

# Central and Eastern European migrant worker status, co-living situation and SARS-CoV-2 exposure and transmission risk

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**Background:** Central and Eastern European (CEE) migrant workers in essential industries are at higher risk of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) exposure and transmission. We investigated the relationship of CEE migrant status and co-living situation with indicators of SARS-CoV-2 exposure and transmission risk (ETR), aiming to find entry points for policies to reduce health inequalities for migrant workers. **Methods:** We included 563 SARS-CoV-2-positive workers between October 2020 and July 2021. Data on ETR indicators were obtained from source- and contact-tracing interviews via retrospective analysis of medical records. Associations of CEE migrant status and co-living situation with ETR indicators were analyzed using chi-square tests and multivariate logistic regression analyses. **Results:** CEE migrant status was not associated with occupational ETR but was with higher occupational-domestic exposure [odds ratio (OR) 2.92;  $P = 0.004$ ], lower domestic exposure (OR 0.25,  $P < 0.001$ ), lower community exposure (OR 0.41,  $P = 0.050$ ) and transmission (OR 0.40,  $P = 0.032$ ) and higher general transmission (OR 1.76,  $P = 0.004$ ) risk. Co-living was not associated with occupational and community ETR but was with higher occupational-domestic exposure (OR 2.63,  $P = 0.032$ ), higher domestic transmission (OR 17.12,  $P < 0.001$ ) and lower general exposure (OR 0.34,  $P = 0.007$ ) risk. **Conclusions:** The workforce poses an equal SARS-CoV-2 ETR for all workers. CEE migrants encounter less ETR in their community but pose a general risk by delaying testing. When co-living, CEE migrants encounter more domestic ETR. Coronavirus disease preventive policies should aim at occupational safety for essential industry workers, reduction of test delay for CEE migrants and improvement of distancing options when co-living.

## Introduction

Approximately 5% of the global labour force is constituted by 169 million international migrant workers worldwide, delivering critical jobs in essential industries, such as health care, transportation, agriculture and food processing.<sup>1</sup> Owing to a multifactorial interplay of behavioural determinants; cross-border movements; adverse socio-economic pressures; unstable living and working conditions; and administrative, financial, language, belief and cultural barriers to healthcare access, migrant workers are at a higher risk of contracting and transmitting infectious diseases.<sup>2–9</sup> Consequently, migrant workers worldwide have been disproportionately affected by the coronavirus disease (COVID-19) pandemic.<sup>10–13</sup> There is a potential risk for the further spread of infectious diseases to the general population; hence, international migrant workers are of public health importance.

Central and Eastern European (CEE) migrant workers in Western Europe are exposed to unsafe, unhealthy and unfair working and living conditions, particularly in relation to COVID-19.<sup>10,13,14</sup> Exempted from restrictive policies,<sup>15</sup> they continued to work on-site throughout the pandemic in essential industries where one-third to half of the companies took suboptimal preventive measures, such as physical distancing, (hand) hygiene and cleaning and appropriate use of personal protective equipment.<sup>10,16,17</sup> In the Netherlands, 85% of CEE migrant workers are dependent on temporary employment agencies for employment, housing, transport

and sometimes healthcare. Temporary contracts with inadequate disability policies incentivise continuing to work while ill.<sup>14,17–19</sup> Agency dependency on housing and transportation results in crowded environments with an often changing composition of co-habitants, which has been associated with higher attack rates, higher infection doubling times and more severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections within the social network or household.<sup>16,20–23</sup> Observation tells us that companies that depend on migrant workers, from slaughterhouses to warehouses and orchards, have suffered from severe COVID-19 outbreaks throughout the pandemic.<sup>10</sup>

To date, evidence on the extent to which COVID-19 outbreaks in Western European essential industries are attributable to transmission in occupational or non-occupational settings and the role of the CEE migrant and co-living working population is lacking. Scarce scientific evidence indicates that although CEE migrants and resident workers are equally at risk of SARS-CoV-2 exposure and transmission on the workforce, CEE migrant workers are at higher risk in the domestic setting, especially when co-living or agency-dependent.<sup>16,20</sup> This study investigated the association of CEE migrant status and co-living situation with indicators of occupational, domestic, occupational-domestic, community and general SARS-CoV-2 exposure and transmission risk (ETR). We aimed to build on existing knowledge of infectious disease ETR in migrant workers and to contribute to more targeted infection prevention and mitigation policies for migrant workers and the companies that are responsible for

procuring their employment and housing, ultimately reducing health inequalities.

