

# Uncovering the History of Operating Room Attire through Photographs

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## ABSTRACT

**Background:** Although early proponents for each of the four basic articles of operating room clothing—gowns, caps, masks, and gloves—can be identified, it is unclear from historical commentaries when each article achieved general acceptance and was consistently worn by surgeons and by anesthesia providers.

**Methods:** Historical photographs were identified from the Web sites of the National Library of Medicine, Google, and the archives of the Wood Library-Museum of Anesthesiology for the 11 decades 1860 to 1970. The presence or absence of each article of clothing was then determined for the surgical and anesthesia providers depicted.

**Results:** Over 1,000 photographs were identified and examined. Photographs were then eliminated for repetition, lack of available dating, questionable dating, and poor quality. In 338 remaining photographs that met inclusion criteria, 640 surgical providers and 219 anesthesia providers were depicted and used in the analysis. Statistical definitions for historical terms general acceptance and routine use were proposed. The probability that a surgeon was wearing nonstreet clothes (gown) was 0.66 (95% CI, 0.22 to 0.93) in 1863. The years (95% lower bound to 95% upper bound) associated with a 0.5 probability for wearing cap, gloves, and mask were 1900 (1896 to 1904), 1907 (1903 to 1910), and 1916 (1913 to 1919), respectively. The years associated with a 0.5 probability that an anesthesia provider would be wearing nonstreet clothes (gown), cap, and mask were 1883 (1863 to 1889), 1905 (1900 to 1911), and 1932 (1929 to 1937), respectively.

**Conclusion:** Timelines for the adoption of each basic article of surgical attire by surgeons and anesthesia providers were determined by analysis of historical operating room photographs from 1863 to 1969. (*ANESTHESIOLOGY* 2016; 124:19-24)

THE development of modern surgical attire is a consequence of the acceptance of the germ theory of disease that was theorized in the mid-16th century and validated in the mid- to late-19th century. Burns states that before this time, “most surgery was, as it had always been, a public event. Physicians operated in nonhospital attire or perhaps donned a favorite jacket on which some wiped their bloody contaminated knives rather than wash them as they went from case to case.”<sup>1</sup> In paintings and staged photographs of the first public demonstration of anesthesia administered for surgery on October 16, 1846, the participants wore business suits. In contrast, the basic operating room (OR) attire of today consists of clean, nonsterile hospital-laundered clothes or “scrubs,” caps, masks, and gloves. Although early proponents for each of these four basic articles of clothing can be identified, it is unclear from historical commentaries when each element achieved general acceptance and was consistently worn by surgeons and anesthesia providers.

Photography coincidentally developed during the same period in history. In *Photographing Medicine*, Fox and Lawrence<sup>2</sup> assert that photographs are “windows through which the past can be viewed with great accuracy” and have been considered as the “norm of truthfulness” and “frozen instants

### What We Already Know about This Topic

- Operating room attire has changed over time
- A systematic analysis of changes in attire has not been performed

### What This Article Tells Us That Is New

- A systematic analysis of over 1,000 historic photographs of operating room personnel was conducted to provide a timeline of changes in attire
- The years for which general acceptance of various elements of operating room attire (gown, cap, and mask) differed between anesthesia providers and surgeons
- Anesthesia providers lagged behind surgeons in adoption of standard operating room attire

of reality.” Historians have long used “photographs to supplement accounts based on written sources or as illustration to prove a factual point.”<sup>2</sup> Therefore, the information in OR photographs from the 11 decades between 1860 and 1970 should enable one to determine the proportion of time each element of OR attire was worn as a function of the year in which the photograph was taken. The purpose of this study is to determine from available photographs the timelines for

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the adoption of OR attire by both surgeons and anesthesia providers and to quantify the vague historical terms for use (*e.g.*, general acceptance, commonplace, and consistency).

