Association between personal protective equipment and SARS-CoV-2 infection risk in emergency department healthcare workers

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Background and importance   Healthcare personnel working in the emergency department (ED) is at risk of acquiring severe acute respiratory syndrome coronavirus-2 (SARS-Cov-2). So far, it is unknown if the reported variety in infection rates among healthcare personnel is related to the use of personal protective equipment (PPE) or other factors.

Objective   The aim of this study was to investigate the association between PPE use and SARS-CoV-2 infections among ED personnel in the Netherlands.

Design, setting and participants   A nationwide survey, consisting of 42 questions about PPE-usage, ED layout - and workflow and SARS-CoV-2 infection rates of permanent ED staff, was sent to members of the Dutch Society of Emergency Physicians. Members were asked to fill out one survey on behalf of the ED of their hospital. The association between PPE use and the infection rate was investigated using univariable and multivariable regression analyses, adjusting for potential confounders.

Outcome measures   Primary outcome was the incidence of confirmed SARS-CoV-2 infections among permanent ED staff between 1 March and 15 May 2020.

Results   Surveys were sent to 64 EDs of which 45 responded (70.3%). In total, 164 ED staff workers [5.1 (3.2–7.0)%] tested positive for COVID-19 during the study period compared to 0.087% of the general population. There was significant clustering of infected ED staff in some hospitals (range: 0–23 infection). In 13 hospitals, an FFP2 (filtering facepiece particles >94% aerosol filtration) mask or equivalent and eye protection was worn for all contacts with patients with suspected

or confirmed SARS-CoV-2 during the whole study period. The unadjusted staff infection rate was higher in these hospitals [7.3 (3.4–11.1) vs. 4.0 (1.9–6.1)%, absolute difference + 3.3%]. Hospital staff testing policy was identified as a potential confounder of the relation between PPE use and confirmed SARS-CoV-2 infections (collinearity statistic 0.95). After adjusting for hospital testing policy, type of PPE was not associated with incidence of COVID 19 infections among ED staff (P=0.40).

Conclusion   In this cross-sectional study, the use of high-level PPE (FFP2 or equivalent and eye protection) by ED personnel during all contacts with patients with suspected or confirmed SARS-CoV-2 does not seem to be associated with a lower infection rate of ED staff compared to lower level PPE use. Attention should be paid to ED layout and social distancing to prevent cross-contamination of ED personnel. *European Journal of Emergency Medicine* 28: 202–209 Copyright © 2020 The Author(s). Published by Wolters Kluwer Health, Inc.

Introduction

Since the first cases of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) were discovered in China, the virus has spread rapidly over the world, causing a global pandemic [1,2]. The clinical spectrum of SARS-CoV-2, ranges from asymptomatic infections to a systemic illness with severe pneumonia causing acute respiratory distress syndrome (ARDS). Droplet transmission through coughing and sneezing is the primary form of transmission, although transmission can also occur through direct and indirect contact with surfaces in the immediate vicinity of the infected person. Furthermore, airborne transmission may occur under specific circumstances in which procedures

or treatments generate aerosols [nebulization, bag-valve-mask ventilation, noninvasive ventilation, cardiopulmonary resuscitation (CPR) and endotracheal intubation] [3–5].

Healthcare personnel working in emergency departments (EDs) or in the prehospital setting are at particular risk for SARS-CoV-2 transmission because the number of patient contacts on a daily basis is high, it is not always possible to obtain a reliable history and aerosol-generating procedures (AGPs) are performed regularly. Personal protective equipment (PPE) has, therefore, been considered of paramount importance to protect healthcare personnel [6].

On the basis of the mode of transmission, the WHO recommends droplet and contact precautions for healthcare personnel working with COVID-19 patients and airborne PPE precautions when AGPs are carried out [5]. At the same time, other organizations, including the US Centers for Disease Control (CDC) and the European Centre for Disease Prevention and Control (ECDC), recommend airborne precautions for all contact with patients with a (suspected) COVID-19 infection. However, the evidence underlying these recommendations is limited and largely translated from experiences with outbreaks of other viral infections, such as influenza [6,7].

