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An Emergency Department Study of White Coat and Related Provider Role Identifiers as Role Signifiers and an Assessment of a Patient Education Intervention on Patient Choice of Physician Dress: *When the Evidence Indicates That a White Coat Based Role Identification System Underperforms a Homan's Sign, It's Time to Say Goodbye*

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ABSTRACT

A remarkable debate is forming up, concerning white coats in particular, and hospital personnel dress/uniform practices in general. Currently, the white coat is worn by physicians, medical students, nurse managers, pharmacists, physical therapists, nutritionists, and case managers. How accurate is the current signaling system in a hospital setting, in specific provider roles, as perceived by patients? How do patients feel their physicians should dress? Would their choices change after a brief educational intervention related to the potential of the white coat as a fomite? The purpose of this study was to look at those questions, with a particular interest in the role of the white coat as a physician identifier.

This study demonstrated that a group of non-medical participants moved rather strongly in the direction of non-white coat physician provider choices, after a brief educational intervention on the fomite nature of the white coat. The performance of the white coat, and the white coat related dress system to indicate provider identity was very poor. The overall accuracy was only 29%. Sensitivity of the overall system was only 44%, with related poor performance in specificity, positive predictive value, negative predictive value, positive likelihood ratio and negative likelihood ratios. The signaling system of coats, no coats, scrubs and professional wear performed at the level, or worse, than the antiquated and evidence-based medicine rejected Homan's sign.

Perhaps it is time to say goodbye to the white coat and to build a role-identification signaling system that performs with more accuracy.

KEYWORDS

White Coats in Healthcare; White Coats and Physicians; Physician Dress; Healthcare Uniforms; Healthcare Provider Uniforms; Symbolism in Medicine; Physician Attire; Nursing Uniforms in Healthcare; Ancillary Provider Uniforms in Healthcare.

INTRODUCTION

A remarkable debate is forming up, concerning white coats in particular, and hospital personnel dress/uniform practices in general. A recent hospital leadership newsletter article, entitled, *Hospitals Debate the Pros, Cons of White Coats for Doctors*, frames an important aspect of the debate. Referring to dressing for work in a hospital, specifically in reference to doctors, the article notes that "it can get complicated in the hospital with the variety of choices, as each article of clothing has its own symbolic meaning—short coat, long coat, no coat, tie, no tie, and scrubs" [1]. Manton expresses the opinion that "so many people other than doctors wear white coats that it has lost any significance" [2]. Symbolic meaning systems of this sort, including clothing related to social role, create the sort of signaling system that is the domain of several disciplines. Sociology as a field has an interest in the relationship of clothing and dress to social function and status. The aforementioned article by Cheung alludes to such a connection, when it notes that "the politics of the iconic white coat runs deep in most institutions' hierarchy and tradition." In a recent article in the Journal of Hospital Medicine, concerning white coats in medicine, Dr. Jeffery Spiegel notes that in specific reference to the white coat, length of the coat is intended to relate to seniority [3]. This is a sort of sociological observation of the intent of a dress code based signaling, or "semiotic" system. The discipline of semiotics looks at the meaning of symbols and symbolic systems. Studies of how human beings perceive the meaning of dress and uniform related symbols are found in the literatures of sociology, anthropology, philosophy (semiotics) and applied and behavioral psychology.

Generally, such dress or uniform semiotic systems have historical roots. This is true with white coats.

Historically, the white coat has been a symbol used to identify a physician since the late 19th century. Some authors have looked at the nature of the white coat in relation to the intent of the semiotic signal. Brandt, for example, notes that the white coat provided physicians with the image of "scientific validity for their treatments and to represent purity and cleanliness: praise worthy qualities in a healer" [4]. Early in the history of the white coat, physicians appear to have adopted the white coat rather widely, to emphasize the transition to a more scientific approach to medicine by representing themselves as scientists. In other words, the white coat is not only clean and pure - it is also a symbol of dress of the scientist, as might be seen in a laboratory researcher.

Patients seem, as a consequence, and over time, to have learned to identify the white coat as a symbol of the physician. This may be particularly true in older patients [5]. The debate about the role of the white coat is not regional. Many of the articles cited above are from international thinkers in this area, including the United Kingdom, United States, New Zealand, Australia, Italy and Canada. Sotgiu et al looked at evidence for preferences for physician attire among Italian patients using a survey methodology that included pictures of male and female physicians [6]. A study from the University of Hawaii found that patients in their survey study did not prefer that physician providers wear a white coat [7]. A Canadian study of families of ICU patients used a survey method that included ratings of factors felt to be important in physician attire. In this part of the study, only 32% of respondents felt that a white coat was important. In a picture selection part of the study, families were asked to select their preferred physician from a set of 32 photographs of physician models [8]. Physicians with white coats received the highest percentage of selections (52%).A study of hospitalized patients in Australia that 36% of patients preferred doctors to wear white coats. However, 45% had no preference and 19% preferred doctors not to wear white coats [9].

White coat dress use by physicians appears to vary, to some degree, by specialty. It has been observed that white coats are less commonly worn by pediatric and psychiatrics residents and attendings [10]. Patient perception of what a physician should wear appears to vary by setting. For example, a study of emergency department patients found that the majority of patients found that provider dress did not alter their attitudes towards the staff [11].

A very important element of the white coat/provider dress coat debate is related to research that demonstrated potential infectious disease and nosocomial risk aspects of the white coat. That is to say, white coat as fomite. This research led to dress code policy changes in some parts of the world, principally in the United Kingdom. These policy changes went beyond the white coat, and led to an appreciation of the fomite role of such dress elements as jewelry and wrist watches. As the strongest example of such a policy change, in 2007 the United Kingdom instituted the "bare below the elbow" (BBE) rule. The BBE rule called for physician to wear short sleeves. No wrist watches, jewelry, or neckties could be worn while carrying out clinical activities. The traditional long-sleeved white coat, however, was central in the BBE policy change. As one author puts the relationship of the BBE policy to the wearing of a white coat, "the traditional white coat is not just passé, it's not allowed [12]. The "once ubiquitous white coat" was proscribed [13]. This policy change was clearly based on research that demonstrated that the white coat was a fomite.

