Factors associated with an increased risk of SARS-CoV-2 infection in healthcare workers in aerosol-generating disciplines

Risikofaktoren für SARS-CoV-2-Infektionen bei medizinischem Personal in aerosol-generierenden Disziplinen

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Schlüsselwörter

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ABSTRACT

Background Healthcare workers (HCWs) are at a high risk of SARS-CoV-2 infection due to exposure to potentially infectious material, especially during aerosol-generating procedures (AGP). We aimed to investigate risk factors for SARS-CoV-2 infection among HCWs in medical disciplines with AGP.
Methods A nationwide questionnaire-based study in private practices and hospital settings was conducted between 12/16/2020 and 01/24/2021. Data on SARS-CoV-2 infections among HCWs and potential risk factors of infection were investigated.

Results 2070 healthcare facilities with 25113 employees were included in the study. The overall infection rate among HCWs was 4.7 %. Multivariate analysis showed that regions with higher incidence rates had a significantly increased risk of infection. Furthermore, hospital setting and HCWs in gastrointestinal endoscopy (GIE) had more than double the risk of infection (OR 2.63; 95 % CI 2.50–2.82, $p < 0.01$ and OR 2.35; 95 % CI 2.25–2.50, $p < 0.01$). For medical facilities who treated confirmed SARS-CoV-2 cases, there was a tendency towards higher risk of infection (OR 1.39; 95 % CI 1.11–1.63, $p = 0.068$).

Conclusion Both factors within and outside medical facilities appear to be associated with an increased risk of infection among HCWs. Therefore, GIE and healthcare delivery setting were related to increased infection rates. Regions with higher SARS-CoV-2 incidence rates were also significantly associated with increased risk of infection.

ZUSAMMENFASSUNG

Hintergrund Medizinisches Personal ist durch die Exposition gegenüber potenziell infektiösem Material einem erhöhten Infektionsrisiko ausgesetzt. Dies gilt insbesondere für Fachdisziplinen mit aerosolgenerierenden Prozeduren (AGP). Hierfür gibt es jedoch kaum Daten, insbesondere für den ambulanten Versorgungssektor. Ziel dieser Studie war es, die Häufigkeit sowie potenzielle Risikofaktoren für SARS-CoV-2-Infektionen bei medizinischem Personal von aerosolgenerierenden Disziplinen zu erheben und zu identifizieren.

Methoden Zwischen dem 16.12.2020 und 24.01.2021 wurde eine bundesweite Umfrage in den Disziplinen der gastrointestinalen Endoskopie (GIE); Hals-, Nasen-, Ohrenheilkunde (HNO); Mund-, Kiefer-, Gesichtschirurgie (MKG) und der Zahn-, Mund-, Kieferheilkunde (ZMK) durchgeführt. Hierbei wurden Daten zu SARS-CoV-2-Infektionen beim medizinischen Personal sowie potenzielle Risikofaktoren erfasst.

Ergebnisse 25113 Beschäftigte in 2070 Einrichtungen wurden in die Studie eingeschlossen. Die Gesamtinfektionsrate unter dem medizinischen Personal betrug 4,7 %. Die multivariate Analyse zeigte, dass Regionen mit höheren Inzidenzraten ein deutlich erhöhtes Infektionsrisiko aufwiesen. Außerdem war das Infektionsrisiko in Krankenhäusern und bei Beschäftigten der GIE um mehr als das Zweifache erhöht (OR 2,63; $p < 0,01$ und OR 2,35; $p < 0,01$). Ein tendenziell erhöhtes Infektionsrisiko bestand in Einrichtungen, die bestätigte SARS-CoV-2-Fälle behandelt haben (OR 1,39; $p = 0,068$).

Fazit Das SARS-CoV-2-Infektionsrisiko für medizinisches Personal wird sowohl von Faktoren innerhalb als auch Faktoren außerhalb von medizinischen Einrichtungen bestimmt. Die Fachrichtung der GIE sowie die Tätigkeit in einem Krankenhaus beeinflussen signifikant die Infektionsraten. Eine höhere SARS-CoV-2-Inzidenzrate in der Region geht ebenfalls mit einem signifikant erhöhten Infektionsrisiko einher.

Introduction

For more than a year, the "coronavirus disease 2019" (COVID-19) has kept the world and especially the healthcare sector on tenterhooks. An initially small outbreak of the virus "severe acute respiratory syndrome coronavirus type 2" (SARS-CoV-2) has since developed into a worldwide pandemic with over 200 million cases (as of 08/30/2021) [1].

Healthcare workers (HCW) have been particularly exposed during the pandemic, and data shows an increased infection rate among HCW compared to the general population [2]. Data from different countries emphasise the increased risk for HCW, especially those with direct patient contact [3, 4, 5]. Based on these data and the risk of transmission between HCWs, the Standing Committee on Vaccination (STIKO) had initially issued a prioritized vaccination recommendation for people working in medical facilities. Transmission of SARS-CoV-2 mainly takes place via respiratory droplets and aerosols [6]. Numerous medical procedures typical for specific medical disciplines are widely recognized to generate aerosols and, therefore, are assumed to increase the risk of infection. HCWs who carry out aerosol-generating procedures (AGP) or activities close to patients' faces were given higher priority for vaccination in Germany, even though real-world data demonstrating the increased risk is limited [5]. In particular, evidence for this within the outpatient-care sector is lacking.

