A risk estimate of a SARS-CoV-2 coronavirus infection among grocery and drugstore retail employees

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baua: Focus

Approximately 780,000 employees work in grocery and drugstore retail in Germany. Due to its systemic relevance, this sector was largely exempt from closures as an infection control measure against the SARS-CoV-2 coronavirus in spring of 2020. Thus, employees continued to work in the majority of cases, even though frequent contact with customers could pose infection risks - particularly during the payment process at the checkout counter.
The SARS-CoV-2 infection risk for employees in grocery and drugstore retail is estimated here using epidemiological data from scenarios outside the retail sector. An initial risk assessment under pandemic conditions is thus possible, even when no data on infection risk on site is available.
The investigated infection risk is primarily dependent on the current infection frequency on site - in addition to the number and duration of customer contacts. Technical, organizational and personal protective measures can further reduce the estimated risk.

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1 SARS-CoV-2 infection risk in retail as a systemically relevant sector

The grocery and drugstore retail sector in Germany employs about 780,000 people, who have approximately 15 billion customer contacts per year (HDE, 2018). In retail, short but frequent contacts with customers typically occur, particularly at the checkout.
As a systemically relevant sector of society, grocery and drugstore retailing has been largely exempt from temporary closures as an infection control measure during the onset of the

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COVID-19 (Coronavirus Disease 2019) pandemic (an der Heiden and Buchholz, 2020; Federal Press and Information Office, 2020; RKI, 2020a). As a result, frequent customer contact could be associated with an increased occupational risk of infection with SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2).

This risk is estimated here using epidemiological data obtained in other scenarios with contacts between individuals. This allows for an initial risk assessment under pandemic conditions, even though parameters on site are not yet supported by data, like SARS-CoV-2 concentrations in the air and exposure of employees at the checkout counter. Already published data from hospital settings and modelling studies appear to be less suitable for an application to the retail workplace (Schijven et al., 2020; Liu et al., 2020).
Thus, this approach differs from the risk assessment outlined in the Biological Agents Ordinance according to § 5 ArbSchG, which focuses on biological agent quantities and species range as well as on workplace exposure of employees (BGBl. I, 2017).

2 COVID-19 and transmission of the pathogen SARS-CoV-2

COVID-19 is a pandemic disease, which causes primarily fever, cough, and pneumonia with mainly mild course, but also with severe course, hospitalization, and death. Both symptomatic and asymptomatic infected people can transmit the etiologic agent SARS-CoV-2 (Cummings et al., 2020; RKI, 2020b).
Droplets containing SARS-CoV-2, expelled from the respiratory tract of infected people through speaking, coughing, sneezing and breathing are considered the main cause of COVID-19 spread (Bandiera et al., 2020; Zhang et al., 2020a; Stadnytskyi et al., 2020). Due to the physical properties of these droplets, distances of less than 1.5 to 2 meters between people are therefore considered particularly critical for droplet infections (Fennelly, 2020). In addition, laboratory studies and data from indoor outbreaks indicate that with unfavourable airflow, infections can occur even over distances of several meters and after several hours of aerial suspension of the virus (van Doremalen et al., 2020; Shen et al., 2020; Fears et al., 2020).

Studies on SARS-CoV-2 seroprevalence, i.e., the fraction of individuals who have developed antibodies against SARS-CoV-2, indicate that reported cases in Germany represent only a part of the infection events. For example, in a North Rhine-Westphalian community, antibodies against SARS-CoV-2 were detected in 15.5 % of the examined individuals (Streeck et al., 2020). In contrast, the total number of reported infection cases accounted for only 3.1 % of the inhabitants of this community and was thus lower by a factor of 5 than the determined seroprevalence. SARS-CoV-2 seroprevalence rates in people without COVID-19 disease and without knowledge of a past infection were 0.66 % in Hesse, 1.22 % in Lower Saxony, and 0.94 % in North Rhine-Westphalia. The study period was from March to June 2020 (Fischer et al., 2020).

3 Infection rate of SARS-CoV-2 as a function of conditions on site

The infection rate is the fraction of people who become infected as a result of contact with an infected person. In case of SARS-CoV-2, the infection rate noticeably increases with longer duration of contact and with closer physical proximity between infected and susceptible person. For example, infection rates of contacts in shared households ranged from 6.9 % to 30 %, depending on the study (Table 1). Outside shared households, the infection rate was about 1 % after brief contact with an infected person and hence considerably lower (Table 2).

In comparison to that at festive and cultural events, with up to several hundred and thousand people in a confined space, much higher infection rates of 14.8 % to 70 % could be determined. Also unfavourable conditions at collective work in closed indoors facilities (call center, 43.5 %) and quarantine of a person with family members in a confined space (75 %) resulted in high infection rates (Table 2).