For example, 28% of white coats in one microbial flora study were shown to be colonized with various organisms, include Staphylococcus species, E. coli species and even Methicillin-resistant Staphylococcus aureus [14]. In fact, some of the bacteria isolated have been resistant organisms. In a white coat study by Uneke and Ijeoma, 91% of all white coats cultured had bacterial contamination. Cultures collected from the cuffs and pocket lips of the white coat have proved to be resistant to multiple antibiotics. Cuffs of white coats had a higher bacterial load than pocket lips [15]. The speed of contamination is remarkable [13].

Some researchers are calling for an extension of the BBE rule, to include stethoscopes, pens, and cell phones, since these objects have been shown to potentially become colonized with the same species of organisms that have been cultured from white coats. The clear intent of the BBE approach is not only to reduce possible direct fomite contact, but also, to facilitate easier hand hygiene, which, in turn, has been clearly shown to decrease the nosocomial infection transmission rate. It has well established that proper hand washing is the single most important intervention in nosocomial infection control [16,17]. What is likely less well known is that there is data to show that healthcare workers who wear a white coat frequently miss (fail to cleanse) areas of their wrist while hand washing, specifically, both the anterior and posterior wrist and the lateral aspect of the hand. The actual clinical association between failure to wash the wrist and healthcare acquired infections is not yet established. In reference to alcohol gel use, the study cites evidence that shows that alcohol gel hand antisepsis technique "is largely dependent on hand-washing technique." Hence, both alcohol and soap and water hand-washing would have a higher incidence of failure to wash the wrist in association with wearing a white coat [18].

This is not to say that the white coat is no longer felt to be a prestigious symbol in and of itself, outside of clinical practice. For example, the white coat ceremony performed at many medical schools across the country represents a prestigious milestone for its students. This ceremony symbolically signifies the passage from the "realm of strictly academic learning to one of clinical experience" [19].

However, in clinical practice, current data shows that physicians in some locales are wearing the white coat less. In reference to the UK, research performed at the Royal Free Hospital, London, showed that only one out of every eight physicians wore a white coat. Seven out of 10 doctors felt the coats spread infection, while six out of 10 thought the white coat was hot and uncomfortable [20].

The white coat, in clinical use has been linked to patient anxiety. The "white coat syndrome" seen in some patients, refers to a relationship of elevated measured blood pressure in the presence of a white coat [21].

In the United States, the Mayo Clinic, for example, has enforced a new dress code for their physicians. Patients no longer "encounter doctors in casual attire or white coats," instead their physicians wear business attire, unless they are in surgical scrubs, to convey professionalism and expertise [22].

Patient satisfaction data has expressed that patients wish to know who is treating them, both as the name of the provider but also in relation to the role of the provider. Patients often experience what has been called "a parade of faces" in the course of a hospital stay, whether inpatient or out-patient.

If the white coat does not support hygiene clinically, and can be a source of anxiety for some patients, then what is its positive value?

One possible positive role for the white coat is that of physician identifier. As noted above, the white coat historically and traditionally was a signifier, a "signaler" of a physician. Currently, the white coat is worn by physicians, medical students, nurse managers, pharmacists, physical therapists, nutritionists, and case managers.

The authors of this study (EK, LM, JE, VS) have all observed the ambiguity of the current dress code, as expressed by misunderstandings of patients.

How accurate is the current signaling system in a hospital setting, in specific provider roles, as perceived by patients? How do patients feel their physicians should dress? Would their choices change after a brief educational intervention related to the potential of the white coat as a fomite? And how accurate is the current white-coat, non-white-coat, scrub and professional attire based signaling systems at conveying provider roles?

The purpose of this study was to look at those questions, with a particular interest in the role of the white coat as a physician identifier.

MATERIALS AND METHODS

This study was prospective, with four objectives:

1. To study participants' choice for physician dress, with an intent on determining if there was a preference for white coats vs. non-white-coat patterns, based on four common patterns of dress. Two patterns included white coats. Two patterns did not include white coats. The two non-white-coat choices

were: 1) Professional attire, 2) Scrub attire The two choices that included white coats were: 3) Professional attire and white coat and 4) Scrub attire and white coat

2. To assess whether participants would change their choice in physician dress preference, with an intent on determining if there was a preference for white coats vs. non-white-coat patterns, having read a short paragraph that embedded information relating white coats to the potential spread of nosocomial infections.

3. To study participants' identification of providers by role, based on possible role choices, in each of 12 photographs of actual providers illustrating common dress patterns for hospital garb.

4. To develop an overarching statistical sense of accuracy of the current common patterns of dress, as depicted in the 12 photographs, in relationship to specific roles, as well as in relationship to grouped roles (doctor provider, nurse provider, ancillary provider). The patterns of dress will be considered a communication gestalt, or "semiotic system" and the accuracy of the grouped roles will be assessed in reference to the commonly used biomedical probabilistic indicators of specificity, sensitivity, positive predictive value and negative predictive value.

The setting was ED based, involving three community-based, University affiliated EDs. IRB approval was obtained for the study. The participants were emergency department patients. Consent was obtained for each patient [30]. Emergency department patients, non-pregnant, above the age of 18 were eligible for inclusion. A convenience sample was used. Exclusion criteria were pregnant patients, patients below the age of 18 and patients unable to provide informed consent (e.g. dementia).

Part One of Study Process

Participants were provided a question form. The form had several questions. The first question asked the participants how they would prefer their physician to dress. Participants were offered one of four choices:

1) professional attire, 2)scrub attire, 3) professional attire and 4) white coat and scrub attire and white coat After the participants made their selections, they were asked to read a paragraph that embedded information relating white coats to the potential spread of nosocomial infections.

The paragraph was the following:

In 2007 the United Kingdom Department of Health issued a new guideline which required all medical professionals to be "bare below the elbows." This means that no jewelry, long sleeves, or the traditional white coat could be worn when completing clinical duties. Male medical professionals were also encouraged to avoid wearing neck ties. A study done in Nigeria looked at colonization on different areas of the white coat. The white coat sleeves had the highest bacterial load. Bacteria isolated from the cuffs were resistant to multiple antibiotics. Due to the risks of infection in the hospital several institutions in the United States have banned white coats, particularly in the ICU setting.