As part of the collaborative project B-FAST of the Network of University Medicine (NUM), initiated by the German Federal Ministry of Education and Research, Augsburg University Hospital was commissioned to acquire data on facial and AGP-associated medical subspecialties such as gastrointestinal endoscopy (GIE), otorhinolaryngology (ORL), oral and maxillofacial surgery (OMS), and dentistry (DM). The study was supported by the Bavarian State Ministry of Science and Arts, as well as the respective professional societies, including the German Society of Gastroenterology, Digestive and Metabolic Diseases (DGVS), the German Society of Dentistry and Oral Medicine (DGZMK), the German Society of Oral and Maxillofacial Surgery (DGMKG), The German Society of Oto-Rhino-Laryngology, Head and Neck Surgery (DGHNO-KHC) and the Professional Association of Gastroenterologists in Private Practice (bng).

Material and methods

Questionnaire

The present study is a descriptive, explorative, cross-sectional, questionnaire-based study conducted in Germany between 16th December 2020 and 24th January 2021, aiming at investigating the prevalence of SARS-CoV-2 infection among HCW exposed to AGP in hospitals and private practices as well as at identifying potential risk factors for infection in medical facilities. The questionnaire for the survey was designed based on detailed literature research and on expert suggestions provided by the respective disciplines GIE, ORL, OMS, and DM (**Supplement 1**).

The study's primary outcomes are the prevalence of SARS-CoV-2 cases among HCW in the AGP-related specialties and the rate of medical facilities that have had at least one SARS-CoV-2 case among their HCW.

Descriptive data collected by the questionnaire comprised the healthcare delivery setting, medical specialty, number of procedures performed per day, and number of HCW working in the respective medical unit. Furthermore, the questionnaire focused on pandemic-related information, including the number of SARS-CoV-2 infections in a medical unit, pre-interventional testing, and treatment of confirmed SARS-CoV-2 cases.

Pandemic-related information was cumulated from the beginning of the pandemic in Germany until the end of the survey (3rd calendar week of 2021). The first two digits of the ZIP code of each participating medical facility were used to correlate the local incidence rates in the region with the infection rate among participating HCW.

The questionnaire was addressed to hospitals and private practices of GIE, OMS, ORL, and DM specialties. Medical facilities not attributable to one of the four aforementioned medical specialties were considered ineligible and excluded from the data analysis. Study participants were recruited via e-mail invitations distributed by the respective professional societies (DGVS, DGZMK, DGMKG, DGHNO-KHC, bng). Recruitment was done through the heads of department or private practice owners, who were invited to answer the online questionnaire implemented in UniPark©. Participation in the survey was anonymous and voluntary, without direct contact with the study site.

Statistical analysis

Statistical analysis was performed using SPSS version 27.0. Categorical variables such as ZIP-code region, medical specialty, type of medical facilities such as a hospital or private practice, the presumed source of infection, pre-interventional testing of patients, and treatment of confirmed SARS-CoV-2 cases are presented as absolute frequencies and percentages. The interval-scaled variables such as the number of employees and the number of procedures performed per day are presented as mean values and standard deviations.

The prevalence of SARS-CoV-2 among HCWs was defined as the aggregated number of SARS-CoV-2 positive HCW within a considered healthcare delivery setting and within a considered medical specialty divided by all HCW reported for the respective category. The rate of medical units positive for SARS-CoV-2 was defined as the aggregated number of medical units reporting at least one positive HCW SARS-CoV-2 case within a considered healthcare delivery setting and within a considered medical specialty divided by all medical units in the respective category.

Mean COVID-19 incidences were calculated using official county-granular data from the Robert Koch Institute (RKI), the leading governmental institution in biomedicine in Germany, aggregated to 10 ZIP-code regions over the whole period considered in the survey [7].

In the present manuscript, GIE data are compared with the aggregated data from the other AGP disciplines such as ORL, OMS, and DM. The latter three were termed Non-GIE. The relationships between nominal-scaled variables were tested inferentially using Chi-square independence tests or Fisher's exact test. Mean values were compared using Mann-Whitney-U test. The analysis of the risk factors associated with infections among HCW was carried out using multivariate logistic regression with the occurrence of a SARS-CoV-2 infection as a dependent variable and potential influencing variables considered in the manuscript as independent variables. The ZIP-code region with the lowest incidence (20–29) was chosen as a reference group. Furthermore, private practice, Non-GIE specialty, treatment of SARS-CoV-2 cases, and no pre-interventional testing were also chosen as reference groups in the multivariate logistic regression. The significance level was set as $p < 0.05$.

Results

Sample characteristics

Twenty thousand facilities were contacted, and 2,096 facilities participated in the survey. Twenty-six facilities were excluded from the data analysis based on prespecified eligibility criteria. Consequently, 2070 remaining questionnaires were analyzed, of which 113 (5.5 %) had non-exclusionary missing data. Analyzed study participants included 1828 (88.3 %) private practices and 242 (11.7 %) hospitals. 284 GIE private practices (13.7 %) and 145 (7.0 %) GIE hospitals were included (▶ **Table 1**). The distribution of the Non-GIE facilities between the different disciplines can be found in the supplement (**Supplement 2**).

