44% pt.  $\pm$  0.42% pt., a trivial decrease. This must be viewed in the context of the pulse oximeter's own much larger measurement error of  $\pm$ 2.0%.

The results of Experiment #2 are shown in Figures 3 and 4. In Experiment #2, there was a small but statistically significant drop in oxygen saturation reading when fingers with blue, pink, and white nail polish were tested with the Nonin pulse oximeter [Figure 3]. However, these tiny drops with the blue, pink, and white nail polish were too small to be clinically significant.

In both Experiments #1 and #2, the Nellcor pulse oximeter readings did not have any statistically significant change with any color [Figures 2 and 4]. The Nellcor pulse oximeter is a larger and more expensive monitor used in intensive care units, while the Nonin pulse oximeter is a convenient, compact, portable model often used in medical offices.

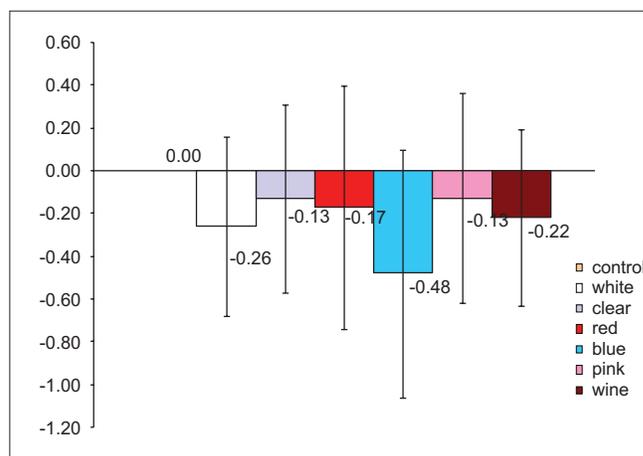
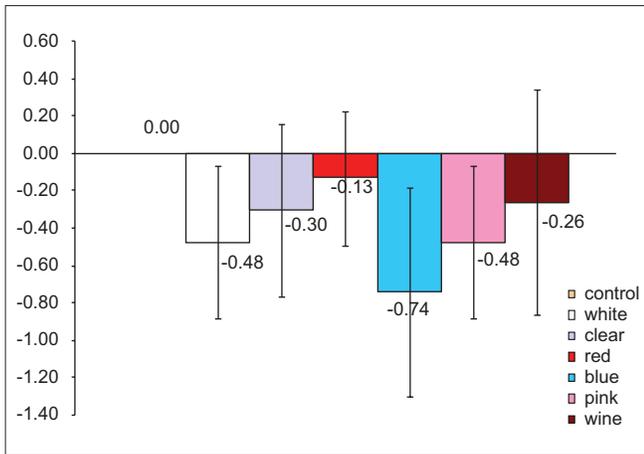


Figure 2: Mean change in Oxygen saturation readings (%pt.) Experiment #1: Artificial Nail Experiment on 23 Subjects Nellcor Pulse Oximeter



**Figure 3: Mean change in Oxygen saturation readings (%pt.) Experiment #2: Nail Polish Experiment on 23 Subjects Nonin Pulse Oximeter**

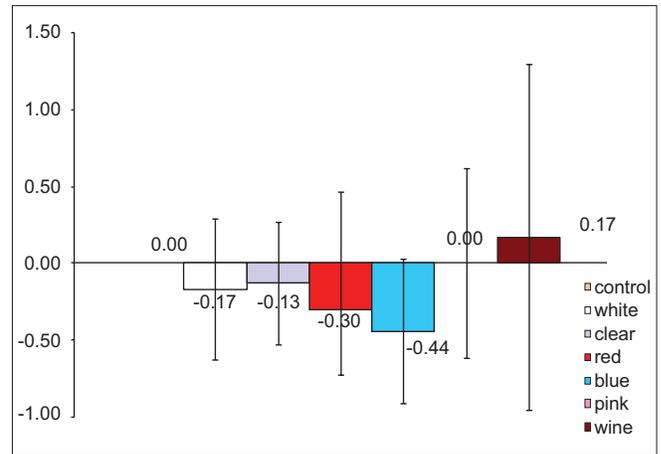
The finding that most colors of artificial nails and nail polish have little or no significant effect on oxygen saturation readings reveals that the technology in some pulse oximeters is sophisticated enough to single out the pulsating arterial blood, in order to avoid interference from non-pulsating substances such as artificial nails.

The slightly differing results between the two different pulse oximeters suggest that the controversy in the literature on nail polish might be due to differences in the technology of the pulse oximeters used in those studies. There have been advances in the technology of pulse oximeters, and more recent studies on nail polish have found less interference.

In Experiment #3, 27 different colors of different brands of nail polish were tested on a single subject to determine if the research findings could be generalized to many brands and colors of nail polish [Tables 2 and 3]. Only 2 of the 27 colors caused a drop in reading of over 2% when measured with the Nonin pulse oximeter and only 1 of the 27 colors caused a drop when measured with the Nellcor pulse oximeter.