A study of an outbreak in Germany revealed that contacts outside shared households and with at least 15 min contact duration had an infection rate of 4.4 % (Böhmer et al., 2020). The contact duration of 15 minutes is used as a guide value to distinguish between contacts with a high infection risk and those with a lower infection risk (RKI, 2020c; CDC, 2020; Cheng et al., 2020). Regardless of this guide value, infections can also occur after shorter contact duration, e.g., after particularly high inhalation of respiratory droplets with SARS-CoV-2 from infected individuals.

In this paper, the contact duration of 15 minutes is also used as a guide value, to estimate the occupational SARS-CoV-2 infection risk from cumulative contact durations of employees working at the checkout with potentially infected individuals.

Table 1 SARS-CoV-2 infection rates in shared households

Place of study	Infection rate in shared household	Reference
Guangzhou, China	17.1 %	Jing et al., 2020
Guangzhou, China	10.2 %	Luo et al., 2020
Guangzhou, China	16.1 %	Zhang et al., 2020b
Shenzhen, China	11.2 %	Bi et al., 2020
Wuhan, China	30 %	Wang et al., 2020
Wuhan, China	16.3 %	Li et al., 2020
Hong Kong, China	20.7 %	Lai et al., 2020
Taiwan	4.6 % symptomatic, with correction factor 6.9 % [2]	Cheng et al., 2020
South Korea	7.6 %	Korea CDC, 2020
South Korea	16.2 % symptomatic, with correction factor 24.3 % [2]	Park et al., 2020
Bavaria, Germany	10 %	Böhmer et al., 2020
USA	10.5 % symptomatic, with correction factor 15.7 % [2]	Burke et al., 2020
Malaysia	10.6 %	Chaw et al., 2020
	mean value 15.1 %	
	standard deviation 6.8 %	

[2] In case of reports on symptomatic infected individuals, and considering that only a part of the infections is symptomatic (55 – 85 %, RKI, 2020b) and that infection rates could hence be higher by a factor of 1.2 to 1.8, a correction factor of 1.5 was used before calculating the mean value

Table 2 SARS-CoV-2 infection rates outside shared households

Place of study	Infection rate (in brackets contact scenario, if reported)	Reference
Infection rate lower than in a shared household		
Bavaria, Germany	4.4 % (high risk contacts, at least 15 min contact) 0 % (low risk contacts, unprotected contact with lower intensity than in high risk contacts)	Böhmer et al., 2020
Guangzhou, China	3.3 % (general) 1.1 % (social contacts) 0 % (occupational contacts)	Zhang et al., 2020b
South Korea	0.55 % (general)	Korea CDC, 2020
USA	0.45 % (at least 10 min contact under 1.80 m) symptomatic, with correction factor 0.68 % [3]	Burke et al., 2020
Lombardy, Italy	0.3 % (general population)	Riccardo et al., 2020
Taiwan	0.7 % (high risk contacts, at least 15 min contact)	Cheng et al., 2020
Infection rate higher than or equal to that of a shared household		
North Rhine-Westphalia, Germany	21.3 % (traditional festivities with several hundred participants)	Streeck et al., 2020
Seoul, South Korea	43.5 % (call center with 216 employees)	Park et al., 2020
Kuala Lumpur, Malaysia	14.8 % (religious festivities with approx. 16,000 participants)	Chaw et al., 2020
Bavaria, Germany	75 % (in quarantine with infected person)	Böhmer et al., 2020
Washington, USA	53.3 % (choir practice, 2.5 h)	Hamner et al., 2020
France	70 % (choir practice)	Charlotte, 2020
Hong Kong, China	64.7 % (festive dinner)	Lai et al., 2020

[3] In case of reports on symptomatic infected individuals, and considering that only a part of the infections is symptomatic (55 – 85 %, RKI, 2020b) and that infection rates could hence be higher by a factor of 1.2 to 1.8, a correction factor of 1.5 was used before calculating the mean value

4 The contact duration as a temporal parameter for a potential SARS-CoV-2 exposure

The contact duration with SARS-CoV-2 infected people may result from contact with a single infected person or from the duration of multiple contacts. This cumulative contact duration for employees working at the retail checkout is calculated here from the fraction of SARS-CoV-2 infected people among customers and the average time customers spend in the check-out area.

In 2012, the average queue time at checkouts when shopping in Germany was approximately 4 minutes, with an average queue length of 4 people (MSPA, 2012). This corresponds to an average duration of 1 minute for the payment process. In addition, the next customer waiting in the queue may be critically close to the employee in terms of droplet infection, i.e. 1.5 to 2 m, with an average waiting time of 1 min behind the paying customer. Thus on average, a virus-emitting individual in the queue could lead to 2 min of SARS-CoV-2 exposure of the employee. This potential contact duration of 2 minutes is used here as an average value for a single customer contact.