Overall, hospitals performed significantly more procedures per day compared with private practices (41.5 vs. 32.9 $p < 0.01$). Non-GIE hospitals and private practices performed significantly more

▶ **Table 1** Absolute and percentage distribution of medical facilities by type and specialty, and mean number of procedures performed per day.

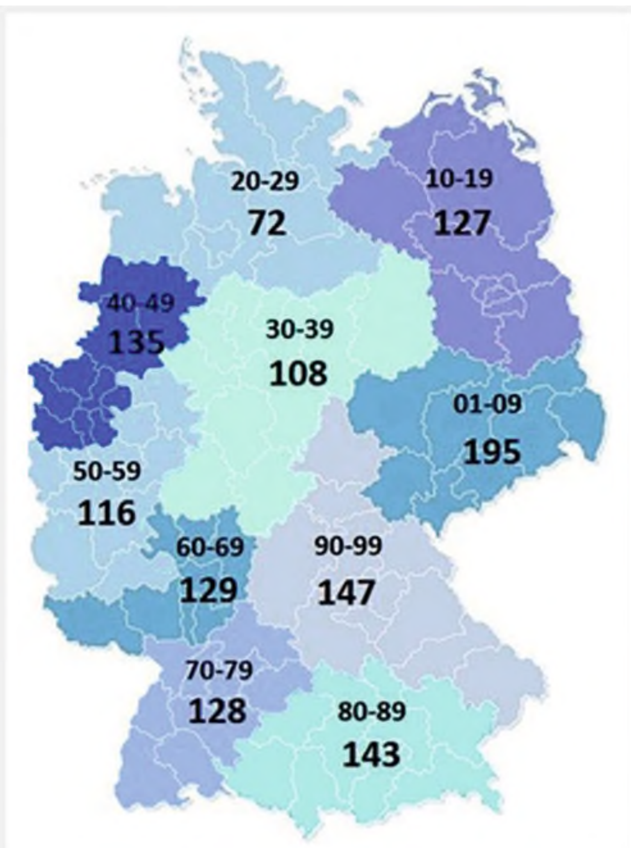
Specialisation	Number of facilities	% of all facilities	Mean number of procedures per day (SD)
Private practices			
GIE	284	13.7	21.2 (15.3)**
Non-GIE	1544	74.6	24.9 (12.9)
Total	1828	88.3	32.9 (26.8)
Hospital			
GIE	145	7.0	34.7 (27.7)**
Non-GIE	97	4.7	58.6 (35.6)
Total	242	11.7	41.5 (23.4)##

GIE: Gastrointestinal Endoscopy; Non-GIE: other AGP-associated specialties: otorhinolaryngology, oral and maxillofacial surgery, and dentistry; SD = Standard deviation.
**Significance level $p < 0.01$; *Significance level $p < 0.05$; n. s. not significant: comparison of GIE vs. Non-GIE.
##Significance level $p < 0.01$; #Significance level $p < 0.05$; n. s. not significant: comparison of hospital vs. private practice.

procedures per day than GIE hospitals and private practices, respectively (hospitals: 58.6 vs. 34.7, p < 0.01 and private practices: 24.9, vs. 21.2, p < 0.01).

Distribution of the study participants according to ZIP-code region and corresponding mean incidences

From the beginning of the pandemic, incidences showed a similar development in all ZIP-code regions with a wave-like development from the 12th to the 18th calendar week. A steady increase of incidence rates but varying amplitudes was observed from the 40th calendar week of 2020 (**Supplement 4**). Regarding the rate of new infections during the considered period, the highest mean incidence was observed in the ZIP-code regions 01–09 (195, SD = 143.0), 90–99 (147, SD = 90.3), and 80–89 (143, SD = 71.7), all of which are located in the eastern part of Germany. The lowest mean incidences were reported in the ZIP-code regions 20–29 (72, SD = 38.3) in the northern and 30–39 (108, SD = 60.6) central part of Germany (► **Fig. 1**). The largest proportion of participating medical facilities belonged to the districts with the ZIP-codes 80–89 (13.4 %), and the most seldomly represented districts were those of 01–09 (4.8 %) (**Supplement 3**).



► **Fig. 1** Mean incidence of COVID-19 infection per 100 000 inhabitants in Germany according to the ZIP-code, region beginning from the 2nd COVID-19-wave (40 h calendar week of 2020) until the end of the survey (3rd calendar week of 2021) Source: Robert Koch-Institut: SurvStat@RKI 2.0, https://survstat.rki.de, Data request: 02.08.2021.

HCW status per specialty

Two thousand seventy medical facilities included in the analysis comprised a total of 25113 HCW in the respective fields of specialisation (see ► **Table 2**). In total, the rate of HCW who were reported to have had a SARS-CoV-2 infection was 4.7 %, with a significantly higher proportion of infected HCW in hospitals than private practices (6.3 % vs. 4.0 %, p < 0.01). The overall rate was significantly higher in GIE than Non-GIE (7.7 % vs. 3.5 %, p > 0.01). GIE and Non-GIE were significantly different for both private practices and hospitals (5.3 % vs. 3.6 %, p < 0.01 and 9.9 % vs. 3.1 %, p < 0.01), respectively. Information on the occurrence of SARS-CoV-2 infections on the facility level can be found in **Supplement 5**.

