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## Major Article

## Modified gloves: A chance for the prevention of nosocomial infections

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## Key Words:

Examination gloves  
Skin contamination  
Infection prevention

**Background:** Non-sterile gloves primarily serve as a barrier protection for health care workers (HCWs). However, pathogens may often contaminate the skin of HCWs during glove removal; therefore, pathogens may be further transmitted and cause nosocomial infections.

**Methods:** A field study was conducted comparing contamination rates when using standard gloves or a new modified product equipped with an additional flap (doffing aid) for easier removal. Gloves were removed after bathing gloved hands in an artificial fluorescent lotion. The number of contamination spots was then visually examined using ultraviolet light.

**Results:** There were 317 individuals who participated in this study: 146 participants (104 nurses and 42 physicians) used standard gloves, whereas 171 participants (118 nurses and 53 physicians) used the modified product. Use of the modified gloves instead of the standard product (15.8% vs 73.3%, respectively;  $P < .001$ ) and being a physician rather than a nurse (29.5% vs 47.7%, respectively;  $P = .003$ ) were the only independent risk factors for reduction of contamination.

**Conclusions:** This study shows that the modified product could, at least in vitro, significantly reduce the rate of hand and wrist contamination during removal compared with standard gloves. By this, it may significantly improve the overall quality of patient care when used on the wards directly at the patient's site.

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## BACKGROUND

A significant proportion of hospital-acquired infections result from cross-contamination via the hands of health care workers (HCWs). Personal protective equipment, such as medical examination gloves, effectively protects against potentially hazardous contamination of hands, and its use is therefore strongly recommended for the prevention of pathogen transmission.<sup>1-3</sup> Medical gloves in particular may reduce, but still cannot completely eliminate, the risk of pathogen contamination on the hands of HCWs.<sup>4</sup> Despite the use of gloves, contamination of hands can occur in at least 2 instances. The first is during use: gloves may fail because of mechanical damage (eg, needle strike) or have preexisting pinholes.<sup>5</sup> The second is during glove removal: skin contamination can occur in >50% of HCWs during

the glove removal process.<sup>4</sup> Therefore, subsequent hand hygiene (eg, alcohol-based hand disinfection) still needs to be performed after the removal of gloves.<sup>3</sup> However, hand hygiene compliance after the use of gloves often remains insufficient.<sup>6,7</sup>

Based on these findings, there is an urgent need either to improve glove removal techniques or to modify the product accordingly to reduce skin contamination and pathogen spread. This field study examined the frequency and sites of contamination of health care personnel during removal of standard gloves in comparison with newly developed gloves. Visual feedback was provided by fluorescent lotion contamination of skin.

## MATERIALS AND METHODS

## Materials

Standard nitrile medical examination gloves were compared with a newly developed product, Doffy Gloves (both provided by IP Gloves GmbH, Aachen, Germany). The modified Doffy Gloves are equipped with a textured doffing aid (small flap) above the thumb area (positioned laterally of the wrist when the glove is worn) that can be

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gripped during glove removal. To ensure no other mechanical difference or a difference in handling performance, both glove types (standard gloves and Doffy Gloves) were made according to the same material formulation and manufacturing process by the same company on behalf of IP Gloves GmbH and resembled standard nonsterile medical gloves as used in daily routine settings.

### Hospitals and participants

Surgical wards, internal medicine wards, and intensive care units of a German tertiary care university hospital were visited consecutively, and volunteers were recruited to participate right away. A total of 317 HCWs on 35 hospital wards participated in this semi-quantitative analysis of hand contamination. Informed consent was retrieved from all participants (ethical board approval no. 7388). For each participant, an anonymous questionnaire on age, sex, duration of work experience, and position in the hospital (physician or nurse) was completed.

### Study protocol

In this proof of principle field study, participants were randomized for the use of either standard gloves or Doffy Gloves on an alternate daily basis. HCWs used gloves in their personal appropriate size and then wetted each hand using 5 mL of a fluorescent solution (Schülke Optics Training fluorescent lotion; Schülke & Mayr GmbH, Vienna, Austria) and distributed this solution equally on the gloves' surfaces to simulate an external glove contamination. Immediately thereafter, they removed their gloves, and their hands were then examined using a UV Box (Hand Hygiene Teaching Box "Sharing Expertise"; B. Braun, Melsungen, Germany). Contamination rates including the location of contamination were determined visually. The end point of this study was whether hand contamination of participants occurred at all. In addition, contamination sites were categorized in the right and left hands, thumbs, fingers, palms, and backs of the hands and the wrists. Both, the fluorescent solution and the nitrile gloves were tested for use on humans by the manufacturers. Therefore, no adverse effects for the user were expected.