## Methods

### Study design

In this cross-sectional study, data on CEE migrant status, co-living situation and indicators of SARS-CoV-2 ETR were collected from the Public Health Service Gelderland-South (PHS) medical records of COVID-19 cases.

### Data source

As part of regular COVID-19 control measures, trained staff from the PHS conducted semi-structured telephonic contact-tracing interviews with notified COVID-19 cases (individuals testing positive for SARS-CoV-2 RNA in nose and throat swabs using reverse transcription polymerase chain reaction or validated antigen test) and stored the obtained information in the PHS patient file. If a company outbreak (two or more cases with a maximum of 14 days between the onset of illness attending the same workplace during their infectious period) was identified, PHS-trained staff conducted a semi-structured telephonic interview with a company representative and stored the obtained information in the PHS company outbreak file.

### Participants

We included all COVID-19 cases that were part of a COVID-19 company outbreak where at least one case was a CEE migrant, and who were reported to the PHS between 1 October 2020 (when uniform company outbreak reporting in PHS medical records was implemented) and 30 June 2021 (the point at which COVID-19 vaccination commenced for the Dutch working population).

### Variables

The information obtained from the source and contact-tracing interviews was stored in the PHS medical records (including patient and company outbreak files). Files comprised open text data fields (e.g. explanation of the household composition) and data fields with a pre-fixed number of entry possibilities (e.g. sex and country of birth). Data were extracted from the medical records and stored in a data file without patient identification by a data specialist from the PHS. Not all data were complete because cases were unable or unwilling to disclose information to the interviewer. From the company outbreak files, data on company type, sector, outbreak attack rate (number of cases among the total number of workers) and outbreak duration were collected. Data on sex; age; nationality; living situation; last working day; disease discourse, i.e. COVID-19 symptomatic, date of symptom onset and date of testing; and source and contact information, i.e. suspected source of infection, household contacts, work floor close contacts and total close contacts in the infectious period, were obtained from patient files. Pre-fixed data were directly transported into the same variables in the new dataset. A research assistant read and recoded the open text into new variables. Data of cases were categorized into socio-demographic and clinical variables (age, sex and COVID-19 symptoms), determinants (CEE migrant status and living situation) and outcomes (occupational domestic, occupational-domestic, community and general ETR indicators).

### Determinants

CEE migrant status was assigned if the country of birth was a CEE country and file research showed that the case met at least one of the following criteria: identified him/herself as a CEE migrant, had no command of the Dutch language, was on a temporary contract with an employment agency for CEE migrants and lived together with one or more CEE migrants. Three cases that originated from a Southern European country (Italy and Portugal) and met at least one of the

abovementioned criteria, except CEE country of birth, were included as CEE migrants. Co-living status was assigned when a case reported living with at least one person who was not a first- or second-degree relative, partner, or spouse.

### Outcomes

In this study, the outcomes were indicators of the SARS-CoV-2 ETR. Data on sources; contacts (total, occupational and household); and dates of symptom onset, testing and last working day were used to form indicators of ETR per setting, as presented in [Box 1](#). Indicators of exposure risk are based on the source of infection as suspected and reported by the index case (see the middle column of [Box 1](#) for all exposure risk indicators). Indicators of transmission risk are the number of contacts made in the infectious period and suboptimal adherence to self-isolation and testing guidelines, operationalized as attending the work floor during the infectious period and test delay. These indicators were chosen because the SARS-CoV-2 virus spreads from an infected person when in their infectious period (2 days before to 7 days after symptom development) to people whom they are in close contact with (contact for over 15 min at <1.5 m distance) and COVID-19 guidelines promote testing and self-isolation to prevent further spread of the virus.<sup>24</sup> The number of contacts that was considered above average, and thus, a risk indicator, was set at two household contacts, one occupational close contact, and one community close contact. This was based on studies that found that during the COVID-19 pandemic, the employed and working-age population in Western industrialized countries had ~50% of close contacts at home, 25% at work and 25% others;<sup>25</sup> had a mean total of four close contacts in their infectious period, of which two were outside their household,<sup>26,27</sup> and the average Dutch household size was two individuals.<sup>28</sup>