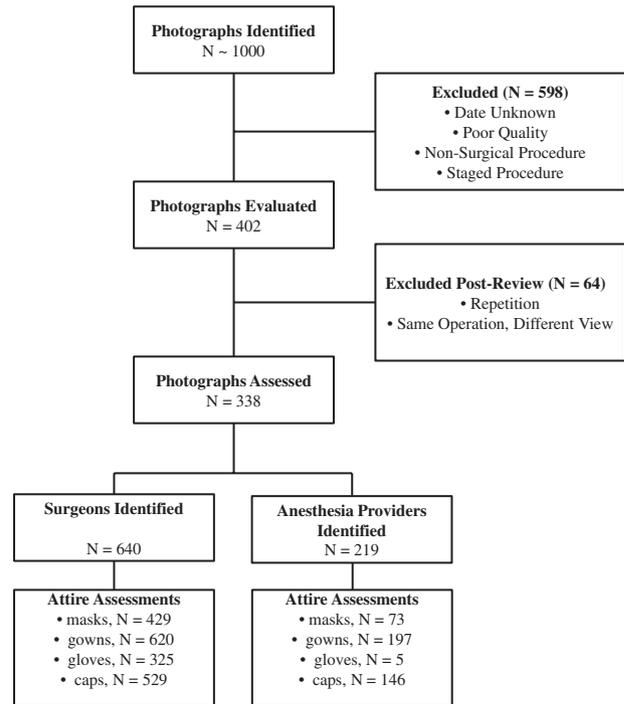
## Materials and Methods

Following Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines,<sup>3</sup> Web sites from the National Library of Medicine, Google, and the archives of the Wood Library-Museum of Anesthesiology (WLM) were searched to identify over 1,000 historical photographs related to the administration of anesthesia and surgery from 1863 to 1969. Key search terms included the following: “surgery,” “anesthesiology,” “surgical theater,” “surgical theatre,” “surgical amphitheater,” “surgical amphitheatre,” “anaesthesia,” “operating theater,” “operating room,” “surgery,” “anesthesia,” and the specific years that are inclusive in the study. For example, one exact search phrase used was “operating room 1935.” Many of the Google search results led to university Web sites where photographs were obtained. Photographs obtained from the WLM were found after extensive search of the textbooks and journals available there with the assistance of WLM staff. Additional photos were evaluated during the peer review process, but of them, none met the criteria for additional inclusion.

Photographs were excluded if the quality was poor, the date was uncertain, or surgery was not depicting an actual operation. Exclusions were also made if there were repetitions or photographs of the same operation from different views (*fig. 1*). Each of the photos were assessed (*i.e.*, rated) for utilization of hospital attire, masks, caps, and gloves by one author (L.W.A.). A concordance exercise was performed by a blinded second rater (R.C.R.), who independently assessed 52 randomly selected photographs that contained 154 providers who could be rated on 610 attire items (*i.e.*, six items could not be evaluated as they were out of view). Potential disagreements were found in 13 of 610 (2.1%) attire ratings from 7 of 52 (13.5%) photographs and adjudicated by a third author (C.A.A.) who agreed with the initial assessment in two photographs and with the new assessment in five photographs.

## Statistical Analysis

The photographic data were a convenience sample based on availability through the search strategy. Sample size was thus based on logistical considerations, and no *a priori* statistical power calculations were conducted. Photographic evidence was assumed to represent a sample of behavior for the individuals in the photograph at the time the photograph was taken. Increased frequency of specific attire was interpreted as an increased probability that the professionals at the time had adopted the attire. To account for the fact that providers were nested within photographs, separate generalized estimating equation models were implemented to predict the proportion of subjects in the photographs wearing hospital attire, masks, caps, and gloves as a function of year and by provider type (anesthesia provider or surgeon). As there were numerous



**Fig. 1.** Flow diagram depicting the photograph inclusions and exclusions with provider and attire summaries.

institutions, and many institutions were not well represented, an additional sensitivity analysis was conducted that used origin (Europe, United States, other, or unknown) of institution as an additional clustering variable in the models. Because all four outcomes were binary (*e.g.*, wearing gloves or not), a binomial distribution with a logit link was specified for all models. The robust estimator was used to provide the covariance estimation along with an independent correlation matrix (*i.e.*, the providers’ behaviors were assumed independent of one another within the same photograph).