Reported infection rates of healthcare personnel differ widely [8–11]. Whether this variety is caused by variation in prevalence of SARS-CoV-2, by exposure to AGP or by variety in PPE-usage (due to the variety in recommendations or shortage in PPE at the height of the pandemic), has never been reported.

Therefore, the aim of this study is to investigate the association between PPE use and SARS-CoV-2 infections among ED personnel in the Netherlands in a nationwide study.

Materials and methods
Study design and setting
We performed a nationwide cross-sectional study among permanent ED staff (doctors and nurses) working in EDs across the Netherlands at the time of the SARS-CoV-2 pandemic, in order to investigate if the level of PPE used for aerosol- and nonaerosol generating procedures in the ED were associated with SARS-CoV-2 infections among healthcare personnel.

The Netherlands is a relatively small country (41.543 km^2), with 78 EDs serving a population of 17.4 million people 24/7. Hospitals are spread across the country, with most hospitals being situated in the west of the country where population density is highest. In most hospitals ($n = 64$), the ED has a permanent staff of both ED physicians (consultants and residents) and ED nurses. Patients are seen both by ED physicians and by physicians and trainees from other specialties who work together with permanent personnel in most EDs [12].

Study period
The study period (1 March until 1 May) was chosen to include peak exposure for all hospitals across the country. The first case of SARS-CoV-2 in the Netherlands was reported on 27 February 2020 in the south of the country, after which SARS-CoV-2 spread rapidly, with relatively sparing of the northern regions [13]. Peak of the pandemic was encountered at the beginning of April with 1399 daily new cases, 611 hospitalizations and 175 COVID related fatalities, after which the curve flattened. The geographical distribution of COVID cases at the peak of the epidemic in the Netherlands is depicted in Fig. 1.

Study participants and data acquisition
An online survey was sent to all members of the Dutch Society of Emergency Physicians (DSEP). Members were asked to fill out a survey on behalf of the ED of the hospital where they practiced. The survey contained 42 questions about the number of ED attendances during the study period, the organization of care for patients with (suspected) SARS-CoV-2 provided in their EDs, the number of AGPs performed, SARS-CoV-2 testing policy of the hospital, PPE use and the number of suspected- and confirmed COVID-19 infections under healthcare personnel during the study period. Data about PPE use were requested for both the start- and end of the study period to account for changes in the PPE regime during the study period. Data were obtained both for patient contacts with and without AGPs.

