Adviesaanvraag

Vraagsteller	Regeringscommissariaat Corona
Datum van adviesaanvraag	26/07/2021
Onderwerp	Maatregelen vanaf september 2021
Vraag	Welke NPI's zullen zo nodig nog relevant/belangrijk zijn, rekening houdend met de evoluerende vaccinatiecampagne?

Adviesverstrekking t.a.v. het Overlegcomité

Datum van adviesverstrekking	17/08/2021
Dit advies werd opgesteld door	De volgende leden van de GEMS: Isabelle Aujoulat, Philippe Beutels, Steven Callens, Mathias Dewatripont, Lode Godderis, Niel Hens, Yves Kreins, Tinne Lernout, Romain Mahieu, Christelle Meuris, Geert Molenberghs, Karine Moykens, Céline Nieuwenhuys, Michel Thieren, Pierre Van Damme, Steven Van Gucht, Yves Van Laethem, Marc Van Ranst, Dimitri Van der Linden, Maarten Vansteenkiste, Erika Vlieghe, Dirk Wildemeersch

Executive summary and main GEMS-recommendations

1. This advice builds further on the GEMS-advice 'Autumn-winter' dd. 30/6/2021. We kindly refer to this earlier advice for general concepts and recommendations.
2. The epidemiological situation and further evolution over the next weeks and months is still unclear and warrants remaining vigilant and prudent. There is a progressive increase in cases and hospitalisations: the large majority are not (yet) vaccinated persons, but also occasional outbreaks in fully vaccinated vulnerable persons (e.g. nursing homes). A clear correlation remains present between number of cases, (lack of) vaccination and returning travellers and between number of cases and hospitalisation.
3. The risk of the introduction of new variants with the capacity of immune escape, from areas with higher viral circulation and lower vaccine coverage, remains a real possibility to take into account, but the extent of immune escape is difficult to estimate. The delta variant has established its dominance over the summer in Belgium and in many other countries within and outside Europe.
4. We expect for the upcoming weeks a further increase in viral circulation due to returning travellers, increasing number of events and gatherings, reopening of schools, change of season and the dominant presence of the more contagious delta variant. This may be in part counteracted by the further progress in vaccination status in the population. Careful further follow-up of the net impact on cases and hospitalisation patterns is required. High rates of viral circulation may cause disease primarily among the not-vaccinated, but can spread further to fully vaccinated vulnerable persons (as levels of protection may vary between individuals and may decrease over time).
5. In addition, the rhythm of other respiratory viral infections (e.g. RSV, influenza) seems to be disturbed (no influenza 2020, later RSV-season,...), so these other infections may cause additional or unpredictable burden of disease in the upcoming winter season.
6. National and international evidence show that people remain cautious within the given relaxations and maintain a lower number of social contacts as compared to pre-pandemics times.
7. Taking everything into account we aim for:
   a. maintaining a basic set of NPI's to keep the overall viral circulation level low in the upcoming months while vaccination can be maximized, and while the longer term epidemiological evolution can be observed. This may allow for a sustainable, stepwise return to pre-pandemic societal activities.
   b. maximizing the vaccination level in all layers of society, with specific focus on 'blind spots' in large cities and population groups (we refer to the upcoming GEMS+ advice).
8. Concrete recommendations (we refer also to our advice dd. 30/06)
   a. **Schools and higher education**:
      i. We refer to GEMS_024 advice dd. 30/06, with suggested measures depending on the epidemiological situation (RAG-alarm level).
      ii. It can be considered to differentiate these measures also by the loco-regional vaccination status (e.g. province or region).
      iii. Priority should be given to outdoor activities. Indoor air quality should be monitored and ventilation should be optimized at all times, given higher density of pupils in classrooms.
      iv. In particular, mask wearing by teachers and students 12-18y during the first weeks of the school year should be considered as a bridging measure to allow the epidemiological situation to stabilise (e.g. returning travellers), maximize the vaccination coverage of adolescents while keeping infection rates in the not (yet) vaccinated. This measure should be re-assessed regularly. Likewise, if masks are worn in schools, they should be applied in other areas of society, too (see below).

v. Specific attention and creative solutions should be developed and disseminated urgently to stimulate vaccination among adolescents and young adults (students), e.g. by intensifying information, peer-stimulation, include buy-in from higher education institutions, organize on-campus vaccination, present student vaccination as part of a complete package to ensure a better and sustainable academic year (including vaccination, masks, ventilation, recommendations for safer student life, low threshold testing on campus,...).

b. **Workplace**:

i. We refer to GEMS 024 advice dd 30/06 and to the general and sector guide, which provides a framework of measures that can be customized by the sectors and by each employer in order to ensure that activities can be restarted in conditions that are as safe and healthy as possible.

ii. Maintain (partial) telework as a sustainable intervention to reduce crowding in public transport and at workplaces. Reduce sustainably the number of live meetings.

iii. Provide means to occupational health professionals to identify the vaccination coverage within their company. Work health committees should perform the assessment and formulate interventions at company level taking into account risks linked to the work activities and vaccine coverage. High risk sectors can be identified based on e.g. repeated RSZ-data on infection among workers. Interventions could include: low-threshold vaccination and testing at the workplace, providing information, strengthened cluster management, sharing best practices, improving indoor air quality,...

iv. Consider mandatory vaccination for professions with (1) particular societal risk (e.g. health care sector (as recommended by the Royal Academies of Medicine of Belgium) and (2) for professions with high occupational (individual) risk (e.g. education, horeca, meat processing, professional sporters, close contact professions); taking all epidemiological and sociological advantages and drawback into account. A targeted information and communication campaign on the advantages and importance of vaccination and the health gains made due to vaccination is anyhow needed.

c. **Mask wearing and ventilation**

i. Mask wearing should be maintained in all settings where groups of people convene, in particular: in ill-ventilated public indoor settings, when safe distance cannot be maintained, when vaccinated and non-vaccinated persons mix (particularly if vulnerable persons are present). This measure will also help to reduce the burden of influenza and other respiratory tract infections.

ii. Further steps in the sustainable improvement of air quality in all public indoor settings should be taken (e.g. schools, workplace, health care settings, public transport, fitness and other indoor sports facilities,...).

d. **Testing, contact tracing, cluster management**: see specific RAG advice

e. **International travel**: We refer to our earlier advice on details of the delta variant characteristics (GEMS_024 advice dd 30/06 and international travel dd. 7/05/2021). We suggest to strengthen the current travel policy according to the RAG advice, i.e. adding 2nd test for non-vaccinated from red zone within EU and applying 2 tests for vaccinated from EU VOC country.

f. **Vaccination**/DCC/CST (preliminary, ahead of final GEMS+-advice)
   i. We still expect a significant number of Belgian citizens planning to get vaccinated in the coming weeks (e.g. return from holidays) out of intrinsic motivation. Therefore, the current vaccination campaign (including for the 12-15 y old) should be further continued and supported, with a gradual switch to decentralisation, local tailor-based approach (‘*bringing the vaccin to the people and not vice versa*’). In addition to already ongoing efforts, specific attention should be given to e.g. low threshold, local vaccination booths in universities and high schools, event venues, testing centres, hospitals,...and tailored information sessions to help people make their decisions.
   ii. Communication on vaccination should educate more clearly on the large scale population advantages, focus less on rare side effects and explain the phenomenon of breakthrough infections
   iii. If an expanded domestic use of the DCC is considered, it should be well examined in terms of its pros and cons. It may be interpreted as a hidden obligation, next to its falsifiability and difficulties in responsibility for control. However, it could be useful to open the possibility for organizers of smaller events to apply the CST too (which requires changing the legal base). In situations or times with higher viral circulation, it may be considered to add a negative test for fully vaccinated persons before granting a CST. The use of the CST should depend on the epidemiological situation (e.g. Israel suspended the use of the pass for several weeks when the epidemiological situation allowed it).
   iv. A step-wise mandatory vaccination to specific target groups in society may need to be considered as well, e.g. those working with medically vulnerable persons (health care sector) and or those working in sectors where incidence rates remain high. However, before obligation, all efforts to stimulate intrinsic motivation need to be mobilized and exploited (capitalize on the success of the vaccination campaign) and the possible collateral damage towards public trust in the government and other vaccination programs (measles, pertussis,...) needs to be taken into account.

9. Endpoint of recommendations/definition of ‘normal’
   a. We refer to GEMS_024 advice dd 30/06
   b. The current epidemiological situation can be seen as a <u>transition period</u>, between pandemic and ‘returning to normality’. At the present date, it is very difficult to foresee the natural evolution of this pathogen. We defined a set of tentative criteria to define what could be a ‘(near)-normal epidemiological situation’:
      - Having passed a fall/winter season without major disturbances of the health care system due to covid-cases and hospitalisations.
      - Covid-waves evolving into seasonality and predictability (in timing and size) or into constant but low level endemicity.
   c. It should be considered that certain NPI’s could remain part of our habits on specific places and times of the year (e.g. wearing masks in crowded public transport and health care settings in winter time, sustainable efforts to improve indoor air quality,...).

1. Epidemiological situation

1.1. Overall evolution (for in depth analysis: see RAG report)

In spite of high rates of vaccination, we observed over the past weeks a gradual but clear and steady increase in cases, positivity rates and a slower, but clear increase of hospitalisations, within a context of a stable n of testing. This is to be interpreted as a real increase. For an extensive assessment of the epidemiological situation, we refer to the latest weekly RAG-report dd. 11/08/2021.
Of note are the following observations:

- The large majority of hospitalised cases are persons who are not yet fully vaccinated. We observe important regional differences in vaccination status (e.g. Brussels), which warrant targeted urgent interventions at local or provincial level. In addition, infections in fully vaccinated persons with weak immune systems occur sporadically (e.g. outbreak in the nursing home in Nossegem).
- There is still a remaining connection between n of cases and hospitalisations (as explained in depth in paragraph 1.2); this means that a very large increase of n of cases still can lead to a significant number of hospitalisations (see paragraph 2). Therefore efforts remain needed to keep the viral circulation under control, which can be seen as a triangular relationship between viral transmission, vaccination status and NPI's. We refer to our GEMS_024 advice dd. 30/06 for in-depth explanation.
- We expect for the upcoming weeks a further increase in viral circulation due to returning travellers, increasing number of events and gatherings, reopening of schools, change of season and the dominant presence of the more contagious delta variant. This may be in part counteracted by the further progress in vaccination status in the population. Careful further follow-up of the net impact on cases and hospitalisation patterns is required. High rates of viral circulation may cause disease primarily among the not-vaccinated, but can spread further to fully vaccinated vulnerable persons (as levels of protection may vary between individuals and may decrease over time).
- In addition, the rhythm of other respiratory viral infections (e.g. RSV, influenza) is disturbed, and may cause additional burden of disease in the upcoming winter season.
- The actual settings of clusters include the workplace (see 1.3) and youth camps although in general transmission still occurs most commonly at home and in private contacts. However, evidence from contact-pattern studies in Belgium shows that the number of contacts are still at a lower level than pre-pandemic times; similar findings were noted in the UK.
- On the other hand, the volume of returning travellers is much larger than in 2020. We also observe a difference among weekly rates of returning travellers (Brussels (4.3/100 pop/w) > Vlaanderen (3.5/100 pop/w) > Wallonia (2.4/100 pop/w), see Figure 1 below) and significant differences in positivity rates among returning travellers. In particular PR in people returning from Morocco are worrisome (i.e. 10%) and warrants targeted actions (i.e. strengthened follow-up of testing post-travel as well as continued efforts to work with trusted intermediaries to convey the messages to different communities).
- Taken together, the situation in Brussels is worrisome, with the lowest vaccination levels, a diverse population with the highest number of persons entering from abroad. In combination with the start of the new school year, the reopening of the large-scale events and mass-gatherings (since 13/8/21), this may lead to a fast increase in cases followed by a stronger increase in the number of hospitalisations. Brussels will probably become dark red on the ECDC map (very high incidence) at the next review, while Wallonia has become red (high positivity) at the next review. This is to be seen as a threat to public health but may also jeopardize the international reputation of the European capital.

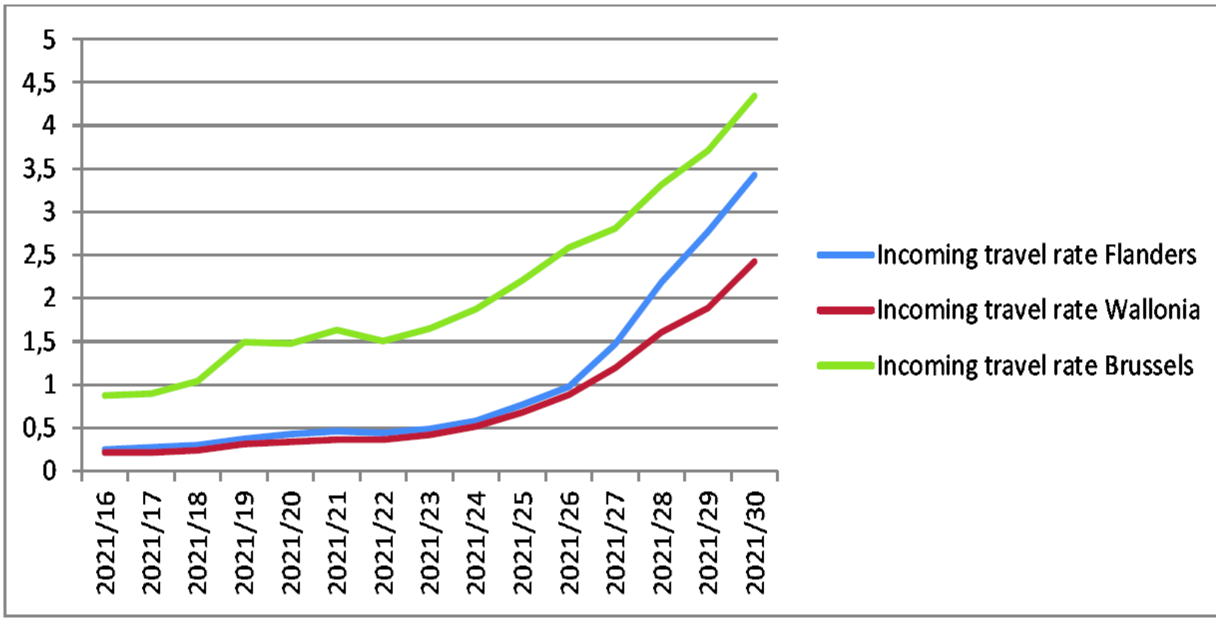


Figure 1. Trends of the incoming returning travellers rates among the population of the 3 regions

1.2. Correlation cases, hospitalizations and vaccination status

Observations from Belgium (analysis by G. Molenberghs, see Annex 1). Strong correlations were identified between confirmed cases on the one hand and vaccination plus spread of the delta variant on the other hand over June and July 2021; this is true in each Flanders, Wallonia, and Brussels. Likewise, hospitalizations correlate very strongly with confirmed cases and vaccination rate. This implies that vaccination reduces hospitalizations, but that there is still a residual impact of confirmed cases. Over this period, the three Belgian regions have reached rather different vaccination levels, have reached different case incidences, and have received differing volumes of travellers coming in from abroad. Each of these indicators have been changing over time.

Precisely, it was noted that in every region, the 14-day incidence of confirmed cases (infections) is expected to be higher with lower vaccination levels and with a higher fraction of delta variant circulating. This is a strong correlation (R^2 values are around 0.95). This conclusion holds within every region separately, but the strength of the effect of each variable changes across regions. The effect of delta is largest in Brussels and smallest in Wallonia. The effect of vaccination is larger in Flanders and Wallonia. This suggests that there are differences between regions that are as of yet unexplained. Let us turn to this.

Indeed, by introducing the effect of volume of returning travellers, a common relationship is reached for the three regions. Thus, there is a very high (multiple) correlation between confirmed infections on the one hand and vaccination rate and volume of returning travellers on the other. The same predictors are highly correlated with weekly hospitalizations. For example, Brussels has the lowest vaccination rate and the highest volume of returning travellers, and consequently the highest incidence of confirmed cases and highest hospitalization incidence over the period under study.

Furthermore, the 7-day incidence of hospitalisations is strongly correlated with vaccination status and n of cases (R^2 = 0.90). Over the period where the delta variant became dominant (examined June 21 – August 14, 2021), a doubling of confirmed cases led to a 41% increase in hospitalizations. Over the second half of July 2021, there is some initial evidence for a creep upwards to about 50%.

Observations from other countries (see Annex 2). In Annex 2, we compiled observations on the evolution of cases and hospitalisation in different countries of the EU and outside the EU with fairly high vaccination coverages. In all countries with rapid increases of confirmed cases, either measures were relaxed to the point as to open nightlife and large events, with little or no remaining measures (Netherlands, Spain, Portugal, Cyprus, Greece) and/or tourism plays an important role (Spain, Portugal, Cyprus, Greece, Malta).

A frequent observation is that a period of low to very low incidence, which sets in when vaccination coverage starts to rise, and apparently sooner than the usual herd immunity threshold calculations would suggest, can be followed by rapid incline again, i.e., an unstable situation (e.g., Israel rising from incidence 2 to incidence above 600 at this time!). This phenomenon was described, among others, by Tkachenko et al. (2021), and ascribed to superspreading. Sneppen et al. (2021) assert, in the same vein, that this superspreading (also referred to as overdispersion in spread) leads to increases in the effectiveness of limiting nonrepetitive contacts. These authors state:

"*Evidence indicates that superspreading plays a dominant role in COVID-19 transmission, so that a small fraction of infected people causes a large proportion of new COVID-19 cases. (…) The results indicate that superspreading is the virus 'Achilles' heel: Reducing random contacts – such as those that occur at sporting events, restaurants, bars, and the like – can control the outbreak at population scale.*"

1.3. Infections at the workplace based on RSZ-data (see Annex 3)

The workplace is among the main activities for a large proportion of the population, and consequently a source of potential infection. In the most recent report (see Annex 3, 12th version August 6 2021), we can conclude that vigilance is needed in those sectors where telework is not possible, where workers are often exposed to close physical proximity, and where climatic conditions favour transmission of the virus. Contact tracing shows that the highest incidences occur in public transport and government segments and that the increasing incidence pattern is observed throughout the country.

Actual high risk sectors. With increased circulation of SARS-CoV-2, it is important to carefully monitor the incidence of COVID-19 in the sectors where multiple people are in close contact, especially with younger, unvaccinated persons. The sectors 'Passenger air transport', 'Sports', 'Entertainment and recreation', 'Sports and recreation education', 'Performing arts and its organization and promotion', many retail sectors and 'Eating and drinking places' for example show a steeper increase in incidence and require careful attention. It would be worthwhile to review hygiene protocols and practice in sectors where the reason for the steeper increase in the number of incidents is not immediately clear, such as accountants, interior decorators, advertising, real estate agents, other personnel services, private security, call centers, and computer consulting.

Infections among health care workers. The 14-day incidence in health and care workers follows the general trend in the population. While the incidence in the health care sector remains well below the average for the general population, the incidence in the home care sectors rises from below the average for the general population to close to the average for the working population. It is possible that this increase can be partially explained by the fact that COVID-19 infection remains possible despite vaccination (45 out of 472 cases or 10%), as shown by contact tracing data. The majority of index cases are observed in partially vaccinated people.

Workplace as source of infections. From 5790 index cases, we have information about perceived work relatedness of the source of infection. While 38% of the index cases did not know whether the infection took place at work, 21% responded that they were certainly or probably infected at work. From 1927 (33%) of the index cases that answered they were certainly, probably, or possibly infected at work, further information was obtained on how the infection took place. 40% got infected through a colleague at work, 3.7% during transport and 5% during breaks. The last four weeks (thus since the beginning of the summer holidays and alleviation of corona restrictions in private and public life), the index cases who mentioned to be infected outside the workplace is about 10 percent higher than before summer holidays.

1.4. Infections in fully vaccinated people (breakthrough infections)

General considerations on breakthrough infections

While vaccination is very effective to prevent hospitalization and death by delta, vaccinated people can get infected and can carry a high viral load, hence can be highly transmissible (Brown CM et al., 2021). There are several reasons: all available vaccines have < 100% VE on the prevention of infection. In certain patient groups with weak immune systems, vaccine effectiveness may be somewhat lower. In addition, over time, vaccine-induced immunity may wane. Thirdly, the delta variant, which became recently the dominant circulating strain, is associated with increased transmissibility and possibly also higher virulence. Therefore, NPI's, such as wearing masks, safe distance and good ventilation are essential to prevent continued spread.

Although breakthrough infections are still relatively rare (certainly severe infections) and were not unexpected on the introduction of the vaccines, more large scale education and communication on the issue is needed to reassure the public this is not concerning a large scale failure of the vaccination campaign, and to explain the individual risk among the vaccinated, i.e.

- Risk of severe disease or death reduced **10-fold or greater** in vaccinated,
- Risk of infection reduced **3-fold** in vaccinated.

To prevent breakthrough infections at a maximum, the following actions are to be considered:

- consider vaccine mandatory vaccination for Health Care Personnel to protect vulnerable populations as recommended by the Royal Academies of Medicine of Belgium;
- keep the use of masks in settings where people meet outside the household (workplace, schools, public transport,...);
- keep a low index of suspicion and indication for testing fully vaccinated persons with limited symptoms, especially when they are in contact with more vulnerable persons.