Because only the decade that the photograph was taken was available for 262 of 338 (77.5%) photographs, we conducted a multiple imputation using 100 runs of each model with a date imputed from a uniform distribution using  $\pm 4$  yr from the available decade year. Such an approach assumes that the published dates for the photographs were rounded to the nearest even decade when the actual photo date was not known according to common mathematical rounding rules (*e.g.*, 1894 was rounded to 1890, whereas 1895 was rounded to 1900). The model coefficients were then reestimated using each of the 100 runs to account for the variability across different imputations (*i.e.*, guesses) of what year the photograph may actually have been taken. This allowed us to estimate the predicted values for each piece of attire in the context of the uncertainty associated with the available information. The model predictions were interpreted based on point estimates with 95% CIs. To estimate the uncertainty in year that 50% of providers adopted certain attire, we examined the lower bounds (LBs) and upper bounds of the 95% CIs from the imputations.

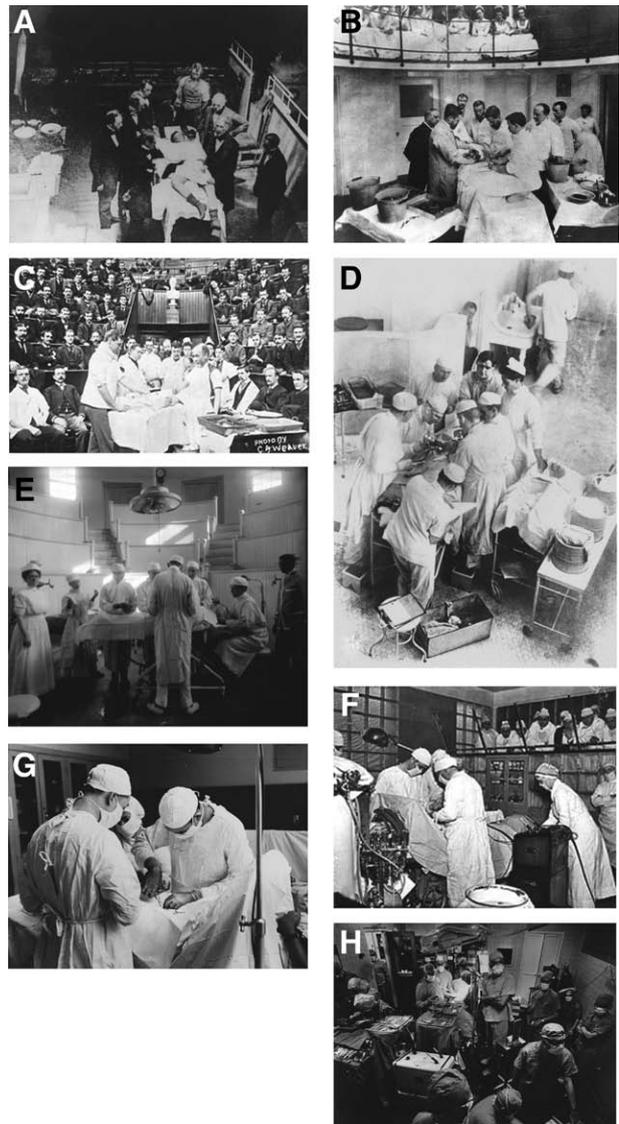
We propose that the definition for the year of “general acceptance,” “more probable,” or “widespread” be the most recent (latest) year when the LB of the 95% CI from the prediction interval surpasses 0.5 (*i.e.*, when the predicted probability exceeds 50%). Similarly, for the definition for the year of “commonplace,” “consistently,” or “routine,” we propose the most recent (latest) year when the LB of the 95% CI from the prediction interval surpasses 0.9 (*i.e.*, when the predicted probability exceeds 90%).

All analyses were conducted by using the Statistical Package for the Social Sciences (SPSS for Window, version 22.0, USA), R version 3.0.2 (R Foundation for Statistical Computing, Austria), and RStudio version 0.98.953 (RStudio, Inc., USA).

## Results

The search strategy identified 338 dated photographs that included 640 surgeons and 219 anesthesia providers. Figure 1 displays the disposition of photographs examined in the study. These photos were taken at 135 different institutions, 49 (14.5%) were taken in Europe, 240 (71%) were taken in the United States, 18 (5.3%) were taken in other location, and 31 (9.2%) were taken at an unknown location. Figure 2 displays examples of photographs taken over the course of several decades. The number of surgeons and anesthesia providers identified in the photographs by each decade of the observation period is displayed in figure 3. Relatively few photographs (and thus providers) were found before the 1880s.