Pre-interventional testing

Patients were tested pre-interventionally, significantly more often in hospitals than in private practices (80.0 % vs. 14.1 %). In private practices, Non-GIE specialties tested their patients significantly more frequently than GIE (15.2 % vs. 7.7 %, p < 0.01). In hospitals, 75.6 % of Non-GIE patients and 82.7 % of GIE patients were tested before procedures (p = 0.06). Furthermore, GIE hospitals reported testing their patients significantly more frequently using rapid antigen testing than Non-GIE hospitals (36.4 % vs. 22.3 %, p < 0.01) (► **Table 3**).

Treatment of confirmed SARS-CoV-2 cases

In total, 26.3 % of medical facilities reported to have treated confirmed SARS-CoV-2 cases. Hospitals treated patients with SARS-CoV-2 infection almost four times more often than private practices (77.3 % vs. 19.5 %, p < 0.01) (► **Table 4**). Overall, GIE treated significantly more SARS-CoV-2 patients than Non-GIE (32.4 % vs. 24.7 %, p < 0.01). This difference was significant for GIE and Non-GIE private practices (7.7 % vs. 21.8 %, p < 0.01), but not for the hospital setting.

Multivariate analysis of risk factors associated with SARS-CoV-2 infection of HCW

The ZIP-code region significantly influenced the risk of infection of HCW. The ZIP-code regions 60 to 89 was associated with an increased risk of infection among HCW. For the ZIP-code regions, 01–09 with the highest SARS-CoV-2 incidence rates in Germany, the risk of infection was 2.04 times higher than the reference group (95 % CI 1.12–3.69, p = 0.019).

Comparing the risk of infection between facilities, HCW in hospitals had 2.63 times (95 % CI 2.50 – 2.82, p < 0.01) increased risk of infection. Comparing the specialty area, HCW in GIE had 2.35 times (95 % CI 2.25–2.50, p < 0.01) increased risk of SARS-CoV-2 infection. The number of procedures carried out per day in a medical facility increased the probability of infection, however, only marginally (OR 1.01, 95 % CI 1.01–1.01), p < 0.01). Treatment of confirmed SARS-CoV-2 patients was related to increased risk of infection (OR 1.39, 95 % CI 1.11–1.63, p = 0.068); however, this association was only marginally insignificant (► **Fig. 2**).

▸ **Table 2** SARS-CoV-2-positive HCW according to facility type and specialty.

	Specialty	Aggregated number of HCW	Number of SARS-CoV-2 infections	Prevalence of SARS-CoV-2 infection
Private Practice	GIE	3324	177	5.3 %**
	Non-GIE	14411	527	3.6 %
Hospital	GIE	3516	348	9.9 %**
	Non-GIE	3862	120	3.1 %
Total	GIE	6840	561	7.7 %**
	Non-GIE	18273	647	3.5 %
	Private Practice	17735	704	4.0 %**
	Hospital	7378	468	6.3 %
	Total	25113	1172	4.7 %

The relation between specialty and proportion of SARS-CoV-2 positive HCW was statistically tested using chi-square independence test. A model was calculated for each type of facility and the total sample.
**Significance level $p < 0.01$; *Significance level $p < 0.05$; n. s. not significant.
GIE: Gastrointestinal Endoscopy; Non-GIE: other AGP-associated specialties: otorhinolaryngology, oral and maxillofacial surgery, and dentistry; SD: Standard deviation.

▸ **Table 3** Pre-interventional testing according to facility type and specialty.

	Total		Non-GIE		GIE		
	Number of facilities	%	Number of facilities	%[a]	Number of facilities	%	p-value
Private practices							
No testing	1565	85.9	1303	84.8	262	92.3	< 0.01
Testing	256	14.1	234	15.2	22	7.7	
▪ PCR	149	58.2	143	61.1	6	27.3	< 0.01
▪ Antigen	107	41.8	91	38.9	16	72.7	0.89
Hospital							
No testing	92	20.0	42	24.4	50	17.3	0.06
Testing	369	80.0	130	75.6	239	82.7	
▪ PCR	253	68.6	101	77.7	152	63.6	0.19
▪ Antigen	116	31.4	29	22.3	87	36.4	< 0.01

GIE: Gastrointestinal Endoscopy; Non-GIE: other AGP-associated specialties: otorhinolaryngology, oral and maxillofacial surgery, and dentistry.
PCR: Polymerase chain reaction.
[a] Rates refer to the total of answers given by participating facilities.

Discussion

This study is the first to present cumulative data on the prevalence of SARS-CoV-2 infection in HCW in different medical subspecialties and healthcare delivery settings. In particular, this manuscript focuses on medical disciplines associated with AGP, including GIE, ORL, OMS, and DM. Data from private practices and hospitals were collected via a nationwide questionnaire-based survey conducted in Germany (83.02 Mio inhabitants) between 16th December and 24th January 2021 [8].