The number of customers with whom an employee has contact at the checkout depends primarily on size and number of employees of the respective retail facility, and thus on the market profile (Turban, 2007). In a supermarket with an average of 20 employees and 1,170 customers per day, one employee has contact with about 58 customers per day. In a soft discounter with an average of 7 employees and 922 customers per day, one employee has contact with around 131 customers per day. The figures published by the German retail association Handelsverband Deutschland (HDE) provide a similar picture when converted (equation (1)): 778,700 employees in the grocery sector with 15 billion customer contacts per year result in 84 customer contacts per employee and workday, assuming 230 workdays (HDE, 2018).

$$\frac{\text{15 billion customer contacts}/\text{230 workdays}}{\text{778,700 employees}} = \text{83.75 customer contacts per employee and workday} \qquad (1)$$

Another factor influencing the number of daily customer contacts is the individual distribution of responsibilities among employees of a retail facility, which is not taken into account here.

5 Contact duration with SARS-CoV-2 infected people in grocery and drugstore retail based on SARS-CoV-2 prevalence

When summing up contact durations at the checkout, and assuming an average contact duration of 2 min for a single customer contact, it becomes evident that the fraction of SARS-CoV-2 infected people among customers is critical, and thus the prevalence (equation (2)).

$$\text{cumulative contact duration} = \frac{\text{customer contacts}}{\text{workday}} * \text{2 minutes} * \frac{\text{prevalence}}{100} \qquad (2)$$

The prevalence of an infection describes the relative fraction of infected individuals among all considered, e.g. inhabitants of a region, at a certain point in time (RKI, 2015). For the estimate carried out here, a scenario with high prevalence is considered first. Scenarios with different prevalence are subsequently discussed.

In a community in North Rhine-Westphalia, 3.59 % of the examined non-hospitalized people tested positive for SARS-CoV-2 (Streeck et al., 2020). A few weeks earlier in this community, a COVID-19 outbreak had occurred after festivities with several hundred participants.
The SARS-CoV-2 prevalence of 3.59 % is considered a representative value of a scenario with comparably high prevalence.

With 84 customer contacts on average per employee and workday at the checkout counter, and with a SARS-CoV-2 prevalence of 3.59 %, 3 customers (3.02) are potential carriers of SARS-CoV-2, leading to a cumulative contact duration of 6 minutes. In a soft discounter with on average 131 customer contacts, approximately 5 customers (4.70) could potentially be infected, leading to a contact duration of about 10 minutes.
These contact durations are shorter than 15 minutes, i.e. shorter than the threshold minimum duration applied for the definition of high-risk contacts, with an observed infection rate of 4.4 % (Böhmer et al., 2020; RKI, 2020c).

Based on the considerations outlined above, it can hence be assumed that grocery and drugstore retail employees, while working at the checkout counter, are not inevitably exposed to high risk contacts, even in regions with increased case numbers. This assumption is made for average contact durations and customer numbers, and does not include further risk factors, e.g. unusually high virus spread by some of the infected people.
Two factors are critical in this regard: the current SARS-CoV-2 prevalence and the contact duration occurring at the checkout. The short contact duration at the checkout is remarkably different from longer contact durations, which e.g. render personal conversation critical for high infection risks, and even more from contact durations in shared households.

In addition to prevalence and contact duration, other factors that may increase infection risks are poor airflow, close physical proximity, as well as coughing, sneezing, and loud talking. The regional and temporal distribution of SARS-CoV-2 infections in Germany has been heterogeneous since the beginning, with local outbreaks on one side and regions with few infections on the other side (RKI, 2020d; RKI, 2020e; an der Heiden and Hamouda, 2020). Accordingly, it can be assumed that infection risks for retail employees vary considerably. It should be kept in mind that the SARS-CoV-2 prevalence primarily depends on the ratio between new infections and recovering past infections. It cannot be derived directly from case numbers (Rothman et al., 2008). Studies conducted in the United States reported a SARS-CoV-2 prevalence of 1.74 % for the general population of the state of Indiana, with an estimated variance between 0.01 and 4.1 (Menachemi et al., 2020; Sacks et al., 2020). Studies in Europe revealed for regions with high infection rates, e.g. northern Italy, a SARS-CoV-2 prevalence of 2.6 %, and lower values for the general population (ECDC, 2020). A local, unusually severe outbreak in an emergency shelter in the state of Massachusetts, however, was associated with a SARS-CoV-2 prevalence of 36 % (147 of 408 individuals) (Baggett et al., 2020).

Possible contact durations between retail employees at the checkout and potentially SARS-CoV-2 emitting people are shown in Figure 1, based on different prevalence values. Based on the above mentioned data, the prevalence of 10 % has been estimated as a very high value representing acute outbreaks.