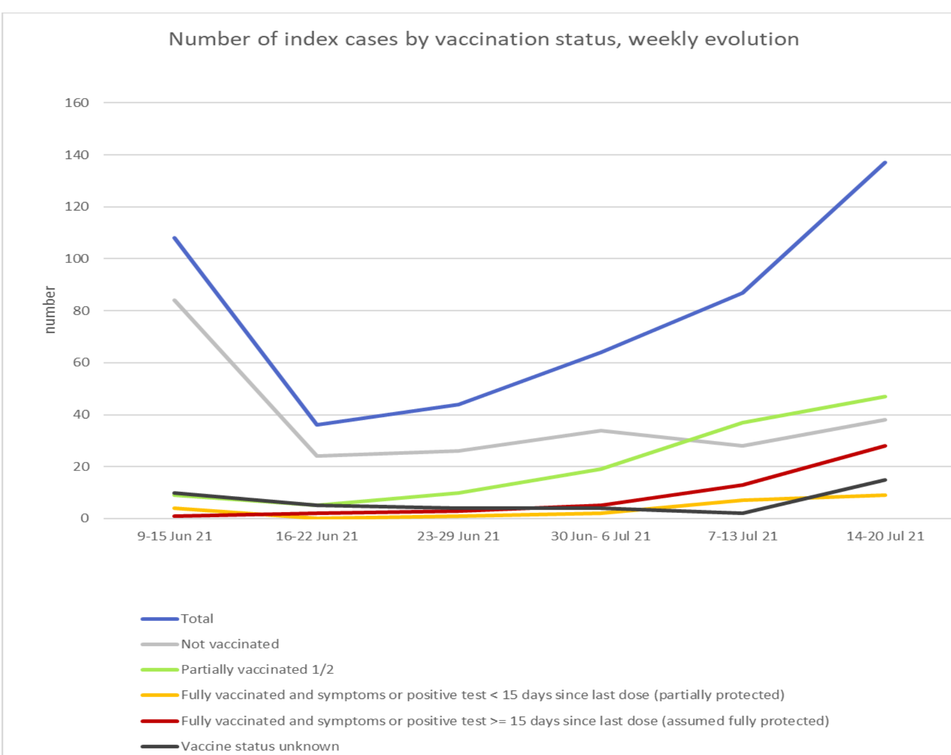
Breakthrough infections among hospitalised patients in Belgium. Based on the latest RAG report on breakthrough infections (which should be published on the Sciensano website this week), we note that: "Clinical information on hospitalized COVID-19 patients is collected in the COVID-19 Clinical Hospital Surveillance. This surveillance covers approximately 2/3rds of all hospitalized COVID-19 patients in Belgium. Data is obtained with a delay of approximately 1-3 weeks. Linking with Vaccinnet+ data allows us to identify the vaccine status of these cases.

From January 1 to August 8, 2021 there have been 19 723 hospitalized patients registered. Of these, 2.1% (416 / 19 723) were fully immunized (≥14 days after completing vaccination schedule). Patients with partial vaccination (≥14 days after dose 1 and <14 days after dose 2) accounted for 6.4% of hospitalizations (1267 / 19 723). A comparison was made between the 416 fully immunized and the 16 866 non-vaccinated hospitalized COVID-19 patients. Median age of the fully immunized patients (= breakthrough cases) was 82 years, 47.6% were nursing home residents, and 61.3% were females.

92.5% of fully-immunized COVID-19 patients had underlying comorbidities versus 75.2% among the non-vaccinated patients, a difference that could result from the older age of the former. a large proportion of the hospitalized breakthrough cases were identified through systematic screening (50.2%, 209/416) rather than because of COVID-19 compatible symptoms at admission (44.2%, 184/416). Nonetheless, patients identified through systematic screening may still go on to develop severe symptoms and complications during hospitalization".

Breakthrough infections in Belgian workers. In the most recent incidence report per economic sector (12th version August 6 2021), we have analysed vaccination status of index cases traced by IDEWE. The vaccination dates are retrieved from Vaccinnet. Since 6 June 2021, vaccination status from 472 adult index cases were known: 210 were partially or completely vaccinated (155 Cominarty, 33 Vaxzevria, 16 Moderna and 6 Johnson % Johnson). With an increasing vaccination coverage in the working population, which was 80% on 21 July 2021 (data derived from Sciensano), it is important to evaluate these breakthrough index cases in time. The mean time between notification of infection and the second vaccine dose (or the only dose in case of Johnson & Johnson) for the breakthrough cases was 73 days (SD 44), minimum 15 days, maximum 151 days. The index cases who are not or only partially vaccinated form the largest proportion, but also number of positive fully vaccinated index cases are rising.

Figure 2: The weekly evolution of index cases and their vaccination status



Outbreaks with breakthrough infections in other countries. Annex 4 highlights the case of a large community outbreak in the US, associated with summer festivities, among whom 74 % was fully vaccinated, and 90% of the infections was caused by the delta variant. Persons with COVID-19 reported attending densely packed indoor and outdoor events at venues that included bars, restaurants, guest houses, and rental homes. This and other similar experiences led to adaptation of the CDC-guidelines on the use of masks and other NPI's for fully vaccinated persons, stating that "*Findings from this investigation suggest that even jurisdictions without substantial or high COVID-19 transmission might consider expanding prevention strategies, including masking in indoor public settings regardless of vaccination status, given the potential risk of infection during attendance at large public gatherings that include travellers from many areas with differing levels of transmission*."

1.5. Role of variants of concern (now, future, …)

Over the past 2 months, the delta variant has established its dominance in Belgium and in many other countries within and outside Europe. Once again, this has altered the evolution of the actual epidemic due to its higher transmissibility and possibly also higher virulence. However, vaccine-related protection for severe disease remains very high. We refer to our earlier advice on details of the delta variant characteristics (GEMS_024 advice dd 30/06 and international travel dd. 7/05/2021)

Although it is difficult to foresee how the pandemic will evolve, Rella et al. (2021) have modelled the probability of emergence of a vaccine-resistant strain. Their results show that:

- (global) vaccination rate has a large influence on the probability of the emergence of a resistant strain - which raises concern, given that not all (European) countries vaccinate at a fast pace.
- their modelling results show that when a relaxation of NPIs happens at a time when most individuals of the population are vaccinated and transmission is high (to check), the probability of emergence of a resistant strain is largely increased.
- Their data also suggest that delays in vaccination in some countries relative to others will make the global emergence of a vaccine-resistant strain more likely.
- They state that without global coordination, vaccine resistant strains may be eliminated in some populations but could persist in others.
- Thus, a truly global vaccination effort is necessary to reduce the chances of a global spread of a resistant strain

Taken together, the risk of the introduction of new variants with the capacity of immune escape, from areas with high viral circulation and low vaccine coverage, remains a real possibility to take into account as long as vaccination levels globally are still low, but the extent of immune escape is difficult to estimate.
Within this context, we want to stress the importance of limiting import of new strains through large scale international travel, by continuing to apply the actual travel restrictions. See also our earlier advice on international travel dd. 7/05/2021. In addition, the international community has the responsibility to ensure fast improvements of the global vaccination status.

2. Possible scenarios from modelling *(How will the upcoming weeks and months evolve?)*

Short term model (Christel Faes). As displayed in Figures 3 a and 3b underneath, if the actual epidemiological trend continues, the number of hospitalisations is expected to further increase by September 1st to averages of

40-50/day for Brussels, Flanders and Wallonia respectively. ICU-occupancy rate is expected to reach 15% overall, and to exceed the 25% threshold for Brussels.

Figure 3a. Short term prediction of n hospitalizations (C. Faes)

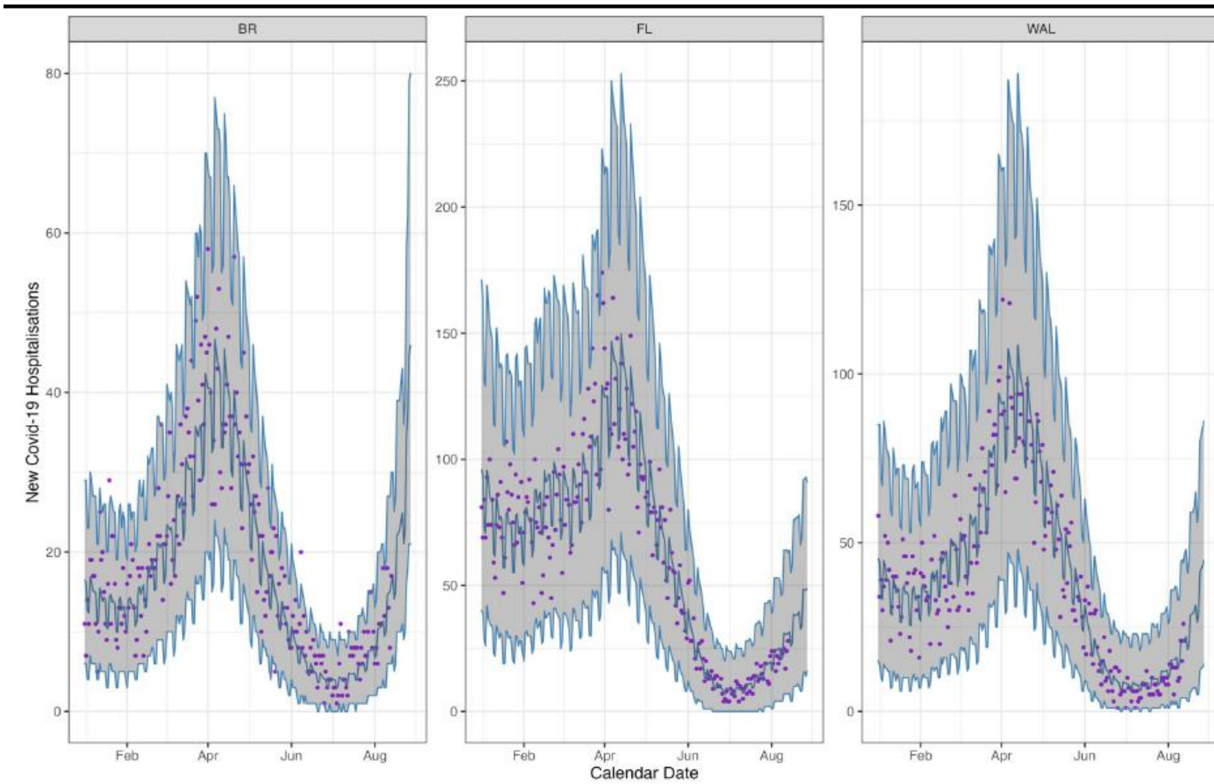
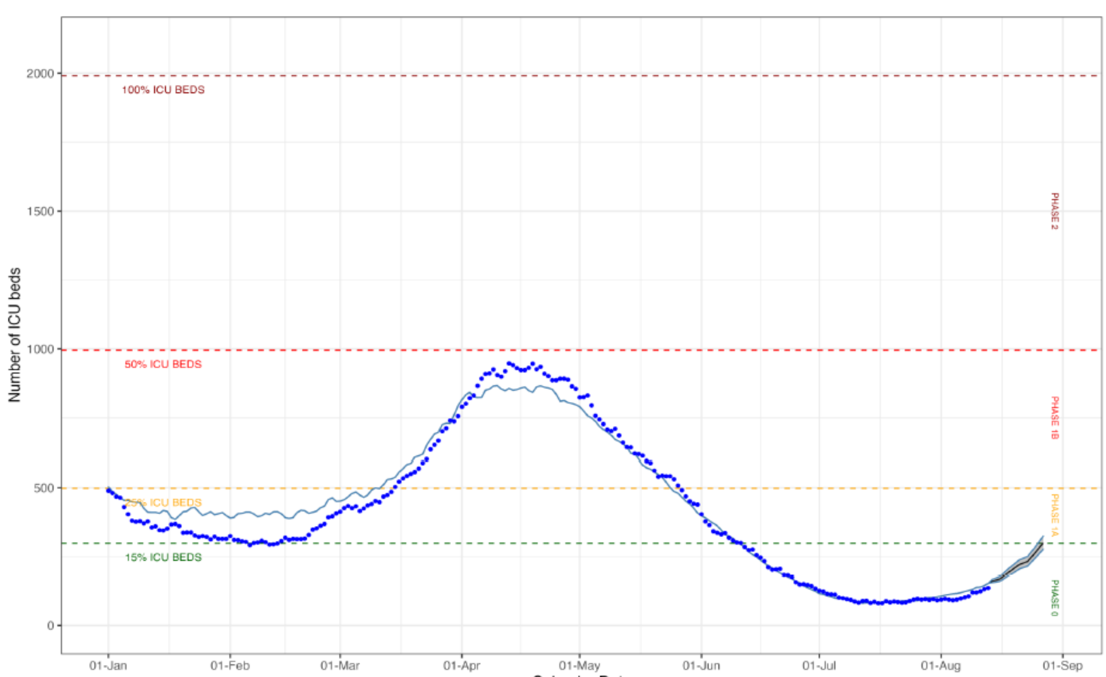


Figure 3b. Short term prediction of ICU occupancy rate (C. Faes)



Mid-long term model (Niel Hens et al). The reference model has previously been adapted for both the presence of the delta variant as well as for an increase in vaccine uptake (taking the specific vaccine schedule into account) over the different age-categories. The preliminary results of which one scenario was highlighted in GEMS_024 advice dd 30/06 (p4) describes well the current evolution of the daily hospital admissions. As a consequence, the counterfactual of returning to prepandemic behaviour on 1 September still stands and shows it is important to take a gradual approach in the months to come to ensure sufficient hospital capacity is preserved. Depending on the changes in risk behaviour (including reopening of schools on 1 September), it is expected that the number of hospitalisations and also the number of beds occupied in- and outside ICU will further increase; the extent to which is determined by the increase in risk behaviour. [*currently a new report is being written and will be made available*].

3. Tentative definition of the (new) 'normal' (*Where will we end up?*)

As described in GEMS_024 advice dd 30/06, the actual epidemiological situation can be seen as a transition period, between pandemic and 'returning to normality'. At the present date, it is very difficult to foresee the natural evolution of this pathogen. We defined a set of tentative criteria to define what could be a '(near)-normal epidemiological situation':

- Having passed a fall/winter season without major disturbances of the health care system due to covid-cases and hospitalisations;
- Covid-waves evolving into seasonality and predictability (in timing and size) or into constant but low level presence;
- It should be considered that certain NPI's could remain part of our habits on specific places and times of the year (e.g. wearing masks in crowded public transport settings in winter time, sustainable efforts to improve indoor air quality,...).

4. How do we bridge between the actual status and (new) 'normal' *(i.e. which NPI's do we still need for the upcoming months)?*

4.1. Increasing vaccination levels in age and population groups with low vaccination coverage

It is becoming increasingly clear that full vaccination is the best available protection against large numbers of hospital admissions. It is therefore important to continue to motivate people to be vaccinated.

The group of unvaccinated persons is actually quite heterogenous and consist of several groups, including (1) a small group, which is consciously anti-(Covid-19) vaccination mainly because of a deep distrust; (2) a larger group which is well informed, but hesitant or doubtful, sometimes mediated by a distorted view on risk perceptions through social media or likeminded peers; (3) probably the largest group, which is unaware or overwhelmed and/or has practical issues with receiving vaccination (e.g. single parents). This group includes also those who had prior COVID-19 infection and considers themselves as safe. The second group is a mixture, but may consist on average of higher educated persons, while the third group is by far the most vulnerable group, for which proximity interventions are a priority and should be pursued

In a separate report by GEMS+, we will discuss the pro and contra of diverse interventions to increase the actual vaccination coverage, including intensified information and promotion campaigns, vaccinated persons and first line health care workers as ambassadors, lowering the logistic threshold by community outreach, broadening the application of the CST/DCC, mandatory vaccination, applying positive or negative incentives.

Preliminary conclusions from the first GEMS+ meeting:

- We still expect a significant number of Belgian citizens planning to get vaccinated in the coming weeks (e.g. return from holidays) out of intrinsic motivation. Therefore, the actual vaccination campaign (including 12-15 y old) should be further continued and supported, with a gradual switch to decentralisation, local tailor-based approach (‘*bringing the vaccine to the people and not vice versa*’). In addition to already ongoing efforts, specific attention should be given to e.g. low threshold, local vaccination booths in universities and high schools, event venues, testing centra, hospitals,...
- Communication on vaccination should focus more clearly on the large scale population advantages and focus less on rare side effects and breakthrough infections
- Broad expansion of the domestic use of the DCC (= CST) to other societal activities (e.g; horeca, work, school,...) may be contra-productive and interpreted as a hidden obligation, next to its falsifiability and difficulties in responsibility for control. However, it could be useful to open the possibility for organizers of smaller events to apply the CST too (which requires changing the legal base). In situations or times with higher viral circulation, it may be considered to add a negative test for fully vaccinated persons before granting a CST
- A step-wise mandatory vaccination to specific target groups in society may need to be considered as well, e.g. those working with medically vulnerable persons (health care sector) and or those working in sectors where incidence rates remain high. However, before obligation, all efforts to stimulate intrinsic motivation need to be mobilized and exploited (capitalize on the success of the vaccination campaign) and the possible collateral damage towards public trust in Government and other vaccination programs (measles, pertussis,...) needs to be taken into account.

4.2. Keeping a minimal set of NPI’s during the upcoming months

International recommendations. Against the background of still low global vaccination rates and an increasing dominance of the delta variant, the WHO has warned against easing coronavirus restrictions too soon also despite increasing vaccination coverages given that this could lead to spikes in the number of cases and hospitalisations as is also clear from the international situation. Also ECDC has established advice on the maintained use of NPI’s over the upcoming months, as well as targeted recommendations for specific settings e.g. schools and long term care facilities (see Annex 5)

Actual stringency of NPI’s in Belgium. As shown in the table underneath, Belgium ranks fairly high in stringency and has for a long time been able to keep curves of cases and hospitalisations under control (in contrast with e.g. the Netherlands, Spain, France). However, with large numbers of returning travellers returning from red zones within and outside Europe (e.g. Morocco), Belgium will not be able to keep its moderate incidence position and become a red country soon on the ECDC-list. In addition, the epidemiological impact of the reopening of the large scale events and mass-gatherings (since 13/8/21) is yet to be observed. The reopening of the school year from September 1st will again cause large numbers of contacts between vaccinated and non-vaccinated persons. The net impact of these evolutions in combination with increasing vaccination rates and remaining NPI’s (triangular relationship) will need to be carefully observed and mitigated where needed.

Table 1. Comparison of stringency index and new cases in selected European countries (source: Our World in Data, 16/08/2021)

Country	Daily new cases per 1 M (7-day rolling avg)	Stringency Index	Cases/Stringency index
Hungary	7	28	0,3
Czechia	17	35	0,5
Denmark	175	35	5,0
Netherlands	149	36	4,1
Sweden	79	37	2,1
Luxembourg	67	38	1,8
UK	426	38	11,1
Poland	5	39	0,1
Spain	280	48	5,9
Ireland	356	48	7,4
Greece	309	49	6,4
Italy	103	50	2,1
Belgium	**166**	**53**	**3,2**
Austria	95	56	1,7
Portugal	230	58	3,9
Germany	54	62	0,9
France	212	66	3,2

Actual behaviour and motivation of the population. Even though the long term respect for measures such as NPI's is a constant societal challenge which requires continued explanation and information, data from the 'Motivation Barometer' are reassuring when it regards motivation to respect the remaining measures. In addition, data from the COMIX-study indicate that the overall actual contact-behaviour is still lower than in pre-pandemic times, but that the number of contact has increased particularly in the vaccinated (N. Hens).

The youngest wave of the motivation barometer, a long-standing study that charts Belgian citizens' motivation and well-being (see www.motivationbarometer.com), took place between August 12th and 15th (N = 7285; 65% females; 86.9% vaccinated persons; 66.7% highly educated persons; 78.8% Dutch speaking persons). Three key findings need being highlighted:

· First, individuals' voluntary motivation and commitment to adhere to the measures has been fairly stable over the summer: 35.96% is still highly motivated and 21.63% is still somewhat motivated to follow the sanitary measures. Yet, substantial differences emerge between vaccinated and unvaccinated persons[1], with the motivational gap between both subgroups widening over time (see Figure 4). In contrast to what can be intuitively expected, unvaccinated (instead of vaccinated) individuals have become increasingly discouraged over time. The erosion of motivation is even more visible among unvaccinated individuals who got COVID-infected. These trends are presumably due to (a) a selection effect, with motivated individuals gradually getting vaccinated over time and (b) previously infected, unvaccinated individuals not seeing a valid reason to stay motivated neither to get vaccinated.

· Second, paralleling the motivational differences, vaccinated persons are more adherent to the measures than unvaccinated persons. This behavioural gap is visible for all assessed sanitary measures (i.c., keeping physical distance, limiting social contacts, wearing mouth masks, and disinfecting hands), is fairly robust (as it emerges after controlling for various other socio-demographics) and has been growing over time (see Figure 5). Notably, especially previously infected, unvaccinated individuals are adhering less to the measures, presumably because they are the least motivated overall.

· Third, when asked whether participants want to abolish the current measures altogether, a similar contrasting pattern emerged between vaccinated and unvaccinated individuals. Unvaccinated persons are more strongly in favour of abolishing the current measures, regardless of whether they are interacting with a vaccinated or non-vaccinated person (see Figure 6). In contrast, vaccinated persons adopt a more differentiated approach, with 12% strongly favouring the abolishment of measures when interacting with non-vaccinated persons and 31% strongly favouring the abolishment of the measures when interacting with vaccinated persons. This percentage is somewhat measure-dependent, with for instance 23% and 43% of vaccinated persons wanting to abolish the mouth mask in interaction with, respectively, unvaccinated and vaccinated persons.

Overall, these findings indicate that (a) in spite of the increasing vaccination coverage citizens remain somewhat motivated to adhere to the measures; (b) unvaccinated individuals should not be treated as a homogeneous group, as infected unvaccinated individuals have in their view a good rationale for being less motivated and adherent; (c) vaccinated persons want to preserve a sense of safety as only a minority is in favour of abolishing the current measures when interacting with non-vaccinated persons. Yet, as the number of vaccinated people is increasing, it can be expected that an increasing number of vaccinated people may want to abolish the current measures and may lose their motivation for adhering to the measures.