The probabilities that individuals were assessed to be wearing specific attire are displayed in figure 4. As expected, these probabilities increased during the considered years for both provider types. In general, anesthesia providers lagged behind the surgeons in adopting each element of OR attire (*i.e.*, the anesthesia provider curves are right shifted). The probability that a surgeon in a photograph would be wearing hospital attire reached 0.66 (95% CI, 0.22 to 0.93) in 1863. For anesthesia providers, hospital attire reached a probability of 0.50 between approximately 1863 and 1890. In 1883, the probability that anesthesia providers wore hospital attire was 0.51 (95% CI, 0.22 to 0.76). By 1929, both reached a 0.99 probability (fig. 4A). The probability that a surgeon would be wearing a mask reached 0.50 between 1913 and 1919. In 1917, the probability of a surgeon wearing a mask was 0.55 (95% CI, 0.45 to 0.64); 0.50 probability was reached for anesthesia providers between 1929 and 1937 with a probability of 0.53 (95% CI, 0.40 to 0.65) in 1933. By 1964, both providers reached 99% utilization (fig. 4B). The probability that surgeons and anesthesia providers would be wearing caps reached 0.50 between 1896 and 1904 for surgeons and between 1900 and 1911 for anesthesia providers. The probability that a surgeon was wearing a cap was exactly 0.50 (95% CI, 0.40 to 0.60) in 1900 and 0.51 (95% CI, 0.42 to 0.60) in 1906 for anesthesia providers. By 1958, both providers reached 99% utilization (fig. 4C). The probability that a surgeon would be wearing gloves reached 0.50 sometime



**Fig. 2.** Representative examples of photographs studied by decade: (A) “Ether Days” (potentially posed) (reproduced, with permission, from the Library of Congress, Washington, D.C.); (B) 1880s (reproduced, with permission, from the Massachusetts General Hospital Archives and Collections, Boston, Massachusetts); (C) 1890s (reproduced, with permission, from the Thomas Jefferson University, Archives & Special Collections, Philadelphia, Pennsylvania); (D) 1900s (reproduced, with permission, from the Yale University, Harvey Cushing/John Hay Whitney Medical Library, New Haven, Connecticut); (E) 1910s (reproduced, with permission, from the University of Virginia Library, Charlottesville, Virginia); (F) 1930s (reproduced, with permission, from the Seattle Post-Intelligencer Collection, Museum of History & Industry, Seattle, Washington); (G) 1940s (reproduced, with permission, from the Library of Congress, Washington, D.C.); and (H) 1960s (reproduced, with permission, from Adrian Kantrowitz).

between 1903 and 1910 with probabilities of 0.50 (95% CI, 0.41 to 0.60) in 1907 and 0.99 (95% CI, 0.94 to 1.00) in 1944. Anesthesia providers reached a probability of 0.40 (95% CI, 0.15 to 0.74) in 1968 (fig. 4D).