## Conclusion

Contrary to the study's hypothesis, this research found that most of the artificial nails and nail polish tested did not interfere with the measurement of oxygen saturation by pulse oximetry. Most colors had little or no significant effect. No changes found in this study were clinically significant. These results contradict the view widely held by many medical personnel that nail polish and artificial nails must



**Figure 4: Mean change in Oxygen saturation readings (%pt.) Experiment #2: Nail Polish Experiment on 23 Subjects Nellcor Pulse Oximeter**

**Table 2: Experiment #3 extended experimentation with nonin pulse oximeter**

Color	Oxygen saturation (%)	Δ Oxygen saturation
<b>Test 1</b>		
Control	99	0
Ocean Frost, Jordana	98	-1
Berry Blue, Savvy	98	-1
Mean Streak, Sally Girl	98	-1
Dumped, Sally Girl	98	-1
Cool Blue Blast, Wetnwild	98	-1
Metal Ice, Kleancolor	98	-1
Spun, Sally Girl	98	-1
Caribbean Frost, Wetnwild	99	0
It's So Me, Sally Girl	98	-1
Fearless, L'Oreal Paris	98	-1
<b>Test 2</b>		
Control	100	0
Impulsive, L'Oreal Paris	97	-3
Island Fuchsia, Jordana	95	-5
Gorgeous Grape, Jordana	98	-2
Fuchsia, Heaven	98	-2
So Disco, Sally Girl	98	-2
Steel, Wetnwild	98	-2
Strong, L'Oreal Paris	98	-2
Lemon Tropic, Jordana	98	-2
Wild Green Sizzle, Savvy	99	-1
<b>Test 3</b>		
Control	98	0
Black, NYC	99	1
Gotta Have It, Sally Girl	98	0
Sandstone, Jordana	98	0
Night Spell, Revlon	97	-1
Yellow, Heaven	98	0
Orange, Heaven	99	1
Bronze, Wetnwild	98	0
Amped, Sally Girl	99	1

be removed to obtain an accurate measurement of oxygen saturation.

This research is original in that a Medline search shows no studies on colored artificial plastic nail tips in the peer-reviewed published medical literature. In

**Table 3: Experiment #3 extended experimentation with nellcor pulse oximeter**

Color	Oxygen saturation (%)	Δ Oxygen saturation
Test 1		
Control	99	0
Ocean Frost, Jordana	99	0
Berry Blue, Savvy	99	-2
Mean Streak, Sally Girl	97	-2
Dumped, Sally Girl	98	-1
Cool Blue Blast, Wetnwild	98	0
Metal Ice, Kleancolor	99	0
Spun, Sally Girl	98	-1
Caribbean Frost, Wetnwild	98	-1
It's So Me, Sally Girl	98	-1
Fearless, L'Oreal Paris	99	0
Test 2		
Control	100	0
Impulsive, L'Oreal Paris	99	-1
Island Fuchsia, Jordana	100	0
Gorgeous Grape, Jordana	99	-1
Fuchsia, Heaven	99	-1
So Disco, Sally Girl	99	-1
Steel, Wetnwild	100	0
Strong, L'Oreal Paris	97	-3
Lemon Tropic, Jordana	99	-1
Wild Green Sizzle, Savvy	100	0
Test 3		
Control	99	0
Black, NYC	99	0
Gotta Have It, Sally Girl	98	-1
Sandstone, Jordana	97	-2
Night Spell, Revlon	99	0
Yellow, Heaven	99	0
Orange, Heaven	99	0
Bronze, Wetnwild	99	0
Amped, Sally Girl	97	-2

addition, this study has a larger sample size than most published studies on nail polish. It is also the first study of nail polish to use two different brands of pulse oximeters, and thus it clarifies some of the contradictory results found in the published literature on nail polish. Certainly, the sophistication of technology in each particular pulse oximeter used in research will sway the results.

This research provides valuable information for paramedics, nurses, and physicians dealing with emergency situations involving patients in respiratory distress. Nail polish should not be removed when a patient presents in respiratory distress, as the fumes from nail polish remover could exacerbate asthma.

## Acknowledgments

I would like to thank my mother, Karen Jakpor, for letting me use her pulse oximeters. I am also grateful to my many test subjects, without whom this research would not have been possible.

## Reference

1. "Faststats Asthma." Centers for Disease Control and Prevention. Available from: <http://www.cdc.gov/nchs/fastats/asthma.htm> [Last updated on 2009 May 15, accessed on 2009 Aug 11].

## About the Author

**Otana Jakpor**, a seventeen-year-old is a freshman at the University of Southern California (USC), studying global health. She is enrolled in USC's Baccalaureate MD Program. Otana's special interest in respiratory health stems from her concern over her mother's frequent hospitalizations for severe asthma. Otana serves as a volunteer spokesperson for the American Lung Association. Otana gave a poster board presentation of her research on the effects of artificial nails and nail polish on pulse oximetry at the American Thoracic Society (ATS) meeting in San Diego on May 17, 2009. She joined the *Young Scientists Journal's* board of editors after meeting Professor Ghazwan Butrous at the ATS meeting.