Each participant was then asked whether the participant's opinion had changed. If an opinion had changed, the participant was asked to make a second choice. The same four possible choices were used.

Part Two of Study Process

Participants were shown 12 photographs of 12 different healthcare providers. The photographs were of actual providers in the Kennedy system, obtained with their verbal consent to be photographed. The photographs were selected so as to include providers wearing white coats as well as without white coats, with scrub wear or with street clothes. The photographs included male and female healthcare providers. The participants were asked to identify the providers by role, based on possible role choices. 1) doctor 2) nurse 3) nurse manager 4) dietician 5) resident 6) case manager 7) physical therapist. The intention in the study of choice 1 (doctor) was that of an attending (non-resident) doctor (in contrast to choice 5, resident).

The data collected included:

- Age, participant
- Gender, participant
- How would you like your physician to dress? Selection: one of four choices (two white coat attire related answers, two non-white-coat attire related answers) Non-white coat choices were the following 1) professional attire, 2)scrub attire White coat based choices were the following 3) professional attire and white coat and 4)scrub attire and white coat
- Did your opinion change after the reading? (yes, no)
- Given a change in opinion, what was the new choice? The same four possible answers were used. Selection: one of four choices (two white coat attire related answers, two non-white-coat attire related answers) Non-white coat choices were the following 1) professional attire, 2)scrub attire White coat based choices were the following 3) professional attire and white coat and 4)scrub attire and white coat
- Participant selection of identity of the provider for each of

12 pictures, based on 7 possible choices. 1) doctor 2) nurse 3) nurse manager 4) dietician 5) resident 6) case manager 7) physical therapist. The intention in the study of choice 1 (doctor) was that of an attending (non-resident) doctor (in contrast to choice 5, resident)

METHODS

Statistical Analysis

A number of standard parametric and non-parametric tests were used in the analysis of the data. For purposes of the determination of the accuracy of assessments of participant impression of the role depicted by the pictures, role specific and grouped role averages of accuracy and inaccuracy were used. Statistical analysis was performed predominantly with Minitab-16 [State College, PA].

In addition, biomedical tests of accuracy, based on sensitivity, specificity, positive predictive value and negative predictive value were generated based on the data returned from participant impressions of the role depicted by the pictures. [MedCalc, Medcalc.com] In this analysis, the current role depiction system, as exemplified by the pictures, was considered to be a "test". In other words, in this analysis, the accuracy of the visual signaling system was assessed as though it were a "test" of the "diagnosis" of the identification of the provider, by the participant, using the signaling (semiotic) system of the dress code depicted in the pictures. This approach studies the capabilities of the signaling system (provider dress and patient recognition) in reference to the actual specific role, and grouped "type roles" of the provider. Three "provider type" bins were created.

These bins (groups) were:

• Ancillary all types vs. all others [all physicians, all nurses]

• Nurse of any type (RN, Nurse Manager) vs. all others

• Physician any type (Resident and Attending) vs. all others combined

The usual 2 x 2 matrix table for the capabilities of a test was adapted to this application.

Table 1: General 2 x 2 matrix for analysis of capabilities of a test.

	Disease Present	Disease Absent
Test positive	True positives	False positives
Test negative	False negative	True negatives

This matrix was then populated with definitions for true positive, false negative, false positive and true negative, by the three grouped types (ancillary, nursing, physicians).

Table 2: General 2 x2 matrix adapted to: Ancillary all types vs. all others [all physicians, all nurses]

	Ancillary	Non-Ancillary
Identified as Ancillary	Are ancillary providers , correctly identified as ancillary providers (TP)	Are non-Ancillary providers , incorrectly identified as Ancillary (FP)
Identified as non-Ancillary	Are ancillary providers , incorrectly identified as non-ancillary providers (FN)	Are non-ancillary providers , correctly identified as non-ancillary providers (TN)

The medical definitions of sensitivity, specificity, positive predictive value and negative predictive value were then adapted to this analysis as follows:

Table 3: General medical definitions of sensitivity, specificity, positive predictive value and negative predictive value.

	Definition (Common Medical Definition)
Sensitivity	*Sensitivity:* probability that a test result will be positive when the disease is present (true positive rate).
Specificity	*Specificity*: probability that a test result will be negative when the disease is not present (true negative rate)
Positive Predictive Value	*Positive predictive value:* probability that the disease is present when the test is positive
Negative Predictive Value	*Negative predictive value:* probability that the disease is not present when the test is negative

This led to a generalized definition in this context:

Table 4: Application to this context of the general medical definitions of sensitivity, specificity, positive predictive value and negative predictive value.

	GENERALIZED DEFINITION IN THIS CONTEXT
Sensitivity defined in this context	*Sensitivity:* probability that THE BINNED GROUP PROVIDER WILL BE IDENTIFIED WHEN THE PROVIDER REALLY IS FROM THAT BINNED GROUP
Specificity defined in this context	*Specificity*: probability that THE PROVIDER WILL BE IDENTIFIED AS NOT FROM THAT BINNED GROUP WHEN THE PROVIDER REALLY IS NOT FROM THAT BINNED GROUP
Positive predictive value defined in this context	Positive predictive value: probability that THE PROVIDER IS FROM THE BINNED GROUP WHEN THAT BINNED GROUP IS IDENTIFIED
Negative predictive value defined in this context	Negative predictive value: probability that the identity is not present [NOT BINNED GROUP PROVIDER] when the test is negative [IDENTIFIED AS NON-BINNED GROUP PROVIDER]

The generalized definition was then applied to the three specified bins (provider groups).

RESULTS

Number of Participants and Age: There were 30 participants in the study. The mean age of the participants was 46.93, with a standard deviation of 19.84. The median age was 48. The youngest patient was 18 years of age. The oldest patient was 90 years of age. The distribution was normal, as evidenced by the Anderson-Darling Normality test, which demonstrated a normal distribution. [P-value for non-normality was p = .21].