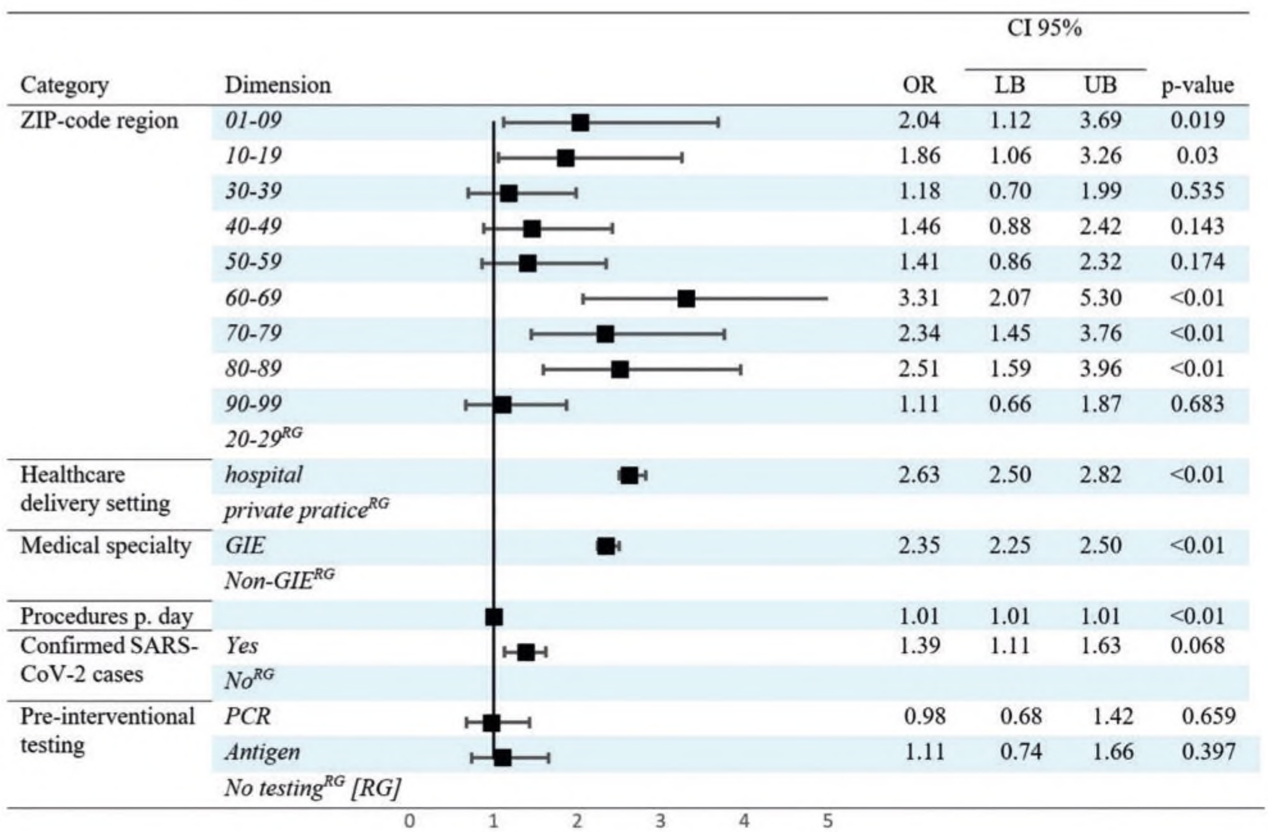
SARS-CoV-2 prevalence

Current data on the prevalence of SARS-CoV-2 infections among HCW are inconsistent, ranging from 4.3 % to 32.5 % [3, 4, 9, 10, 11, 12, 13, 14, 15]. Our study shows a nationwide HCW-infection

▸ **Table 4** Treatment of confirmed SARS-CoV-2 cases according to facility type and specialty.

	Total		Non-GIE		GIE		
	Number of facilities	**%**	**Number of facilities**	**%**	**Number of facilities**	**%**	**p-value**
Private practice	356	19.5	336	21.8	22	7.7	< 0.01
Hospital	187	77.3	70	72.2	117	80.7	0.548
Total	545	26.3	406	24.7	139	32.4	< 0.01

GIE: Gastrointestinal Endoscopy; Non-GIE: other AGP-associated specialties: otorhinolaryngology, oral and maxillofacial surgery, and dentistry.



▸ **Fig. 2** Multivariate logistic regression of risk factors associated with SARS-CoV-2 infections among HCW. HCW: healthcare worker; GIE: Gastrointestinal Endoscopy; Non-GIE: other AGP-associated specialties: otorhinolaryngology, oral and maxillofacial surgery, and dentistry. OR: odds ratio, CI: confidence interval, LB: lower bound, UB: upper bound, RG reference group.