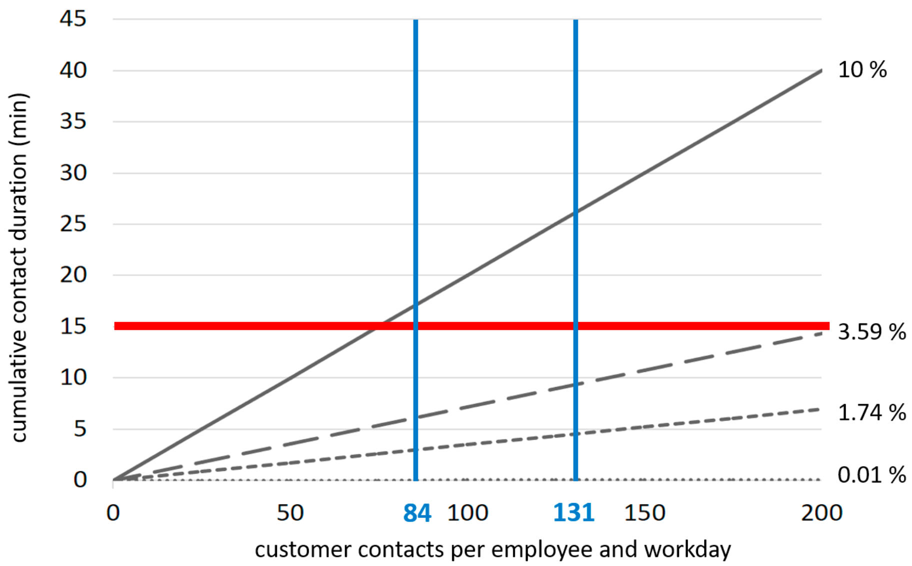

Figure 1 Cumulative contact duration with potentially SARS-CoV-2 infected people as a function of customer contacts and SARS-CoV-2 prevalence (in %); the guide value of 15 minutes and average numbers of customers (grocery: 84, soft discounter: 131) are highlighted.

At a prevalence of 10 %, the risk of SARS-CoV-2 infection would also be increased for grocery and drugstore retail employees. Assuming customer contacts as described before, the contact duration with 8.4 potentially SARS-CoV-2 emitting people would increase to approximately 17 minutes (soft discounter: 26 minutes). Contact durations of 17 and 26 minutes are longer than 15 minutes and thus fall within the category of high risk contacts.
The prevalence potentially leading to a cumulative contact duration of 15 minutes, as a result of contact with 84 customers (soft discounter: 131 customer contacts) is 8.93 % (soft discounter: 5.73 %). Also these prevalence values are very high in the light of so far available data from regional investigations.
In contrast to this, it becomes evident that at low prevalence, also the number of contacts with SARS-CoV-2 emitting people at the checkout is lower. Accordingly, the cumulative contact duration does not exceed 15 minutes, i.e. the guide value for high risk contacts.

In addition to the present study, a survey and evaluation of COVID-19 risks in different occupational sectors revealed that retail employees are not exposed to those infection risks that are critical in the sectors of, e.g., health care and law enforcement (Die Zeit, 2020; Möhner et al., 2020). In a different risk assessment based on expected contacts with infected people, medium risk was assigned to occupational activity in retail, in comparison to high and very high risk in healthcare and low risk for separate workplaces like offices (Occupational Medicine Committee, 2020).

It should be noted that since about mid-March of 2020, readily available protective measures against SARS-CoV-2 infections came also into use in the retail sector. In retail stores, these were primarily standards for safe distances, mouth-and-nose coverings for customers and employees, improved air and surface hygiene, maximum customer numbers in the store, and protective shields in the checkout area (Exner, 2020; RKI, 2020f; Bandiera et al., 2020). It could be shown that the combination of several protective measures together with contact reduction and mouth-and-nose coverings in public spaces decisively contributed to lower case rates and a better control of the SARS-CoV-2 pandemic (Mitze et al., 2020; Zhang et al., 2020c; Pozo-Martin et al., in press).

6 Conclusion

The SARS-CoV-2 infection risk among grocery and drugstore retail employees was estimated here based on epidemiological data from other scenarios, in order to enable an initial risk assessment without available workplace exposure data. The infection risk of employees primarily depends on the fraction of currently infected people among customers. Even in case of prevalence values observed for SARS-CoV-2 outbreaks, average customer contacts with an approximate duration of 2 minutes not necessarily lead to high risk contacts of at least 15 minutes duration. High infection risks may nevertheless arise independently of prevalence – among others from close physical proximity to infected individuals.
Protective measures like mouth-and-nose coverings as well as organizational and technical provisions for distancing can also effectively reduce SARS-CoV-2 infection risks in grocery and drugstore retail. Mindful consideration of the risk factors prevalence and acute, unusually high exposure as well as protective measures against SARS-CoV-2 infections are an important part of infection control.

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