Gender of participants in study: Of the 30 participants, 17 were female (mean = 56.7%, StDev = 20.18) and 13 were male (mean = 43.3%, StDev = 20.18).

"How would you like your physician to dress? Pre-intervention results: The 4 distinct choice results, by grouping as white coat choices or non-white-coat choices, were as follows:

- **White coat choices:** Scrub attire and white coat, 12 (40%), professional attire and white coat, 7 (23.3%)
- **Non-white-coat choices:** Scrub attire 7 (23.3%) and professional attire 4 (13.3%)

Thus, in the pre-intervention system, there were 19 white coat selections (63.3%) and 11 non-white-coat selections (36.7%).

"Did your opinion change" [after reading the interventional paragraph]: After reading the paragraph (cited above, under Material and Methods), 7 participants changed their selection of the four attire choices (50%) and 7 did not change their selection (50%).

"How would you like your physician to dress? Post-intervention results: Post-intervention choice results, by grouping as white coat choices or non-white-coat choices, were as follows:

- **White coat choices:** scrub attire and white coat, 5(16.67%), professional attire and white coat, 2 (6.67%)
- **Non-white-coat choices:** scrub attire, 18 (60.0%) and professional attire, 4 (16.67%)

Thus, there were 7 white coat selections (23.33%) and 23 non-white-coat selections (76.67%).

Pre-intervention and Post-intervention choices compared:

In reference to grouped white coat and non-white coat choices:

White coat choices: the percent of white coat selections decreased 40%, from 63.3% in the pre-intervention selection to 23.33 % in the post-intervention selection (Figure 1).

Non-white-coat choices: the percent of non-white coat selections increased 40% from 36.67% in the pre-intervention selection to 76.67% in the post-intervention selection.

The change in the pre-intervention and post-interventions system (selections) was very statistically significant: [Fisher's exact test, p = .004, Chi-squared with Yates correction p = .004, Chi-squared without Yates correction p = .002] All three of these measures indicate a high level of statistical significance.

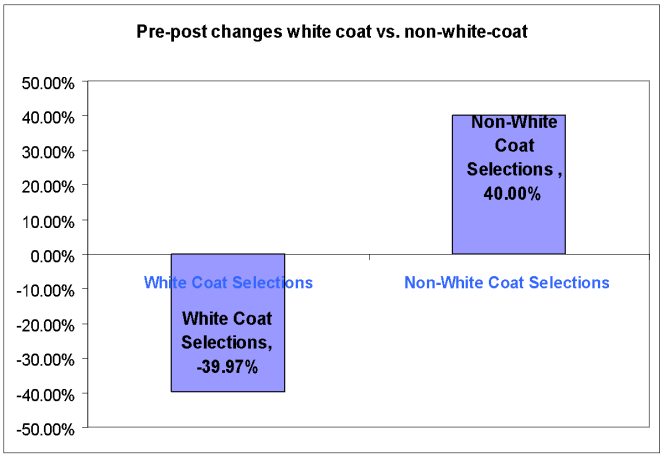

Figure 1: Column chart. Change in Pre to Post choices by number and percent, by white coat and non-white-coat groupings.

In reference to individual selections: [Figure 2]

- Scrub attire and white coat decreased 23.33% from 40% in the pre-intervention selection to 16.67% in the post-intervention selection. This change was statistically significant. [Fisher's exact test p = .04, Z-test proportions p = .02]
- Professional attire and white coat decreased 16.67 percent from 23.33% in the pre-intervention selection to 6.67% in the post-intervention selection. This change was not statistically significant. [Fisher's exact test p = .07, Z-test proportions p = .06]
- Scrub attire (non-white-coat) increased 36.67% from 23.33% in the pre-intervention selection to 60% in the post-intervention selection. This change was statistically significant. [Fisher's exact test p = .01, Z-test proportions p = < .01]
- Professional attire (non-white-coat) increased 3.33% from 13.3% in the pre-intervention selection to 16.67 % in the post-intervention selection. This change was not statistically significant. [Fisher's exact test p = .5, Z-test proportions p = .7].

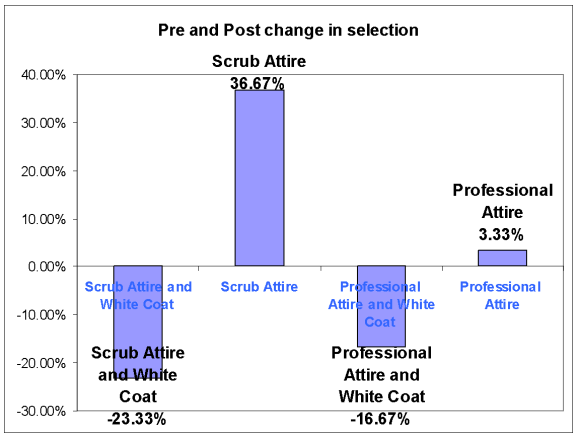

Figure 2: Column chart. Change in Pre to Post choices by number and percent, by all four choices.

Analysis of pre and post interventions selections in reference to participant age: Pre and post interventions choices of participants in the 18 to 64 years of age range were compared to participants in the > 65 years of age range. These two age range groups did not differ in coat vs. non-white coat preferences in the pre-intervention phase [Fisher's exact test p = .6]. These two age range groups did not differ in the percent of opinion change. [Fisher's exact test p = .32]. These two age range groups did not differ in coat vs. non-white coat preferences in the post-intervention phase [Fisher's exact test p = 1.0] Thus, the results noted above did not appear to be a function of the age of the participants.

Analysis of pre and post interventions selections in reference to participant gender: Female participants did not significantly differ from male participants in coat vs. non-white coat preferences in the pre-intervention phase. [Fisher's exact test p = 1.0] There was no significant gender difference in reference to the percent of opinion change. [Fisher's exact test p = 0.46] There was not significant gender difference seen in reference to the post-intervention phase [Fisher's exact test p = 1.0] The results noted above did not appear to be a function of the gender of the participants.

What sort of shifts occurred post intervention? There were 15 participants who did not change their selection. (50%). Thus, there were 15 participants who did change their selection. (50%).