rate of 4.7 % within the four examined specialties. This infection rate aligns with a recently published seroprevalence study from Germany, reporting an HCW-infection rate of 4.6 % in the period until February 2021 [5]. Due to the current state of research, there is no consensus regarding the increased infection rate of HCW compared to the normal population. Jungo et al. (2021) could not confirm an increased rate of infections in dental offices compared to the normal population [16]. Nevertheless, there is rising evidence that HCW are at higher risk for SARS-CoV-2 infection than the general population [4, 5]. At the end of our survey, on 24th January 2021, the RKI officially reported 2 134 936 confirmed cases in Germany [17]. According to this data, approximately 2.6 % of the German population had been infected with SARS-CoV-2. Based on these figures, it can be inferred that HCW involved in AGP may have an increased risk of infection compared to the general population. However, the official figures of the RKI do not consider unreported cases, as some infections, such as an asymptomatic course of the disease, may not be recorded in official registries [18, 19]. The project “Dunkelzifferradar”, funded by the Federal Ministry of Education and Research, used a mathematical model to estimate about 6.5 million infections in Germany by the end of January 2021. This would have resulted in a Germany-wide prevalence of 7.8 % at the time of the survey [20, 21]. Another estimate is given by the Gutenberg COVID-19 study, which indicates that around 42 % of infections in Germany are undetected, resulting in a Germany-wide prevalence of 4.5 % at the time of the survey [22]. Considering these estimates, our study cannot clearly demonstrate an increased risk for SARS-CoV-2 infection for HCW in the examined disciplines, except for HCW in GIE hospital settings who had a prevalence of 9.9 %.

Healthcare setting and AGP procedures

According to our multivariate model, the hospital setting was associated with an increased risk of SARS-CoV-2 infection among HCW. Assuming that patients are a potential source of infection in a medical facility, the number of patients seen per day and the volume of procedures performed may influence the risk of infection. This consideration was confirmed in our study by a significant association between the occurrence of infection and the number of procedures performed per day. Hospitals perform overall more procedures and more urgent or emergency procedures than private practices. In addition, hospitals treat COVID-19 patients more often than private practices. In line with this, our survey showed that hospitals treated confirmed SARS-CoV-2 patients almost four times more often than private practices. According to our multivariate model, treatment of confirmed SARS-CoV-2 cases showed a tendency towards a higher risk of infection; however, this association was not significant.

Medical subspecialties

GIE showed a significant association with increased HCW infection rate in both healthcare delivery settings (hospitals and private practices). The reason for the higher infection rates in the GIE, specifically in a hospital setting, might be the higher rate of non-elective procedures conducted on COVID-19 patients [23], which is reflected in a higher number of confirmed SARS-CoV-2 cases treated in GIE specialty. Repici et al. (2020) discussed other specific characteristics of GIE applicable to private practices, such as the high level of unnoticed exposure of HCW during endoscopic procedures [24, 25]. Many COVID-19 patients show gastrointestinal symptoms [26]; hence, they might undergo endoscopic examination before identifying SARS-CoV-2 infection. Furthermore, COVID-19 patients often require endoscopic procedures such as bronchoscopies and gastroscopies due to pulmonary involvement and bleeding complications, respectively [27]. Another reason for the higher rate of SARS-CoV-2 positive HCW in GIE, especially in hospitals, may have been the transfer of HCW from GIE to COVID-19 wards, implicating direct contact to confirm COVID-19 patients. Data on the risk of infection among HCW in designated COVID-19 wards is heterogeneous [28, 29, 30]. A monocentric survey in a tertiary care hospital in Turkey showed an increased risk of infection for HCW working on COVID-19 wards compared with non-COVID-19 areas [3].

Pre-interventional testing

Pre-interventional testing may reduce the transmission of SARS-CoV-2 in medical facilities. In our study, multivariate analysis revealed no significant association of pre-interventional testing with SARS-CoV-2 infection among HCW in a medical unit. However, pre-interventional testing of patients was performed only in roughly 10 % of the cases in private practices, with Non-GIE testing twice as often as GIE. Pre-interventional testing was done in all patients in the hospital setting, irrespective of the medical specialty (GIE and non-GIE). This notwithstanding, the prevalence of SARS-CoV-2 positive HCW was significantly higher in hospitals than private practices, indicating that testing may not play a crucial role at low to moderate community incidence levels, as discussed by guidelines [31, 32]. On the one hand, it suggests that AGP can be safely performed by HCW using adequate personal protective equipment and following hygienic concepts [33]; on the other hand, it raises the question of how COVID-19 cases penetrate medical facilities despite a high rate of pre-interventional testing, especially in hospitals. One reason for this may be the poor sensitivity of antigen tests (between 50 % and 60 %) often used for pre-interventional testing [34].

Impact of the local incidence of SARS-CoV-2 on the risk of infection

The prevalence of SARS-CoV-2-infected HCW might depend strongly on the local incidence rates. According to our multivariate model, ZIP-code regions with higher mean incidences within the examined period were associated with a higher risk of infection than the ZIP regions with lower incidences. However, not all associations were significant; for instance, the ZIP-region 90–99 with the second-highest mean incidence in the considered period was not significantly different from the region with the lowest mean incidence. This observation highlights the difficulty of associating the community circulation of infection and local incidence rates to the prevalence of SARS-CoV-2 infections in medical facilities. Firstly, a mean incidence reflects a tendency across a defined period, neglecting the development over time. Secondly, medical facilities might apply protective measures and guidelines, cancel procedures and limit visitor access to prevent transmission of the infection. Thirdly, political and social measures to control local transmission rates may differ even between counties and districts, which may also affect the transmission within the respective medical facilities.

Limitations

Our study has various limitations, especially inherent to cross-sectional studies. Due to the recruitment strategy via the professional associations, a selection bias cannot be ruled out. In particular, facilities that established extensive and costly protective hygiene measures might have been more motivated to participate in our study. On the other hand, facilities with infected HCW may also have been more motivated to participate. Secondly, there is an uneven distribution of the medical facility types between examined specialties. For instance, in dental medicine, hardly any hospital was represented compared to the more than 1000 participating private practices.