### Data analysis

Descriptive analyses were performed using IBM SPSS version 22, and the chi-square test was used for associative analyses of CEE migrant status and co-living situation with socio-demographic and clinical characteristics and indicators of SARS-CoV-2 ETR. Cases were grouped first by CEE migrant status into CEE migrant workers and resident workers (all other), followed by the living situation into the co-living and non-co-living situations (all other). Since only three resident workers met the criteria for co-living situation the second analysis was restricted to CEE migrant workers. Unadjusted and adjusted multivariate logistic regression was used to analyze the association of CEE migrant status and co-living situation with the presence of ETR indicators (see [Box 1](#)). We adjusted for age, sex and COVID-19 symptoms since we expected these variables to be associated with ETR. Adjusting for age, sex and being COVID-19 symptomatic did not alter the significance of associations; therefore, only adjusted odds ratios (ORs) and associated 95% confidence intervals were reported. The unadjusted results are presented in [Table A1](#). Statistical significance was set at  $P < 0.05$ . If values were missing, the calculations were based on existing values.

### Medical ethical clearance

Outbreak investigations of notifiable diseases, such as COVID-19, and collection and storage of data of a case in the PHS medical record upon notification of such a disease are the legal tasks of the PHS, as described under the Dutch Public Health Act.<sup>29</sup> Scientific research in which anonymous data are obtained by studying medical records, does not fall under the Dutch Medical Scientific Research with Humans Act and does not require separate medical ethical clearance.<sup>30</sup>

## Results

### Characteristics of SARS-CoV-2-positive workers

A total of 563 SARS-CoV-2-positive workers were linked to 68 COVID-19 outbreaks, with a mean duration of 25 days [standard deviation (SD) 20.8; range 0–93] and an attack rate of 21.2% (SD 16.3; range 2–64). Outbreaks occurred in 57 companies, in industrial (39.7%), transportation and storage (22.1%), agricultural (19.1%), wholesale (7.4%), construction (4.4%) and other (6%) sectors. The companies had a mean number of 253 (SD 302.2; range 7–1300) employees. Workers were 38.7 years old on average, predominantly men (67%), and COVID-19 symptomatic (87.7%). Approximately half (44.7%) were CEE migrant workers, originating predominantly from Poland (75%), Romania (8%) and Bulgaria (3%). Co-living was reported by 22.3% of all workers, 1% of the resident workers and 51.1% of the CEE migrant workers. CEE migrant workers were significantly more often women, younger, COVID-19 asymptomatic and co-living (all  $P < 0.001$ ) than resident workers. Co-living CEE migrant workers were significantly more often men, asymptomatic and younger than non-co-living CEE migrant workers (Table 1). A co-worker (that is not a housemate) was the most often reported suspected source of infection, followed by a lack of certainty, and a housemate. Over half of the workers in all groups suspected a co-worker as their source (occupational exposure risk) and attended the workplace whilst experiencing symptoms (occupational transmission risk). Approximately 42% of the workers reported more than two household contacts. Co-living CEE migrant workers reported this domestic transmission risk most often (74.8%), non-co-living CEE migrant workers least often (14.7%). Community ETRs were not often reported in any of the groups. Delaying testing by more than 1 day was reported by over half of the workers, most often by CEE migrant workers (60.1%) and least often by resident workers (47.9%) (Table 2). Associations of CEE migrant status and co-living situation with ETR per setting are described in detail below and are presented in Table 2.

### The occupational setting

We did not find a significant association of CEE migrant status and co-living situation with occupational ETR.