Of those who made a change post intervention (15): The breakdown of those who made a change post intervention is summarized in the following table. [Table 18, Figure 28] Given white coat and non-white coats as binary functions, there were therefore 2 x 2 possible changes (4) that might have occurred. Only three of these four combinations actually occurred. 0 participants (0%) changed from a non-white-coat type to a white coat type post intervention.

Change from non-white-coat type to white coat type: (0) 0 participants (0%) changed from a non-white-coat type to a white coat type post intervention.

Change from white coat to a non-white-coat: 12 of 15 who changed type, (80%)

A change from a white coat to a non-white-coat occurred in 12 of 15 who changed type, (80%) Of these 12 participants, the most common change was from Scrubs and White Coat to Scrubs only (7 participants, 58%). 3 participants changed from Professional and White Coat type to scrubs only (25%) and 2 changed from Scrubs and White Coat to Professional (non-white-coat) 16.67%. [Table 19, Figure 29]

Change from white coat type to another white coat type: 2 of 15 who changed type, (13.3%) A change from a white coat to another white coat type occurred in 2 of 15 who changed type, (13.3%) Of these 2 participants, both changed from Professional and White Coat to Scubs and White Coat [T

Change from non-white- coat type to another non-white-coat type: 1 of 15 who changed type (7%) changed from one non-coat-type to another. There were two possible ways that a non-white-coat type could change to another white-coat type. (Scrubs to Professional, Professional to Scrubs). The only change seen was in the directions of Professional to Scrubs.

Results: Picture Identification of Provider Roles.

The 12 pictures displayed a number of combinations of white coat, non-white coat based provider dress, in combinations that reflect the choices offered in the pre and post treatment system discussed above.

Specific role accuracy by picture: The overall role specific accuracy was 29%. [Correct answers: 29%, incorrect answers: 71%) [Table 5].

Table 5: Role Specific Accuracy by Picture.

	Role Specific Accuracy by Picture		
Picture Number	**Correct Answer**	**Correct Answer %**	**Incorrect Answers %**
1	Nurse	56.7%	43.3%
2	Doctor (Fellow)	70.0%	30.0%
3	Nurse	70.0%	30.0%
4	Doctor (Resident)	10.0%	90.0%
5	Doctor (Resident)	30.0%	70.0%
6	Doctor (Resident)	20.0%	80.0%
7	Doctor (Attending)	23.0%	77.0%
8	Dietician	10.0%	90.0%
9	Nurse Manager	20.0%	80.0%
10	Doctor (Attending)	10.0%	90.0%
11	Doctor (Attending)	36.7%	63.3%
12	Doctor (Resident)	3.30%	96.7%
		29%	**71%**

The 12 elements of role specific accuracy were grouped [Nurse and nurse manager were combined, physician resident and physician attending were combined and ancillary was created as a bin.

Based on three bins of general accuracy that were created, accuracy of the ancillary provider group was 10%, nursing (all) and physician (all) were both approximately 31%.

Table 6: Role specific accuracy, by elements of three groups.

Role Specific Accuracy Details		
Correct Answer	**Correct Answer %**	**Incorrect Answers%**
Ancillary	10%	90.0%
Nursing: RN	41.68%	58.3%
Nursing:Nurse Manager	20%	80.0%
Physician: Resident	26.44%	73.6%
Physician: Attending	35%	65.1%

Table 7: Role specific accuracy, by three groups.

Pooled (Type) Accuracy Details	Accuracy (% Correct)	Incorrect Answers %
Ancillary (all)	10%	90.0%
Nursing (all)	30.84%	69.16%
Physician (all)	30.68%	69.32%

Accuracy (role specific) by white coat/non-white coat in picture:

The role specific accuracy by the six pictures with a white coated provider was 26%. The six pictures with a non-white-coated provided had a role specific accuracy of 32%. *Although the accuracy associated with the white coat provider pictures was lower than that associated with the non-white-coated providers, the difference was not statistically significant.*

Table 8: Accuracy by white coat/non-white coat in picture.

Accuracy by white coat/non-white coat in picture	% Accuracy Specific Role
Pictures with coats	26.00%
Pictures with no coats	32.50%
	29.25%

Accuracy by gender of provider in picture: The role specific accuracy of the six pictures with male providers (35%) was higher than that of the six pictures with female providers (23.5%). *The difference was not statistically significant.*

Table 9: Accuracy by gender of provider in picture.

Accuracy by gender of provider in picture	% accuracy specific role
Pictures of females	23.50%
Pictures of males	35.00%
	29.25%

White coat v non-white coat by gender (picture): The highest role specific accuracy was for a white coated picture depicting a male provider (45%). [Pictures 2 and 6] The lowest role specific accuracy was for a white-coat picture depicting a female provider. (19%) [Pictures 4, 8, 9, 11]. *These differences were not statistically significant. [Z test proportions, p = .6].*

Table 10: White coat v non-white coat by gender (picture).

White Coat v Non-White Coat by Gender (Picture)	% accuracy specific role
Coat	
picture of female	19.00%
picture of male	45.00%
No Coat	
picture of female	28.00%
picture of male	37.00%

Gender (picture) female v male, by white coat/non-white coat: the highest role specific accuracy was for a picture depicting a male provider with a white coat (45%). [Pictures 2 and 6] The lowest role specific accuracy was for a female provider with a white coat. (19%) [Pictures 4, 8, 9, 11]. *These differences were not statistically significant. [Z test proportions, p = .6].*

The results of the sensitivity, specificity, positive predictive value and negative predictive value analysis were as follows:

Overall system: The overall "signaling system" had a sensitivity of 43.89%, [95% CI: 38.69 % to 49.19 %], a specificity of 77.92% [95% CI: 74.44 % to 81.14 %], a positive predictive value of 53.74% [95% CI: 47.86 % to 59.55 %] and a negative predictive value of 70.38% [95% CI: 66.80 % to 73.79 %] The positive likelihood ration was 1.99 [95% CI: 1.65 to 2.40] and the negative likelihood ratio was 0.72. [95% CI: 0.65 to 0.80] Positive likelihood ratios in the 1.0 to 2.0 range are related to a minimal statistical increase in likelihood of the test increasing the detection of the underlying signal. Negative likelihood ratios greater than 0.5 and less than 1.0 are related to a minimal statistical decrease in the likelihood of the test decreasing the likelihood of the underlying signal. Thus, the ratios show only minimal performance.