SARS-CoV-2 infection rates of the general population in the catchment area of each hospital were obtained from the Dutch National Institute for Public Health and the Environment (Rijksinstituut voor Volksgezondheid en Milieu).
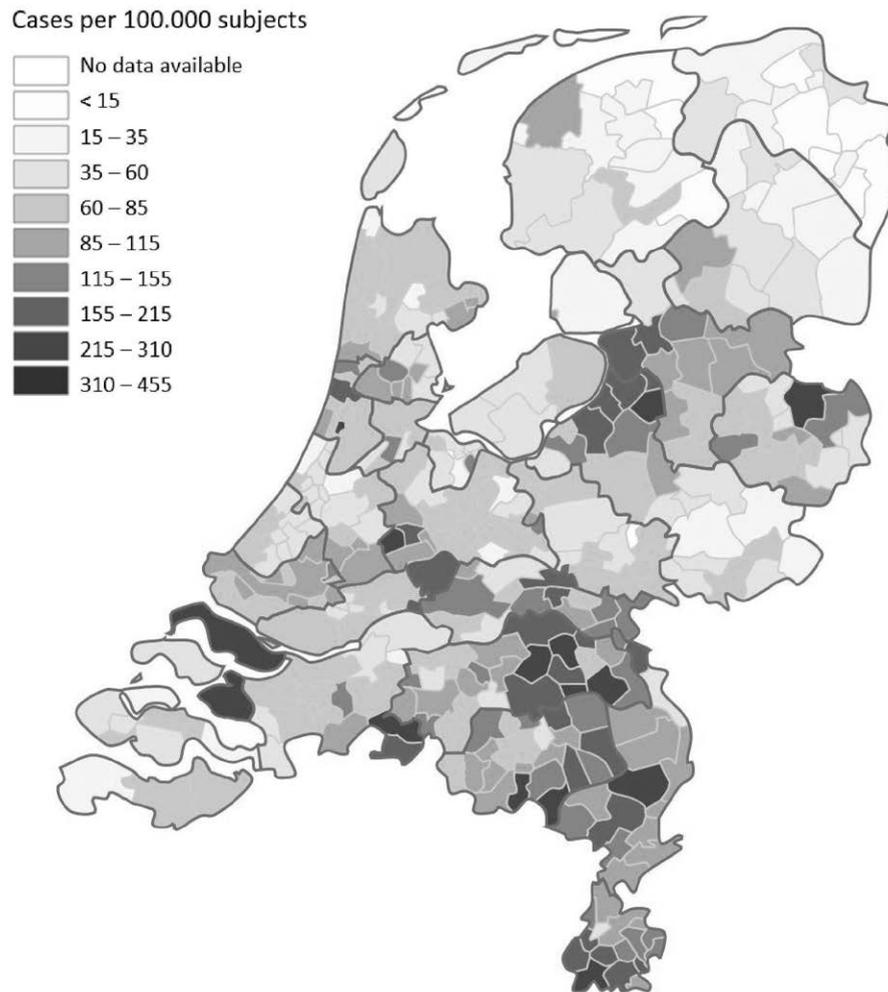
The study was regarded as exempt research by the medical ethical committee of the Medical Centre Leeuwarden (protocol number 1099).

Outcome
The primary outcome was the rate of confirmed SARS-CoV-2 infections among permanent ED staff between 1 March and 15 May 2020. The secondary outcome was the rate of confirmed and suspected SARS-CoV-2 infections among permanent ED staff between 1 March and 15 May 2020. SARS-CoV-2 infections were regarded as confirmed when viral DNA was detected by reverse transcriptase PCR (RT-PCR) in the nasopharynx swab.

To account for a maximum 14 day incubation time of SARS-CoV-2, 15 May and not 1 May was chosen. Permanent staff was defined as ED physicians (consultants and residents) and nurses who were working in the ED only (and not in other hospital locations or healthcare facilities) during the study period. The study was limited to permanent personnel to make it possible to calculate infection rates more accurately and minimizes the chance that personnel acquired infections elsewhere in the hospital.

Fig 1.

Cases per 100.000 subjects

- No data available
- < 15
- 15 – 35
- 35 – 60
- 60 – 85
- 85 – 115
- 115 – 155
- 155 – 215
- 215 – 310
- 310 – 455

Geographical distribution of COVID cases at the peak of the first wave of the epidemic in the Netherland.

Sample size calculation.
Based on an expected infection rate of at least 2% (on average 2% of the general population had SARS-CoV-2 antibodies during the study period [14]), and the general rule of thumb that the sample size should be 10 times larger than the number of variables in the study, we estimated that 2000 fulltime equivalent (FTE) of ED staff would be needed to adjust the relation of PPE use with our primary endpoint for 4–6 potential confounders in regression analysis [15]. With an anticipated average ED workforce of 50 FTE, we, therefore, aimed to recruit at least 40 EDs.