### The occupational-domestic setting

CEE migrant workers reported a co-worker–housemate as their source significantly more often than resident workers (13.3% vs. 3.9%; OR 2.92;  $P = 0.004$ ). Co-living CEE migrant workers reported this ETR most often and significantly more often than non-co-living CEE migrant workers (20.5% vs. 7.3%; OR 2.63;  $P = 0.032$ ).

### The domestic setting

Compared to resident workers, CEE migrant workers were significantly less likely to suspect a housemate (that is not a co-worker) as

the source of infection (4.3% vs. 13%; OR 0.25;  $P < 0.001$ ). Co-living CEE migrant workers were 17 times more likely (74.8% vs. 14.7%,  $P < 0.001$ ) to report more than two household contacts compared to non-co-living CEE migrant workers. Residents and CEE migrant workers did not differ in terms of the domestic transmission risk indicator.

### The community setting

Compared to resident workers, CEE migrant workers were significantly less likely to suspect a community member as the source of infection (3.0% vs. 7.5%; OR 0.41;  $P = 0.050$ ) and less likely to report an above-average number of community close contacts (3.8% vs. 9.8%; OR 0.40;  $P = 0.032$ ). Community ETRs did not differ significantly between the co-living and non-co-living CEE migrant workers.

### The general setting

CEE migrant workers were significantly more likely to report a test delay than resident workers (60.1% vs. 47.9%; OR 1.76;  $P = 0.004$ ). Co-living CEE migrant workers were less likely to be unsure of the source of infection (9.8% vs. 27.5%; OR 0.34;  $P = 0.007$ ) than non-co-living CEE migrant workers.

## Discussion

To the best of our knowledge, this is the first study to investigate the relationship of CEE migrant status and co-living situation with indicators of SARS-CoV-2 ETR in multiple settings. We found that resident and CEE migrant workers and non-co-living and co-living workers had different ETRs. CEE migrant workers pose and run a lower risk of SARS-CoV-2 infection in their community than resident workers; however, they pose a higher transmission risk in all settings by delaying testing. Co-living CEE migrant workers significantly more often report an above average number of household contacts and a co-worker–housemate as their source, which poses a higher transmission risk to their domestic environment with possible spill-over to and from the occupational setting. The workflow, albeit a plausible place for exposure to and transmission of SARS-CoV-2, poses a risk for residents, CEE migrants and co-living and non-co-living CEE migrant workers equally.

### Occupational setting

Unsurprisingly, a co-worker is the most often reported source of infection in this working population, which spends a large amount of time in the workplace amidst co-workers. More interestingly, our findings indicate that occupational ETR is equal for residents, CEE migrants and co-living and non-co-living CEE migrant workers. These findings suggest that not CEE migrant status but the nature of work in essential industries in which CEE migrant workers are overrepresented is a determinant of occupational ETR. This is in line

**Table 1** Socio-demographic and clinical characteristics and their association with CEE migrant status and the co-living situation of 563 workers who became SARS-CoV-2-positive between October 2020 and June 2021 in company COVID-19 outbreaks in the Netherlands

	All workers (n = 563)	Resident workers (n = 311)	CEE migrant workers (n = 252)	P	Non-co-living CEE migrant workers (n = 109)	Co-living migrant CEE workers (n = 114)	P
Male sex (%)	67	75.2	56.7	<b>&lt;0.001</b>	45.9	62.3	<b>0.014</b>
Age in years; mean (SD)	38.7 (12.8)	40.6 (13.8)	36.4 (11)	<b>&lt;0.001</b>	38.5 (10.7)	34.6 (11.2)	<b>0.008</b>
COVID-19 symptomatic (%)	87.7	94.9	78.3	<b>&lt;0.001</b>	87.2	71.4	<b>0.004</b>
CEE migrant (%)	44.7	–	–	–	–	–	–
Co-living (%)	22.3	1.0	51.1	<b>&lt;0.001</b>	–	–	–

CEE, Central and Eastern European; CI, confidence interval; OR, odds ratio; SD, standard deviation. Bold values denote statistical significance at the  $P < 0.05$  level.