Table 11: Results of overall system, by 6 evidence-based parameters.

Overall system	Result	Confidence Intervals
Sensitivity	43.89%	95% CI: 38.69 % to 49.19 %
Specificity	77.92%	95% CI: 74.44 % to 81.14 %
Positive Predictive Value	53.74%	95% CI: 47.86 % to 59.55 %
Negative Predictive Value	70.38%	95% CI: 66.80 % to 73.79 %
Positive Likelihood Ratio	1.99	95% CI: 1.65 to 2.40
Negative Likelihood Ratio	0.72	95% CI: 0.65 to 0.80

Table 12: results of overall system, by 6 parameters, with rounding of sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) to nearest whole number for clarity of comparison. Positive likelihood ratio (PLR) and negative likelihood ratio (NLR) not rounded.

Overall system	Sensitivity	Specificity	PPV	NPV	PLR	NLR
	44%	78%	54%	71%	1.99	0.72

Analysis by provider group:

Results Ancillary group

Table 13: Results of ancillary group, by 6 evidence-based parameters.

Ancillary (all)	Result	Confidence Intervals
Sensitivity	10.00%	95% CI: 2.23 % to 26.56 %
Specificity	93.68%	95% CI: 90.07 % to 96.27 %
Positive Predictive Value	15.00%	95% CI: 3.38 % to 37.92 %
Negative Predictive Value	90.32%	95% CI: 86.23 % to 93.52 %
Positive Likelihood Ratio	1.58	95% CI: 0.49 to 5.09
Negative Likelihood Ratio	0.96	95% CI: 0.85 to 1.09

Results Nurse Group

Table 14: Results of nurse group, by 6 evidence-based parameters.

Nursing (all)	Result	Confidence Intervals
Sensitivity	53.33%	95% CI: 42.51 % to 63.93 %
Specificity	56.54%	95% CI: 49.20 % to 63.68 %
Positive Predictive Value	36.64%	95% CI: 28.40 % to 45.50 %
Negative Predictive Value	72.00%	95% CI: 64.09 % to 79.02 %
Positive Likelihood Ratio	1.23	95% CI: 0.95 to 1.58
Negative Likelihood Ratio	0.83	95% CI: 0.64 to 1.06

Results Physician Group

Table 15: Results of physician group, by 6 evidence-based parameters.

Physician (all)	Result	Confidence Intervals
Sensitivity	44.58%	95% CI: 38.19 % to 51.11 %
Specificity	76.92%	95% CI: 69.51 % to 83.28 %
Positive Predictive Value	74.83%	95% CI: 66.89 % to 81.70 %
Negative Predictive Value	47.43%	95% CI: 41.14 % to 53.78 %
Positive Likelihood Ratio	1.93	95% CI: 1.40 to 2.66
Negative Likelihood Ratio	0.72	95% CI: 0.62 to 0.83

Table 16: Results of three groups, by 6 parameters, with rounding of sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) to nearest whole number for clarity of comparison. Positive likelihood ratio (PLR) and negative likelihood ratio (NLR) not rounded.

Pooled (Type) Details	Sensitivity	Specificity	PPV	NPV	PLR	NLR
Ancillary (all)	10%	94%	15%	90%	1.58	0.96
Nursing (all)	53%	57%	37%	72%	1.23	0.83
Physician (all)	45%	77%	75%	47%	1.93	0.72

The ancillary group had the lowest sensitivity (10%) and the highest specificity, 93.68%). The ancillary group also had the lowest positive predictive value (15.00%) and highest negative predictive value (90.32%). The nursing group was relatively close in sensitivity (53.33%) to the physician group (44.58%). The specificity for the physician bin (76.92%) was higher than for nursing (56.54%) with a higher positive predictive value for the physician bin (74.83%) than for nursing (36.64%). The negative predictive value for the physician group (47.43%) was lower than that seen in nursing (72.00%). The physician group had the highest positive likelihood ratio (1.93) and the lowest negative likelihood ratio (0.72). The nursing group had the lowest positive likelihood ratio (1.23). The ancillary group had the highest negative likelihood ratio (0.96).

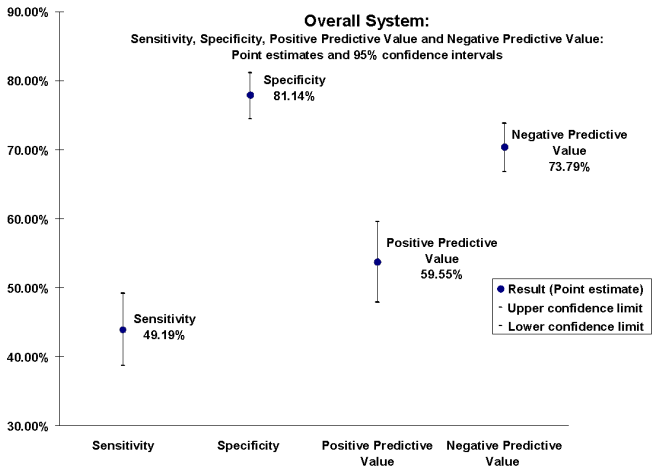

Figure 3: Overall System: Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value: Point estimates and 95% confidence intervals.

DISCUSSION

There were two essential components to this study. The first was a survey study of participant choice for physician dress, pre-administration and post-administration of a brief educational intervention. The second component of the study was an assessment of patient accuracy of identification of role provider, based on pictures of actual providers. In this component, average accuracy was used, as well as accuracy based on the evidence-based medicine parameters of sensitivity, specificity, positive predictive value, negative predictive value and positive and negative likelihood ratios.

The first study component: Survey study of participant choice for physician dress with educational intervention:

In this component of the study, 30 participants were asked how they would like their physician to dress. They were then provided a written educational intervention, which was read by the participant, and the question was posed a second time.