Nonetheless, Non-GIE specialties had significantly more private practices due to the regional specificity of the respective fields of activity. Thirdly, this study is cross-sectional; information was gathered over a considerable period, comprising three quarters of 2020. Finally, all calculations presented in the manuscript are based on answers provided by a single person, who was usually the head of the department. Nevertheless, we assume that these answers can be considered valid as the detected SARS-CoV-2 HCW infection rate aligns with a recently published German seroprevalence study among HCW [5]. In addition, the survey was conducted before the emergence of the Delta and Omikron variant. Whether the results are applicable to these more infectious variants is not certain.

Despite the limitations mentioned above, the present study is the first to provide data on prevalence and underlying risk factors of SARS-CoV-2 infection among HCW in medical disciplines associated with AGP, such as GIE, ORL, OMS, and DM. Due to the results provided in this scientific manuscript, GIE seems to be at a higher risk of infection compared to the other investigated disciplines.

Ethics approval

The study was conducted in accordance with the Declaration of Helsinki and Good Hospital Practices. The Ethics Committee of the Faculty of Medicine of the Technical University of Munich (713/20 S-SR) approved the study.

Patient consent for publication

Not required.

Data availability statement

Data are available upon reasonable request.

Contributors' Statment

Conception and design: CR, AE, HM, MK, SZ, CTH. Analysis and interpretation of the data: AM, CR, AE, HM, MK, SZ. Drafting of the article: CR, AM, SZ, MK. Critical revision of the article for important intellectual content: AE, HM. Final approval of the article: all authors; Statistical expertise: AM. Administrative, technical or logistic support: GH, CB, AB, JR, TS, JZ, BA, RF, JH, CA, FL. Collection and assembly of data: CR, AE, MK, SZ.

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Conflict of Interest

The authors declare that they have no conflict of interest.

References

[1] Center JHCR. COVID-19 Map. 2020 https://coronavirus.jhu.edu/map.html

[2] Kambhampati AK, O'Halloran AC, Whitaker M et al. COVID-19-Associated Hospitalizations Among Health Care Personnel – COVID-NET, 13 States, March 1-May 31, 2020. MMWR Morb Mortal Wkly Rep 2020; 69: 1576–1583. doi:10.15585/mmwr.mm6943e3

[3] Çelebi G, Pişkin N, Çelik Bekleviç A et al. Specific risk factors for SARS-CoV-2 transmission among health care workers in a university hospital. Am J Infect Control 2020; 48: 1225–1230

[4] Jespersen S, Mikkelsen S, Greve T et al. SARS-CoV-2 seroprevalence survey among 17971 healthcare and administrative personnel at hospitals, pre-hospital services, and specialist practitioners in the Central Denmark Region. Clin Infect Dis 2020. doi:10.1093/cid/ciaa1471.

[5] Wachtler BN, Neuhauser H, Haller S et al. The risk of infection with SARS-CoV-2 among healthcare workers during the pandemic. Findings of a nationwide seroepidemiological Study in Germany. Dtsch Arztebl Int 2021. doi:10.3238/arztebl.m2021.0376.

[6] Bahl P, Doolan C, de Silva C et al. Airborne or droplet precautions for health workers treating COVID-19? J Infect Dis 2020; 225: 1561–1568. doi:10.1093/infdis/jiaa189

[7] Robert Koch-Institut: SurvStat@RKI 2.0. https://survstat.rki.de

[8] (Destatis) SB. 2021 https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Bevoelkerungsstand/Tabellen/bevoelkerung-nichtdeutsch-laender.html

[9] Garcia-Basteiro AL, Moncunill G, Tortajada M et al. Seroprevalence of antibodies against SARS-CoV-2 among health care workers in a large Spanish reference hospital. Nature Communications 2020; 11. doi:10.1038/s41467-020-17318-x

[10] Rudberg AS, Havervall S, Månberg A et al. SARS-CoV-2 exposure, symptoms and seroprevalence in healthcare workers in Sweden. Nat Commun 2020; 11: 5064. doi:10.1038/s41467-020-18848-0

[11] Brehm TT, Schwinge D, Lampalzer S et al. Seroprevalence of SARS-CoV-2 antibodies among hospital workers in a German tertiary care center: A sequential follow-up study. Int J Hyg Environ Health 2021; 232: 113671. doi:10.1016/j.ijheh.2020.113671

[12] Korth J, Wilde B, Dolff S et al. SARS-CoV-2-specific antibody detection in healthcare workers in Germany with direct contact to COVID-19 patients. J Clin Virol 2020; 128: 104437. doi:10.1016/j.jcv.2020.104437

[13] Gomez-Ochoa SA, Franco OH, Rojas LZ et al. COVID-19 in Health-Care Workers: A Living Systematic Review and Meta-Analysis of Prevalence, Risk Factors, Clinical Characteristics, and Outcomes. Am J Epidemiol 2021; 190: 161–175. doi:10.1093/aje/kwaa191

[14] Poletti P, Tirani M, Cereda D et al. Seroprevalence of and Risk Factors Associated With SARS-CoV-2 Infection in Health Care Workers During the Early COVID-19 Pandemic in Italy. JAMA Netw Open 2021; 4: e2115699. doi:10.1001/jamanetworkopen.2021.15699