**Table 2** The presence of indicators of SARS-CoV-2 ETR per setting and their association with CEE migrant status and co-living situation via adjusted multivariate logistic regression in 563 workers who became SARS-CoV-2-positive between October 2020 and June 2021 in company COVID-19 outbreaks in the Netherlands

	All worker (n = 563)	Resident workers <sup>a</sup> (n = 311)	CEE migrant workers (n = 252)	Adjusted <sup>b</sup> OR (95% CI)	P	Non-co-living CEE migrant workers <sup>a</sup> (n = 109)	Co-living CEE migrant workers (n = 114)	Adjusted <sup>b</sup> OR (95% CI)	P
Occupational setting									
Suspected a co-worker (that is not a housemate) as the source of infection (%)	56.2	53.2	60.1	1.33 (0.92–1.92)	0.131	57.8	63.4	1.21 (0.69–2.15)	0.507
More than one occupational close contact in infectious period (%)	10.2	8.8	12.2	1.73 (0.94–3.18)	0.078	11.3	13.5	1.24 (0.52–2.97)	0.627
Attended the workplace while experiencing symptoms (%)	53.2	51.7	55.4	1.30 (0.88–1.93)	0.182 <sup>c</sup>	53.2	61.5	1.55 (0.82–2.91)	0.179 <sup>c</sup>
Attended the workplace awaiting or after a positive test result (%)	0.9	8.5	1.9	0.24 (0.02–3.03)	0.270	5.6	0.0	Not applicable <sup>d</sup>	–
Occupational-domestic setting									
Suspected a co-worker that is also a housemate as the source of infection (%)	7.9	3.9	13.3	2.92 (1.40–6.08)	<b>0.004</b>	7.3	20.5	2.63 (1.09–6.34)	<b>0.032</b>
Domestic setting									
Suspected a housemate (that is not a co-worker) as the source of infection (%)	9.2	13.0	4.3	0.25 (0.11–0.54)	<b>&lt;0.001</b>	6.4	1.8	0.33 (0.06–1.72)	0.188
Had more than two household contacts in infectious period (%)	42.1	40.6	44.1	1.08 (0.74–1.58)	0.685	14.7	74.8	17.12 (8.31–35.27)	<b>&lt;0.001</b>
Community setting									
Suspected a community member as the source of infection (%)	5.5	7.5	3.0	0.41 (0.17–0.998)	<b>0.050</b>	0.9 <sup>e</sup>	4.5	5.22 (0.58–46.89)	0.140
Had more than one community close contact in infectious period (%)	7.3	9.8	3.8	0.40 (0.17–0.92)	<b>0.032</b>	5.7	2.1	0.38 (0.07–2.00)	0.253
General setting									
Was not sure where exposure to the source of infection took place (%)	21.1	22.4	19.3	1.03 (0.65–1.60)	0.915	27.5	9.8	0.34 (0.16–0.75)	<b>0.007</b>
Delayed testing with more than 1 day (%)	52.7	47.9	60.1	1.76 (1.19–2.60)	<b>0.004</b>	60	57.5	0.92 (0.49–1.72)	0.795

CEE, Central and Eastern European; CI, confidence interval; ETR, exposure and transmission risk; OR, odds ratio; SD, standard deviation. Bold values denote statistical significance at the  $P < 0.05$  level.

a: Reference.

b: Adjusted for age, sex and being symptomatic.

c: Adjusted for age and sex only because experiencing symptoms is inherent in reporting this indicator.

d: Occupational transmission risk indicator 'Attended the workplace awaiting or after a positive test result' is not presented, because zero co-living migrants attended the workplace awaiting or after a positive test result.

e: Fisher's exact test is performed because of  $<5$  observations per cell, which does not change the significance.

with findings of other studies that found no differences in occupational ETR between CEE migrant and resident workers,<sup>20</sup> and between agency-employed and non-agency-employed CEE migrant workers.<sup>16</sup> One should be careful when comparing CEE migrant workers with resident workers, without acknowledging the differences in employment settings in which these groups are working. For example, 20% of the 6000 notifications of violations of occupational health and safety that the Dutch labour inspectorate received during the pandemic involved CEE migrant workers, who only accounted for 5% of the labour market.<sup>17</sup> This may lead to a biased conclusion that CEE migrant workers violate regulations more often. However, based on our findings, this most likely reflects CEE migrant workers' overrepresentation in essential industries that continued on-site work during the pandemic, rather than a difference in risk behaviour.