There were four discrete choices offered the pre-interventional and post interventional period.

In the pre-interventional period, the majority of participants (63.3%) selected a choice in which their expressed preference for physician dress involved a white coat.

After reading the educational passage, in which evidence was presented in which the white coat shown as a possible carrier of bacterial contamination, 50% of the participants changed their choice. The percent of white coat selections decreased 40%, from 63.3% in the pre-intervention selection to 23.33 % in the post-intervention selection. The percent of non-white coat selections increased 40%, from 36.67% in the pre-intervention selection to 76.67% in the post-intervention selection. The change in the pre-intervention and post-interventions system (selections) was very statistically significant.

This is a very interesting finding, and begs the question as to the nature of the choice changes. The study is responsive to that question. In reference to dress selections, choice of Scrub attire and white coat decreased 23.33% from 40% in the pre-intervention selection to 16.67% in the post-intervention selection. This change was statistically significant. The other possible white-coat related choice (of the two white coat and two non-white coat selections offered as choices) was that of professional attire and white coat. Professional attire and white coat decreased 16.67 percent from 23.33% in the pre-intervention selection to 6.67% in the post-intervention selection. This change was not statistically significant.

Scrub attire (non-white-coat) increased 36.67% from 23.33% in the pre-intervention selection to 60% in the post-intervention selection. This change was statistically significant. Professional attire (non-white-coat) increased 3.33% from 13.3% in the pre-intervention selection to 16.67 % in the post-intervention selection. This change was not statistically significant.

Thus, on exposure to the educational intervention, there was a very statistically significant decrease in white coat choices ($p = .002$ to $.004$) of which the greatest bulk of the change was in a statistically significant decrease in a selection of scrub attire and white coat ($p = .02$ to $.04$). There was a statistically significant increase in the non-white-coat choice of scrub attire (without a white coat) at a level of $p = .01$.

Thus, the educational intervention in this study had an effect on participant choices, in the direction of the movement away from white coat choices and towards non-white-coat choices, principally towards scrubs without a white coat.

In the pre-interventional period, the majority of participants (63.3%) selected a choice in which their expressed preference for physician dress involved a white coat. This is somewhat higher than the preference noted rate noted in Au's study of the families of ICU patients in which 52% of families preferred that a physician wear a white coat [8]. It is significantly higher than Gooden's study of hospitalized patients in Australia, in which 36% of patients preferred doctors to wear white coats.9 The results seen in this study (63.3%) was very similar to a study of patient preferences on physician attire (white coat preference 65%) conducted in teaching hospitals in Boston and San Francisco [23].

Was this movement related to participant age and gender? The data demonstrate that this was not the case. The movement in choices in this study did not appear to be a function of age or gender. Other studies have seen a relationship of age and white coat preference. One study which showed a preference for white coats for providers in older age groups also showed a non-age-group dependent shift to non-white coats after an educational intervention concerning BBE policy [24]. In a study by Douse et al, patients older than age 70 preferred white coats [5]. Lill et al found no relationship between age and the selection of a semi-formal study for female physicians in their picture-based New Zealand study of in-patients and out-patients. The study researchers did see a relationship of age and a preference for white coats for male physicians. This study added an interesting element to the discussion---patient preferred providers who smiled. Lill notes that "a big smile is a definite advantage" and that "a friendly manner may be more important than sartorial style" [25].

Of those patients who made a change in their choice, the vast majority of the choice change (80%) derived from a movement from a white coat type to a non-white-coat type. There was no case (0%) in which a participant changed from a non-white-coat type to a white coat type. It is interesting to note that of the 15 patients who changed their minds, as it were, 2 of the changes were from one white coat type to another coat type. Both changed from professional and white coat to scrubs and white coat. The reason for this choice is not clear. The movement to scrubs, as an overall theme of the post intervention theme, is lastly noted in the fact that the only movement of a non-white-coat type to another non-white coat type was in a participant who moved from the category of professional dress to scrubs.

The movement seen after the intervention is similar to the shift seen by Ardolino, in which all age groups showed a movement to non-coat provider dress after being informed of the BBE policy and its reasons. "Results show that patient opin-

ion is malleable….and that patients are not averse to change" [24]. Similarly, a review of the literature on physician dress notes that patients exhibit flexibility (perhaps, the review notes, even more flexibility than their providers) about what they consider to be professional dress [26]. This is also noted in a review by Brandt, who notes that "physicians are more conservative in their opinions about their attire than are their patients" [4].

The second study component--Participants' ability to identify provider roles:

Participants were shown 12 pictures which displayed a number of combinations of white coat, non-white coat based provider dress, in combinations that reflect the choices offered in the pre and post treatment system discussed above. The pictures were of real providers seen in the real-world setting of the hospital. The use of provider pictures as a survey tool and as a provider role assessment tool has been used in various studies of this sort in the literature [6,8]. According to Beach, the use of photographs may allow for the surfacing of "unconscious rather than conscious preferences." Lill's research in New Zealand used a picture based survey method [25].

The overall role-specific accuracy in this study was 29%. [Correct answers: 29%, incorrect answers: 71%] The accuracy of participants to identify the provider role in individual pictures varied from a low of 3.3% to a high of 70%.

The 12 elements of role specific accuracy were then grouped. Nurse and nurse manager were combined, physician resident and physician attending were combined and an ancillary was created. This grouping was to create general bins for analysis. Based on three groups that were created, accuracy of the ancillary provider group was 10%. The accuracy of the nursing (all) group and the physician (all) group were both approximately 31%.

The 12 pictures were then grouped by those with providers who wore white coats and those with providers who did not wear white coats. The role specific accuracy by the six pictures with a white-coated provider was 26%. The six pictures with a non-white-coated provider had a role specific accuracy of 32%. Although the accuracy associated with the white coat provider pictures was lower than that associated with the non-white-coated providers, the difference was not statistically significant.

The 12 pictures were then grouped by those with pictures of female providers and those with pictures of male providers. The role specific accuracy of the six pictures with male providers (35%) was higher than that of the six pictures with female providers (23.5%). The difference was not statistically significant.