[15] Kumar Goenka M, Bharat Shah B, Goenka U et al. COVID-19 prevalence among healthcare workers of Gastroenterology department: An audit from a tertiary-care hospital in India. JGH Open 2021; 5: 56–63

[16] Jungo S, Moreau N, Mazevet ME et al. Prevalence and risk indicators of first-wave COVID-19 among oral healthcare workers: A French epidemiological survey. PLOS ONE 2021; 16: e0246586. doi:10.1371/journal.pone.0246586

[17] COVID-19 Datenhub: RKI Corona Bundesländer. https://npgeo-corona-npgeo-de.hub.arcgis.com/datasets/ef4b445a53c1406892257fe63129a8ea_0/explore?location=51.164254%2C8.127781%2C6.78&showTable=true

[18] Gao Z, Xu Y, Sun C et al. A systematic review of asymptomatic infections with COVID-19. J Microbiol Immunol Infect 2021; 54: 12–16. doi:10.1016/j.jmii.2020.05.001

[19] Zhao H, Lu X, Deng Y et al. COVID-19: Asymptomatic carrier transmission is an underestimated problem. Epidemiology and Infection 2020; 148: E116. doi:10.1017/S0950268820001235

[20] e.V. D. COVID-19 Dunkelzifferradar. 2021 https://covid19.dunkelzifferradar.de/

[21] Liu Z, Magal P, Webb G. Predicting the number of reported and unreported cases for the COVID-19 epidemics in China, South Korea, Italy, France, Germany and United Kingdom. J Theor Biol 2021; 509: 110501. doi:10.1016/j.jtbi.2020.110501

[22] Dashboard Gutenberg COVID-19 Studie. https://www.unimedizin-mainz.de/GCS/dashboard/#/app/pages/AktuelleErgebnisse/ergebnisse

[23] Repici A, Pace F, Gabbiadini R et al. Endoscopy Units and the Coronavirus Disease 2019 Outbreak: A Multicenter Experience From Italy. Gastroenterology 2020; 159: 363–366.e3. doi:10.1053/j.gastro.2020.04

[24] Repici A, Maselli R, Colombo M et al. Coronavirus (COVID-19) outbreak: what the department of endoscopy should know. Gastrointestinal Endoscopy 2020; 92: 192–197. doi:10.1016/j.gie.2020.03.019

[25] Tang JW, Li Y, Eames I et al. Factors involved in the aerosol transmission of infection and control of ventilation in healthcare premises. J Hosp Infect 2006; 64: 100–114. doi:10.1016/j.jhin.2006.05.022

[26] D'Amico F, Baumgart DC, Danese S et al. Diarrhea During COVID-19 Infection: Pathogenesis, Epidemiology, Prevention, and Management. Clin Gastroenterol Hepatol 2020; 18: 1663–1672. doi:10.1016/j.cgh.2020.04.001

[27] Holtermüller KH, Ebener B, Kühl HJ et al. Stress ulcerations: pathogenesis and prevention. Z Gastroenterol 1983; 21: 88–100

[28] Finkenzeller T, Faltlhauser A, Dietl KH et al. SARS-CoV-2 antibodies in ICU and clinic staff : From Germany's region with the highest infection rate. Med Klin Intensivmed Notfmed 2020; 115: 139–145. doi:10.1007/s00063-020-00761-5

[29] Bahrs C, Kimmig A, Weis S et al. Seroprevalence of SARS CoV-2 antibodies in healthcare workers and administration employees: a prospective surveillance study at a 1400-bed university hospital in Germany. medRxiv 2020. doi:10.1101/2020.09.29.20203737

[30] Weinberger T, Steffen J, Osterman A et al. Prospective Longitudinal Serosurvey of Health Care Workers in the First Wave of the SARS-CoV-2 Pandemic in a Quaternary Care Hospital in Munich, Germany. Clin Infect Dis 2021. doi:10.1093/cid/ciaa1935

[31] Sultan S, Siddique SM, Altayar O et al. AGA Institute Rapid Review and Recommendations on the Role of Pre-Procedure SARS-CoV-2 Testing and Endoscopy. Gastroenterology 2020; 159: 1935–1948.e5. doi:10.1053/j.gastro.2020.07.043

[32] Ebigbo A, Rommele C, Bartenschlager C et al. Cost-effectiveness analysis of SARS-CoV-2 infection prevention strategies including pre-endoscopic virus testing and use of high risk personal protective equipment. Endoscopy 2021; 53: 156–161. doi:10.1055/a-1294-0427

[33] Kahn MZS, Ebigbo A, Muzalyova A et al. Ein Jahr COVID-19: Testung, Verwendung von Schutzausrüstung und Auswirkungen auf die Gastrointestinale Endoskopie in Deutschland. Zeitschrift für Gastroenterologie 2021. doi:10.1055/a-1649-8184

[34] Kahn M, Schuierer L, Bartenschlager C et al. Performance of antigen testing for diagnosis of COVID-19: a direct comparison of a lateral flow device to nucleic acid amplification based tests. BMC Infect Dis 2021; 21: 798. doi:10.1186/s12879-021-06524-7