### Statistics

A sample size calculation was performed by the institute of biometry of the university hospital. Based on the study of Tomas et al.,<sup>4</sup> a difference in the degree of skin contamination of at least 15%-20% was to be expected. Given a significance level of 5% and a power of 80%, the number of participants per group was calculated between 105 and 185.

We investigated risk for contamination (primary outcome) depending on the following parameters: type of gloves (standard gloves or Doffy Gloves), sex (man or women), age (<20, 20-40, or >40 years), work experience (<5, 5-10, 11-20, or >20 years), profession (doctor or nurse), and site of contamination (thumb, finger, palm, back of hand, or wrist). In the descriptive analysis, number and percentage were calculated. Differences were tested by  $\chi^2$  test.

In the multivariable analysis, logistic regression analysis was performed for the outcome contamination. The investigated parameters of type of gloves, sex, age, work experience, and profession were considered in the model building strategy. Variable selection was stepwise forward with the significance level of  $P < .05$  for including a parameter in the model.  $P < .05$  was considered significant. All analyses were performed using SPSS (IBM SPSS Statistics, Somers, NY) and SAS version 24 (SAS Institute, Cary, NC).

**Table 1**  
Baseline demographic data

Characteristics		Doffy Gloves	Standard gloves
Years of working experience	<5	37 (22)	44 (30)
	5-10	59 (35)	37 (25)
	11-20	33 (19)	24 (16)
	>20	42 (25)	41 (28)
Age group (y)	<20	7 (4)	7 (5)
	20-40	117 (68)	95 (65)
	>40	47 (27)	44 (30)
Profession	Physician	53 (31)	42 (29)
	Nursery	118 (69)	104 (71)
Sex	Male	56 (33)	40 (27)
	Female	115 (67)	106 (73)
Total		171 (100)	146 (100)

NOTE. Values are n (%).

## RESULTS

### Study population

There were 146 participants using standard gloves versus 171 persons using the modified Doffy Gloves. Baseline demographics of both groups were comparable as shown in Table 1. About two-thirds of all participants were women and employed as nurses. Participants were distributed equally in both groups (Table 1).

### Contamination

In total, out of 317 participants, 134 participants (42.3%) showed some kind of contamination after glove removal. In the univariate analysis (Table 2), 2 variables were significantly associated with reduced contamination rates: (1) physicians were significantly less likely to contaminate their hand during glove removal (29.5% vs 47.7%, respectively;  $P = .003$ ); and (2) contamination rates significantly and also independently decreased when using Doffy Gloves instead of standard gloves (15.8% vs 73.3%, respectively;  $P < .001$ ).

The following 2 factors were confirmed by multivariate logistic regression analysis as independent variables for the outcome of contamination: (1) physicians were significantly less likely to have contaminated their hand during glove removal (odds ratio, 0.33; 95% confidence interval, 0.18-0.64) compared with nurses, and (2) Doffy Gloves (odds ratio, 0.06; 95% confidence interval, 0.03-0.11) were superior than standard gloves.

### Contamination sites

Overall, 27 participants contaminated themselves in the Doffy Gloves group, and we found 28 contamination sites as shown in Table 3. In this group, the thumb of the left hand was most often affected. In the standard glove group, 107 participants had 126 contaminations, mostly at the wrists and palms (Fig 1). Of those, 17 participants were contaminated at >1 site. Multiple contaminations occurred significantly more often when using normal gloves than Doffy Gloves (11.6% vs 0.6%, respectively;  $P < .001$ ).

## DISCUSSION

Alcohol-based hand disinfection is recommended after direct contact with patients even after the use of gloves because of the potential risk of unnoticed hand contamination.<sup>1</sup> This despite precautions transmission might be caused by contamination during the removal of protective clothing.<sup>8,9</sup> Hand contamination may either occur already during the use of gloves by leakage through microlesions or by spilling of pathogens during the stretching of the glove as it is removed.<sup>10,11</sup> However, data on exact hand

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