Data analysis
Descriptive statistics were represented as means (95% confidence interval) when normally distributed or median (IQR) when skewed. Categorical data were presented as number (n, %). PPE use in the ED during the study period was stratified according to the level of mucous membrane protection provided. The reference was EDs where FFP-2 (filtering facepiece particles >94%

aerosol filtration) masks (or equivalent or higher level of protection masks) and eye protection were worn during all patient contacts (irrespective of AGP were performed) throughout the whole study period. Unadjusted SARS-CoV-2 infection rates of personnel working in these EDs were compared to infection rates in other EDs by the chi-square test. Infection rates between various types of ED staff members (physicians, residents and nurses) were compared with analysis of variance with post hoc Tukey. Univariate correlation analysis was performed to investigate the effect of potential confounders on the relation between PPE use and SARS-CoV-2 infection rates.

Potential confounders considered were: the SARS-CoV-2 prevalence in the catchment area of the hospital (both cases and hospitalizations/100 000 subjects), the estimated number of patient contacts- and AGP per FTE ED personnel during the study period, organization of SARS-CoV-2 patient triage and care (triage before- or in ED), dedicated SARS-CoV-2 rooms (y/n), availability

of isolation room (y/n), reuse of PPE (y/n) and hospital testing policy for healthcare personnel [(was all ED personnel with complaints that could possibly be related to COVID tested (y/n)]. As testing policy changed in many institutions during the study period, a factor (between 0 and 1) was created as a proxy for testing policy, accounting for the date of policy change, wherein one was equivalent to 100% of the time testing all ED personnel with complaints.

Multivariable linear regression analysis was performed to investigate the association of PPE use and infection rate of ED personnel. All potential confounders significantly ($P < 0.1$) related to the SARS-CoV-2 infection rate in univariate analysis were included in the final regression model (forward entry). Missing data are reported according to the Strengthning the Reporting of Observational studies in Epidemiology guidelines [16].

All analyses were performed using, SPSS version 26.0 (SPSS inc.,Chicago, USA).

Results

Study population and logistics of COVID-19 care

Surveys were sent to all DSEP-members, representing 64 of the 78 different ED's across the country. In total, 45 surveys were returned (response rate 70.3%) of which 24 had filled out all 42 questions, and 21 had one or more missing data. The primary endpoint (SARS-CoV-2 infection rate of permanent ED personnel) was available for 43 ED (infection rates for ED nurses were not reported in two hospitals) and these were included for further analysis. Participating ED were spread across the country (7 in the northern provinces, 17 in the west, 8 in the south and 11 in the east). Table 1 depicts the characteristics of these 43 departments.

Triage of patients with a (suspicion of) a SARS-CoV-2 infection was performed outside the ED ($n = 18$) or in the ED ($n = 25$). Most EDs ($n = 39$, 90.7%) had dedicated areas or rooms where patients suspected of a SARS-CoV-2 infection were seen, either of fixed- ($n = 14$) or flexible ($n = 25$) size. Only a minority ($n = 7$, 16.3%) of the EDs had the capacity to treat all these patients in a sluice room. In all participating hospitals, ED physicians (consultants and registrars) and ED nurses were directly involved in the triage and primary care for SARS-CoV-2 patients, including AGP's such as CPR (88.4%) and initiation of noninvasive ventilation (44.2%). During the COVID-19 pandemic, endotracheal intubation in the ED was performed by anesthesiologists in the majority of the hospitals ($n = 39$, 90.7%).

At the start of the study period, as per protocol in 20 hospitals (46.5%), ED personnel with health complaints that could possibly be related to SARS-CoV-2 infection were immediately tested for SARS-CoV-2 with a nasopharynx swab. At the end of the study period, this was standard policy in 38 hospitals (88.4%).

Table 1   Hospital characteristics of participating hospitals

	Total	Median (IQR) per hospital
Hospital characteristics		
Urban hospital (*n*)	37	
Academic medical center (*n*)	6	
Yearly ED census (*n*)	114.3642	25.500 (16.000–31.359)
EM physicians (FTE)	354.5	8.2 (4.5–11.2)
EM residents (FTE)	384.0	8.2 (6.0–11.8)
ED nurses (FTE)	1546.7	34.3 (25.0–45.8)
ED characteristics during study period		
ED attendances (*n*)	125.728	2852 (1882–3798)
ED procedures (*n*)		
CPR	399	7 (2–13)
RSI	218	4 (0–7)

CPR, cardiopulmonary resuscitation; ED, emergency department; FTE, fulltime equivalent; IQR, interquartile range; RSI, rapid sequence intubation.