[1] the unvaccinated people in this study are probably not representative of the unvaccinated people in Be (see 2 groups above), with an under-representation of the most vulnerable/less educated people who would not participate in such a study

Figure 4. Shifts in voluntary motivation to adhere to the measures among vaccinated and non-vaccinated individuals since February 2021. (Motivation Barometer)

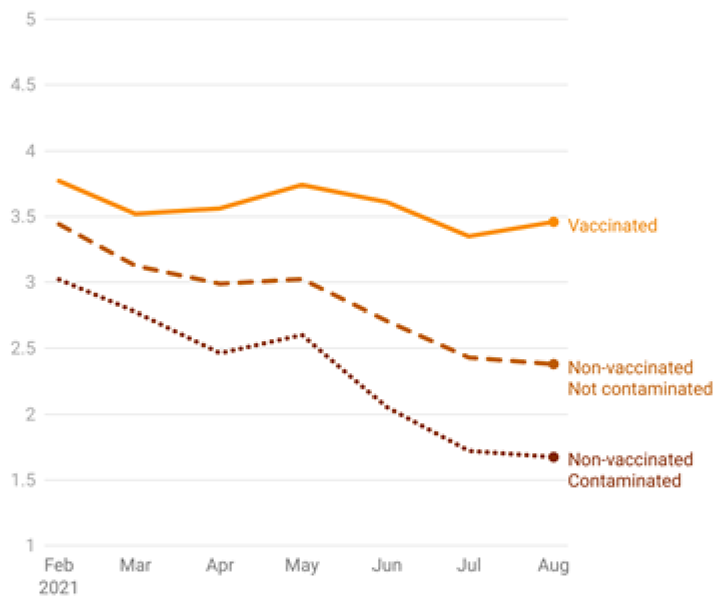


Figure 5 Shifts in adherence to the measures among vaccinated and non-vaccinated individuals since February 2021 (Motivation Barometer)

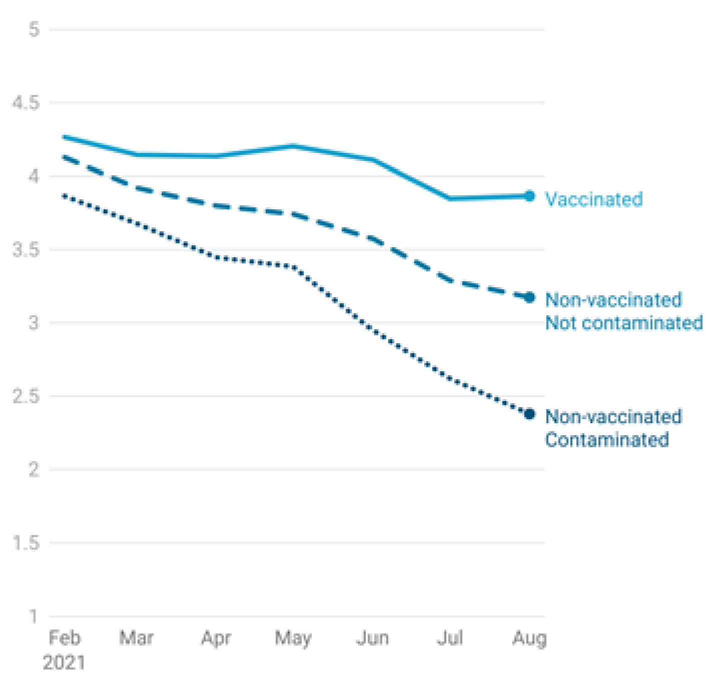
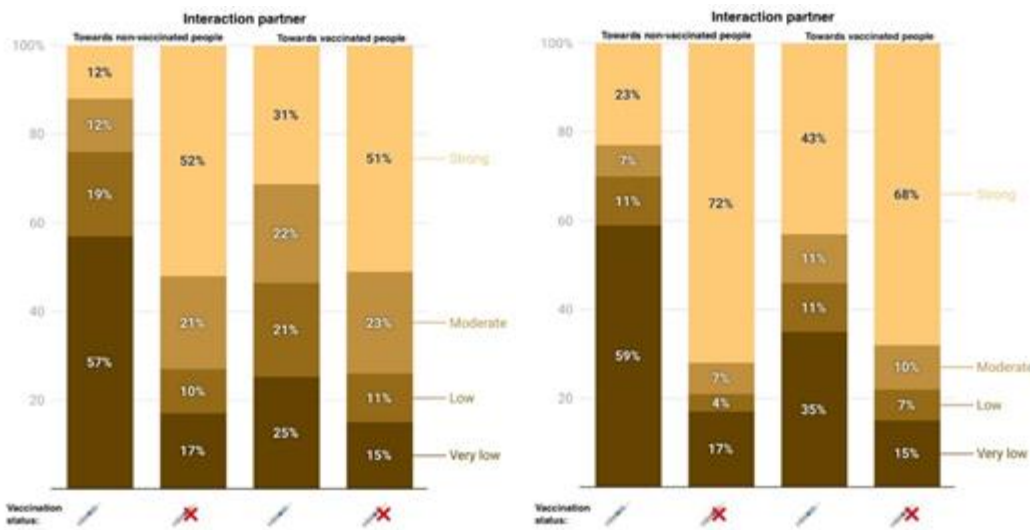


Figure 6 Participants' preference to abolish measures as a function of their own vaccination status and the vaccination status of their interaction partner; the left panel is an aggregation across measures, while the right panel concerns wearing mouth masks (Motivation Barometer)



Conclusion. Taking together the rapid spread of the delta variant, the still ongoing vaccination campaign, low vaccination levels world wide, the upcoming winter season and the planned restart of the school- and academic year, the GEMS recommends to maintain at least a basic set of NPIs over the next months to come - in line with the recommendations of WHO and ECDC and based on the experiences over the past weeks world wide.
This should include maintaining reduced n of contacts, wearing masks in public indoor settings, promoting outdoor activities, strengthened ventilation, maintenance of testing, quarantine/isolation,... and tapering this down only very gradually under guidance of the epidemiological situation.
New variants and particularly VoCs should be kept out of the country as long as possible to allow the current vaccination campaign to be rolled out and achieve solid levels of immunity as a protection to avoid major new waves.

It is important to maintain a multi-layered approach (masks + ventilation + reduction of contacts (both random and close contacts) + vaccination + testing n indication), and not to rely on one single intervention (e.g. testing, vaccination,...), as no single intervention is 100% effective, particularly not in the presence of the delta variant. For instance, while testing can offer an extra layer of defence to keep circulation low when already at low levels, there are important risks associated with overly strong reliance on testing as a strategy to enable large events, especially when these take place with little or no other NPIs, as was observed e.g. in the Netherlands in early July upon the reopening of events and nightlife (Annex 6).

Annex 1. Empirical Relationships Between Confirmed Cases (Infections), Hospitalizations, Vaccination, and Spread of the Delta Variant Over June and July 2021 in Flanders, Wallonia, and Brussels

Geert Molenberghs
Interuniversity Institute for Biostatistics and statistical Bioinformatics, Data Science Institute, Hasselt University, Belgium
Interuniversity Institute for Biostatistics and statistical Bioinformatics, KU Leuven, Belgium

1 Summary

1.1 Goal

The goal is to analyze the correlation (relationship) between the 14-day incidence of cases and a set of predictors, as well as between the 7-day incidence of hospitalizations and a set of predictors. All variables are computed on a weekly basis, over weeks 2021/16 – 2021/30, and for each of the regions Brussels, Flanders, and Wallonia separately. One exception is the spread of the delta variant, available on a weekly basis but only for the country as a whole.

The focus of the analysis is over the weeks 2021/21 – 2021/30, i.e., the period of increasing figures. Predictor variables prior to 2021/21 are used in some cases.

Over this period, the three Belgian regions have reached rather different vaccination levels, have reached different case incidences, and have received differing volumes of travellers coming in from abroad. Each of these indicators have changed over time.

The two outcome variables, with their potential predictor variables:

14-day incidence of cases: with potential predictors: vaccination rate; spread of the delta variant; standardized volume of returning travellers.

7-day incidence of hospitalizations: with potential predictors: 14-day incidence of cases; vaccination rate; spread of the delta variant; standardized volume of returning travellers.

While obvious predictor variables would be time (week) and region, it is the explicit aim not to use these, as they would offer no insight. For example, rather than observing that there are differences between the regions, we aim to identify plausible predictor variables.

A good model is considered to be one that fits the data well as captured by a high R^2value and which exhibits plausible relations between variables.

1.2 Limitations

The following limitations should be kept in mind:

- The models are of a statistical, descriptive nature. They should not be causally interpreted, regardless of how plausible the results may be.
- As such, they are not intended for extrapolation. At most, they can be used for interpolation or towards values that are only very slightly outside of the data ranges of the predictor variables.
- Over the time period under study, the Belgian stringency index has been constant. Hence, stringency cannot be part of the model and the results might not automatically hold when stringencies change drastically.

- Hospitalizations may take place in a region different from one's own. This is especially important for Brussels. However, this fact is ignored in this report.
- It would be of interest to undertake the modeling exercises per province, rather than per region. We consider this outside of the scope of this analysis. However, the issue of hospitalization outside of one's own region would apply even more than at regional level. Furthermore, over certain time periods, hospitalization numbers in smaller provinces may be very small and hence unstable.

1.3 Results for 14-day Incidence of Cases

In every region, the 14-day incidence of confirmed cases (infections) is highly multiply correlated with the inverse of fully vaccinated fraction of the population and the spread of the delta variant (expressed on a logit scale). R^2values are around 0.95. Using the inverse of vaccination fraction allows for a non-linear effect on incidences, even in a linear model.

The conclusion, in line with intuition, is that incidence of cases is expected to be higher given lower vaccination levels and given a higher fraction of delta variant circulating. This conclusion holds within every region separately, but the strength of the effect of each variable changes across regions. The effect of delta is largest in Brussels and smallest in Wallonia. The effect of vaccination is larger in Flanders and Wallonia. That said, all effects are highly significant.

Nevertheless, there is unexplained between-regional variability, which is corroborated by the fact that if the effects of vaccination and delta are forced to be the same across regions, then the R^2drops to 0.35.

To address, this, a different model is considered, for all data combined, and with predictor variables inverse vaccination, standardized amount of returning travellers, their interaction, and the squared effect of returning travellers. These variables taken together correlate highly with incidence of cases (R^2= 0.95), without the need to differentiate parameters between regions. Stated differently, the same model describes well the incidences for all three regions.

The conclusion is that the 14-day case incidence for a region increases with lower vaccination rate, with increasing volume of returning travellers, and with the square of the volume of returning travellers. There is a significant, and negative, interaction between vaccination and travel, implying that the effect of these variables is not additive, necessitating a correction.

1.4 Results for 7-day Incidence of Hospitalizations

In every region, the 7-day incidence of hospitalizations is moderately to highly correlated with the 14-day incidence of cases (infections). The fraction of vaccinations is relatively highly correlated with hospitalizations in Wallonia, moderately in Flanders, and weakly in Brussels. However, when both variables (incidence of cases & vaccination fraction) are jointly considered, there is a near perfect correlation in Flanders and Wallonia (R^2 around 0.98), and a very high correlation in Brussels (R^2 = 0.91). When hospitalization incidences for the three regions are analyzed together, forcing the effects of both variables to be identical, the high correlation is upheld (R^2 = 0.90).

This means that, unlike for the incidence of cases, both the within-region as well as the between region differences in incidence of hospitalizations are explained in terms of incidence of cases and vaccination. In principle, one can add the volume of travel to the model. While its effect is significant, even with vaccination and incidence of cases present in the model, it adds little to the multiple correlation, which becomes $R^2 = 0.91$.

Hence, incidence of hospitalizations is influenced by vaccination fraction and by incidence of cases. A slightly modified version of the hospitalization model (log-linear, to avoid negative predictions), can be used to examine the effect of varying the vaccination percentage and/or the incidence of cases:

• In Brussels, a case incidence of 300 and 40% full vaccination rate leads to a predicted 6–10 hospitalizations per day, whereas an incidence of 50 and 70% vaccination rate would lead to only 1–2 hospitalizations.

• For Flanders, the higher daily hospitalization numbers would be 12–24, with the lower end 1–3.

• For Wallonia, the corresponding ranges are 11–20 and 1–3, respectively.

As incidence of cases, together with vaccination, influences incidence in hospitalizations, but incidence of cases is itself influenced by vaccination, it is attractive to replace the predictor variable incidence of cases in the hospitalization model by its own predictors. Upon carrying out this "folding" exercise, an elegant pair of similar models with high multiple correlations is obtained.

Estimates for case incidence model

		Belgium	
Effect	Par.	Est.(s.e.)	p-value
Intercept	β_0	-205.6(31.0)	
Vaccination	β_1	8.1(0.6)	< 0.0001
Travel	β_2	134.6(25.3)	< 0.0001
Vacc.×Travel	β_3	-3.9(0.4)	< 0.0001
Travel^2	β_4	9.5(3.7)	0.0166
Variance	σ^2	346.1(91.0)	
Explained var.	R^2	0.95	

Estimates for hospitalization incidence model

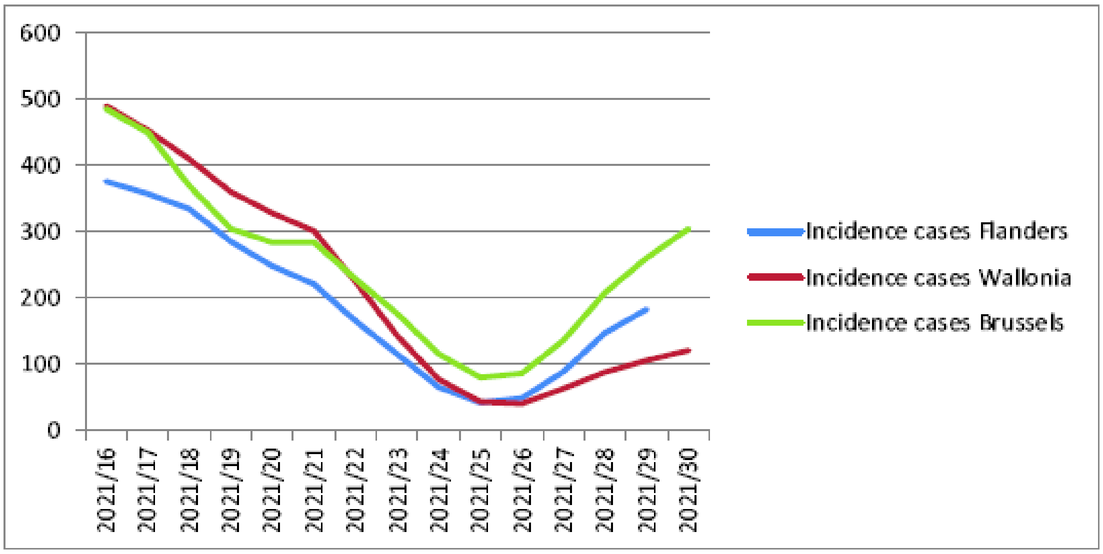
		Belgium	
Effect	Par.	Est.(s.e.)	p-value
Intercept	β_0	-0.80(0.86)	
Vaccination	β_1	0.106(0.017)	< 0.0001
Travel	β_2	-0.69(0.71)	0.3397
Vacc.×Travel	β_3	-0.025(0.011)	0.0256
Travel^2	β_4	0.50(0.11)	0.0001
Variance	σ^2	0.317(0.082)	
Explained var.	R^2	0.91	

2 Data

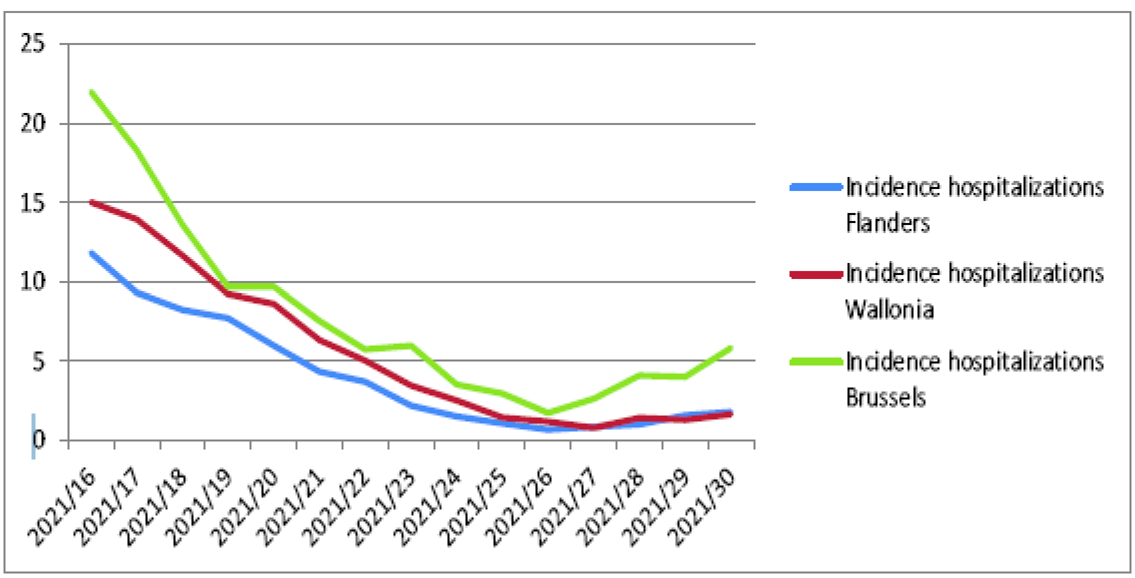
The period over which data are considered runs from week 2021/16 (ending 25/04/2021) to week 2021/30 (ending 01/08/2021). The models that will be described refer to weeks 2021/21 (ending 30/05/2021) to 2021/30 only, but predictive variables may refer to weeks prior to the starting point.

Let the index *r* refers to region (FLA, WAL, BRU) or the country as a whole (BEL) and *w* to week (running from 21 to 30 for the outcome variables, and in some cases to earlier weeks as well).

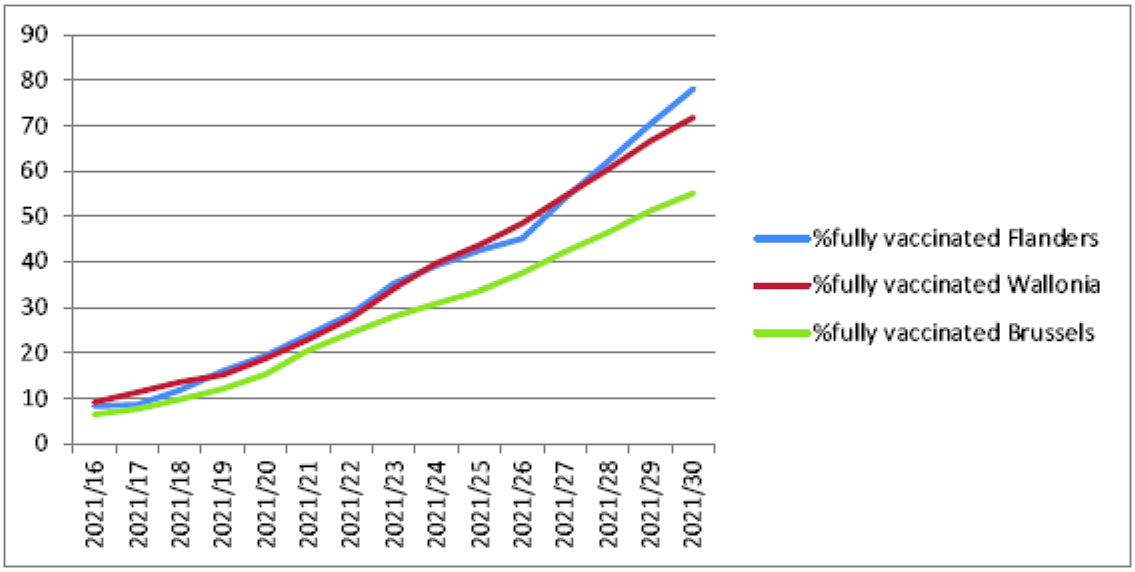
14-day incidence of confirmed cases (infections). The variable $IC14_{rw}$ refers to the 14-day incidence of confirmed infections (henceforth simply referred to as 'cases'), for region *r* and over weeks *w−1* and *w*. It is obtained from the ECDC open database that contains incidences at NUTS2 level, which for Belgium coincides with the aforementioned regions.



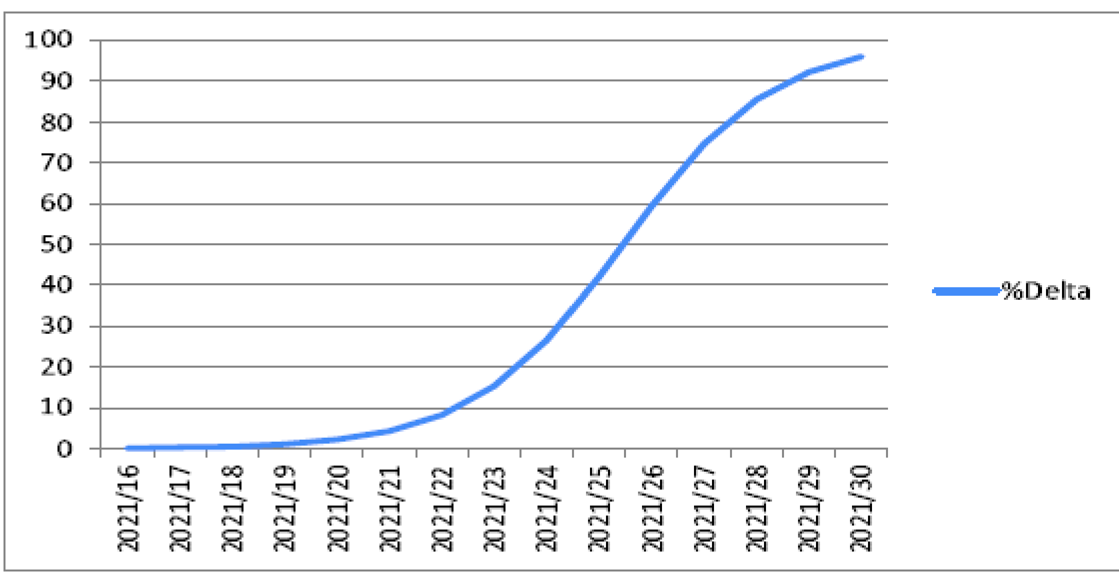
7-day incidence of hospitalizations. The variable $IH7_{rw}$ refers to the 7-day incidence of hospitalizations per region *r* and over week *w*. The variable is derived from the number of hospitalizations per region, as available in Sciensano's open data.