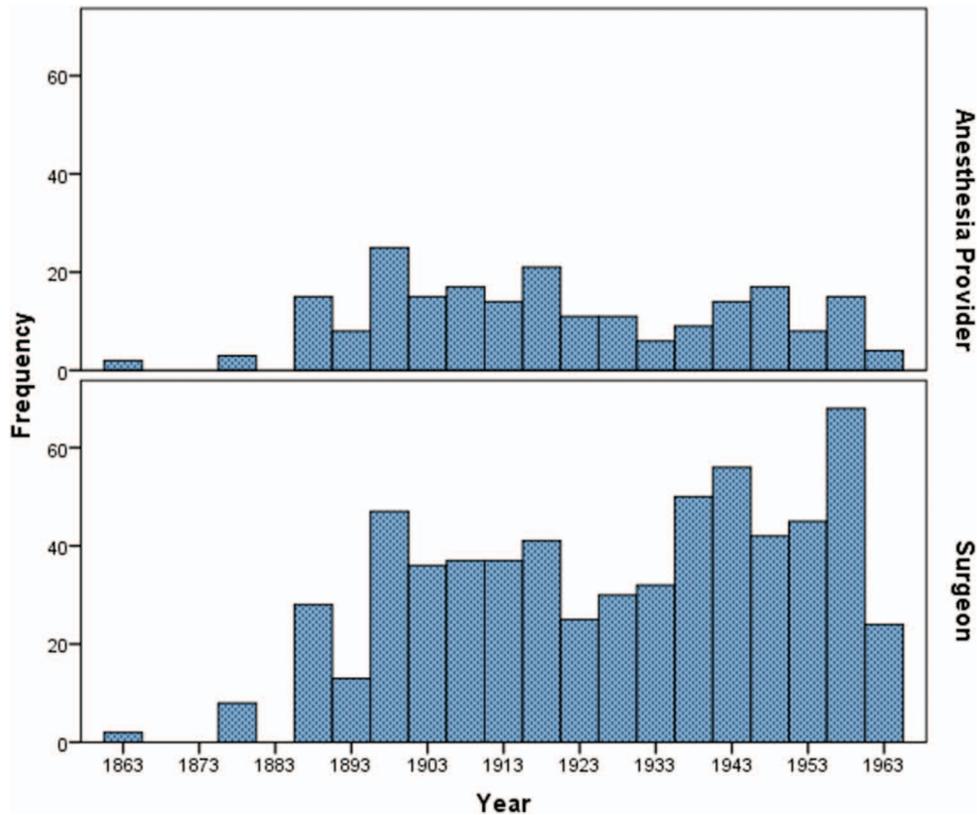


Fig. 3. Frequency of photographs studied by year and provider type.

The years associated with general acceptance based on the definitions described in the Materials and Methods for surgeons are 1876 for gowns, 1904 for caps, 1919 for masks, and 1911 for gloves. The years associated with general acceptance for anesthesia providers are 1890 for gowns, 1910 for caps, and 1937 for masks, with gloves not reaching our definition of general acceptance by 1963.

The years associated with consistently worn for surgeons are 1901 for gowns, 1930 for caps, 1937 for masks, and 1937 for gloves. The years associated with consistently worn for anesthesia providers are 1919 for gowns, 1948 for caps, and 1957 for masks.