Basic hand hygiene was practiced in all 43 hospitals, and a protective base layer ($n = 43$, 100%), a fluid repellant overcoat ($n = 42$, 98%), gloves ($n = 42$, 98%) and eye protection ($n = 39$ (91%) for non-AGP contacts and $n = 41$ (95%) for AGP contacts were worn in most EDs at the start of the study period. A hood was worn in about half of the hospitals. For non-AGP patient contacts, considerable variation was present in the type of face masks used (Table 2). For AGP, FFP2 or equivalent level face masks were worn in all but three hospitals for AGP, and in all but two hospitals, eye protection was worn, with additional face protection in the form of a welding mask in 13 hospitals. In between the start- and end of the study period, PPE-policy for non-AGP changed in 27/43 hospitals, with more hospitals starting to use lower-level FFP face masks for non-AGP patient contacts. At the same time, eye protection (glasses or goggles) use and the use of fluid repellant overcoats increased. PPE use for AGP remained unchanged in the vast majority of hospitals (Table 2). Shortage of PPE was reported by two hospitals during the study period. FFP masks were sterilized and re-used in 17 hospitals (39.5%) during the study period and 18 hospitals (41.8%) reported the (temporarily) use of PPE from nonregular providers.

In 13 hospitals, representing 41 938 (32.8 %) of the patient contacts and 944 (30.8%) ED staff members, FFP-2 masks (or equivalent) and eye protection were worn during all patient contacts (irrespective of AGP) throughout the whole study period. This 'high level of protection' group was used as a reference group in subsequent analysis. The use of other PPE (baselayer, overcoat, gloves and hood) was not different in these hospitals compared to other hospitals.

Unadjusted SARS-CoV-2 infection rates

During the study period, 164 ED staff members from one of the 43 participating EDs were tested positive for SARS-CoV-2 (16 consultants, 27 residents and 121 nurses). The number of infected ED staff members per hospital ranged from 0 to 23 (corresponding to 0 and

Table 2   Personal protective equipment use as per 1 March 2020 and 1 May 2020 for ED staff in Dutch hospitals (n=43)

Non-AGP		PPE 1 March n (%)	PPE 1 May
Base layer	White jacket + trousers	37 (86)	37 (86%)
	Scrub suit	2 (5)	2 (5%)
	White jacket + trousers OR scrub suit	4 (9)	4 (9%)
Gloves	Single	41 (95)	41 (95%)
	Double	1 (2)	2 (5%)
	None	1 (2)	0
Overcoat	Overcoat with long sleeves	36 (84)	38 (88%)
	Plastic apron	3 (7)	1 (2%)
	Overcoat and apron	3 (7)	3 (7%)
	None	1 (2)	1 (2%)
Surgical hat	Surgical hat or orthopedic hoody	23 (53)	19 (44%)
	None	20 (47)	24 (66%)
Eye protection	Splash goggles/fire goggles/splash shield/similar alternative	39 (91)	42 (98%)
	None	4 (9)	1 (2%)
Face mask	Surgical face mask or FFP1	11 (26)	26 (60%)
	FFP2 or N95	29 (67)	16 (37%)
	Surgical face mask/FFP1 OR FFP2/N95	2 (5)	1 (2%)
	None	1 (2)	0
AGP			
Base layer	White jacket and trousers	37 (86)	37 (86%)
	Scrub suit	3 (7)	4 (9%)
	White jacket+ trousers OR scrub suit	3 (7)	2 (5%)
Gloves	Single	39 (91)	37 (86%)
	Double	4 (9)	6 (14%)
	None	0	0
Overcoat	Overcoat with long sleeves	38 (88)	38 (88%)
	Plastic apron	0	0
	Overcoat and apron	4 (9)	5 (12%)
	None	1 (2)	0
Surgical hat	Surgical hat or orthopedic hoody	28 (65)	28 (65%)
	None	15 (35)	15 (35%)
Eye protection	Splash goggles/fire goggles/splash shield/similar alternative	41 (95)	43 (100%)
	none	2 (5)	0
Face mask	Surgical face mask or FFP1	1 (2)	1 (2%)
	FFP2 or N95	40 (93)	41 (95%)
	Surgical face mask/FFP1 OR FFP2/N95	1 (2)	1 (2%)
	None	1 (2)	0
Additional PPE	Welding screen	13 (30)	15 (35%)