The data was then analyzed looking at and white coat vs. non-white coat pictures and by gender. The highest role specific accuracy was for a white coated picture depicting a male provider (45%). The lowest role specific accuracy was for a white-coat picture depicting a female provider. (19%) These differences were not statistically significant. [Z test proportions, p = .6] However, this lack of statistical significance does not mean that gender does not play a role in role identification as studied through the aperture of the patient identification of pictures. Beach, commenting on the ICU study by Au et al, notes it is possible that race and gender play a role in picture survey studies. The study by Au was different than this study, in that it did not assess role identity [27]. A picture based survey study by Rehman set in an out-patient clinic found that female physicians' dress appeared to be significantly more important to respondents than male physicians' dress [28].

Epidemiologic tests were applied, as discussed under methodology, above.

The overall "signaling system" of provider dress had a sensitivity of 43.89%, [95% CI: 38.69 % to 49.19 %], a specificity of 77.92% [95% CI: 74.44 % to 81.14 %], a positive predictive value of 53.74% [95% CI: 47.86 % to 59.55 %] and a negative predictive value of 70.38% [95% CI: 66.80 % to 73.79 %] The positive likelihood ratio was 1.99 [95% CI: 1.65 to 2.40] and the negative likelihood ratio was 0.72. [95% CI: 0.65 to 0.80]

The ancillary group had the lowest sensitivity (10%) and the highest specificity, 93.68%). The ancillary group also had the lowest positive predictive value (15.00%) and highest negative predictive value (90.32%).

The nursing group was relatively close in sensitivity (53.33%) to the physician group (44.58%). The specificity for the physician bin (76.92%) was higher than for nursing (56.54%) with a higher positive predictive value for the physician bin (74.83%) than for nursing (36.64%). The negative predictive value for the physician group (47.43%) was lower than that seen in nursing (72.00%).

The physician group had the highest positive likelihood ratio (1.93) and the lowest negative likelihood ratio (0.72) The nursing group had the lowest positive likelihood ratio (1.23). The ancillary group had the highest negative likelihood ratio (0.96).

Positive likelihood ratios in the 1.0 to 2.0 range are related to a minimal statistical increase in likelihood of the test increasing the detection of the underlying signal. Negative likelihood ratios greater than 0.5 and less than 1.0 are related to a minimal

statistical decrease in the likelihood of the test decreasing the likelihood of the underlying signal.

The data, including sensitivity, specificity, positive predictive value and negative predictive value, as well as the likelihood ratios show only minimal performance for the signaling system in its ability accurately convey provider role.

By way of comparison, a Homan's sign, formerly used rather commonly as a clinical sign of deep vein thrombosis, has fallen into disuse because of its poor performance in sensitivity and specificity. The sensitivity of the Homan's sign is in the range of 60% to 80%, with specificities in the range of 30-72%, in well-designed studies in which a venography reference standard was used [29].

The overall sensitivity of the current signaling system of provider dress is approximately 44%, which is inferior in performance to the Homan's sign. The specificity of the overall system is 78%, which is comparable to the higher end performance of the Homan's sign and is an indication of a poorly performing sign. A positive predictive value of 54% and a negative predictive value of 71% also convey the same evidence of a poorly performing sign. This is supported by the likelihood ratios.

The study had several possible limitations. The sample size was relatively small and was not randomized. However, the data was collected in random, albeit convenience samples, in which the patients who were in the ED were a real-life "thin slice" of the overall sample of ED patients. In fact, the data demonstrate that the sample was normal in distribution in reference to patient age and gender. It is also likely that the process capabilities of ED patients as participants would be relatively similar to hospitalized patients, since the vast majority of hospitalized patients in most US hospitals originate from the ED. Another possible limitation is that provider badges were not visible, by design, in the study pictures. It is possible that some patients may utilize provider badges in their identification of a provider. However, the intent of the pictures was to focus the participant on the dress of the provider. In addition, a providers name and title would not be visible from several feet of distance, which would constitute a common distance in the "parade of faces" seen in a hospital.

CONCLUSION

This study demonstrated that a group of non-medical participants moved rather strongly in the direction of non-white coat physician provider choices, after a brief educational intervention on the fomite nature of the white coat. This change in physician provider preference was very statistically significant.

This study also took a look at the white coat, and the white coat related dress system, as a semiotic and complex sign of sorts, indicating provider identity. The performance of this system was very poor. Overall accuracy was only 29%. Sensitivity of the overall system was only 44%, with related poor performance in specificity, positive predictive value, negative predictive value, positive likelihood ratio and negative likelihood ratios.

The signaling system of coats, no coats, scrubs and professional wear, in the various permutations and combinations seen in the 12 provider pictures, performs at the level, or worse, than the antiquated and evidence-based medicine rejected, Homan's sign.

And even more provocatively, given the fomite nature of the white coat in clinical use, shouldn't the "white coat" ceremony be rethought? There are many symbols that could be given to medical students. A set of embroidered scrubs might be a symbol worth consideration. This sort of thinking is discussed by Beach, who notes that "brand labels can be changed, and if the disadvantages of the white coat or any other professional symbol are demonstrated to outweigh their benefits, we should consider a different branding mechanism. (eg, badges or other identifying attire)" [27]. Even more profoundly, Wear suggests a rather radical rethinking of the white coat ceremony. Wear's critique is based on a challenge to the implicit hierarchical symbolism of the white coat. However, the paper supports the implicit notion at this heart of this study—that the white coat and its related symbolism is a meaning-transmitting (semiotic) system [30].

Overall, then, this study showed a willingness and flexibility of patients to move in the direction of non-white coat dress preferences for physicians, after a brief educational intervention. The study also applied evidence-based parameters to the analysis of the white-coat and related dress signaling system in relation to accuracy of provider role. The data suggest that the current semiotic signaling system performed poorly.

When the evidence indicates that a provider role identification system underperforms a Homan's sign, and that patients are willing to move in the direction of non-white coat dress preferences, then perhaps it's time to say goodbye to the core white coat and to build a role-identification signaling system that performs with more accuracy.

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