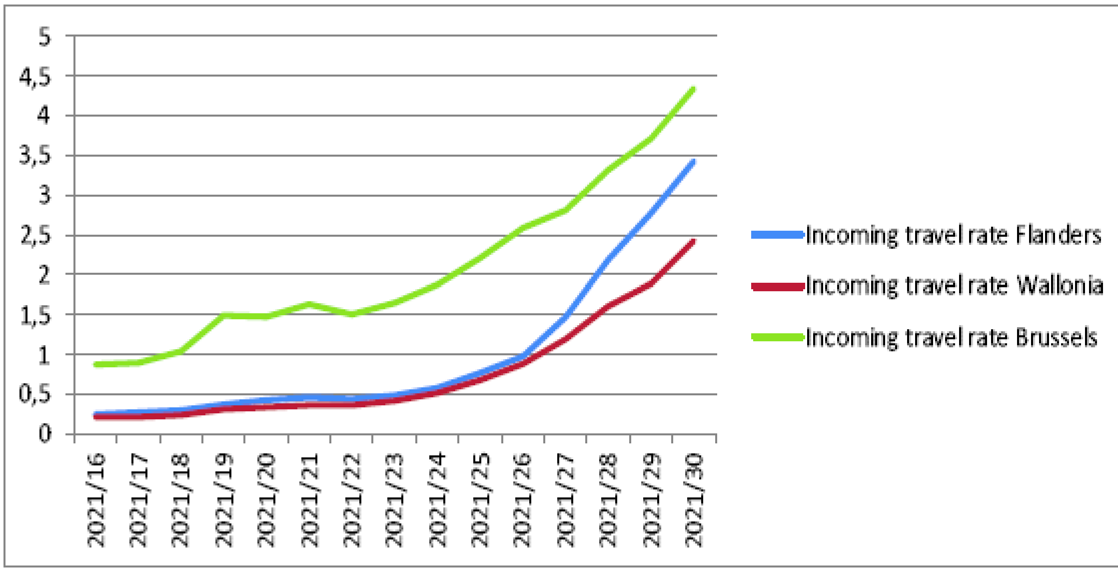
Vaccination. In what follows, vaccination refers to full vaccination in the entire population of a region. Hence, $0 \leq v_{rw} \leq 1$is the fraction of fully vaccinated individuals in region *r* on the last day of week *w*. In some models, vaccination at earlier weeks will be considered, hence the notation $v_{r,w-k}$ where k = 0, 1, 2, 3. Evidently, one might consider alternative vaccination metrics, such as partial vaccination, or vaccination restricted to the 18+ population. Given the higher level of protection after full vaccination, we believe that the choice made is sensible.



Spread of the delta variant. The variable $0 < \Delta_w < 1$ refers to the smoothed fraction of delta variant circulating in week w in Belgium. Of note, this variable is considered at national, rather than at regional level. The variable is obtained by fitting a logistic model to the baseline genomic surveillance data as available in the Sciensano weekly reports.



Travel rate. The variable t_{rw} trw represents the incoming travel rate in region *r* over week *w*. The rate is defined as the total number of incoming travellers (regardless of zone and of mandate to get tested), divided by the population of the region and multiplied by 100. Here also, alternative choices would be possible, such as travellers returning from a red zone, or number of travellers that tested positive.



Over the period under investigation, the stringency index was equal to 60.19 in week 2021/16, 54.62 in week 2021/17, and 50.93 in weeks 2021/18–2021/30. Hence, it cannot serve as an explanatory variable. This points to an important limitation: all models should be seen against the background of stringency 50.93, beyond which extrapolation is difficult. For the purpose of studying changing contact behavior, mathematical modeling and its induced scenario analysis is the preferred tool (cf. work by colleagues Niel Hens, Philippe Beutels, Steven Abrams, Lander Willem, and others).

In what follows, analyses at regional level will be presented, as well as for Belgium as a whole. It is very important to realize that neither incidences nor other variables are computed at Belgian level. For example, only incidences per week and per region will be used. In models for Belgium, simply the incidences and other variables for all three regions will be entered together. This will allow us to explain both within-regions as between-region effects. In particular, this avoids the ecological fallacy at geographical level.

3 Descriptive Model for Confirmed Cases (Infections)

The variable under investigation is $IC14_{rw}$.

Linear model with predictor variables $v_{r,w-k}$, for all values of *k*, are extremely poor. In Brussels and Flanders, all corresponding R^2< 0.05. Only for Wallonia can R^2= 0.35 be reached for *k* = 0, 1, 2, but with a borderline significant effect only.

A much better fit is obtained when not only $v_{r,w-k}$ but also its inverse is used. The corresponding R^2values are 0.90, 0.92, and 0.96 for Brussels, Flanders, and Wallonia, respectively, when *k* = 0 and hence v_{rw} is to be preferred should this model be retained. However, while these are excellent fits to the data, the model results run counter to intuition: the coefficients of both $v_{rw}^{-1}$and $v_{rw}$are positive. While this is to be expected forv_{rw}^{-1} , it is not for v_{rw}. Indeed, it points to both an initial decrease as well as a subsequent increase in vaccination level. Clearly, such an effect of vrw may point to the presence of confounding.

When only v_{rw}^{-1} is used, the results are plausible but with a disappointing set of R^2 values (0.002 for Brussels; 0.14 for Flanders; 0.66 for Wallonia).

Given that the delta variant has run its full course over the period under investigation, it is logical to take it into account. This leads to the following model:

$$IC14_{rw} = \beta_0 + \beta_1 ln(\frac{\Delta_w}{1-\Delta_w}) + \beta_{r2}\frac{10}{vr,w-k} + \varepsilon_{rw}, \quad (1)$$

with error term $\varepsilon_{rw} \sim N\ (0, \sigma_r^2)$ and $\beta_{r0}, \beta_{r1}, \beta_{r2}$ region-specific regression parameters. Note that the spread of the delta variant is entered on the logit scale, so that it ranges over the real line, rather than over the unit interval or the percentage range.

For Brussels, k = 4 provides the best fit, meaning that the highest predictive power is obtained when full vaccination status corresponding to four weeks earlier in time is used (R^2= 0.95). For Flanders and Wallonia, a two-week interval is optimal, hence k = 2, leading to R^2= 0.94 for Flanders and R^2= 0.98 for Wallonia.

The parameter estimates (standard errors) and p-values are presented next, not only for each of the regions separately, but also when the model is fitted to Belgium as a whole, but without regional indicators in the model.

Estimates for case incidence model

		Brussels		Flanders		Wallonia		Belgium	
Effect	Par.	Est.(s.e.)	p-value	Est.(s.e.)	p-value	Est.(s.e.)	p-value	Est.(s.e.)	p-value
Intercept	β_{r0}	-178.7(31.9)		-296.6(43.8)		-285.6(25.0)		34.6(33.1)	
Logit(delta)	β_{r1}	100.8(8.7)	< 0.0001	89.6(10.6)	< 0.0001	65.7(5.8)	< 0.0001	18.4(9.8)	0.0723
Vacc.$^{-1}$	β_{r2}	6.1(0.5)	< 0.0001	12.9(1.4)	< 0.0001	12.2(0.7)	< 0.0001	2.6(0.7)	0.0015
Variance	σ_r^2	286.0(127.9)		211.6(99.8)		99.1(44.3)			
Explained var.	R^2	0.95		0.94		0.98		0.35	

In contrast to each of the regions separately, the variability at the level of the country is not well described, with R^2= 0.35 merely. Hence, while the within-region variability is adequately captured, there is considerable unexplained between-region variability.

While it is possible to include regional indicators in the model for Belgium, this would merely consolidate the fact that there are regional differences, without offering an explanation.

Therefore, a more elaborate model is considered with apart from delta and vaccination, also travel as an explanatory variable. An adequate fit (R^2 = 0.95) is obtained with vaccination, travel, their interaction, and the square of travel in the model. Given these, delta is not needed in the

model.

The model takes the form:

$$IC14_{rw} = \beta_0 + \beta_1\frac{10}{vr,w-k} + \beta_2 t_{rw} + \beta_3\frac{10}{vr,w-k} t_{rw} + \beta_4 t_{rw}^2 + \varepsilon_{rw}. \quad (2)$$

The corresponding estimates:

Estimates for case incidence model			
		Belgium	
Effect	Par.	Est.(s.e.)	p-value
Intercept	β_0	-205.6(31.0)	
Vaccination	β_1	8.1(0.6)	< 0.0001
Travel	β_2	134.6(25.3)	< 0.0001
Vacc.×Travel	β_3	-3.9(0.4)	< 0.0001
Travel^2	β_4	9.5(3.7)	0.0166
Variance	σ^2	346.1(91.0)	
Explained var.	R^2	0.95	

The squared multiple correlation of R^2 = 0.95 leads to the conclusion that vaccination, travel, its square, and the interaction between vaccination and travel explain almost all of the variability in the incidence in a given week in a given region. This is achieved without putting time or region in the model, even though the outcome and predictor variables in (5) are incidences per week and per region.

In model (5), inverse vaccination accounts for 40% of the variability, given the other variables. The amount explained by travel is a modest 6%, but the interaction harbors another 24%. The independent effect of the square of travel is only 1%, but it is left in the model because of its significance.

4 Descriptive Model for Hospitalizations

The variable under investigation is $IH7_{rw}$.

Simple, univariate and multiple correlation analysis between the outcome $IH7_{rw}$on the one hand, and either incidence or vaccination on the other, gives the following results, expressed asR^2 values, for the regions separately and for all data combined:

Univariate and bivariate hospitalization incidence models. R^2 values.				
Effect	R^2 Brussels	R^2 Flanders	R^2 Wallonia	R^2 Belgium
Incidence	0.62	0.54	0.88	0.74
Vaccination (0 weeks)	0.12	0.34	0.67	0.40
Vaccination (1 week)	0.14	0.37	0.66	0.40
Vaccination (2 weeks)	0.17	0.41	0.66	0.41
Vaccination (3 weeks)	0.19	0.45	0.61	0.39
Vaccination (4 weeks)	0.17	0.46	0.56	0.36
Incidence & vaccination (0 weeks)	0.90	0.98	0.99	0.90
Incidence & vaccination (1 week)	0.89	0.97	0.99	0.89
Incidence & vaccination (2 weeks)	0.89	0.96	0.99	0.89
Incidence & vaccination (3 weeks)	0.906	0.977	0.989	0.89
Incidence & vaccination (4 weeks)	**0.913**	**0.981**	**0.989**	**0.90**

Unsurprisingly, case incidence is highly correlated with hospitalization incidence, although strongest in Wallonia and weakest in Flanders.

The correlation between vaccination and hospitalization incidence is relatively strong in Wallonia, less so in Flanders (although significant with lags 2, 3, or 4 weeks), and weak (non-significant) in Brussels.

However, when case incidence and vaccination are entered together, very high multiple correlations are obtained in Flanders and Wallonia, and high correlations in both Brussels and when analyzing all regional data together. We will examine the model in bold typeface, i.e., with case incidence and vaccination four weeks ago, in more detail. The model takes the form:

$$IH7_{rw} = \alpha_{r0} + \alpha_{r1}\,(100v_{r,w-4}) + \alpha_{r2}\,IC14_{rw} + \varepsilon_{rw}, \quad (3)$$

with $\varepsilon_{rw} \sim N\,(0, \tau_r^2)$.

The results for the regions:

Estimates for linear hospitalization incidence model							
		Brussels		Flanders		Wallonia	
Effect	Par.	Est.(s.e.)	p-value	Est.(s.e.)	p-value	Est.(s.e.)	p-value
Intercept	α_{r0}	2.84(0.62)		2.10(0.23)		1.92(0.27)	
Vacc. (4 wk)	α_{r1}	-0.094(0.019)	0.0019	-0.072(0.006)	< 0.0001	-0.053(0.006)	< 0.0001
Inc. cases	α_{r2}	0.019(0.002)	< 0.0001	0.013(0.001)	< 0.0001	0.017(0.001)	< 0.0001
Variance	τ_r^2	0.2568(0.1148)		0.02881(0.01358)		0.03413(0.01526)	
Explained var.	R^2	0.91		0.98		0.99	

Next, the results for all regions combined (Belgium) are presented. Unlike for case incidence, the R^2did not drop in important ways when data are combined. Nevertheless, we consider an extension of (3) with also the effect of travel added:

$$IH7_{rw} = \alpha_0 + \alpha_1\,(100v_{r,w-4}) + \alpha_2\,IC14_{rw} + \alpha_3 t_{rw} + \varepsilon_{rw}. \quad (4)$$

The results of both models:

Estimates for linear hospitalization incidence models					
		Belgium		Belgium	
Effect	Par.	Est.(s.e.)	p-value	Est.(s.e.)	p-value
Intercept	α_0	2.05(0.41)		2.39(0.41)	
Vaccination (4 weeks)	α_1	-0.069(0.011)	< 0.0001	-0.091(0.014)	< 0.0001
Incidence cases	α_2	0.0182(0.0016)	< 0.0001	0.0158(0.0018)	< 0.0001
Travel	α_3	—	—	0.355(0.160)	0.0354
Variance	τ_r^2	0.38(0.10)		0.32(0.08)	
Explained var.	R^2	0.90		0.91	

Returning to Model (3), it is of interest to examine what a given case incidence combined with a given vaccination percentage would imply in terms of expected hospitalizations. For this purpose, and to avoid issues with negative predictions that could result from linear models, a logarithmic version of (3) is considered. A very comparable fit is obtained for:

$$IH7_{rw} = exp\{\tilde{\alpha}_{r0} + \tilde{\alpha}_{r1}\,(100v_{r,w-4}) + \tilde{\alpha}_{r2}\,ln(IC14_{rw})\} + \varepsilon_{rw},$$

with estimates:

Estimates for log-linear hospitalization incidence model				
		Brussels	Flanders	Wallonia
Effect	Par.	Est.(s.e.)	Est.(s.e.)	Est.(s.e.)
Intercept	$\tilde{\alpha}_{r0}$	-2.13(0.64)	-1.66(0.51)	-1.45(0.37)
Vaccination (4 weeks)	$\tilde{\alpha}_{r1}$	-0.016(0.004)	-0.034(0.004)	-0.026(0.004)
Incidence cases	$\tilde{\alpha}_{r2}$	0.76(0.12)	0.64(0.09)	0.63(0.06)
Variance	$\tilde{\tau}_r^2$	0.356(0.159)	0.045(0.021)	0.049(0.022)

Prediction intervals of daily hospitalization numbers, based on this model, are as follows:

Predicted daily hospitalization range				
	Percentage fully vaccinated			
Incidence cases	40%	50%	60%	70%
Brussels				
300	6–10	5–9	4–8	3–7
200	5–7	4–7	3–6	2–5
100	3–5	2–4	2–4	1–3
50	1–3	1–3	1–2	1–2
Flanders				
300	12–24	7–18	4–14	3–11
200	10–18	6–14	4–10	2–8
100	7–11	4–8	3–6	2–5
50	4–7	3–5	2–4	1–3
Wallonia				
300	11–20	8–16	5–13	3–11
200	9–15	6–12	4–10	3–8
100	6–9	5–7	3–6	2–5
50	4–6	3–5	2–4	1–3

The conclusion of this model is that keeping the incidence of cases low and the percentage of fully vaccinated people high will lead to a considerable reduction in daily hospitalizations. The case incidence and vaccination values are chosen so as not to move too much outside of the range observed over the study period, to avoid extrapolation, as the model is not intended for that. Still, any extrapolation should be interpreted as holding under sufficiently similar circumstances.

Of course, because incidence of cases is a predictor, and this variable itself is influenced by vaccination and travel, it is of interest to "fold" one model into the other, to obtain:

$$IH7_{rw} = \gamma_0 + \gamma_1 \frac{10}{vr_{,w-k}} + \gamma_2 t_{rw} + \gamma_3 \frac{10}{vr_{,w-k}} t_{rw} + \gamma_4 t_{rw}^2 + \varepsilon_{rw}. \quad (5)$$

The corresponding estimates:

Estimates for hospitalization incidence model			
		Belgium	
Effect	Par.	Est.(s.e.)	p-value
Intercept	β_0	-0.80(0.86)	
Vaccination	β_1	0.106(0.017)	< 0.0001
Travel	β_2	-0.69(0.71)	0.3397
Vacc. $\times$ Travel	β_3	-0.025(0.011)	0.0256
Travel^2	β_4	0.50(0.11)	0.0001
Variance	σ^2	0.317(0.082)	
Explained var.	R^2	0.91	

The advantage of this model is that, whilst maintaining the R^2obtained earlier, it parallels the model description for case incidences.

Annex 2. The unstable equilibrium between cases, vaccination and hospitalisations in countries outside Belgium

A number of European countries have illustrated that incidences can grow very rapidly, even against the background of an extensive vaccination campaign:

- The **United Kingdom** had 14-day incidences around 40 in the second half of May 2021, but rose to 864 on July 25, 2021. About 55% of the population was fully vaccinated. The rise happened gradually between May 1 and July 20, 2021, with cases doubling every two weeks (from about 2000 to about 60,000 per day). Over the same period, hospitalizations increased with 50% every time cases doubled, implying a rise from about 100 to about 950 hospitalizations per day. The relatively slow but nevertheless steady rise happened against the background of increasing delta variant circulation, and still rather stringent measures. It should be added that case numbers started dropping on July 17, 2021, a trend that continued until July 27, to then reverse. The resurgence may be connected with 'Freedom Day,' i.e., July 19, 2021, on which day most measures in the UK were abandoned. Both the drop in cases as well as the resurgence require further monitoring and investigation.
- In **Israel**, incidence was as low as about 2, in the period between June 7 and 17, 2021. On July 27, 2021, incidence reached 200. Predictions are that there will be 7000 cases/day from mid-August 2021. At the azimuthal point, most measures were relaxed, and then the delta variant, imported by returning travellers, combined with increased contact behavior, led to a rapid increase. About 62% of the Israeli population is fully vaccinated. The reaction by the Israeli government, in terms of measures taken as well as measures under discussion, is extensive:
    - Access to Ben Gurion airport is restricted to passengers;
    - The Green Pass is re-introduced;
    - Rapid tests are sold in pharmacies;
    - A third vaccination dose is being given to vulnerable groups;
    - Vaccination in the 5-11 years old population is under investigation;
    - The government has stated that a period of lockdown might be unavoidable. This measure is particularly unpopular already now, and contested by economic actors.
    - Opening of schools on September 1 is still under discussion.

The most recent data from Israel are disconcerting. 6000 infections are confirmed each day - the doubling time of confirmed cases is about 9 days; the number of hospitalizations per day has increased by a factor 9 in a month. Interestingly and disquieting, most hospitalized patients are vaccinated. Modelling on behalf of the Israeli Ministry of Public Health predicts that there would be 2500 hospitalized COVID-19 patients in a month, which would imply that the system gets overwhelmed. The green pass has been reintroduced. Incoming travellers, even when vaccinated, will have to quarantine for 7 days.

- In the **Netherlands**, incidence started rising after the considerable relaxations of late June 2021. On July 9, 2021, 14-day incidence per 100,000 was about 90, but then quickly rose to about 650 on July 29, 2021. In the second week of July 2021, the doubling time of cases shrunk to about 2.5 days. About 51% of the Dutch population is fully vaccinated.
- Also in **Catalunya, Spain,** confirmed cases rose very quickly. On July 22, 2021, the incidence of the region reached 1245, roughly 15 times that of June 20, 2021 (85). In the same period, the number of hospitalized patients multiplied by a factor 5 (from about 440 to about 2240). It is noteworthy that also deaths rose from 2 to 25 over the same period, and actually further onwards to 66 deaths on July 29, 2021. About

57% of Catalans are fully vaccinated. Of note, based on modeling, doubling in confirmed cases in Catalunya leads to a 55% increase in hospitalizations. The very short doubling time for confirmed cases explains why hospitalizations multiplied by 5 in about one month.

- **Iceland** is another country that reached a very low incidence (below 10 from June 17 to July 9, 2021), to then be followed by a rapid increase to about 200 on July 30, 2021. On the island, about 75% of the population is fully vaccinated. To underscore the severity of the situation, the country will move from 'green' (an ECDC status held since January 2021) to 'red' in two weeks. A number of NPIs are re-established:
    - Le gouvernement islandais s'est réuni le 23 juillet pour réintroduire les restrictions pour l'intérieur du pays, proposées par le chef épidémiologiste Þórólfur Guðnason. Les mesures sont d'application à partir de samedi 24 juillet :
        - Les rassemblements sont limités à 200 personnes maximum
        - Les lieux servant de l'alcool (restaurants, bars, clubs) doivent en arrêter la vente à 23:00 et fermer à minuit.
        - Réduction de la capacité maximum des salles de sport et piscines à 75%.
        - Distanciation sociale d'un mètre au minimum.
        - Port du masque dans le cas échéant. Par exemple : bus, taxis, cabinets médicaux et hôpitaux, musées, commerces, salons de massage / tatouage / beauté / coiffure, stades, théâtres, cinémas, concerts
- Rapid increases were also seen in **Cyprus**, where incidence reached 1532 on July 25, 2021, in Malta, where incidence 560 was reached, etc. Also Portugal saw steep increases, predominantly in Greater Lisbon and Algarve. In most of these countries, either the growth is decelerating or incidences are slightly declining.
- Rapid increases are currently seen in **Greece**, **France**, and **Italy**.

In all countries with rapid increases, either measures were relaxed to the point as to open nightlife and large events, with little or no remaining measures (Netherlands, Spain, Portugal, Cyprus, Greece) and/or tourism plays an important role (Spain, Portugal, Cyprus, Greece, Malta).

In the **United States**, incidence decreased to about 50 a month ago, to then reach 200 again on July 30, 2021. Incidences are rapidly rising. Currently, around 71,000 cases per day are confirmed. When limiting to the vaccinated population, this reduces to 35,000 cases per week. Knowing that there are 162 million people fully vaccinated and the total population is around 331 million, this would lead to the following incidences if these figures were maintained for 14 days:

- Incidence among non-vaccinated: 547
- Incidence among vaccinated: 43

What is clear from this observation is the following. First, circulation is much less among vaccinated than among non-vaccinated people. Second, having said that, 43 is still relatively high, and much higher than several countries realized when they were at minimum circulation *for their entire population.* The conclusion is that, while vaccination dampens the circulation among vaccinated people, it does go up when overall circulation is high. This is underscored by the findings of the CDC investigation of the Barnstable cluster in Massachusetts.

A frequent observation is that a period of low to very low incidence, which sets in when vaccination coverage starts to rise, and apparently sooner than the usual herd immunity threshold calculations would suggest, can be followed by rapid incline again, i.e., an unstable situation. This phenomenon was described, among others, by Tkachenko et al. (2021), and ascribed to superspreading. Sneppen et al. (2021) assert, in the same vein, that this superspreading (also referred to as overdispersion in spread) leads to increases in the effectiveness of limiting nonrepetitive contacts. These authors state:

"*Evidence indicates that superspreading plays a dominant role in COVID-19 transmission, so that a small fraction of infected people causes a large proportion of new COVID-19 cases. (…) The results indicate that superspreading is the virus' Achilles' heel: Reducing random contacts – such as those that occur at sporting events, restaurants, bars, and the like – can control the outbreak at population scale.*"

This finding is consistent with what we observe across Europe in Summer 2021: tourism, nightlife, sporting events, festivals, are exactly of the random contact type that the authors describe. Where these are restricted, the spread remains under control or is, at worst, limited. Where such types of contacts are abundantly allowed, the speed of increase can be formidable, in spite of vaccination. Once again, it is consistent with the CDC Barnstable County case.