AGP, aerosol generating procedures; FFP1, filtering facepiece particles >80% aerosol filtration; FFP2, filtering facepiece particles >94% aerosol filtration; N95: >95% aerosol filtration; PPE, personal protective equipment.

31.1% of the ED workforce). The majority of the participating hospitals had 1–9 infected staff members, nine hospitals had no infected personnel, whereas four hospitals had >10 infected staff members. In 69 staff members, SARS-CoV-2 was suspected on any time during the study period, but not confirmed by testing. Table 3 shows the number- and profession of ED staff who tested positive for- or were suspected of SARS-CoV-2 during the study period, stratified by the PPE-use group. In hospitals where FFP-2 masks AND eye protection were worn during all patient contacts throughout the whole study period, 7.3 (3.4–11.1) % of personnel met the prespecified primary outcome (confirmed SARS-CoV-2 infection

during the study period), compared to 4.0 (1.9–6.1)% in other hospitals (absolute difference + 3.3%, $P < 0.001$). For suspected infections these percentages were 0.9 (0.0–2.2)% and 2.4 (0.8–4.1)%, respectively (absolute difference –1.5% $P < 0.001$). The infection rate was not significantly different between nurses, residents and consultants ($P = 0.25$). Of the nine hospitals with no infected ED personnel, two used high level of protection PPE throughout the study period for all patient contacts.

Adjusted SARS-CoV-2 infection rates
Univariate correlation analysis was carried out to investigate which variables potentially confounded the relation between PPE use and SARS-CoV-2 infection rate during the study. Results are represented in Table 4. Hospital staff testing policy was identified as a potential confounder of the relation between PPE use and the primary outcome (confirmed SARS-CoV-2 infections among ED staff) in the study period ($r = -0.35$, $P = 0.021$). Interestingly, SARS-CoV-2 population prevalence in the catchment area of the hospitals ($r = 0.17$, $P = 0.28$) and ED-logistics of care and ED-layout variables were not associated with the number of confirmed- (or suspected) infections of ED personnel.

Multivariable analysis with forward entering of variables was carried out to explore if the hospital staff testing policy was a confounder of the relation between the level of PPE used and the primary outcome. In the final model, containing these two variables, PPE use was no longer associated with the primary endpoint ($R^2 = 0.039$, $P = 0.40$) as a more active staff testing policy was present in the hospitals where a higher level of PPE was used, resulting in more confirmed SARS-Cov-2 staff infections (collinearity statistic 0.95).

Discussion
In this nationwide cross-sectional study of permanent ED personnel working in EDs across the Netherlands, we found that the consequent use of high-level PPE (FFP2 mask or equivalent and eye protection) by ED personnel during all contacts with patients with- or suspected of SARS-CoV-2 was not associated with a lower infection rate among ED personnel compared to when a lower level of PPE [FFP1(filtering facepiece particles >80% aerosol filtration) or surgical mask] was used.