### *The occupational-domestic setting*

In this study, CEE and co-living CEE migrant workers were three times more likely to suspect a co-worker-housemate as their infection source, compared to resident and non-co-living CEE migrant workers. An explanation for this finding is that the phenomenon of co-living is specific to the CEE migrant worker population. The co-living rate was found to be 1% in resident workers and 51% in CEE migrant workers, which is in line with other studies that found a 48% and 45% co-living rate among CEE migrant workers and 0% in resident workers.<sup>16,20</sup> In these co-living environments, 85% of renters share kitchen and sanitary facilities, and 65% share a small bedroom with regularly changing tenants,<sup>14,17</sup> thereby making a co-worker-housemate a plausible source of infection when co-living. The small fraction of resident workers in this study who suspected a co-worker-housemate as the source of infection (3.9%) were most likely to work in a family business, which is common in the region of our investigation. The possibility of reverse causation where the living situation was changed as a result of the pandemic has been considered, but was deemed unlikely due to the relative short time frame and restrictions to domestic mobility due to the housing shortage in the Netherlands.

### *The domestic setting*

CEE migrant and resident workers do not differ in the number of reported household contacts, which was also reported in a comparable study.<sup>20</sup> Co-living is associated with being 17 times more likely to report more than two household contacts. This finding is in line with a survey of 153 CEE migrant workers in the Netherlands, which found that 62% of co-living CEE migrant workers reported more than two co-habitants.<sup>16</sup> It is important to state that the number of household contacts made in the infectious period is determined not only by the number of housemates but also by the possibility of distancing and self-isolation. Inspection reports of co-living environments for CEE migrant workers illustrate that these crowded, shared environments are devoid of social distancing and isolation options.<sup>10,14,17</sup> These findings suggest that not CEE migrant status but the nature of a co-living environment, where CEE migrant workers are overrepresented in, is a determinant of domestic ETR.

### *The community setting*

In this study, CEE migrant workers were significantly less likely to report both exposure and transmission indicators in their communities. CEE migrants' long working hours that allow for little leisure time plus an intention to return to the home country, which is negatively associated with socio-cultural integration, most likely account for a less extensive social network.<sup>14,17,31</sup>

### *General setting*

Although reporting test delay was common in all groups, CEE migrant workers were almost twice as likely as resident workers to delay testing for more than 1 day. This finding is in line with evidence that test delay is associated with migrant status through financial, language, belief and cultural barriers to healthcare access.<sup>32,33</sup> Another study with a small sample size investigated the effect of CEE migrant status on test delay and did not find a significant relationship.<sup>20</sup> Delayed COVID-19 diagnosis is a public health concern because it maintains chains of transmission, can be a source of COVID-19 false-negative results and offers a possible explanation for worse morbidity and mortality outcomes.<sup>32,34,35</sup> CEE migrant worker status and co-living situation was associated with being asymptomatic, which could indicate higher readiness to submit to testing in absence of symptoms. More likely it reflects underreporting of symptoms due to possible negative financial consequences or participation in pre-emptive testing imposed by employment agencies as part of COVID-19 control measures in CEE migrants.<sup>14,16,17</sup>

The strengths of this study are the large sample size and narrowing of the knowledge gap by a first-time analysis of the association of both CEE migrant status and living situation with a wide range of ETR in different settings. This study has two major limitations. First, only data on cases were available, limiting the strength of statements that can be made about the risk of infection in the absence of a healthy control group. Second, data processing that was necessary to recode information from a semi-structured interview stored in a medical record into new variables could have decreased data quality. For example, only data on the number of household contacts (not the number of housemates) could be obtained, which was deemed proportionate to household size.<sup>25</sup> Although living situation was not part of the interview, the nature of the relationship with co-habitants was. Therefore, we regarded all living situations other than living with a first- or second-degree relative, partner, or spouse, as a co-living situation. This might account for a slight overestimation of the number of cases in a co-living situation. The co-worker's housemate as a suspected source is likely to be underreported because if a co-worker or housemate was reported as a source, it could not always be determined through file research whether this was a co-worker-housemate.