More broadly, cases in the US are most rapidly increasing in those states with low vaccination rates, especially in the South, such as Florida, Louisiana, and Alabama, where case numbers equal those of the previous peak. Nationally, it is estimated that about 22% of USA citizens adhere to an antivax theory. This finds its way in legislation of both states and cities (e.g., against vaccination in minors).

Countries with very low incidences at this time are **Poland** (3), **Romania** (4), **Slovakia** (7), and **Hungary** (6). Of note, in several of these countries, delta variant circulation is still low. In Central European countries with a more extensive touristic sector, such as the **Czech Republic** (30), **Croatia** (38), or **Bulgaria** (16), incidences are a bit higher, and tend to rise. It should be noted that Romania reports a quick rise in incidence in the major cities; also, the circulation of the delta variant is still very low in Romania.

In **Belgium**, during the delta wave, a doubling of confirmed cases leads to a 40% increase in hospitalizations (examined over the period June 21 – July 15, 2021). Over the second half of July 2021, there is some initial evidence for a creep upwards to about 50%.

In **Italy** the state of emergency is extended until 31 December 2021. Cases increase, hospitalizations only weakly so. Given the comparatively slower rate of increase, a middle ground is sought to find a balance between controlling the epidemic and keep the country functioning, in particular over the tourist season. A Green Pass is introduced (obtainable after 1 vaccination doses, recovery in the preceding 6 months, or a negative PCR/Ag test in the preceding 48 hours), for, among others:

- restaurants, bars (inside)
- large events
- museums, movie theaters, theaters
- Swimming pools, wellness, sports schools
- fairs, conferences, festivals
- casino's
- etc.

In **Germany,** the epidemiological situation is comparatively good, with 14day incidence around 35. The vaccination rates are around 60% (partially) and 50% (full). In spite of low incidence, there is concern about its tendency to increase. Germany classifies some countries as high-risk (14day incidence above 400; currently: the Netherlands, Spain, Portugal, Russia, the United Kingdom) or risk (14day incidence above 100; Monaco, Malta, Greece, Denmark, Ierland, parts of Croatia). There are also virus-variant countries, based on a qualitative analysis. Interestingly, a legal framework exists to evaluate the need for quarantaine among vaccinated returning travellers from such countries as a function of the (EMA approved) vaccine they received. The RKI is legally mandated to publish a list accordingly. A political debate is ongoing relative to larger freedom for vaccinated people and a broader testing policy for incoming travellers.

In **France**, there is the well-known and controversial debate about measures/incentives taken to increase the vaccination rate. The rates have increased to 65% (partial) and 54% (full). Mandatory vaccination has been decided for health care workers. The sanitary pass is introduced for everyone over 12 years of age, and can be obtained based on vaccination or recent negative PCR (<48 h). The aim is to avoid very stringent measures such as lockdowns, against the background of rapidly increasing figures: hospitalizations increased with 50% at the end of July, and ICU occupancy with 80%. In certain regions, incidences are very high. For example, some 14-day incidences are: Provence-Aquitanie-Cote-d'Azur 939; Occitanie 770, and Corse 1113. Of particular concern are some of the DOMTOM, with Martinique at 2082.

Annex 3. Monitoring Belgian COVID-19 infections in work sectors in 2021 (Version 12 – 6 August 2021)

Geert Molenberghs[1,2], Johan Verbeeck[1], Godelieve Vandersmissen[3], and Lode Godderis[3,4]

[1]*Data Science Institute, I-BioStat, Universiteit Hasselt, Hasselt. Belgium*
[2]*I-BioStat, KU Leuven, Leuven, Belgium*
[3]*IDEWE, External Service for Prevention and Protection at Work, Heverlee, Belgium*
[4]*Centre for Environment and Health, Department of Public Health and Primary Care, KU Leuven, Leuven, Belgium*

1 Introduction

The workplace is among the main activities for a large proportion of the population, and consequently a source of potential infection. Hence, it is often (up to 25%) reported in the contact centre database as one of the collectivities visited by the index case. It is important to monitor the incidence of COVID-19 by sector as it can help us to better understand causes of increased infection rates and it can offer us ways to reduce infections without jeopardising the continuity of these sectors/companies for the benefit of all, first and foremost the companies and their workers. Two sources of information on infection in work sectors will be used in this report: the RSZ/ONSS data and the contact tracing data.

1.1 RSZ/ONSS data

The RSZ/ONSS data analyses of COVID-19 infections in the working population were set up in the first place to allow for signal detection. The alerts consist of 2 or more cases in the same company as well as the identification of employment of an index case in a risk sector as defined by the regional contact tracing agencies (daily alerts are sent by the RSZ/ONSS to the regions). Aggregated data show the evolution over time of the incidence in the sectors. It helps to better understand the spread of the virus in the active population. The latter is of interest here.

Data description: RSZ-ONSS has been receiving information regarding positive COVID-19 cases from Sciensano since 8 September 2020. RSZ-ONSS links this information to workplace-related databases, at the level of the national number (NISS). The linkage is allowed during a period of 14 days, after which the information on positive cases is destroyed, while the aggregated output tables are stored. Linkage is done of positive cases with the NSSO Dimona database of active workers since 8 September 2020. This covers most of the workers, such as private and public sectors, interim employment and job students. Since 12 January 2021, additional linkage of positive cases with the ARZA-RGTI (Algemeen Repertorium van de Zelfstandige Arbeiders - Repertoire General des Travailleurs Indépendants) database was allowed, which covers self-employed workers.

Each company is classified by sector of its main activity (as attributed by the RSZ-ONSS), which are identified by the NACE code. This standard code classifies workplaces into 21 main sectors and then in subcategories for which the specificity depends on the chosen granularity (which can have up to 943 subcategories). However, although some companies or self-employed workers may be active in more than one sector, only one NACE number associated with the main activity is used in the analysis. This limitation is particularly important to consider for employees within national education. Because a vast majority of schools provide both primary and secondary education, the employees will be registered as working in “Secondary education” even when in reality they are primary school teachers.

Further, since the link of the cases is only identified at the level of the company, no information is available on the type of the job of the index case (e.g., administrative work in metal industry will be registered under metal industry). Further, information on the exact employment location is not always available and/or accurate (e.g., information on telework or temporary unemployment is not available).

Finally, the actual source of infection (in particular: at the workplace or elsewhere) cannot be traced back from this database. Thus, the size and extent of the database allows us to obtain a clear and precise picture of the level of infection within a given sector, without link to the source and circumstances of infection.

1.2 Contact tracing

For companies affiliated with IDEWE, COVID-19 positive tested employees are reported to IDEWE starting from 22 July 2020. Of these index cases, contact tracing is performed of high and low-risk contact within the company. Subsequently, appropriate measures are taken within the company and by high-risk contacts to limit spread of the infection. Since 11 March 2021, index cases are asked about the work relatedness of their infection. At the start of the contact tracing, data were registered in a shared Excel file. From 29 October 2020 onwards, a ‘tracing application’ was used to register all notifications of index cases in companies under medical surveillance of IDEWE. Note that high and low-risk contacts are registered only for contacts in the company, contacts at home or in leisure time are not registered.

An index case can be any person present in the company. It can be an employee, but also an interim worker, an intern, etc. Importantly, for schools, the index case can also be a student. Of the index cases the employer information is retrieved via the INSZ number by IDEWE. Information of the employer is subsequently grouped by region and by customer segments. Although some customer segments are similar to the NACE code sectors, this is not true in general. IDEWE considers 10 customer segments based on the NACE codes of the companies, but these segments resemble only partially level 1 and 2. The segment classification is based on similarities in the needs of IDEWE’s customers and in the services IDEWE provides for them.

The incidences in the RSZ/ONSS sectors may differ from those in the contact tracing customer segments due to two aspects:

1. The RSZ/ONSS data concerns all employees and self-employed workers, while the contact tracing data concerns only companies under surveillance.
2. Similar named sectors and customer segments may contain different companies.

For instance, the NACE sector ‘education’ contains only information on positive cases among employees, while the contact tracing data also contain pupils. In schools, a considerable amount of index cases were pupils, especially since the onset of increased testing of children in January 2021. Finally, the contact tracing for the education segment is performed by regionally organised Student Guidance Centres (SGC). The organisation of the contact tracing by the SGC can vary from centre to centre and often only index cases with high-risk contacts are reported to IDEWE.

IDEWE has 9 regional offices that cover the surrounding areas and that are called after the city where they are located. Most Belgian provinces have one regional office, except Antwerp that is served by the regions Antwerpen, Mechelen and Turnhout, and Namur that serves all of Wallonia. The sole exception is Public transport. Companies belonging to this segment are not regionally divided.

Note that some larger companies have organised contact tracing by their internal prevention service. Data of these companies are however not included in this analysis, causing an underestimation of index cases in general. For some segments this underestimation might be more important than for others.

2 Methodology

2.1 RSZ/ONSS data

The data provided by RSZ/ONSS will be shown per work sector. Work sectors are divided by NACE codes and grouped into 5 levels of detail, going from 21 sectors at level 1 to 943 sectors at level 5. The evolution of the 14-day incidence of positive COVID-19 cases among all employees registered in the same sector (number of cases per 100,000 employees) is presented for the 5 levels of work sectors. A 95% confidence interval (CI) for the incidence is calculated on a logit transformation of the incidence, after which it is backtransformed to the original scale.

At each of the 5 levels of detail of the work sectors, the highest incidences in the last 14-day period are selected (20 July–2 August 2021) and presented together with the COVID-19 14-day incidence over all work sectors (∼ 4.5 million individuals) and the COVID-19 14-day incidence in the general population (∼ 11.5 million individuals) for reference.

Because the number of employees in some occupational sectors is low compared to others, the precision of the 14-day incidence is low in such small sectors. Therefore, we select the highest incidences for level 1 sectors with a minimum of 10,000 employees and self-employed workers. For level 2 and 3 sectors with a minimum of 5,000 employees and self-employed workers are selected, while for level 4 and level 5, sectors with a minimum of 3,000 and 1,500 employees, respectively, are selected.

Note that for 25% of the self-employed a sector is missing in the ARZA-RGTI data. Positive cases of self-employed worker with missing sector information are left out of the analysis. Linkage to occupational data shows that missing sector information is dispersed over many sectors, so that the impact of missing data is not affecting a single sector excessively. There will be a slight underestimation of the true incidence, but the ordering among sectors is likely not affected.

Finally, we cannot exclude varying testing preparedness and custom between sectors.

2.2 Contact tracing

In addition to the comparison of the 14-day incidence of index cases between customer segments under surveillance, also the 14-day incidence of index cases between regions are compared. The reported day is the last day of the 14-day period.

Since its initiation on 29 October 2020, the tracing application registers in a standardized manner, besides information on incidences, also information on high-risk and low-risk contacts of index cases. Per segment and per region, the mean number of high-risk contacts by the index case over the entire study period (29 October 2020–22 July 2021) and the four-weekly percentage of index cases with two or more high risk contacts are evaluated.

There might be an underreporting of high-risk contacts because the number of contacts for an index case is set equal to 0 by default by the application. For index cases, who for example could not be contacted or who refused to answer, the number of high and low-risk contacts is reported 0, which may not coincide with reality. The incidences reported by contact tracing depend on the testing willingness in sectors and accuracy in reporting high-risk contact.

3 Results

This report is accompanied with an Excel sheet, listing all sectors and all NACE-BEL sectors for further examination.

3.1 Level 1 work sector

Of the 21 sectors at level 1, the sectors with a 14-day incidence on 2 August 2021 significantly above the working population average are Accommodation and food service activities (sector I), Arts, entertainment and recreation (sector R) and Wholesale and retail sale (sector G) (Table 1 and Figure 1). Several sectors have a 14-day incidence significantly lower than the working population and even the general population average, such as Education (sector P). The increase in the 14-day incidence since beginning of July is slowing down in the last weeks.

Figure 1: 14-Day incidence of COVID-19 infection of all 21 sectors at Level 1 in both employees and selfemployed workers

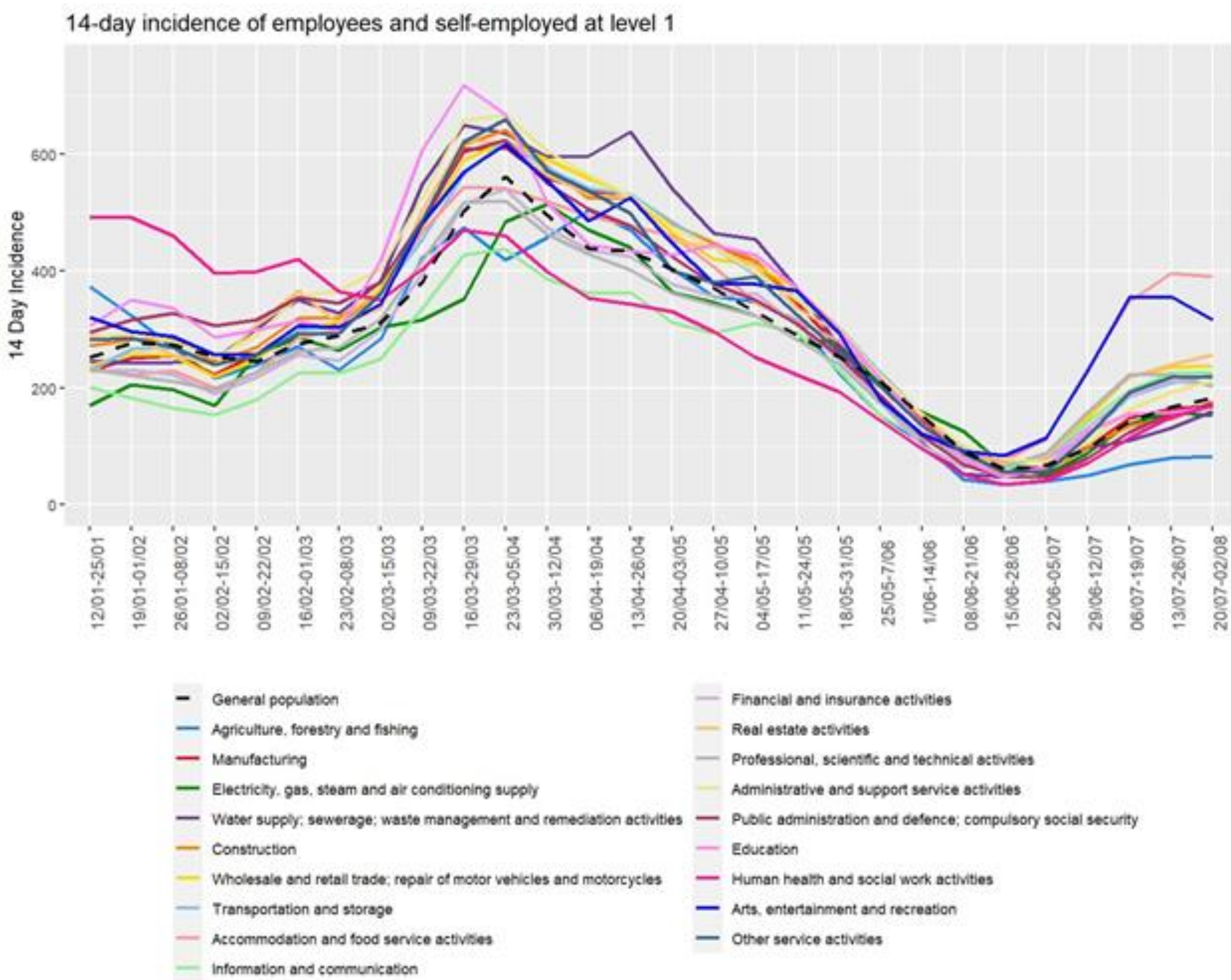


Table 1: 14-Day incidence of COVID-19 infection of all 21 sectors at Level 1 on 2 August 2021

DESCRIPTION	NACE-code	Total number of workers	Incidence (95%CI) all workers	Incidence (95%CI) employees	Incidence (95%CI) self-employed	Percentage of self-employed workers
Accommodation and food service activities	I	314615	390(369;412)	444(418;471)	202(171;238)	23.40
Arts, entertainment and recreation	R	107278	316(284;351)	365(322;414)	235(192;288)	37.99
Real estate activities	L	59144	257(219;301)	264(208;335)	252(204;312)	57.86
Wholesale and retail trade; repair of motor vehicles and motorcycles	G	848319	238(228;249)	249(237;261)	198(179;219)	22.54
Information and communication	J	181498	227(206;250)	235(210;263)	209(174;251)	30.66
Working population		**4438393**	**224(220;228)**	**224(220;228)**		
Transportation and storage	H	311211	223(207;240)	219(202;237)	259(206;325)	9.25
Other service activities	S	161818	220(198;244)	234(203;269)	205(176;239)	49.15
Administrative and support service activities	N	444340	212(199;226)	221(206;237)	172(145;203)	18.25
Financial and insurance activities	K	161275	204(183;227)	206(182;233)	198(157;250)	21.98
Professional, scientific and technical activities	M	390640	203(189;218)	222(203;243)	181(163;201)	48.03
General population			**182**	**182**	**182**	
Construction	F	380791	177(164;191)	185(168;204)	164(145;186)	41.24
Public administration and defence; compulsory social security	O	564162	173(162;184)	173(162;184)		0.19
Manufacturing	C	630588	170(160;180)	172(162;183)	157(129;191)	10.38
Human health and social work activities	Q	665089	169(159;179)	170(160;181)	160(130;198)	8.25
Education	P	467066	167(156;179)	164(152;176)	222(172;287)	5.75
Water supply; sewerage; waste management and remediation activities	E	37500	160(124;206)	168(130;217)		6.30
Electricity, gas, steam and air conditioning supply	D	21569	153(109;215)	143(99;206)		6.13
Agriculture, forestry and fishing	A	91566	83(66;104)	88(63;123)	80(59;108)	58.63

3.2 Level 2 work sector

In the sectors at level 2 with a minimum of 5,000 workers, the sectors with a 14-day incidence on 2 August 2021 significantly higher than the working population average are: Air transport (sector 51), Food and beverage service activities (sector 56), Sports activities and amusement and recreation activities (sector 93), Security and investigation activities (sector 80), Creative, arts and entertainment activities (sector 90), Motion picture, video and television (sector 59), Advertising and market research (sector 73), Postal and courier activities (sector 53), Retail trade (sector 47) Employment activities (sector 78), Office/business support activities (sector 82) and Warehousing and support activities for transportation (sector 52) (Table 2 and Figure 2).

Figure 2: 14-Day incidence of COVID-19 infection in sectors with the highest incidence at Level 2 in both employees and self-employed workers and the incidence in the health care and residential care sector

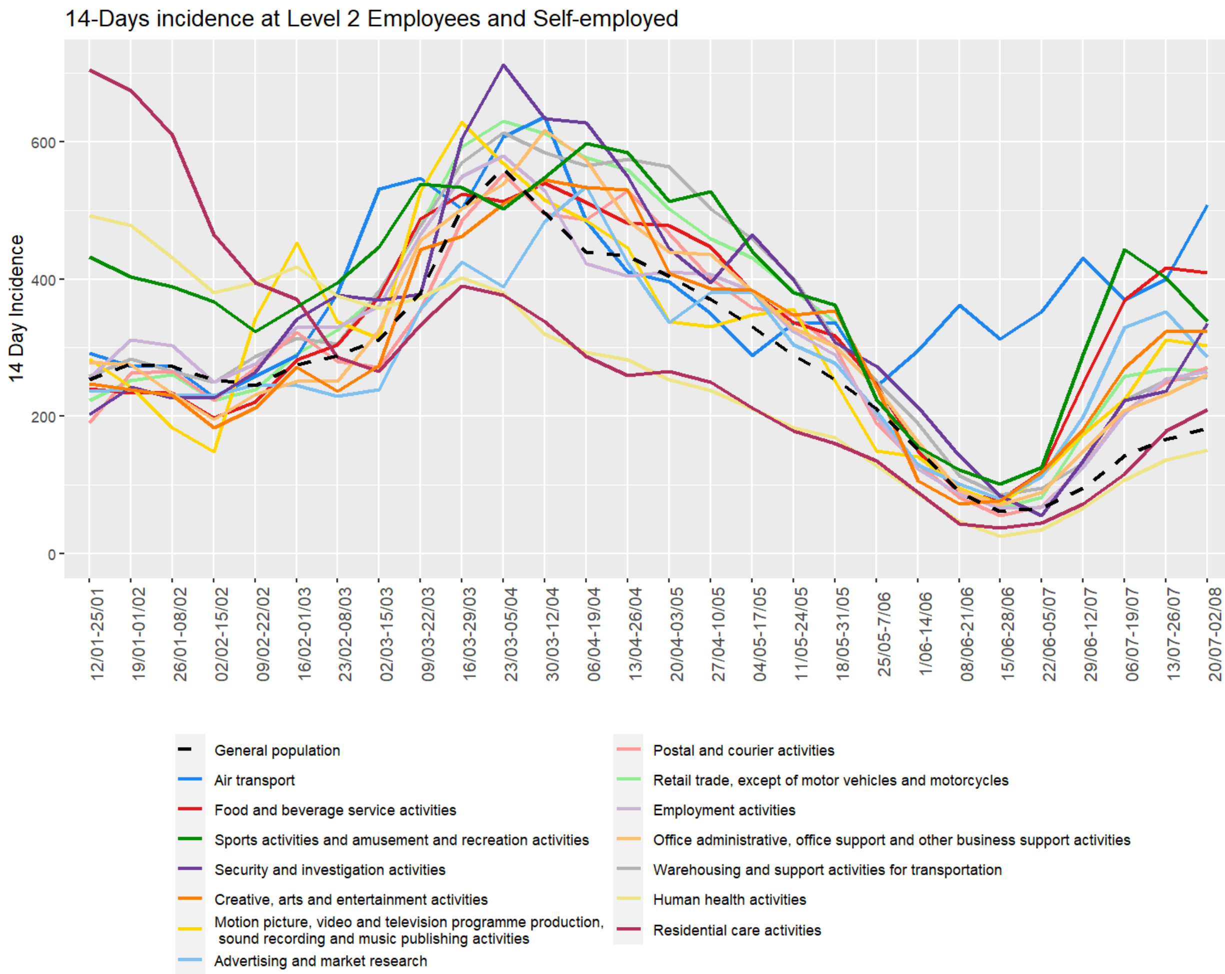


Table 2: 14-Day incidence of COVID-19 infection in sectors with the highest incidence at Level 2 on 2 August 2021

DESCRIPTION	NACE-code	Total number of workers	Incidence (95%CI) all workers	Incidence (95%CI) employees	Incidence (95%CI) self-employed	Percentage of self-employed workers
Air transport	51	6496	508(361;714)	508(361;714)		6.95
Food and beverage service activities	56	279462	409(386;433)	471(443;501)	208(176;246)	24.36
Sports activities and amusement and recreation activities	93	53846	338(292;391)	425(361;500)	185(133;256)	36.47
Security and investigation activities	80	21493	335(266;422)	348(276;439)		5.21
Creative, arts and entertainment activities	90	39628	323(272;384)	360(286;453)	285(219;370)	50.87
Motion picture, video and television programme production, sound recording and music publishing activities	59	14191	303(225;408)	342(238;492)	246(146;415)	41.89
Advertising and market research	73	30420	286(232;353)	429(340;542)	121(75;195)	46.61
Postal and courier activities	53	48162	272(229;323)	266(222;319)	329(202;536)	10.07
Retail trade, except of motor vehicles and motorcycles	47	490262	267(253;282)	288(271;306)	195(170;223)	22.42
Employment activities	78	79623	265(232;303)	260(226;299)	387(220;680)	3.90
Office administrative, office support and other business support activities	82	72797	261(226;301)	293(244;351)	223(177;280)	45.22
Warehousing and support activities for transportation	52	95720	257(227;291)	255(224;290)	283(173;461)	5.93
Working population		**4438393**	**224(220;228)**	**224(220;228)**		
General population			**182**	**182**	**182**	

3.3 Level 3 work sector

In the sectors at level 3 with a minimum of 5,000 workers, the sectors with a 14-day incidence on 2 August 2021 significantly higher than the working population average are: Passenger air transport (sector 511), Restaurants and bars (sector 561, 563), Activities of call centres (sector 822), Sports, amusement and recreation activities (sector 932, 931), Private security activities (sector 801), Professional and technical activities (sector 731, 702), Creative, arts and entertainment activities (sector 900), Retail trade (sector 479, 476, 477, 471), Real estate activities (sector 683) and Other education (sector 855) (Table 3 and Figure 3).