PPE use for SARS-CoV-2 patients has been a topic of much debate over the past few months, especially for patients in whom AGP are not performed. The WHO advises the use of surgical masks when no AGP is performed, whereas the ECDC advises to wear FFP2/N95 (>95% aerosol filtration) respirators at any time when working with COVID-19 suspected or proven patients [5,17,18]. Most of the recommendations are based on limited evidence, and often extrapolated from studies on other respiratory viruses, such as influenza [7]. A recent meta-analysis on the effectiveness of N95 respirators

Table 3 Unadjusted severe acute respiratory syndrome coronavirus-2 infection rates among ED healthcare personnel, stratified by personal protective equipment use during the study period

	All hospitals (n=43)	High level of protection hospitals (n=13)	Other hospitals (n=30)	Missing	*P value*
All personnel					
ED staff members (*n*)	3064	944	2099	2	
Confirmed SARS-CoV-2-Infections [% (95% CI)]	164 [5.1 (3.2–7.0)]	73 [7.3 (3.4–11.1)]	91 [4.0 (1.9–6.1)]	2	<0.001**
Suspected (but not confirmed) SARS-CoV-2- Infections [% (95% CI)]	69 [2.2 (0.8–3.0)]	8 [0.9 (0.0–2.2)]	61 [2.4 (0.8–4.1)]	3	<0.001**
Suspected + Confirmed SARS-CoV-2 infections [% (95% CI)]	233 [7.0 (5.0–9.1)]	81 [8.2 (4.5–11.9)]	152 [6.4 (3.9–9.1)]	4	0.23
ED consultants					
Total number of consultants	459	121	338		
Confirmed SARS-CoV-2-infections (*n*)	16	3	13		0.98**
ED residents					
Total number of residents	431	123	308		
Confirmed SARS-CoV-2-infections (*n*)	27	14	13		0.021**
ED nurses					
Total number of nurses	2153	700	1453		
Confirmed SARS-CoV-2 infections (*n*)	121	56	65		<0.001

CI, confidence interval; ED, emergency department; SARS-CoV-2, severe acute respiratory syndrome corona virus 2.

Table 4 Univariate Spearmann correlation coefficients of variables potentially associated with severe acute respiratory syndrome corona virus 2 infection rate of ED staff

	Confirmed SARS-CoV-2 (n=164)		Confirmed or suspected SARS-CoV-2 (n=233)	
	r	*P* value	*r*	*P* value
High-level PPE throughout study period	0.32	0.036	0.16	0.32
Potential confounders				
SARS-CoV-2 cases/100 000 in catchment area of hospital[a]	0.17	0.28	0.17	0.27
SARS-CoV-2 hospitalizations/100 000 in catchment area of hospital[a]	0.07	0.66	0.16	0.31
Patient contacts/FTE ED personnel	0.14	0.39	−0.06	0.71
AGP/FTE ED personnel	0.004	0.98	0.23	0.19
Dedicated rooms in (separate area of) ED for SARS-CoV-2 patients	−0.02	0.88	0.09	0.55
Triage outside ED (y/n)	−0.04	0.79	0.05	0.77
Isolation room (y/n)	−0.18	0.24	−0.12	0.46
Re-use of PPE (y/n)	0.04	0.80	0.13	0.42
Hospital staff testing policy (% of study period in which all symptomatic personnel was immediately tested)	−0.35	0.021	−0.087	0.58

AGP, aerosol generating procedures; ED, emergency department; FTE, fulltime equivalent; PPE, personal protective equipment; SARS-CoV-2, severe acute respiratory syndrome corona virus 2.
[a]Cases/100 00 and hospitalizations/100 000 in catchment area were measured on 6 May , halfway the study period. . .

versus surgical masks against influenza could not demonstrate a difference between these two [19]. Our findings are in line with this. When adjusted for the hospital staff testing policy (as more liberal testing will result in more confirmed cases), the PPE regime was not a predictor of SARS-CoV-2 infections. In line with this, the combined number of confirmed and suspected ED staff infections was not significantly different between hospitals in which high-level PPE was used for all patient contacts compared to the other hospitals. Thereby our study supports current WHO SARS-CoV-2 PPE recommendations and contributes to the cost-effective use of PPE [5].