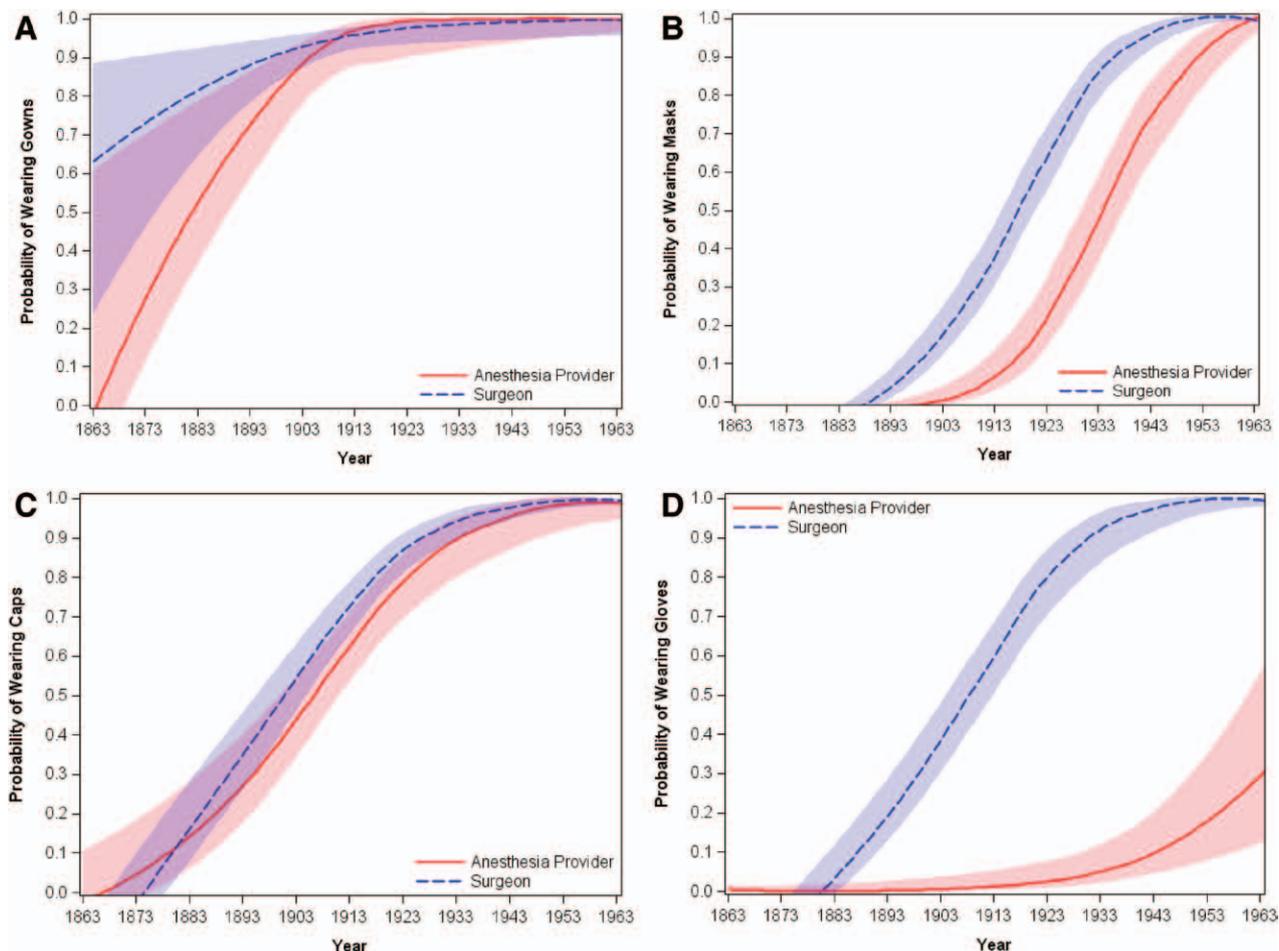
## Discussion

This study is the first to determine the timeline for the adoption of the four basic elements of OR attire by surgeons and anesthesia providers and to quantify the vague historical terms for use (*e.g.*, general acceptance, commonplace, and consistency) that have been applied to wearing them. It fills the gap of knowledge between the more easily identified early proponents for each article of clothing and current recognition as standard practice. The first article to be adopted by surgeons was the gown, followed by the cap, then masks, and gloves about the same time. Consistently, anesthesia providers lagged behind their surgical colleagues in the adoption of each article of OR attire. Presently, surgeons don sterile gloves for the entire surgical procedure, but anesthesia

providers don them intermittently—clean, nonsterile gloves for intubations, extubations, and arterial and IV cannulation and sterile gloves for central line placement and the administration of neuraxial anesthesia. The limitations of this study are significant and fall into two categories: the attire itself and the photographs.

## Attire

The actual material used in each element could not be determined from the photographs. Early gloves were made of permeable cotton or silk, sometimes coated with paraffin, and not rubber.<sup>4</sup> William Stewart Halsted, professor of surgery at Johns Hopkins Hospital, arranged for the Goodyear Rubber Company to make the first rubber surgical glove in 1889 to protect the hands from the irritating effects of carbolic acid or mercuric chloride used to sterilize operating instruments. It was Halsted's senior resident, Dr. Joseph Bloodgood, who noted that the practice of gloving the entire surgical team contributed to a dramatic reduction in infection rate.<sup>5</sup> Bloodgood himself started using gloves during surgery in 1893, but surgeons of this era were reluctant to wear gloves because they were thick and "impaired the sense of touch."<sup>5</sup> It was not uncommon to see the surgeon operating with his bare hands or for "the operator to tear off his gloves and use his naked fingers."<sup>6</sup> The technique of "donning gloves did not appear in nursing texts until 1916."<sup>7</sup> Presently, surgeons don sterile gloves for the entire surgical procedure,



**Fig. 4.** Model-predicted probabilities with 95% CIs (of one bootstrapped run) of wearing: (A) hospital (nonstreet) attire, (B) masks, (C) caps, or (D) gloves by provider type and year.

but anesthesia providers only wear them intermittently for invasive procedures such as intubation, extubation, IV and central line access, arterial cannulation, and administration of neuraxial and regional anesthesia. Thus, we expected the observed differences between the two groups.