Figure 3: 14-Day incidence of COVID-19 infection in sectors with the highest incidence at Level 3 in both employees and self-employed

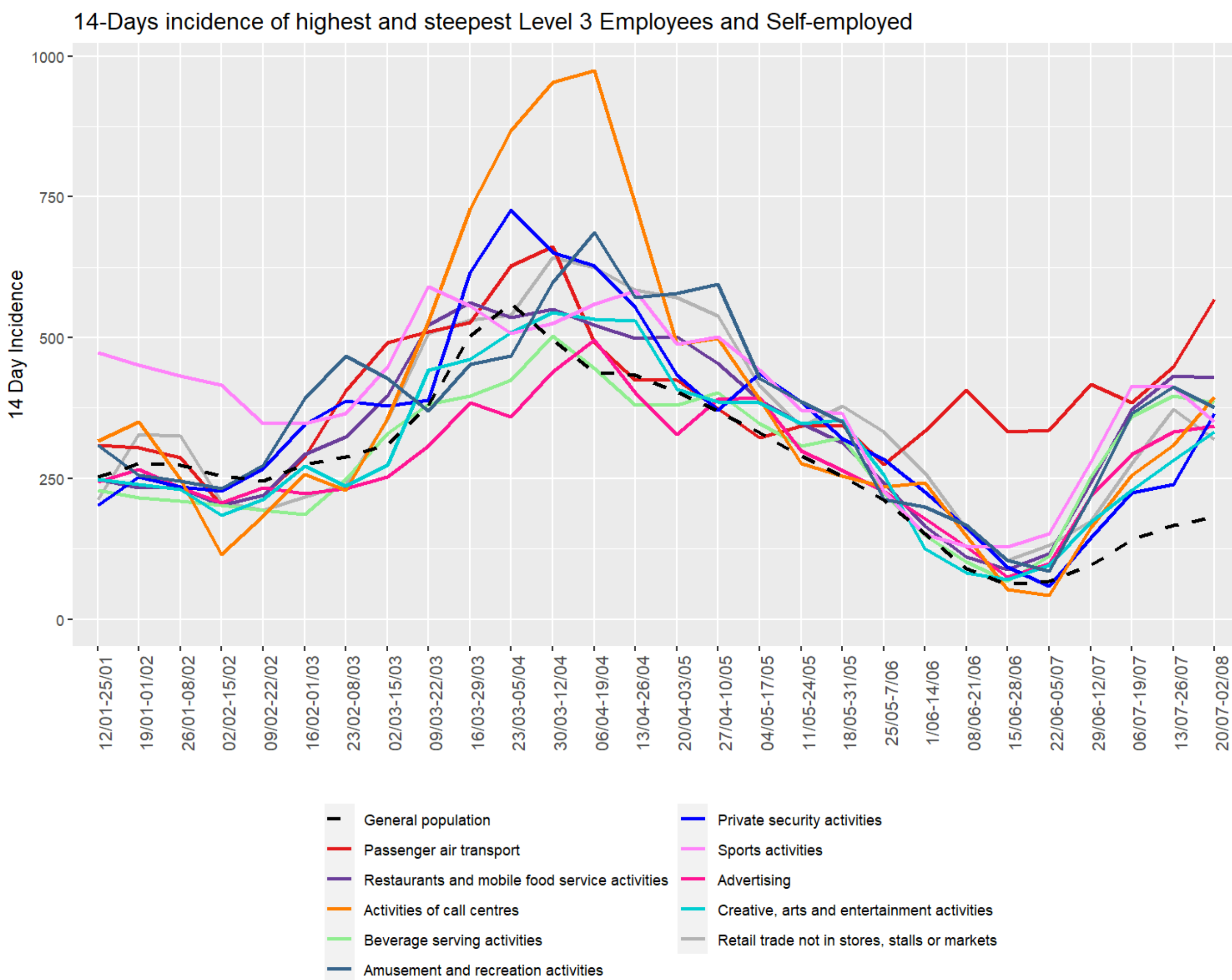


Table 3: 14-Day incidence of COVID-19 infection in sectors with the highest incidence at Level 3 on 2 August 2021

DESCRIPTION	NACE-code	Total number of workers	Incidence (95%CI) all workers	Incidence (95%CI) employees	Incidence (95%CI) self-employed	Percentage of self-employed workers
Passenger air transport	511	5810	568(404;798)	568(404;798)		7.14
Restaurants and mobile food service activities	561	211189	429(402;458)	482(450;516)	229(188;278)	21.55
Activities of call centres	822	11899	395(297;525)	394(295;526)		1.81
Beverage serving activities	563	40625	384(328;449)	566(477;671)	143(97;212)	43.36
Amusement and recreation activities	932	16223	376(293;483)	485(362;649)	230(141;375)	42.61
Private security activities	801	19399	366(290;462)	366(290;462)		3.19
Sports activities	931	37892	351(296;416)	403(332;490)	250(177;353)	34.20
Advertising	731	23032	343(275;427)	435(335;565)	226(150;340)	44.64
Creative, arts and entertainment activities	900	39640	333(281;395)	360(286;453)	306(238;394)	50.87
Retail trade not in stores, stalls or markets	479	18495	319(247;412)		325(242;436)	73.04
Retail sale of cultural and recreation goods in specialised stores	476	22540	315(250;397)	394(309;502)	99(44;220)	26.77
Real estate activities on a fee or contract basis	683	27000	300(241;373)	362(270;485)	247(178;342)	55.17
Retail sale of other goods in specialised stores	477	134138	290(263;320)	332(297;371)	190(152;238)	29.72
Other education	855	49632	272(230;322)	284(226;357)	260(203;333)	49.10
Management consultancy activities	702	107865	267(238;300)	358(300;427)	225(193;262)	68.58
Retail sale in non-specialised stores	471	179528	254(232;278)	263(240;289)	116(67;200)	6.26
Working population		**4438393**	**224(220;228)**	**224(220;228)**		
General population			**182**	**182**	**182**	

1.1 Level 4 work sector

In the sectors at level 4 with a minimum of 3,000 workers, the sectors with the highest 14-day incidences on 2 August 2021 are Passenger air transport (sector 5110), Whole and retail sale (sector 4764, 4775, 4645, 4771, 4791), Sports and recreation (sector 9312, 9329, 9313, 9319, 8551), Processing, preparation of food and horeca (sector 1085, 5610, 5630, 1039), Support activities for performing arts (sector 9002), Activities of amusement parks (sector 9321), Service activities to land and air transport (sector 5221, 5223), Other human resource provision (sector 7830), Activities of call centres (sector 8222), Other amusement and recreation activities (sector 9329), Fitness facilities (sector 9313), Privtae security activities (sector 8010) and Real estate agencies (sector 6831) (Table 4 and Figure 4).

Figure 4: 14-Day incidence of COVID-19 infection in sectors with the highest incidence at Level 4 in both employees and self-employed

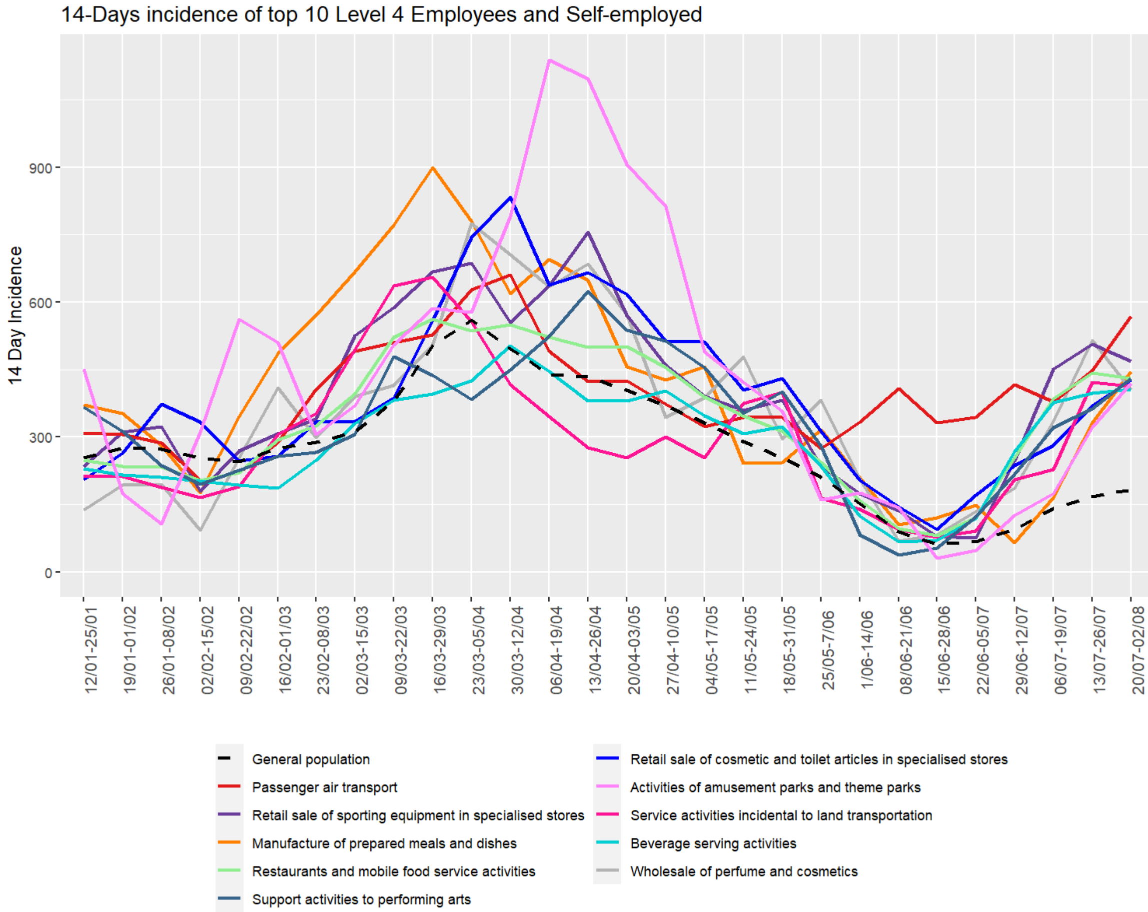


Table 4: 14-Day incidence of COVID-19 infection in sectors with the highest incidence at Level 4 on 2 August 2021

DESCRIPTION	NACE-code	Total number of workers	Incidence (95%CI) all workers	Incidence (95%CI) employees	Incidence (95%CI) self-employed	Percentage of self-employed workers
Passenger air transport	5110	5810	568(404;798)	568(404;798)		7.14
Retail sale of sporting equipment in specialised stores	4764	9615	468(350;626)	517(382;699)		15.48
Manufacture of prepared meals and dishes	1085	3139	446(264;752)	446(264;752)		12.21
Restaurants and mobile food service activities	5610	210930	430(403;459)	482(450;516)	231(190;280)	21.55
Support activities to performing arts	9002	11163	430(324;570)	519(348;773)	367(246;547)	59.05
Retail sale of cosmetic and toilet articles in specialised stores	4775	8685	426(309;587)	502(359;702)	157(51;486)	21.81
Activities of amusement parks and theme parks	9321	4762	420(271;650)	420(271;650)		19.63
Service activities incidental to land transportation	5221	4358	413(260;655)	488(294;808)		29.56
Beverage serving activities	5630	40640	406(349;473)	566(477;671)	194(139;271)	43.36
Wholesale of perfume and cosmetics	4645	3713	404(244;669)	404(244;669)		16.43
Other human resources provision	7830	4467	403(254;639)	375(226;621)		10.44
Activities of call centres	8220	11899	395(297;525)	394(295;526)		1.81
Retail sale of clothing in specialised stores	4771	47826	391(339;451)	418(358;488)	281(193;409)	20.23
Other amusement and recreation activities	9329	10390	385(283;524)	554(375;819)	255(154;423)	56.27
Service activities incidental to air transportation	5223	7050	383(263;558)	390(266;572)		5.46
Fitness facilities	9313	5013	379(242;593)	433(265;706)		26.78
Other processing and preserving of fruit and vegetables	1039	6971	373(254;547)	373(254;547)		3.60
Private security activities	8010	19399	366(290;462)	366(290;462)		3.19
Real estate agencies	6831	20718	362(289;454)	380(266;543)	351(262;470)	62.45
Retail sale via mail order houses or via Internet	4791	14407	354(269;466)	323(191;545)	367(266;506)	69.77
Working population		**4438393**	**224(220;228)**	**224(220;228)**		
General population			**182**	**182**	**182**	

3.5 Level 5 work sector

In the sectors at level 5 with a minimum of 3,000 workers, the sectors with the highest 14-day incidences on 2 August 2021 are Passenger air transport (sector 51100), Wholesale and retail sale (sector 47711, 47640, 47113, 47750, 47192, 46450), Processing, preparation of food and horeca (sector 56102, 10850, 10393, 56301, 56101), Other amusement and recreation activities (sector 93299), Amusement parks (sector 93212), Service activities to land transport (sector 52210), Promotion and organization of performing arts events (sector 90021), Activities of football clubs (sector 93121), Interior architects (sector 71112), Other human resource provision (sector 78300) and Call centers (sector 82200) (Table 5 and Figure 5).

Figure 5: 14-Day incidence of COVID-19 infection in sectors with the highest incidence at Level 5 in both employees and self-employed

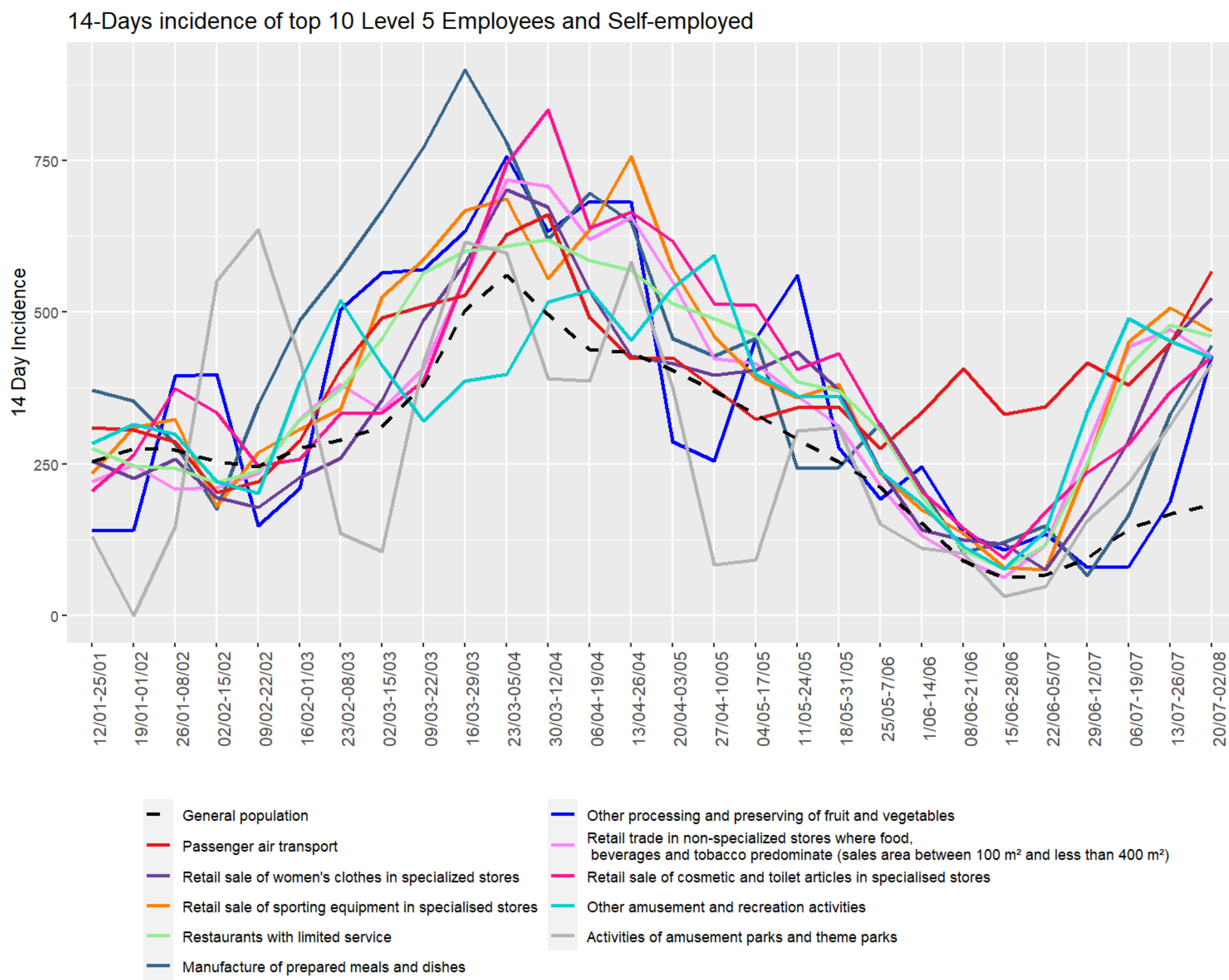
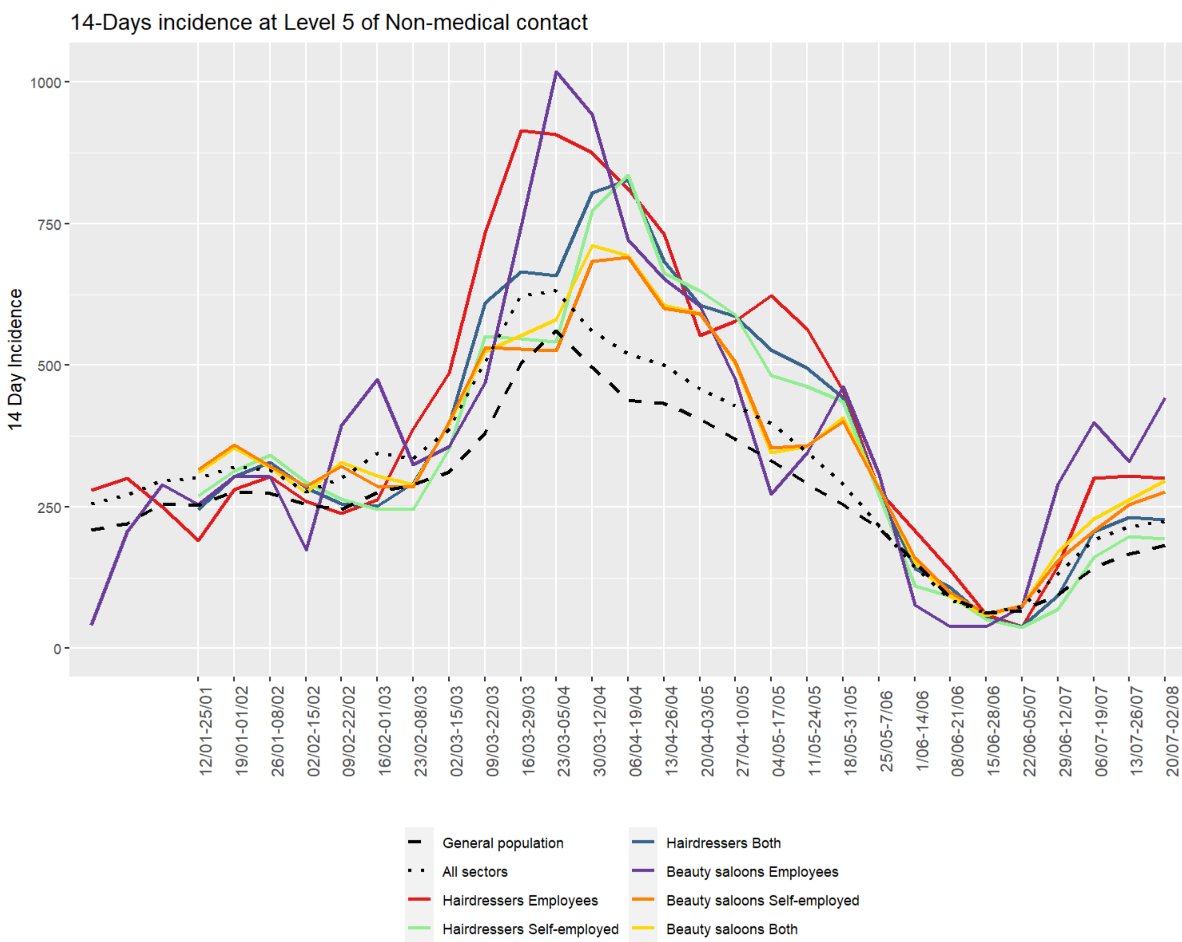


Table 5: 14-Day incidence of COVID-19 infection of sectors with the highest incidence at Level 5 on 2 August 2021

DESCRIPTION	NACE-code	Total number of workers	Incidence (95%CI) all workers	Incidence (95%CI) employees	Incidence (95%CI) self-employed	Percentage of self-employed workers
Passenger air transport	51100	5810	568(404;798)	568(404;798)		7.14
Retail sale of women's clothes in specialized stores	47711	6870	524(378;726)	550(372;813)	473(262;852)	33.89
Retail sale of sporting equipment in specialised stores	47640	9615	468(350;626)	517(382;699)		15.48
Restaurants with limited service	56102	91757	461(419;507)	543(490;601)	234(181;303)	26.84
Manufacture of prepared meals and dishes	10850	3139	446(264;752)	446(264;752)		12.21
Other processing and preserving of fruit and vegetables	10393	3730	429(263;699)	429(263;699)		1.51
Retail trade in non-specialized stores where food, beverages and tobacco predominate (sales area between 100 m^2 and less than 400 m^2)	47113	17757	428(342;536)	473(376;595)	128(41;396)	13.10
Retail sale of cosmetic and toilet articles in specialised stores	47750	8685	426(309;587)	502(359;702)	157(51;486)	21.81
Other amusement and recreation activities	93299	8941	425(309;584)	669(445;1005)	273(165;452)	61.28
Activities of amusement parks and theme parks	93212	4578	415(265;650)	415(265;650)		4.21
Retail trade in non-specialized stores where food, beverages and tobacco do not predominate (sales area from 2500 m^2)	47192	10412	413(306;556)	413(306;556)		2.85
Service activities incidental to land transportation	52210	4358	413(260;655)	488(294;808)		29.56
Promotion and organization of performing arts events	90021	4866	411(265;636)	334(198;563)		23.58
Activities of football clubs	93121	4902	408(263;632)	454(274;752)	312(130;747)	32.37
Interior architects	71112	4412	408(257;647)		409(251;667)	89.09
Wholesale of perfume and cosmetics	46450	3713	404(244;669)	404(244;669)		16.43
Other human resources provision	78300	4467	403(254;639)	375(226;621)		10.44
Cafes and Bars	56301	38653	401(343;469)	556(466;664)	198(141;278)	43.51
Full-service restaurants	56101	123367	398(364;435)	440(401;483)	219(167;287)	19.84
Call centers	82200	11899	395(297;525)	394(295;526)		1.81
Working population		**4438393**	**224(220;228)**	**224(220;228)**		
General population			**182**	**182**	**182**	

Finally, when considering specifically the non-medical contact professions, such as hairdressers and beauty saloons, we see clearly, after the decline in the 14-day incidence in June, a steeper increase in incidence in non-medical contact professions employees in July (Figure 6).