This study addressed the pressing issue of labour migrant well-being and helped to find entry points for policies to reduce health inequalities for workers who migrate from Central and Eastern Europe to work in Western Europe. The urgency for this public health issue will continue to increase. Since the 2004 and 2007 EU enlargement, labour migration from East to West Europe increased to a point where 12% of the CEE working-age population now resides in Western Europe.<sup>36-39</sup> The current demand for 400 000 CEE migrant workers in the Netherlands is expected to increase annually by 50 000 workers.<sup>17,40</sup>

Thus, our findings provide important policy recommendations. First, since the occupational setting of essential industries is a plausible place for exposure to and transmission of SARS-CoV-2 for all workers equally, the body of occupational health and safety legislation in place requires continuous enforcement. Second, we argue that ensuring early access to testing by avoiding barriers, such as access issues, economic loss and social stigma in migrant workforces, facilitates the control of SARS-CoV-2 transmission. This will not only benefit CEE migrant workers but also their host countries' populations. Third, owing to the rising demand for CEE migrant workers and the current Dutch housing shortage, the number of co-habitants in co-living environments is unlikely to decrease. For interventions to reduce household contacts during the infectious period to be effective, they should be targeted at better distancing and isolation options for co-living CEE migrant workers. To ensure their implementation and compliance, these measures need to be supported by

**Box 1** Outcomes and their definitions

Settings	Indicators of SARS-CoV-2 exposure and transmission risk	
	Indicator of exposure risk	Indicator of transmission risk
Occupational	Suspected a co-worker (that is not a housemate) as the source of the infection	Has more than one occupational close contact in the infectious period. Definition: the index case being at <1.5 m distance for over 15 min with a person at the workflow in the period 2 days before to 7 days after symptom onset. Attended the workplace while experiencing symptoms. Definition: the index cases' last working day ensues the day of symptom onset. Attended the workplace awaiting or after a positive test result. Definition: the index cases' last working day ensues the day of testing.
Occupational—domestic	Suspected a co-worker that is also a housemate as the source of infection <sup>a</sup>	
Domestic	Suspected a housemate (that is not a co-worker) as the source of the infection	Has more than two household contacts in the infectious period. Definition: the index case being at <1.5 m distance for over 15 min with a person in their household in the period 2 days before to 7 days after symptom onset.
Community	Suspected a community member as the source of the infection	Has more than one community close contact in the infectious period. Definition: the index case being at <1.5 m distance for over 15 min with a person in the community in the period 2 days before to 7 days after symptom onset, which was calculated as the total number of contacts, minus the number of occupational and household contacts.
General	Was not sure where exposure to the source of infection took place	Delayed testing with more than 1 day. Definition: the index cases' day of testing ensues the day of symptom onset with more than 1 day.

a: If a co-worker or housemate is reported as a suspected source, file research reveals whether this is a co-worker that is also a housemate.

legislation, such as building decrees and continuously enforced directives for employment agencies that provide housing.

Our findings could be extrapolated to other airborne infections and in the light of scarce and COVID-19-focussed research in CEE migrants, we encourage broadly scoped future research into infectious disease burden of this population.

We conclude that preventive efforts should be aimed at the occupational health and safety of all essential industry workers. For CEE migrant workers, public health policies should focus on reducing test delays, and when co-living, improving domestic isolation and distancing options.

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*Conflicts of interest:* None declared.

## Data availability

Because of data-sharing restrictions, files containing anonymized datasets cannot be made publicly available. The data will be shared upon reasonable request with the corresponding author.