The overall infection rate of ED personnel in our study was 5.4%. This was much higher than the population prevalence in the general population during the study period (0.087%) but comparable to previous reports on SARS-CoV-2 infection rates of healthcare personnel [8–10]. The high infection rate may be explained by various factors. First, the number of patient contacts in the ED is high, and for many presenting patients, it is unclear if they have SARS-CoV-2, as a significant proportion of patients is asymptomatic. Second, the ED is a department where many AGPs are performed, which increases the risk of aerosol spread. Finally, ED layout and work conditions may play a role. Whereas the majority of the participating hospitals in our study had 1–9 infected staff members, four hospitals had >10 infected staff members. Staff-to-staff transmission between (asymptomatic) personnel may have occurred in these hospitals, emphasizing the importance of social distancing and other preventive measures on the workfloor as well. The clustering of

infections in some hospitals could not be explained by the shortage of PPE. Although reported by a few hospitals, these were not the hospitals with high staff infection rates. Due to shortage, face masks were sterilized and re-used in a few hospitals during the study period. However, recent literature has confirmed the safety of this procedure [20]. Besides hospital factors, community factors may influence the SARS-CoV-2 ED personnel infection rate as well: when the SARS-CoV-2 prevalence is higher in the catchment area of the hospital (where most personnel live), their theoretical chance of acquiring SARS-CoV-2 outside the hospital is higher as well. Interestingly, we could not demonstrate such a relation, despite considerable variation in the number of infected- or hospitalized patients/100 000 (from 61 to 316) in the various hospital catchment areas.

In this study, we gathered information regarding various potential confounders of the relation between PPE use and our primary endpoint (confirmed ED staff infection rate), including the SARS-CoV-2 population prevalence in the catchment area of the hospital, the number of patient contacts and AGP's performed during the study period and parameters regarding the organization of SARS-CoV-2 care and physical layout of the ED. None of these parameters was significantly associated with our primary endpoint, although it should be mentioned that our study was not powered to detect significant associations of these potential confounders. As both PPE regime and none of the potential confounders was significantly correlated to personnel infection rates, we hypothesize that other (unmeasured) factors, such as the previously mentioned staff-to-staff transmission play an important role.

Limitations
This study had several limitations, most inherent to the retrospective design. First, we were reliant on reliable data registration and data-completeness. As mentioned, we were unable to identify all AGP performed during the study period and could not calculate infection rates for two hospitals as the total number of staff was not provided. Furthermore, the level of detail regarding the organization of SARS-CoV-2 care and physical layout of the ED was limited, as for example, no information was obtained regarding sessional/nonsessional use of PPE, and information regarding floor space and the number of staff working simultaneously was lacking. Furthermore, although we knew the number of patients hospitalized per 100 000 inhabitants for each hospital catchment area, it was unknown how many patients with confirmed SARS-CoV-2 were actually seen in each department during the study period. Further, we cannot completely exclude that the absence of an association between PPE regime and our primary endpoint could be attributed to a type II statistical error, although we render this highly unlikely as the event incidence rate (ED personnel

tested positive) was much higher than 2% we anticipated in our power calculation. Finally, we may potentially have missed ED personnel who had a false negative RT-PCR for SARS-Cov-2 (as sensitivity is reported to be 71–98% [21]) or who tested positive for SARS-CoV-2 when they were tested outside the hospital where they practiced.

Conclusion
In this cross-sectional study, the use of high-level PPE (FFP2 or equivalent and eye protection) by ED personnel during all contacts with patients with suspected or confirmed SARS-CoV-2 does not seem to be associated with a lower infection rate of ED staff compared to lower-level PPE use. Attention should be paid to ED layout and social distancing measures on the work floor in order to prevent cross-contamination.

Conflicts of interest
There are no conflict of interest.

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