Figure 6: 14-Day incidence of COVID-19 infection at Level 5 of non-medical contact professions.



3.6 Additional analyses

3.6.1 Cross-level overview

When contemplating the 14-day incidences across NACE-BEL sectors, it is possible to gauge the contribution of each sub-level sector to the higher level incidence (Figure 7 and 8).

The 14-day incidence in the Accommodation and food service activities (sector I) is markedly elevated compared to the working population, due to the increased incidence in food and beverage service activities, while the incidence in hotels and holiday accommodation is close to the working population average.

Also the Arts, entertainment and recreation activities (sector R) show an increased incidence compared to the working population, which is caused by Performing arts (sector 90011, 90012 and 90021) and all sectors in Sports, amusement and recreation activities (sector 93).

Although the 14-day incidence in Transportation and storage (sector H) is similar to the working population average, the Passenger air transport sector (sector 5110) has one of the highest incidences, but also land transport (sector 4931, 4932) and land and air transport services (sector 5221, 5223) are increased.

While in the Professional, scientific and technical activities (sector M), Real estate activities (sector L), the Information and communication and the Administrative and support service activities (sector N), the 14-day incidence is close to the working population average, individual subsectors show an increased incidence, such as Auditors (sector 69203), Interior architects (sector 71112), Advertising (sector 73110), Real estate agencies activities (sector 6831), Computer consulting activities (sector 6202), Other human resources provision (sector 7830), Private security (sector 8010) and Call centers (sector 8220).

The 14-day incidence in all subsections of Education (sector P) is below the working and general population average, except for the Sports and recreation education (sector 8551). Also, in Hairdressers (sector 96021) the incidence is around the working and general population average as well as employees of cleaning activities (sector 7820, 8121, 8122). The incidence in Beauty salons (96022) is significantly increased compared to the working population average.

The sectors Manufacturing (sector C) and Wholesale and retail trade (sector G) are sectors with the highest number of sublevels. This results in large differences in 14-day incidences within the sector. Although the Processing and preserving of meat and poultry sectors (sector 1011, 1012 and 1013) show an incidence comparable to the working population average, the food sector continues to require vigilance as Processing and preserving of fruit and vegetables (sector 1039) and Manufacture of prepared meals (sector 1085) show an increased incidence. Most of the manufacture sectors however, have a incidence close or below the general population. Although a few sectors in the Wholesale (sector 46) have an elevated incidence (sector 4639, 4642 and 4645), many sectors show an increased incidence in Retail sale (sector 47) (Figure 8).

Finally, the incidence in the Human health and social work sector (sector Q) is below the working and general population average for most subsections.

Figure 7: Forest plot of 14-Day incidence and 95% CI of selected sectors on 2 August 2021 in both employees and self-employed.

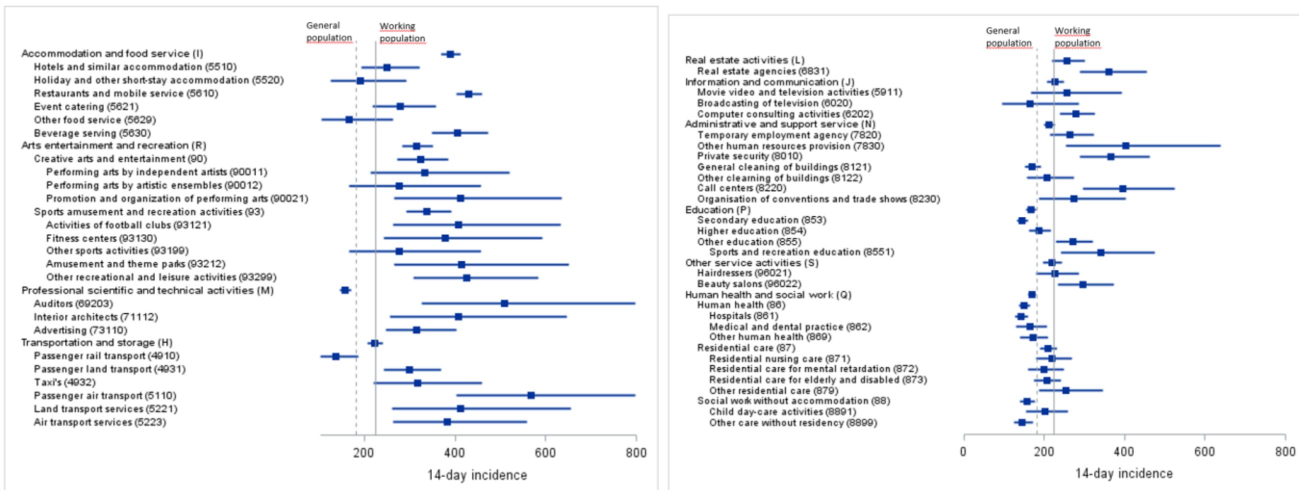
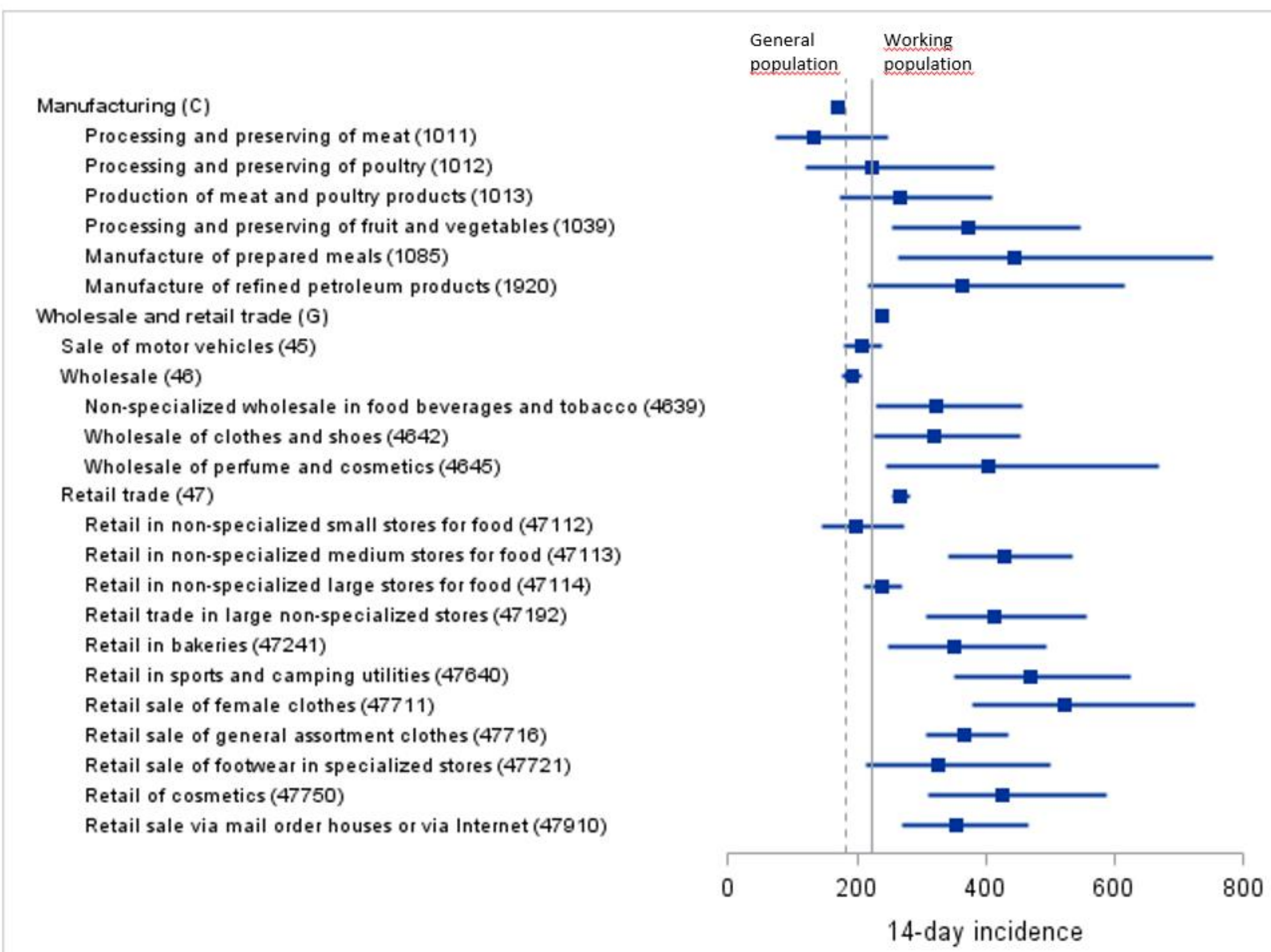


Figure 8: Forest plot of 14-Day incidence and 95% CI of selected sectors on 2 August 2021 in both employees and self-employed.

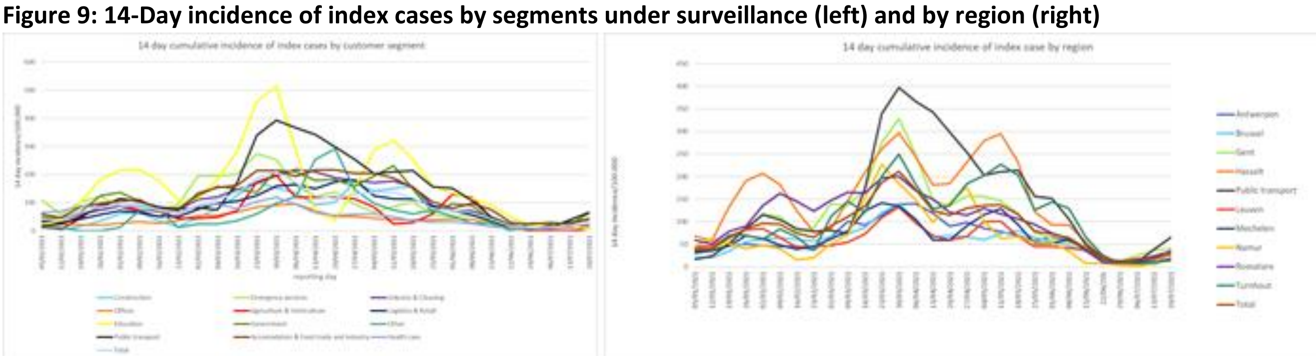


3.7 Contact tracing

In 2020–2021 about 800,000 employees are under medical surveillance of IDEWE. Among these, 19,979 COVID19 index cases were registered between 22 July 2020 (week 30) and 22 July 2021, for whom the customer segment, region and the registration date are known for 19,707 index cases.

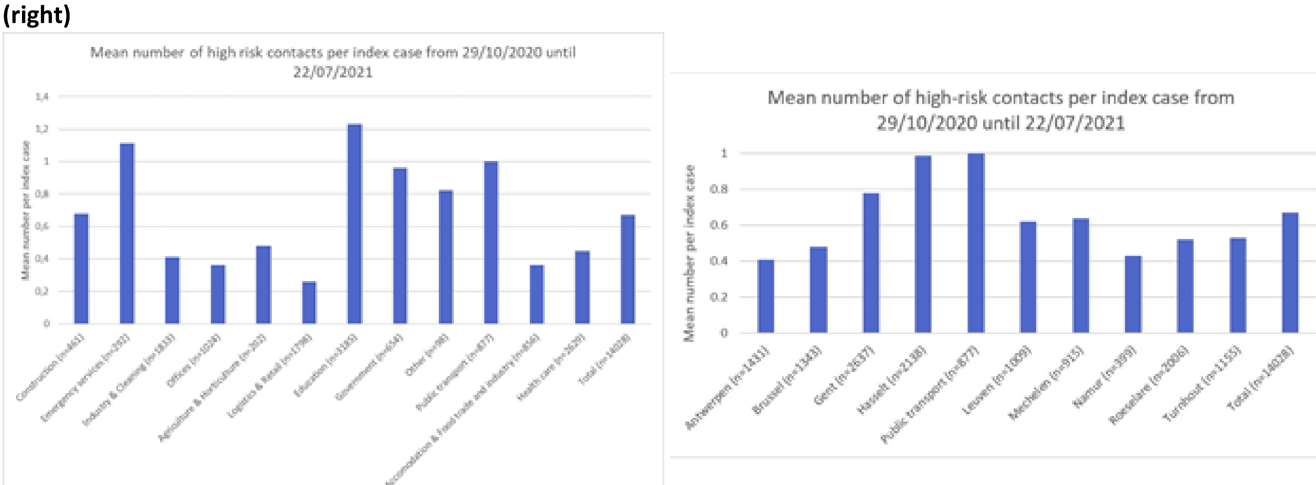
The 14-day incidence declined in all segments and regions since 11 May 2021 and reached the lowest point on 29 June 2021 of 10 cases per 100,000 employees (Figure 9). Since the first week of July incidence is rising again to 28 per 100,000 on July 20th. Segments with a 14-day incidence of 60 or more are Public transport and Government. The region with the highest incidences are Gent, Namur and Roeselare with a 14-day incidenceabove 35 cases per 100,000 employees. Note that two factors, mentioned above, may cause bias in the figures: employees of some large companies are not included and beside employees, external persons are also registered as an index case. Especially students and pupils may influence the figures of Education.

Figure 9: 14-Day incidence of index cases by segments under surveillance (left) and by region (right)



Since the establishment of the tracing app on 29 October 2020, there are 14,028 index cases of whom high-risk contacts were recorded. Of 13,909 index cases, the customer segment and region is known. The mean number of high-risk contacts in segment Education and Emergency services is above 1, while in the Hasselt region a higher mean number of high-risk contacts is reported in the period 29 October 2020–22 July 2021 (Figures 10).

Figure 10: The mean number of high-risk contacts per index case by segments under surveillance (left) and by region (right)

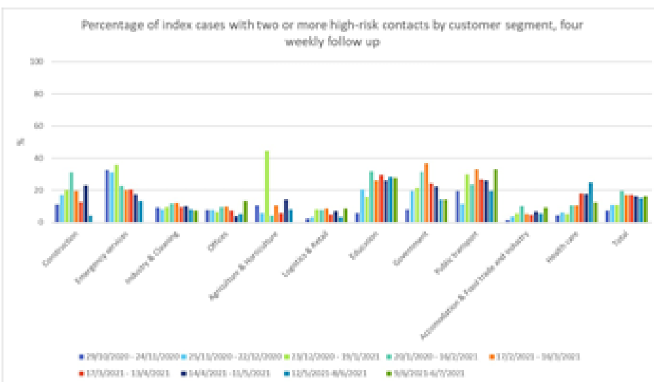


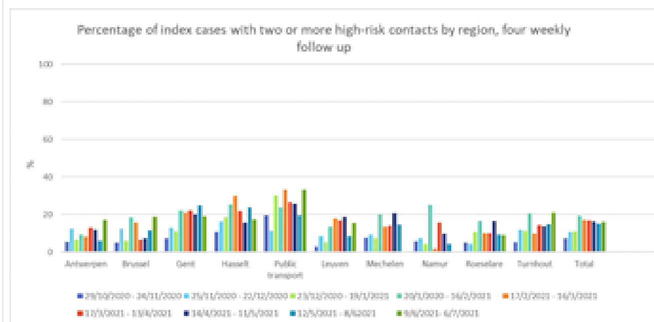
The number of high-risk contacts per index case varies from 0 to 62, with more than 99% being lower than 10 high-risk contacts. Seventy-three percent had 0 high risk contacts. A sole high number of high-risk contact for an index will influence the mean number for a segment importantly, especially when groups are small. To avoid extremely high numbers of contacts influencing results, we report the percentage of index cases who had two of more high-risk contacts per four weeks.

The percentage of index cases with two or more high-risk contacts is decreasing in most segments in the last months, except for Offices, Logistics and Retail, Public Transport and Accomodation and food trade and industry (Figure 11).

The behavior in the percentage of index cases with two or more high-risk contacts is different between regions in the most recent period (9 June–6 July 2021) (Figure 11), reflecting the changed behavior in the working environment.

Figure 11: Four weekly percentage of index cases with two or more high-risk contacts by segments under surveillance (left) and by region (right)

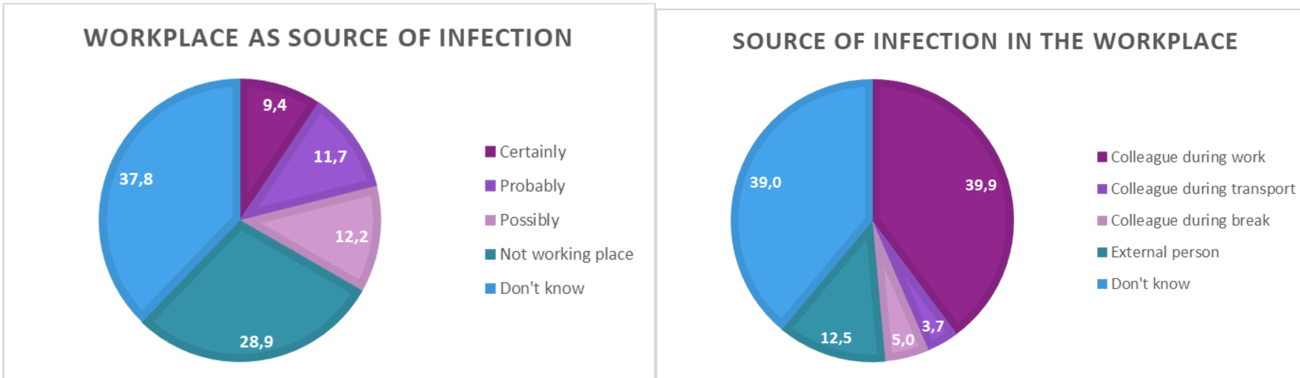




Since 11 March 2021, index cases are asked if they contracted COVID-19 during work and if they did, which were the circumstances or the source of the infection. Note that pupils and other external index cases were left out of the following analyses.

From 5790 index cases, we have information about perceived work relatedness of the source of infection. While 38% of the index cases does not know whether the infection took place at work, 21% responded that they were certainly or probably infected at work (Figure 12 left). From 1927 (33%) of the index cases that answered they were certainly, probably, or possibly infected at work, further information was obtained on how the infection took place (Figure 12 right). A majority of the index cases (61%) indicates to know the source of infection at work. The last four weeks, probably due to the beginning of the summer holidays and alleviation of corona restrictions, the index cases that mentioned to be infected outside the working place is about 10 percent higher than before summer holidays.

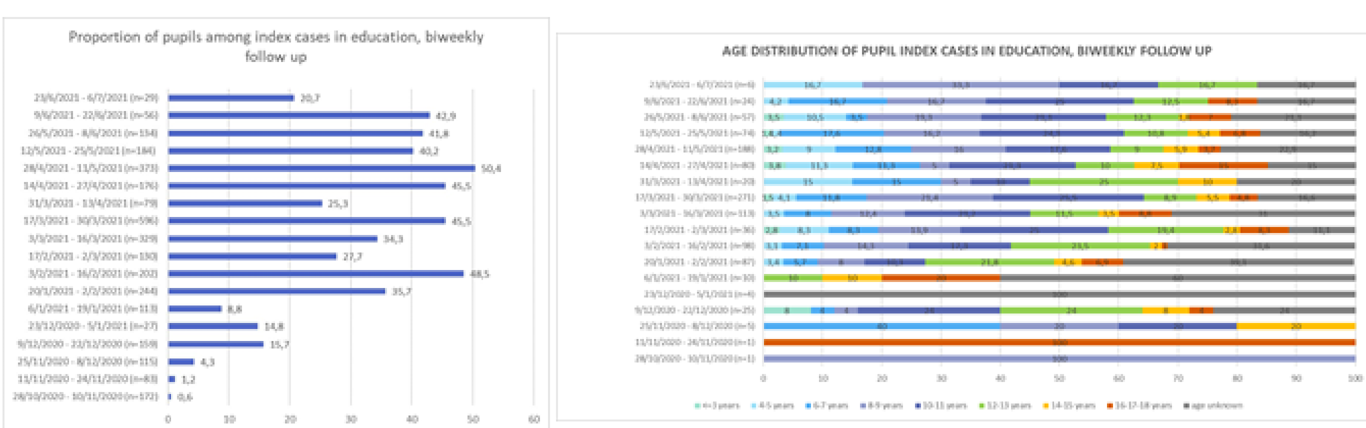
Figure 12: Distribution of the probability and source of infection at work by index case



Since the start of summer holidays there is a steep decline of index cases in education and pupil index cases dropped to zero at 7 July 2021 (Figure 13 left). The interpretation of these data should be undertaken, however, with caution. Index cases in schools, both pupils and teachers, are reported to IDEWE by CLBs and schools in order to reach high-risk contacts among teachers and provide them with prescriptions for PCR tests and quarantine. The working method is, however, not the same for all CLBs and schools and therefore notification of index cases may differ between CLBs and regions. Moreover, index cases with only low risk contacts are often not reported to our service, because they do not need prescriptions for tests or quarantine. This might lead to an underestimation of index cases among pupils and teachers. Note that pupils are tested on a larger scale since January 2021.