## Key points

- The occupational setting of essential industries is a plausible place for the exposure to and transmission of SARS-CoV-2 for all workers equally.
- CEE migrant workers encounter lower SARS-CoV-2 exposure and transmission risk in the community than resident workers.
- Compared to resident workers, CEE migrant workers generally pose a higher exposure risk to their environment by delaying testing.
- When co-living, CEE migrant workers more often report an above average number of household contacts, increasing domestic transmission risk, which is most likely caused by substandard distancing and isolation options.
- SARS-CoV-2 infection prevention policies in essential industries are most effective if they target enforcing occupational health and safety measures for all workers, ensuring early access to testing for CEE migrant workers, and improving distancing and isolation options in co-living environments.

## Appendix

**Table A1** The presence of indicators of SARS-CoV-2 ETR per setting and their association with CEE migrant status and co-living situation via unadjusted multivariate logistic regression in 563 workers who became SARS-CoV-2-positive between October 2020 and June 2021 in company COVID-19 outbreaks in the Netherlands

	All worker (n = 563)	Resident workers <sup>a</sup> (n = 311)	CEE migrant workers (n = 252)	Unadjusted OR (95% CI)	P	Non-co-living CEE migrant workers <sup>a</sup> (n = 109)	Co-living CEE migrant workers (n = 114)	Unadjusted OR (95% CI)	P
Occupational setting									
Suspected a co-worker (that is not a housemate) as the source of infection (%)	56.2	53.2	60.1	1.32 (0.94–1.87)	0.113	57.8	63.4	1.26 (0.74–2.17)	0.395
More than one occupational close contact in infectious period (%)	10.2	8.8	12.2	1.44 (0.81–2.57)	0.210	11.3	13.5	1.23 (0.53–2.84)	0.633
Attended the workplace while experiencing symptoms (%)	53.2	51.7	55.4	1.16 (0.80–1.68)	0.434	53.2	61.5	1.41 (0.77–2.59)	0.272
Attended the workplace awaiting or after a positive test result (%)	0.9	8.5	1.9	0.21 (0.02–1.92)	0.166	5.6	0.0	Not applicable <sup>b</sup>	–
Occupational-domestic setting									
Suspected a co-worker that is also a housemate as the source of infection (%)	7.9	3.9	13.3	3.79 (1.90–7.55)	<b>&lt;0.001</b>	7.3	20.5	3.26 (1.39–7.66)	<b>0.007</b>
Domestic setting									
Suspected a housemate (that is not a co-worker) as the source of infection (%)	9.2	13.0	4.3	0.30 (0.15–0.61)	<b>0.001</b>	6.4	1.8	0.27 (0.05–1.31)	0.103
More than two household contacts in infectious period (%)	42.1	40.6	44.1	1.15 (0.82–1.63)	0.422	14.7	74.8	17.22 (8.67–34.23)	<b>&lt;0.001</b>
Community setting									
Suspected a community member as the source of infection (%)	5.5	7.5	3	0.38 (0.16–0.91)	<b>0.030</b>	0.9 <sup>c</sup>	4.5	5.05 (0.58–43.92)	0.143
More than one community close contact in infectious period (%)	7.3	9.8	3.8	0.36 (0.16–0.80)	<b>0.013</b>	5.7	2.1	0.36 (0.07–1.80)	0.211
General setting									
Not sure where exposure to the source of infection took place (%)	21.1	22.4	19.3	0.83 (0.54–1.26)	0.383	27.5	9.8	0.29 (0.14–0.61)	<b>0.001</b>
Delayed testing with more than 1 day (%)	52.7	47.9	60.1	1.64 (1.13–2.37)	<b>0.009</b>	60	57.5	0.90 (0.49–1.65)	0.738

CEE, Central and Eastern European; CI, confidence interval; ETR, exposure and transmission risk; OR, odds ratio; SD, standard deviation. Bold values denote statistical significance at the  $P < 0.05$  level.

a: Reference.

b: Occupational transmission risk indicator 'Attended the workplace awaiting or after a positive test result' is not presented, because zero co-living migrants attended the workplace awaiting or after a positive test result.

c: Fisher's exact test is performed because  $<5$  observations per cell are not significant.

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