With regard to scrubs, we focused on the shift from street clothes to OR attire. We considered surgical aprons, coats, and nursing uniforms as equivalents to scrubs. Nurses were expected to keep their uniforms clean and change them if they became bloodstained. But, they probably wore them throughout the hospital, and even from home, and thus would not meet current standards. We did not distinguish between scrubs and sterile gowns worn over scrubs. Gustave Neuber of Kiel is credited with being the first to use a sterilized surgical gown. In 1883, he reported a decrease in surgical site infections with the use of both cap and gown.<sup>8</sup> Before his discovery, surgeons “prided themselves on their ability to perform amputations dressed in their fashionable morning frock coats and striped trousers without getting a drop of blood on their clothing.”<sup>8</sup>

The wearing of caps was also problematic. Nurses wore hats symbolic of their nursing school that did not

completely cover their hair. These hats were a standard part of the nursing uniform in and out of the OR. The data associated with the wearing of caps depended on whether the anesthesia providers were physicians (no hats in early photographs) or nurses.

Mikulicz and Flugge, two German scientists, suggested the idea of a facemask in 1897 after they demonstrated the presence of bacterial droplets from the nose and mouth.<sup>9</sup> Hamilton,<sup>10</sup> in 1905, found heavy droplet contamination from surgeons’ mouths and noses during talking. In 1918, Weaver<sup>11</sup> reported a decreased incidence of diphtheria contracted by healthcare providers from infected patients when masks were worn. It was not until 1926 that the first clinical study demonstrated a potential link between wearing masks and reduced surgical site infection.<sup>12</sup> While some suggest that “by 1920, the use of masks became routine practice in the OR,”<sup>13</sup> others recalled that “ORs continued to operate without masks and practice varied widely among the period from hospital to hospital.”<sup>13</sup> Even today, masks are not worn routinely by anesthesiologists in some of the OR units at the Karolinska University Hospital.<sup>14</sup> For this study, we did not distinguish between face masks that covered the mouth and

nose from those that were worn under the nose and only covered the mouth.

### Photographs

Our probabilities can only be correct if the photographs we selected were not artificially posed and were representative of the practice in the years in which they were taken. Long exposure times were required for the early cameras and raise the possibility of some of these photographs being posed. Since individuals in unstaged photographs are more likely to move and cause blurring than in staged settings, more unstaged photographs may have been excluded than staged ones. The degree to which the photographs are truly a random sample cannot be ascertained. The available photographs from the early years may reflect the practice at larger, more affluent institutions and not those in smaller community hospitals. In addition, our samples of photographs are subject to the bias of the individual or institution that donated them. For example, the presence of a photographer in the OR was not a common practice. The presence of photographer may have influenced surgical attire worn by the participants in the direction of less attire, so that the participants could be recognized, or more attire, to make the scene more theatrical. Lastly, most of the photographs were from the United States and may not reflect the adoption of OR attire in other countries.

In summary, this study viewed photographic evidence as a representative sample of behavior at the time the photograph was taken. We utilized statistical modeling to determine quantitatively when the four basic components of OR attire became widely accepted and routinely worn by surgeons and anesthesia providers during the period from 1863 (earliest unstaged photograph we could locate) to 1969. We found that the probability of wearing caps, gloves, gowns, and masks increased steadily during the decades captured in the photographs. For each piece of OR attire, except gloves, both surgeons and anesthesia providers could be observed wearing the items with near 100% frequency in the latter period of observation (*i.e.*, after 1950). We applied criteria for general acceptance and found that the years for which each garment met these criteria ranged widely with 1876 considered general acceptance for surgeons wearing gowns and 1911 for surgeons wearing gloves. Anesthesia providers lagged behind their surgical colleagues in adoption of each piece of OR attire.

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### Competing Interests

The authors declare no competing interests.

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