Since the tracing app came in use, the social security number of most index cases is registered. Age is calculated from the social security number and is available for most index cases. The majority of the index cases is aged 10 years or older (Figure 13 right). Note that some type of schools might be over- or underrepresented in comparison to the Belgian school landscape, as a result of which the proportion of age groups might not be representative for the Belgian school population. Before 20 January 2021, biweekly numbers of cases are too small to allow for an interpretation, as well as the period 31 March–13 April 2021 and 9 June–6 July 2021.

Figure 13: The evolution of index cases of pupils in school (left) and their age distribution (right).



Since 6 June 2021, the vaccination status of index cases is registered, with the type of vaccine if applicable. The vaccination dates are retrieved from vaccinnet to evaluate if a person can be considered fully protected. Because only the date of the notification of the index case is available and not the date of a positive PCR test, index cases are considered fully protected if the second dose (or the only dose in case of the Johnson and Johnson vaccine)

is administered 3 weeks or more before the date of notification. The assumption is made that the latency between a positive PCR test and the registration via de contact tracing app is maximally 1 week.

From 472 adult index cases we had information about their vaccination status: 210 were partially or completely vaccinated (155 Cominarty, 33 Vaxzevria, 16 Moderna and 6 Johnson % Johnson) (Figure 14 left). With an increasing vaccination coverage in the working population, which was 80% on 21 July 2021 (Figure 14 right, data derived from Sciensano), it is important to evaluate these breakthrough index cases in time. The mean time between notification of infection and the second vaccine dose (or the only dose in case of Johnson & Johnson) for the breakthrough cases was was 73 days (SD 44), minimum 15 days, maximum 151 days. The index cases who are only partially vaccinated are the largest proportion in the last weeks (Figure 15 left). The vaccine effectiveness (VE) in fully vaccinated and protected workers is estimated using the screening method (see Giesecke: Modern infectious disease epidemiology):

$$VE = \frac{(PPV - PCV}{(PPV\,(1 - PCV))}$$

$$= \frac{0{,}54 - 0{,}2}{0{,}54\,(1 - 0{,}2)}$$

$$= 0{,}79$$

with PPV= the proportion of the entire population vaccinated and PCV= the proportion of cases that has been vaccinated.

Note that this result and the biweekly evolution (Figure 15 right) should be interpreted with caution. Partially vaccinated and partially protected workers are not taken into account in this calculation nor is the rapidly changing vaccination coverage of the population. This method is not recommended by the WHO in the early stages of vaccine roll-out.

Figure 14: Distribution of the probability of vaccination in the general population (right) and the vaccination status of index cases (left).

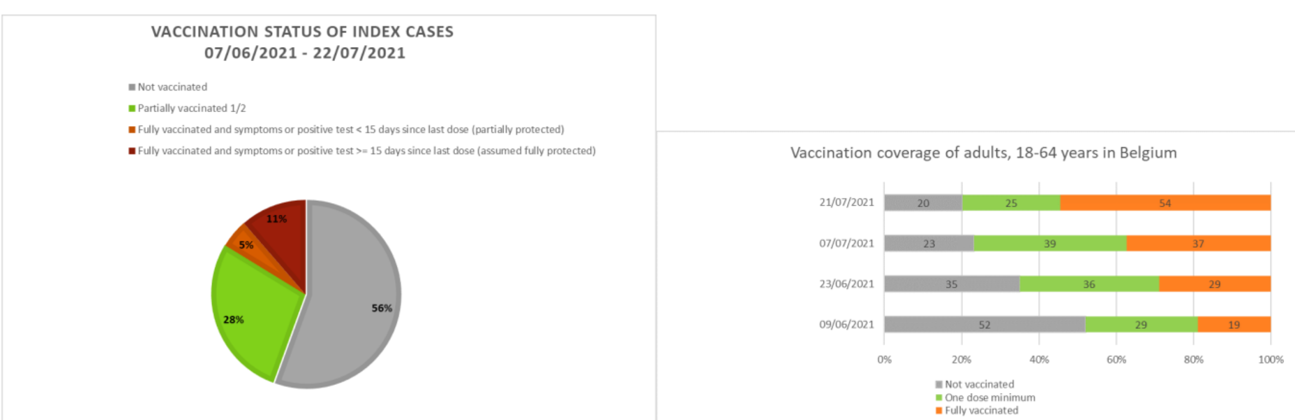
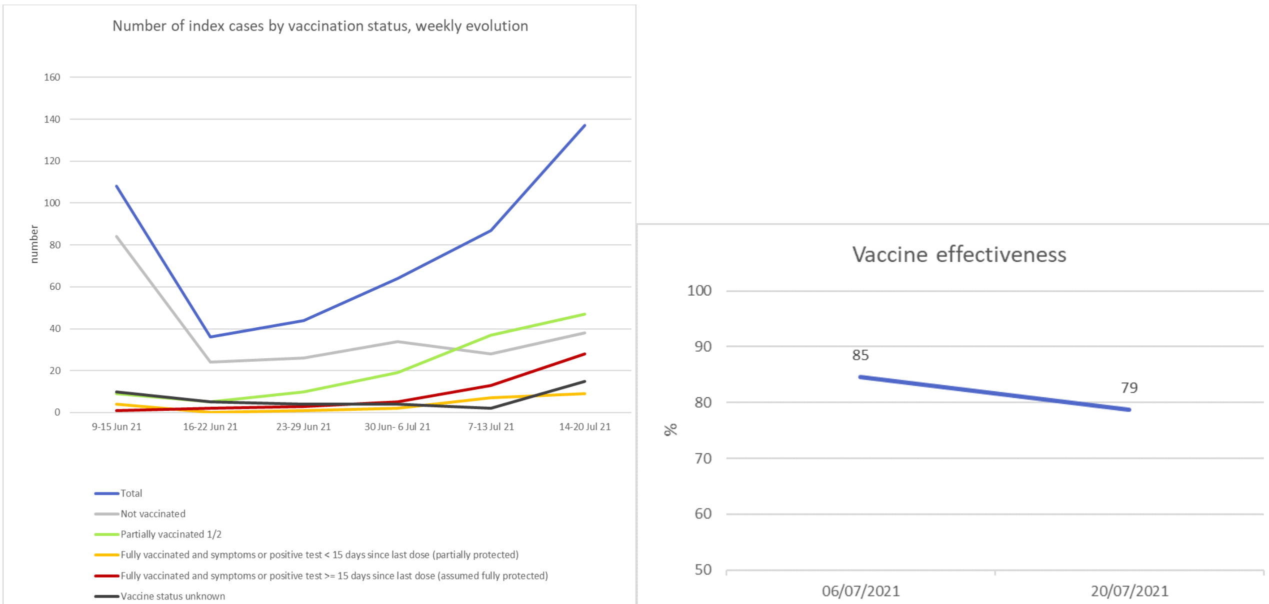


Figure 15: The weekly evolution of index cases and their vaccination status (left) and the vaccine effectiveness (right).



4 Conclusion

Despite the limitations of the data, both the contact tracing as the RSZ/ONSS data demonstrates that the increase of the 14-day COVID-19 incidences in July 2021 is slowing in most sectors. Vigilance is required in those sectors where telework is not possible, where workers are often exposed to close physical proximity, and where climate conditions favors transmission of the virus.

Although no conclusions can be drawn regarding the location of infection (workplace or elsewhere) nor the location of employment (at work, telework, or temporarily unemployed) of the employees in the RSZ/ONSS data, the contact tracing in the segments under surveillance by IDEWE shows that in the index cases, where this information was available, 9% indicated that the workplace was certainly the source of infection. The last four weeks an increased number of index cases (40% compared to 30% before summer holidays) however indicated the potential source of infection certainly not to be work related.

It is clear that in most sectors at level 1 the 14-day incidence follows the pattern that is observed in the general population. Two sectors at level 1 have a sharper increase in incidences than the working population average, Accommodation and food service activities (sector I) and Arts, entertainment and recreation (sector R). The contact tracing however shows the highest incidences in Public transport and Government segments and that the increasing incidence pattern is observed over the entire country.

With an increased circulation of SARS-CoV-2, it is important to carefully monitor incidence of COVID-19 in the sectors with multiple close physical proximity, especially with younger, not yet vaccinated individuals, and are not able to telework. Passenger air transport, Sport, amusement and recreational activities, Sports and recreation education, Performing arts and its organisation and promotion, many Retail sectors and Food and beverage service facilities for example all show a steeper increase of incidences and require careful attention.

For some sectors the reason for the steeper increase in incidences is not immediately obvious, such as auditors, interior architects, advertising, real estate agencies, other human resources provision, private security, call centers and computer consultancy activities. It would be worthwhile to evaluate the hygiene protocols and its practice in these sectors.

Employees in non-medical contact professions show an increased incidence compared to the self-employed professionals. Although the incidence in hairdressers is comparable to the working population average, the incidence in beauty salons is increased.

It is encouraging to note that employees in most manufacturing sectors and wholesale sectors are well protected, as they are often not able to telework.

The 14-day incidences in employees in the health and care activities follow the general trend in the population. Although incidences in human health remain well below the general population average, the incidence in the residential care sectors increases from below the general population average close to the working population average. Possibly, this increase may be partly explained because a COVID-19 infection remains possible despite vaccination (45 out of 472 cases or 10%), as shown in the contact tracing data. Although the largest proportion of index cases is seen in partially vaccinated, the vaccine effectiveness (79% in the IDEWE contact tracing data) for fully vaccinated is lower then expected from trial data.

Acknowledgments

We wish to thank Hilde Vanacker, Chris Verbeek and Hilde de Raeve for their contribution to the analysis of the contact tracing data.

Annex 4. Example of outbreak with breakthrough infections (Barnstable case)

A relevant case is the one that occurred in Barnstable county in Massachusetts, in the first half of July 2021. The case has been thoroughly investigated by the US CDC (Brown et al. 2021; https://www.cdc.gov/mmwr/volumes/70/wr/mm7031e2.htm?s_cid=mm7031e2_w).

The CDC summarizes its main findings as follows: *"In July 2021, following multiple large public events in a Barnstable County, Massachusetts, town, 469 COVID-19 cases were identified among Massachusetts residents who had traveled to the town during July 3–17; 346 (74%) occurred in fully vaccinated persons. Testing identified the Delta variant in 90% of specimens from 133 patients. Cycle threshold values were similar among specimens from patients who were fully vaccinated and those who were not."*

The events that led to the outbreak are described as follows: *"During July 3–17, 2021, multiple summer events and large public gatherings were held in a town in Barnstable County, Massachusetts, that attracted thousands of tourists from across the United States. Beginning July 10, the Massachusetts Department of Public Health (MA DPH) received reports of an increase in COVID-19 cases among persons who reside in or recently visited Barnstable County, including in fully vaccinated persons. Persons with COVID-19 reported attending densely packed indoor and outdoor events at venues that included bars, restaurants, guest houses, and rental homes. On July 3, MA DPH had reported a 14-day average COVID-19 incidence of zero cases per 100,000 persons per day in residents of the town in Barnstable County; by July 17, the 14-day average incidence increased to 177 cases per 100,000 persons per day in residents of the town."*

They suggest the following public health practice implications: *"Jurisdictions might consider expanded prevention strategies, including universal masking in indoor public settings, particularly for large public gatherings that include travellers from many areas with differing levels of SARS-CoV-2 transmission."*

The CDC also suggests: *"Findings from this investigation suggest that even jurisdictions without substantial or high COVID-19 transmission might consider expanding prevention strategies, including masking in indoor public settings regardless of vaccination status, given the potential risk of infection during attendance at large public gatherings that include travellers from many areas with differing levels of transmission."*

Annex 5. Recommendations from international advisory bodies on the use of NPIs

WHO

The International Health Regulations Emergency Committee has clearly stated that (15/07/2021), "despite national, regional, and global efforts, the **pandemic is nowhere near finished**", continuing the health, economic, and social challenges. The Committee further recognised "the strong likelihood for the emergence and global spread of new and possibly more dangerous variants of concern that may be even more challenging to control". They also highlight the **need for a globally harmonised approach**, which in itself is a difficult task, but is further inhibited by the increasingly divergent policy decisions between different countries and regions. To help streamline the approaches countries are taking and to endorse countries to take the right actions and preparations, the WHO has worked out a COVID-19 strategic **preparedness and response plan** (until January 31, 2022), for which an operational planning guideline is available online.

Given the outlook of a continuing pandemic, the WHO has made the following recommendations for countries regarding public health safety measures and community engagement based on real time monitoring of the epidemiologic situation and health system capacities, taking into account the potential cumulative effects of these measures:

- The **use of masks, physical distancing, hand hygiene, and improved ventilation of indoor spaces remains key to reducing transmission** of SARS CoV-2.
- The use of established public health **measures in response to individual cases or clusters of cases**, including contact tracing, quarantine and isolation, must continue to be adapted to the epidemiological and social context and enforced. To facilitate breaking chains of transmission, the WHO further recommends that "countries increase access to free of charge testing, expand sequencing, **incentivise quarantine** for contacts **and isolation** for confirmed cases and ensure those most at risk among our populations are vaccinated".
- "Implement a **risk-management approach for mass gathering events** by evaluating, mitigating, and communicating risks. Recognizing that there are different drivers and risk tolerance for mass gatherings, it is critical to consider the epidemiological context (including the prevalence of variants of concern, the strength of transmission, as well as contract tracing and testing capacity) when conducting this risk assessment in line with WHO guidance."
- "Address **community engagement and communications gaps at national and local levels** to reduce COVID-19 transmission, counter misinformation, and improve COVID-19 vaccine acceptance, where applicable. This will require reinforcing messages that a comprehensive public health response is needed, including the continued use of PHSM alongside increasing vaccination coverage." The WHO also provides guidance on risk communication and community engagement principles within contract-tracing efforts to improve the success rate.

New normal + guidance on process of evaluation to maximise epi suppression while minimising economic cost and negative effects on mental and physical health - Link

ECDC

The ECDC gives similar advice as the WHO regarding some key NPIs that need to remain in place because of the delta variant, at least until more of the (European) population are fully vaccinated. Dr Andrea Ammon, ECDC Director said (23/07/2021), "We need to remain vigilant and continue to use common sense to prevent the spread of the virus. This means getting a full course of vaccination as soon as the opportunity arises and maintaining physical distance, washing hands, avoiding crowded spaces, and wearing a mask when necessary. These are measures that we know work to protect ourselves and others. [...] We should think of these as '**anti-lockdown measures**' because they can help prevent the spread of disease without having to shut down large parts of society."

Apart from general NPIs in society, the ECDC also recently published advice on specific sectors where extra care should be taken, given the low vaccination status or frail population.

On July 8th, 2021, they published a document which discusses the role of schools in transmission, since the large majority of the school-going population might not be vaccinated when the new school year starts The exact burden of COVID-19 and its long-term consequences in the paediatric population is still to be determined and is a priority for further research.

This evidence lead the ECDC to give the following recommendations regarding schools:

- The general consensus remains that closing schools to control the pandemic should only be used as a last resort. The negative physical, mental, and educational impacts of proactive school closures on children, as well as the economic impact on society more broadly, would likely outweigh the benefits. Furthermore, school closures are by themselves insufficient to prevent community transmission and effectiveness of school closures appears to have declined in the second wave as compared to the first wave of the COVID-19 pandemic, possibly in part due to better hygiene measures in school settings. Additionally, ECDC modelling work estimates that closing secondary schools has a larger effect on community transmission of SARS-CoV-2 than does closing primary schools or day nurseries.
- Given the likely continued risk of transmission among unvaccinated children, it is imperative that there is a high level of preparedness in the educational system for the 2021/2022 school year. Implementing combinations of multiple physical distancing and hygiene measures can significantly reduce the possibility of SARS-CoV-2 transmission in school settings (high confidence). School measures should be adapted to levels of community SARS-CoV-2 transmission as well as to the educational setting and age group. Measures should be implemented taking into consideration the age groups and the measures' impact on learning and psychosocial development.
    - Possible physical distancing measures:
        - cohorting of classes and groups;
        - ensuring physical distance in the classroom (e.g. separating tables/chairs);
        - reducing class sizes;
        - staggering arrival times, as well as meal and break times;
        - holding classes outdoors;
        - cancellation of certain indoor activities; and
        - cancelling, where necessary, extracurricular activities that entail spending a lot of time indoors (e.g. theatre plays, choir practice)
    - Hygiene measures:
        - hand-washing;
        - respiratory etiquette;
        - cleaning;
        - ventilation; and
        - face masks in certain circumstances and for certain age groups
- It is important that testing strategies for educational settings aiming at timely testing of symptomatic cases are established to ensure isolation of cases and tracing and quarantine of their contacts. When

positive cases are identified, the school should be informed, contact tracing should be initiated according to local guidelines, and communication to and the testing of close contacts, ideally with rapid diagnostic tests, should be considered.

On July 26, 2021, the ECDC published a document on COVID-19 outbreaks in long-term care facilities (LTCFs) in the context of current vaccination coverage. The population residing in LTCFs may have altered (i.e. lower and shorter) vaccine protection due to their age and underlying conditions, albeit direct vaccine effectiveness data in this population is limited and data on vaccine effectiveness against the Delta variant of concern (VOC) specifically is missing. In addition, vaccine effectiveness against the Delta VOC in the general population is reduced compared to that against other variants, particularly in partial vaccination. Given these element, the ECDC stated several recommendations in their advice:

- The overall level of SARS-CoV-2 transmission in the general population has a direct impact on the risk to LTCF residents; therefore, continued measures to maintain or reduce transmission in the general population will reduce the risk to this vulnerable group.
- Full vaccination coverage of LTCF residents and all people in contact with them should be ensured by promoting further through specific activities targeting vaccine acceptance and barriers to uptake.
- Countermeasures should be put into place to reduce the risk of virus introduction into LTCF communities.
- Early identification of COVID-19 cases in LTCFs should be ensured. It is essential for the introduction of control measures and the prevention of further outbreak spread. Testing, contact tracing and investigation of COVID-19 cases and outbreaks in LTCFs (including whole genome sequencing (WGS)) should remain a priority for public health authorities.
- Meticulous compliance with NPIs for residents, staff and visitors in LTCFs should be maintained, irrespective of vaccination coverage, while ensuring that the mental health needs of residents are taken into consideration.

Annex 6. Dutch experiences with 'testen voor toegang'.

In the Netherlands, the Outbreak Management Team (OMT), in its advice of July 9, 2021 based on its 119th meeting, states: "*Het aantal clusters gerelateerd aan horeca, feesten en studentenverenigingen stijgt snel, na een eerdere stijging in de voorafgaande weken die vooral gerelateerd was aan vakanties en reizen. Ook het aantal grotere clusters (met tientallen betrokkenen en uitschieters naar enkele honderden) neemt toe en is grotendeels gerelateerd aan horeca en in mindere mate aan festivals en studentenverenigingen.*"

The OMT advice encompasses: *"Concreet adviseert het OMT om feesten en samenscholingen in de nachtclubs, feestgelegenheden, studentenverenigingen en discotheken tot een nader vast te stellen tijdstip te sluiten, en wat betreft de horeca een stap terug te gaan en daarin de volgende maatregelen aan te houden: triage en placering met vaste zitplaatsen; aanhouden van de 1,5 m afstand; overweeg beperking van openingstijden van bijv. 06.00 tot 22.00 uur; maximaliseren van bezoekers op grond van 1,5 meter-maatregel en de noodzaak van placering; het aantal personen per tafel te maximaliseren met het respecteren van 1,5 meter afstand onderling."*

Finally, the OMT states: *"Als festivals doorgaan, dan adviseert het OMT deze doorgang te laten vinden met placering en een maximum aantal bezoekers van 1000 per dag*."

At a festival in Utrecht, about 1000 out of 20,000 participants were infected. Detailed scrutiny indicated that many of the participants tested negative, but were apparently infected in the time interval between the moment of testing and the actual event. Many had participated in other events prior to the festival.

In summary, testing alone did not work as well as one would hope, for the following four reasons:

- Someone can become positive in between testing and event;
- There can be fraudulent tests;
- A test can lead to a false positive;
- A person who genuinely tests negative, and remains negative at the start of the event, remains at risk to be infected by others who are positive and participate in the same event. This is exacerbated when the event takes place in superspreading circumstances (e.g., indoor festivals; nightlife;…).

References

Brown CM, Vostok J, Johnson J, et al. (2021). Outbreak of SARS-CoV-2 infections, including COVID-19 vaccine breakthrough infections, associated with large public gatherings – Barnstable County, Massachusetts, July 2021. *Mortality and Morbidity Weekly Report.*

https://www.cdc.gov/mmwr/volumes/70/wr/mm7031e2.htm?s_cid=mm7031e2_w

Sneppen K, Forst Nielsen B, Taylor RJ, Simonsen L (2021). Overdispersion in COVID-19 increases the effectiveness of limiting nonrepetitive contacts for transmission control. *PNAS* 118, 14.

Tkachenko AV, Maslov S, Elbanna A, Wong GN, Welner ZJ, Goldenfeld N. (2020). Persistent heterogeneity not short-term overdispersion determines herd immunity to COVID-19.

https://www.medrxiv.org/content/10.1101/2020.07.26.20162420v4